JAPAN INTERNATIONAL COOPERATION AGENCY

MINISTRY OF ENERGY, ISLAMIC REPUBLIC OF IRAN

THE STUDY
ON
EVALUATION OF ENVIRONMENTAL IMPACT OF THERMAL POWER PLANTS
IN
ISLAMIC REPUBLIC OF IRAN

FINAL REPORT
(SUPPORTING APPENDICES)

DECEMBER 1999

SUURI-KEIKAKU CO., LTD.

TOKYO ELECTRIC POWER ENVIRONMENTAL ENGINEERING CO., INC.

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List of Appendices

Appendix

REFERENCES

List of Abbreviation

Az	Code of Iranian Residual Fuel Oil
BOD	Biological oxygen demands
BS	Particulates having aerodynamic diameter less than 4.5 μm
Bz	Code of Iranian Residual Fuel Oil
COD	Chemical oxygen demands
deg C	Centigrade temperature difference
DF/R	Draft Final Report
DST	Iranian Daylight Saving Time
DO	Dissolved oxygen
DOE	Department of Environment in the Iranian President's Office
ED-MOE	Environmental Department in the organization of the Deputy of Energy Affairs, MOE
EHC	Iranian Environmental High Council
EIA	Environmental Impact Assessment
EIS	Environmental Impact Statement
Fig.	Figure or Figures
F/R	Final Report
GDP	Gross Domestic Product
GNP	Gross National Product
ICES	Iranian Center for Energy Studies
IC/R	Inception Report
I. R. Iran	Islamic Republic of Iran
IT/R	Interim Report
JICA	Japan International Cooperation Agency
JIS	Japanese Industrial Standards
MOE	Iranian Ministry of Energy
MW	Mega Watt
NG	Natural Gas: NGL - Natural Gas Liquid, LNG - Liquefied NG
NIOC	National Iranian Oil Company
NOx	Mixture of mainly Nitrogen oxide (NO) and Nitrogen dioxide (NO_2)
OJT	On the Job Training
PG/R	Progress Report
PM	Particulates emitted from sources (include soot from stacks)
ppb	Parts per billion
ppm	Parts per million
PTIO	2-phenyl-4,4,5,5-tetramethylimidazoline-3-oxide-1-oxyl (used for passive samplers)
Rls.	Iranian Currency Unit (Rials); in this Report U.S. $ 1.00 = Rls. 8,000
SOx	Mixture of sulfur dioxide (SO_2) and sulfur trioxide (SO_3)
SPM	Suspended Particulate Matter in air
SS	Suspended solid in water
TEA	Tri-ethanol-amine (used for passive samplers)
TSP	Total Suspended Particulate in air
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
U.S. EPA	Environmental Protection Agency of the United States
WHO	World Health Organization
¥	Japanese Currency Unit; in this Report U.S.$ 1.00 = ¥120
#	Leading mark of numbers listed in REFERENCES in this Report

Appendix 1-1

SCOPE OF WORK
FOR
THE STUDY
ON
EVALUATION OF ENVIRONMENTAL IMPACT OF THERMAL POWER PLANTS IN ISLAMIC REPUBLIC OF IRAN

AGREED UPON BETWEEN
THE MINISTRY OF ENERGY
AND
THE JAPAN INTERNATIONAL COOPERATION AGENCY

Tehran August 12, 1996

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Mr. HAMID CHITCHIAN
DEPUTY MINISTER FOR ENERGY AFFAIRS
MINISTRY OF ENERGY
I.R.IRAN

Mr. NOBUYUKI YAMAURA
TEAM LEADER
THE PREPARATORY STUDY TEAM
THE JAPAN INTERNATIONAL
COOPERATION AGENCY

I. INTRODUCTION

In response to the request of the Government of the Islamic Republic of Iran (hereinafter referred to as "I. R. Iran"), the Government of Japan decided to conduct the Study on Evaluation of Environmental Impact of Thermal Power Plants in Islamic Republic of Iran (hereinafter referred to as "the Study") in accordance with the relevant laws and regulations in force in Japan.

Accordingly, the Japan International Cooperation Agency (hereinafter referred to as "JICA"), the official agency responsible for the implementation of the technical cooperation programmes of the Government of Japan, will undertake the Study in close cooperation with the authorities concerned of I. R. Iran.

The present document sets forth the scope of work with regard to the Study.

II. OBJECTIVE OF THE STUDY

The objective of the study is;

(1) to contribute the activities carried out by the Ministry of Energy of I. R. Iran to assess the environmental impacts caused by energy sector (thermal power plant) and to implement mitigation plan, and to provide technical advise to improve the efficiency of studied power plants.

(2) to transfer relevant technologies to Iranian counterpart through site work and seminar in the course of the Study.

III. SCOPE OF THE STUDY

1.Study Area

(1) Azarbaijan Province ; Tabriz Power Plant and the surrounding area

(2) Esfahan Province ; Islam-Abad Power plant and the surrounding area

2.Study Item

This study focuses on air pollution and includes the following:

(1) To monitor the present situation of emission and ambient air quality of the environmental impacts which considerably appear to be caused by the thermal power plants.

(2) To formulate and recommend the mitigation plan.

(3) To transfer the monitoring technology to Iranian counterpart in the course of the Study.

(4) To formulate and recommend both the legislative and administrative framework to improve the environmental situation in power sector.

(5) Preparation of Iran's environment impact assessment (hereinafter referred to as "EIA") framework for electric Power sector.

(6) To formulate and recommend practical and economical suggestions for improvement of power plant's efficiency

3.Scope of the study

(1) Collection and Review of Existing Data and Information

1) Socioeconomic conditions and economic development policy with respect to this study
2) Present situation and national policy in power sector
3) Present situation and future plan of power plants
4) Legislation, regulation, criteria, standard and guideline related to environmental protection
5) Future plan for pollution control measures
6) Air, water and soil pollution (meteorology, ambient, emission and effluent sources)

(2).Survey of Present situation

1) Survey of each power plant
   Facility, fuel and liquid and solid waste (including chemicals) of each Power plant
2) Environmental survey
   a) Flue gas measurement of each power plant
      i) SO_2, NO_x (NO and NO_2) soot and dust and combustion parameter (O_2, CO, CO_2)
      ii) Exhaust gas flow
      iii) Analysis of heavy metal (V, Pb, Ni, Zn) in soot and dust
   b) Ambient air quality measurement around each power plant
      i) Continuous measurement of ambient air quality
         SO_2, NO_x (NO and NO_2), and wind direction and velocity

ii) Measurement of particulate substances (Particulate matter and dust fall) and analysis of the heavy metal (V, Pb, Ni, Zn)

iii) Simplified measurement (at many points by the season),
SO_2,NOx (NO and NO_2)

c) Meteorological observation (in the premises of or near the power plant)

i) Surface meteorology (continuous observation)
Wind direction and velocity, atmospheric temperature, solar radiation and net radiation.

ii) Upper layer meteorology by the season
Observation by lower layer sonde and pilot balloon

(3)Formulation and Recommendation of the Mitigation Plan

1) EIA by the air pollutant from each power plant
   a) Present situation (hourly,daily and yearly mean value)
   b) Future prediction (hourly, daily and yearly mean value)
2) Examination of possibility for introduction of air pollution control devices
3) Selection of optimum mitigation plan and the cost estimation
   a) Monitoring and the management organization
   b) Utilization of monitoring results and the feedback to emission source control measures
   c) Cost estimation

(4) Transfer of Monitoring Technology to Iranian Counterpart in the Course of the Study

1) Item
   a) Technology for flue gas measurement
   b) Technology for ambient air quality measurement
   c) Technology for maintenance
   d) Prediction of atmospheric impact with simulation model
2) Methodology
   a) On the job training
   b) EIA seminar

5) Formulation and Recommendation of both the Legislative and Administrative Framework to Improve the Environmental Situation in Power Sector

1) Establishment of environmental management system in power plants
2) Introduction of pollution control manager system

3) Establishment of training center for pollution control manager
4) Subsidy for pollution control measures
5) Recommendation of environmental measuring standardization
6) Recommendation for setting up emission standard
7) Introduction of energy-saving measures

(6) Preparation of Iran's EIA Framework for Electric Power Sector

1) Review of Iran's EIA guideline
2) Selection criteria of power plants for EIA
3) Environmental impact study method
4) Examination of pollution control measures
5) EIA method
6) Environmental monitoring planning

IV STUDY SCHEDULE

The Study will be carried out in accordance with the attached tentative work schedule,as shown in Appendix I.

V. REPORTS

JICA shall prepare and submit the following reports in English to the Government of I. R. Iran in accordance with the tentative work schedule in Appendix I.

(1) Inception Report
Twenty (20) copies at the beginning of the Study in I. R. Iran.

(2) Progress Report
Twenty (20) copies within sixteen (16) months after the commencement of the Study.

(3) Interim report
Twenty (20) copies within twenty two (22) months after the commencement of the Study.

(4) Draft Final Report
Twenty (20) copies at the implementaion of seminar or within thirty (30) months after the commencement

of the Study.

The Government of I. R. Iran shall provide JICA with the written comments on the darft Final Report within one (1) month after the submission of the Draft Final Report.

(5) Final Report

Thirty (30) copies within three (3) months after receiving the written comments of I. R. Iran on the Draft Final Report.

VI. DIVISION OF TECHNICAL UNDERTAKING

The division of technical undertaking for the Study by both Iranian and Japanese side is outlined in the Appendix II.

VII. UNDERTAKING OF THE GOVERNMENT OF I. R. IRAN

1. In order to facilitate a smooth and efficient conduct of the Study, the Department of Environment of the Ministry of Energy (hereinafter referred to as "MOE") shall take the necessary measures:

(1) In case of any natural disaster in the study area MOE will take any measures deemed necessary to ensure the safety of the Team when and as required in the course of those events during the Study;

(2) MOE to permit the members of the Team to enter, leave and sojourn in I. R. Iran for the duration of their assignment therein and arrange entry and exit visas, residence permits, and work permits for the memebers of the Team, if necessary, for the conduct of the Study, and foreign registration requirements and consular fees will be paid by MOE

(3) MOE to exempt the members of the Team from tax, duties, fees and any other charges on equipment, machinery and other materials of the Team brought into and out of I. R. Iran for the conduct of the Study within the laws and regulations in force in I. R. Iran;

(4) MOE to exempt the members of the Team from income taxes and charges of any kind imposed on or in connection with any emoluments or allowances paid to the members of the Team for their services in connection with the implementation of the Study within the laws and regulations in force in I. R. Iran;

(5) MOE to provide necessary facilities to the Team for remittance as well as utilization of the funds introduced into I. R. Iran from Japan in connection with the implementation of the Study within the laws and regulations in force in I. R. Iran;

(6) MOE to secure permission for entry into the area concerned for the implementation of the Study within the laws and regulations in force in I. R. Iran;

(7) MOE, within the laws and regulations in force in I. R. Iran, to secure permission to take all data and documents (including maps and photographs) related to the Study out of I. R. Iran to Japan by the team; and

(8) MOE to prepare medical services as needed. The expenses will be chargeable on the members of the Team.

2. The Government of I. R. Iran shall bear claims, if any arises against the members of the Team resulting from, occurring in the course of, or otherwise connected with the discharge of their duties in the implementation of the Study, except when such claims arises from gross negligence or willful misconduct, within the laws and regulations in force in I. R. Iran, on the part of the Team.

3. MOE shall act as a counterpart agency to the Team and also as a coordinating body in relation with other governmental and non-governmental organizations connected for the smooth implementation of the Study.

4. MOE shall, at its own expense, provide the Team with the following, in cooperation with other relevant Iranian organizations:
   (1) Available data and information related to the Study;
   (2) Counterpart personnel;
   (3) Suitable office space with necessary support staff (typist, computer operator, etc.) equipment and facility (communication facilities such as telephones, facsimile, telex, etc., desk, chair, cabinet, locker, etc.) in Tehran and each power plant;
   (4) Appropriate vehicles with drivers, fuel and maintenance services for the Study;
   (5) Labor for the Study; and
   (6) Credentials or identification cards.

VIII UNDERTAKING OF JICA

For the conduct of the Study, JICA shall take the following measures:

(1) to dispatch, at its own expense, the Team to I. R. Iran;

(2) to pursue technology transfer to the Iranian counterpart personnel in the course of the Study.

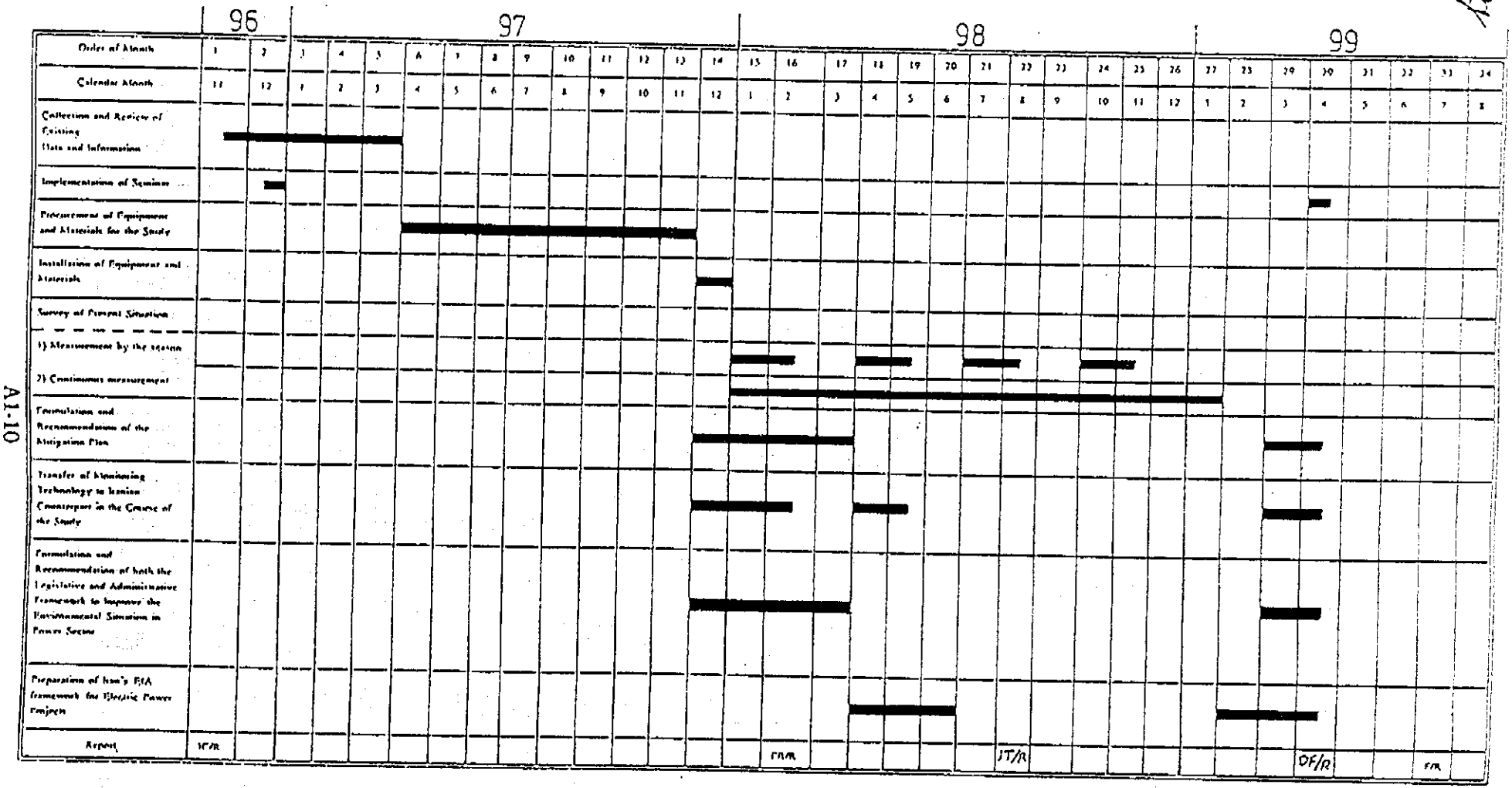
IX. OTHERS

JICA and MOE shall consult with each other in respect of any matter that may arise from, or in connection with the Study.

Appendix II. DIVISION OF TECHNICAL UNDERTAKING

Working Items	JICA Side	Iraninan Side
(1) Collection and Review of Existing Data and Information	- Review, analysis and summarization	- Provision of all necessary data and information
(2) Survey of Present Situation	- Planning - Procurement of equipment - Execution and direction - Data analysis - Review of results	- Arrangement of work site, assistance for installation of equipment, and preparation for measurement and observation (vehicle and electricity, labor, etc.) - Assistance and execution of sampling, measurement and observation - Routine maintenance for automatic analyzers, etc. - Data reporting
(3) Formulation and Recommendation of the Mitigation Plan	- Assessment - Examination of pollution control devices - Formulation of inspection system for emission and monitoring system for ambient air quality - Cost estimation - Scheduling	- Provision of all necessary data and information - Assistance and execution of assessment
(4) Transfer of Monitoring Technology to Iranian Counterpart in the Course of the Study	- Technology transfer in the course of site work and seminar	- Participation in flue gas and ambient air quality measurement, meteorological observation and assessment - Preparation of Seminar
(5) Formulation and Recommendation of both the Legislative and Administrative Framework to Improve the Environmental Situation in Power Sector	- Proposition of environmental management system for power plants, training center for pollution control manager, subsidy for pollution control plan and emission standard - Provision of information for pollution control manager system, energy-saving technology and environmental measuring standardization	- Provision of all necessary data and information
(6) Preparation of Iran's EIA framework for Electric power sector	- Review of Iran's EIA guideline - Selection criteria of power plants for EIA - Proposition of environmental impact study and EIA method, and environmental monitoring planning - Examination of pollution control measures	- Provision of all necessary data and infromation

Appendix I TENTATIVE WORK SCHEDULE



Duration

I C / R: Inception report
P R / R: Progress report
I T / R: Interim report
D F / R: Draft final report
F / R: Final report

Appendix 1-2

MINUTES OF MEETING
FOR
THE STUDY
ON
EVALUATION OF ENVIRONMENTAL IMPACT OF THERMAL POWER PLANTS IN ISLAMIC REPUBLIC OF IRAN

AGREED UPON BETWEEN
THE MINISTRY OF ENERGY
AND
THE JAPAN INTERNATIONAL COOPERATION AGENCY

Tehran - August 11, 1996

Abduli M.A.

DR. M. A. ABDULI
HEAD OF DEPARTMENT OF ENVIRONMENT
MINISTRY OF ENERGY
I.R.IRAN

MR. NOBUYUKI YAMAURA
TEAM LEADER
THE PREPARATORY STUDY TEAM
THE JAPAN INTERNATIONAL
COOPERATION AGENCY

The Preparatory Study Team (hereinafter referred to as "the Team") organized by the Japan International Cooperation Agency (hereinafter referred to as "JICA") of the Government of Japan, headed by Mr. Nobuyuki YAMAURA, Leader of the Team, visited the Islamic Republic of Iran (hereinafter referred to as "I. R. Iran") from August 3 to August 13, 1996 for the purpose of reaching an agreement of the Scope of Work regarding the Study on Evaluation of Environmental Impact of Thermal Power Plants in I. R. Iran.
(hereinafter referred to as "the Study")

The Team had a series of discussion with the Ministry of Energy and the Department of Environment and other concerned authorities (hereinafter referred to as "the Iranian side").
The salient results of the discussions mutually confirmed are as following:

1. **Confirmation on the Minutes of Meeting at the Project Formation Study in March 1996** Both sides confirmed that the Minutes of Meeting agreed upon and signed at the Project Formation Study in March 1996, is still effective and valid for this Preparatory study, unless otherwise specified in this Minutes of Meeting.

2. **Name of the Study**
   Both sides agreed to adopt the name of the study "Evaluation of Environmental Impact of Thermal Power Plants in Islamic Republic of Iran"

3. **Undertaking by the Iranian side**
   The Iranian side confirmed the undertaking shown in the attached Appendix II.

4. **Collected Data and Information**
   The team confirmed that the collected data and information would be used only for the purpose of the Study and should not be disclosed to others without prior consent of the Iranian side.

5. **Provision of Counterparts (C/P)**
   The Team requested that the Iranian side should assign the C/P engineers or specialists of technical expertise and experience covering each field of the Study, who will collaborate with the Full-scale Study Team. The Iranian side accepted the request, and will nominate those names of the candidates at the time of the Inception Report.

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6. Equipment and Materials

The Iranian side requested the Team to provide with the equipment and materials for the implementation of the Study, which will be used for the flue gas and ambient air quality measurement, and meteorological observation.

The Team stated that the request would be conveyed to the Government of Japan.

7. Request of Training

The Iranian side requested that counterpart personnel should participate in the training program in Japan to be arranged in connection with the Study. The Team will convey this request to the Government of Japan.

8. Informing

The Full-scale Study Team shall inform the progress situation between Inception Report and the Progress Report every four (4) months.

9. Answers to Questionnaire

The Iranian side will submit the data information and maps in reply to the Questionnaire to JICA through the Embassy of Japan within 30 days from the date of signing of this Minutes of Meeting .

10. Vehicle

The Iranian side explained the difficulties to procure the vehicles for the transportation of the full scale study team and requested JICA to provide with the vehicles.

APPENDIX I

LIST OF ATTENDANTS

- Ministry of Energy

  Dr. M. A. Abduli, Head of Department of Environment

  Dr. A. R. Karabassi, Department of Environment

- Ministry of Environment

  Dr. N. Moharramnegad, Deputy Director for Research

  Mr. A. H. Hakimian, Director General, Environmental Impact Assessment Bureau

- Tabriz Power Plant

  Dr. A. M. Ali — Power Plant Manager

  Mr. M. Shadravan — Technical officer

- Shahid Rajai Power Plant

  Mr. M. Daneshvar — Manager of Chem - Department

  Mr. M. Vahid — Education Officer

- Eslam Abad Power Plant

  Mr. A. Sepahani — Power Plant Manager

  Mr. s. M. Eftekhary — Operation Chief

- Shahid Mohammad Montazery Power Plant

  Mr. H. Omumi — Director of Power Plant

  Mr. A. A. Ebrahim — Head of Technical Department

- Embasssy of Japan

  Mr. Junji Nakao, Second secretary of Embassy of Japan

- Japanese Team

  Mr. Nobuyuki Yamaura — JICA

  Mr. Shinji Tashiro — JICA

  Mr. Kenji Zenko — JICA

  Mr. Motoji Katsuta — JICA

  Mr. Toru Ogura — JICA

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APPENDIX II

UNDERTAKING BY THE IRANIAN SIDE

1. Procedure for customes clearance of Equipment and Materials

2. Transportation of Equipment, Materials, and the Installation

(1) Measurement of ambient air quality and meteorological observation

1) Arragement for the installation site

a) Stable power source for the equipment (approximately 30 KVA) and the use of site (permission and the procedure)

b) Shelter (container house or shed) for equipment (including air conditioner)

(2) Flue gas measurement at the two (2) power plants

1) Arrangement for the installation site

a) Sampling hole, scafford, power source and permission for the entry and measurement

b) Preparation of vehicle for equipment loading (for example, delivery van)

(3) Meteorological observation

1) Preparation of vehicle for equipment transporting (for example, delivery van)

2) Arrangement for the observation site

Appendix 1-3 **JICA EQUIPMENT LIST**

See the list on the last page for addresses of equipment suppliers.

ITEM	SPECIFICATION	No.of Req'd
T－1	Stack Gas Measurement	
T-1-1	1) Automatic Infrared SO_2 Analyzer SHIMADZU SOA-7000 Principle: Infra-red absorption(single light source, two bundle non-dispersion type) Range: 0-500ppm/1000ppm/0.25%/0.5% Re-producibility: ±0.5% of full scale Zero Drift: ±1.0% of full scale or ±1.5 ppm/day Span Drift: ±1.0%/day Response: within 3 min Sample Gas: Flow rate 2.0 liter/min (Cell 0.5 liter/min) Pressure -100 to +100 mmAq G Soot less than 0.1g/m^3N Contaminants CH_4 less than 30% of SO_2 NH_3 less than 3% of SO_2 SO_3 less than 30 ppm H_2O less than 10 wt% Display: Liquid crystal (320×200 dots), 3 displays simultaneously Output:0-1V DC(2 channels and 1 spare channel) Data: memory card Operation: within 5-40 ℃ Power: AC220, 50Hz	1 set
	2) Carry Case	1 set
	3) Cylinder Gas: SO_2 0.23% in nitrogen (10 liter cylinder)	2 cylinders
	4) Consumable and Spare Parts	
	・Teflon tube 4mmID×6mmOD×5m 2 /set	2 pc's
	・Mist Absorbent 2 /set	2 packs
	・SO_2 Absorbent 2 /set	2 packs
	・O-ring (5 pieces in box) 1 box/set	1 box
	・Polypropylene Cotton (100g) 2 boxes/set	2 boxes
	・Ring Filter (40 pc's in box) 2 boxes/set	2 boxes
	・Diaphragm 4 boxes/set	4 boxes

ITEM	SPECIFICATION	No.of Req'd
T-1-2	1) Automatic NOx O_2 Analyzer · SHIMADZU NOA-7000 Principle: For NOx -Atmospheric chemi-luminescence O_2 -Zirconia Oxygen ion conductivity Range: NOx 0-25/50/100/250/500/1000/2500/4000ppm O_2 0-5/10/25vol% Re-producibility: ±0.5% of full scale Zero Drift: ±1.5% of full scale in 5 ℃ Span Drift: ditto Linear-ability: ±2% of full scale Response : NOx 20/30/60sec changeable O_2 30/60sec changeable Sample Gas: Flow rate 2.0 liter/min Pressure -100 to +100 mmAq G Soot · less than 0.1g/m^3N Contaminants CO less than 500ppm SO_2 less than 1000ppm NO_2 less than 300ppm NH_3 less than 20ppm CH_4 less than 1000ppm CO_2 less than 30vol% SO_3 less than 50ppm H_2O less than 10wt% Display: Liquid crystal (320×200 dots), 3 displays simultaneously Output:0-1V DC (3 channels) Data: Memory card Operation: within 5-37 ℃ Power: AC 220 V, 50 Hz	1 set
	2) Carry Case	1 set
	3) Pressure Regulator: TSU-1090	2 units
	4) Pressure Regulator: TU-1085	3 units
	5) Cylinder Support: for 5 cylinders	1 unit
	6) Cylinder Gas: 250ppm NO in N_2 ,0.5vol% O_2 in N_2 9.0 vol% O_2 in N_2 , N_2 blank gas, each 10 liter cylinder	each 2 cylinders

ITEM	SPECIFICATION	No.of Req'd
T-1-2 cont'd	Consumable and Spare Parts	
	7) Diaphragm for Sample Pump	1 set
	Diaphragm for Air Pump	1 set
	Diaphragm for Drain Pump	1 set
	8) Converter Reaction Tube with Catalyst	1 set
	9) NH_3 Absorbent 6pc's in one box	2 boxes
	10) SO_2 Absorbent 185g packed	2 packs
	11) Mist Scrubber Case for SO_2 Absorbent	1 unit
	12) SO_2 Absorbent (500 g)	4 packs
	13) O-Ring 5pc's in one box	1 box
	14) Polypropylene Cotton (100g)	1 box
	15) Filter Membrane 50 sheets in one pack	1 pack
	16) Ozone Killer Catalyst 300g in one pack	1 pack
	17) Front Filter 2 sheets in one pack	1 pack
	18) Rear Filter 6 sheets in one pack	1 pack
	19) Silica gel Case	1 case
	20) Pretreatment Unit, SHIMADZU CFP-306 with a transformer Cooler Capacity: cool sample down to 1.5-3.5℃ Sampling Rate: max.3 liter/min	1 set
T-1-3	Manuals in English for SO_2, NOx Analyzer (Operation & Maintenance)	1 set
T-1-4	Dust Sampler; consisting of as follows:	
	1) Soot Measurement Suction Tube · NIGORIKAWA Type: Stainless-304, 0.5m,1.0m,1.5m,2.0m×25mmϕ	each 2pc's
	2) Cylindrical Filter Paper Holder Type:NG-23;Stainless-304 ; 25mmϕ×90mm	3 pc's
	3) Drain Catcher	2 pc's
	4) Suction Nozzle Type:NG-25;Stainless-304 4,6,8,10mmϕ	each 3pc's
	5) Carry Case for 1)~3)	1 set
	6) Carry Case for Suction Nozzles	1 set
	7) Carry Case for 20 cylindrical filter papers with 30 glass filter holders	1 set

ITEM	SPECIFICATION	No.of Req'd
T-1-4 cont'd	8) Gas Pump · NIGORIKAWA NG-17S;Capacity:100 l/min Equipped with a mist oil separator, needle valve, and casters; in Al case, AC 100V	1 set
	9) Wet Gas Meter · NIGORIKAWA W-NK-2.5A; 5Liter/revolution ;in Al case	1 set
	10) Mist Separator · NIGORIKAWA NG-Z-19 SO_2 Remover-700ml, Mist separator-700ml Dryer-500ml bottle; each 1 bottle/set in Woody box	1 set
	11) Gas Hose ; 9mmID×21mmOD×15mLength, rubber with a drum roller	2 sets
	12) Clamp;NG-28; Stainless 304	10 pc's
	13) Flange · NIGORIKAWA NG-30 ;280mmϕ×3mm	1 set
	14) Cord Reel; AC100V,20A,30m coil	4 sets
	15) Table Tap; 3 outlets	4 sets
	16) Tool set	1 set
	17) Consumable	
	-1. Thimble Filter; 25mmϕ×90mm, 10 pieces/set; Silica	50 sets
	-2. Tweezers ;1PT-05;120mm Length, Stainless 304	4 pc's
	;1PT-12;165mm Length, Stainless 304	4 pc's
	-3. Glove; 350℃ heat resistance; 400mm Length; Al Coating	4 pairs
	-4. Glove; Cotton	2 dozens
	-5. Glove; Leather	10 pairs
	-6. Teflon Tube; 6mmID×8mmOD×30m Length	4 pc's
	-7. Silicon Tube ; 6mmID×8*mmOD×10m Length	4 pc's
	-8. Silica Gel ; 18 liter canned	2 cans
	-9. Container Case ; Type 75H ; 656×456×356mm	2 pc's
T-1-5	1) H_2O Measurement Suction Tube: NIGORIKAWA Type:NG-11-H with regulator;Stainless-304;in Al case	1 set
	2) Flange ;280mmϕ×3mm ;Stainless-304	1 piece
	3) Wet Gas Meter · NIGORIKAWA W-NK-1A; 1 liter/revolution ;in Al case	1 set
	4) Gas Pump · NIGORIKAWA NG-15-N; Capacity:15 l/min Equipped with needle valve; in Al case	1 set
	5) SO_2 Washer · NIGORIKAWA NG-19;Bottle in a case	1 set

ITEM	SPECIFICATION	No.of Req'd
T-1-5 cont'd	6) Cooling Water Box · NIGORIKAWA NG-15 ;with a support stand and in Al case	1 set
	7) Dehumidifier · NIGORIKAWA NG-12 ;Shefield 10 piece/set in a case	1 set
	8) Electronic Balance · PB303;Metler;310g; Sensitivity 1mg; 100mm Dish; in a cushioned case	1 set
	9) Accessory	
	-1. Seal for Measurement Hole: Silica 50mm x 30m	1 piece
	-2. Stopwatch ;with spare battery	2 pc's
	-3. Gas Hose · 6mmID×15mmOD×15m	2 pc's
	10)Consumable	
	-1. $CaCl_2$ for Water Measurement;500g/bottle	10 bottles
	-2. Shefield Tube	10 pc's
	-3. Silica Wool; 1kg packed	2 packs
	-4. Heat Resistance Adhesive Tape; 0.18mmT×19mmW×10mL	20 pc's
	-5. Vinyl Tape ;0.2mmT×19mmW×10mL	20 pc's
	-6. Seal Tape ; 0.1mmT×13mmW×10mL*	40 pc's
	-7. Silicon Grease; 50g/bottle	10 bottles
	-8. Cotton ;10boxes/case	1 case
T-1-6	1) Velocity Measurement Main Part, NIGORIKAWA	
	-1. Pitot Tube; Western Type; 3m Length	1 piece
	-2. Thermocouple and Thermometer with spare battery 0-1200℃; 1.6mmϕ×3m Length 3 pieces in a case including Item T-1-6-1)	1 set
	-3. Inclined-tube Manometer with glass spare parts and 5 m hose, in a case	1 set
	2) Consumable	
	-1. Hydrogen Peroxide (less than 30%); 500g/bottle,	10 bottles
	-2. JK Wiper; 36 boxes/box	1 box
	-3. Cloth Adhesive Tape	10 rolls
	-4. Rope; 20m and 30m	each 2 pc's
	-5. Toluene; 500 ml/bottle	2 bottles

ITEM	SPECIFICATION	No.of Req'd
T-1-6 cont'd	3) Safety Device	
	-1. Mask; 10 sets/box	1 box
	-2. Eyeglass; SP-66 ; 5 Pairs/box	2 boxes
	-3. Safety Belt	3 pc's
T-1-7	1) Orsat with sampling apparatus in a case	1 set
	2) Detector Tube Pump; GASTECK Type	2 sets
	3) Consumable	
	· Teflon Bag; 5 liter	5 pc's
	· Glass Spare Parts for Orsat Apparatus	3 sets
	· Reagent for Orsat	5 sets
	· Detector Tube 10 pieces in one box	
	; for CO (5-100ppm, 50-1000ppm, >1000ppm)	each
	; for SO_2 (-10ppm, -100ppm, -1000ppm, -0.5%)	10 boxes
	; for NOx (-100ppm, -500ppm, -1000ppm)	
T-1-8	Down Transformer ; AC 240V →110v,20A	3 PC'S
T-1-9	Recorder for SO_2, NOx and O_2 Analyzer's output; 3ch ; in a case	1 set
T-1-10	Container for All (T-1-1~T-1-9) Equipments	1 set
T-1-11	Manuals; Each 4 English edition of Gas Pump, Wet Gas Meter, Electronic Balance, Thermometer, Inclined-tube Manometer, Orsat, Recorder	1 set

ITEM	SPECIFICATION	No. of Req'd
T-2	Ambient Air Monitoring	
T-2-1	Automatic SO_2 Analyzer-HORIBA APSA-360 Method: Ultraviolet Fluorimeter Range: 0-0.1/0.2/0.5/1.0ppm(changeable automatically & manually) Detection Limit: 0.5ppb Zero Drift: ±1.0ppb/ 24hrs or ±2.0 ppb/week Span Drift: ±1.0% of full scale/24 hrs or ±2.0% of full scale/week Analogue output: Selectable of 0-1 V(DC),0-10 V(DC),or 4-20mA(DC) Two Outputs: Current and summation (or average)values Data Memory: 1000 data of 1 hr value(equiv. to 1.5 months data) Light source: Long life xenon lamp Power: Supply-220VAC,50Hz,Consumption-150A	3 sets

Consumable and Spare Parts

Name	Code	Req'd No./Analyzer	
1. Filter Element	F021434400	4 (24 pc's /set)	12 sets
2. Diaphragm	9022002900	1	3 pc's
3. HC Cutter	9022003700	1	3 pc's
4. Xenon Lamp	9022003800	1	3 pc's
5. Air Filter	H443672-02	1	3 pc's
6. Filter Element	F021565700	1	3 pc's
7. CAT Pipe Unit	U800885000	1	3 sets
8. O-ring	U801150900	1	3 pc's
9. Pump Unit(110 V,50Hz)	9022003400	1	3 sets

ITEM	SPECIFICATION	No. of Req'd
T-2-2	Automatic NOx Analyzer HORIBA APNA-360	3 sets
	Method: Chemiluminesence	
	Range: 0-0.2/0.5/1.0/2.0ppm(Changeable automatically & manually)	
	Detectable Limit: 0.5ppb	
	Zero Point Adjustment: Automatic	
	Zero Drift: ±1.0% of Full scale/24hrs or±2.0% of full scale/week	
	Span Drift: ditto	
	Analogue Output: Selectable 0-1 V(DC),0-10 V(DC),4-20 mA(DC)	
	Two Outputs: Current and summation (or average) values	
	Data Storage: 1 hr summation value-1000 data (equiv. to 1.5months)	
	Sensitivity: Zero drift free,0.1 ppm sensitivity, High stability	
	Power: Supply 220VAC,50Hz;Consumption less than 200VA	

Consumable and spare Parts

Name	Code	Req'd No./Analyzer	
1. PPD capillary	U801200600	2	6 pc's
2. Air Filter	H443672-02	1	3 pc's
3. DO Unit	U801154200	1	3 pc's
4. Filter element	F021434400	1	3 sets
5. O-ring	F020223700	1	3 pc's
6. F-Packing	H457606-02	1	3 pc's
7. UV-Lamp Unit	U800952700	1	3 sets
8. UV liner	H533781-01	1	3 sets
9. CAT pipe Unit	U800694300	1	3 sets
10. Diaphragm	9022002900	2	6 sets
11. Silica gel	F022298500	1	3 bottles
12. Pump Unit	U801145900	1	3 pc's
13. Solenoid Valve	U801163300	3	9 pc's

ITEM	SPECIFICATION	No. of Req'd
T-2-3	SO_2 Span Gas Generator-HORIBA SGGU-514	3 sets

SO_2 Span Gas Generator-HORIBA SGGU-514

Blank Gas: Air to be purified in the generator

Purity-SO_2 less than 0.01 ppm

H_2O saturation at 0℃

Stabilized within 5min

Span Gas: SO_2 gas dilution with purified air by regulated flow ratio

Dilution Ratio Indication: ±5%;Accuracy ±2% of indicated dilution

Span Gas Concentration: 0.045 ppm of SO_2 in purified air

Span Gas Flow Rate: 2.5l/min (overflow at 500ml/min)

Span Gas Pressure: 10mmAq Gauge

Span Gas Stabilization: within 10 min

Power: AC 220VAC,50Hz,Consumption-200VA

Consumable and Spare Parts

Name	Code	Req'd No./Generator	No. of Req'd
1. Silica gel	F020902900	8	24 bottles
2. Charcoal, 500 g	F021623000	4	12 pc's
3. Purifier Unit	F021091100	1	3 sets
4. Filter Element	H435126-01	4	12 pc's
5. Gas Filter	F021100400	8	24 pc's

ITEM	SPECIFICATION	No. of Req'd
T-2-4	NOx Span Gas Generator-HORIBA SGGU-514	3 sets

NOx Span Gas Generator-HORIBA SGGU-514

Blank Gas: Air to be purified in the generator

Purity-NO less than 0.01 ppm

H_2O saturation at 0℃

Stabilized within 5min

Span Gas: NO gas dilution with purified air by regulated flow ratio

Dilution Ratio Indication: ±5%;Accuracy ±2% of indicated dilution

Span Gas Concentration:0.09ppm of NO in purified air

Span Gas Flow Rate:2.5 l/min (overflow at 500 ml/min)

Span Gas Pressure:10mmAq Gauge

Span gas Stabilization: within 10 min

Power: AC 220VAC,50Hz,Consumption-200VA

ITEM	SPECIFICATION			No. of Req'd
T-2-4 cont'd	Consumable and Spare Parts			
	Name	Code	Req'd No./Generator	
	1.Silicagel	F020902900	8	24 bottles
	2.Charcoal	F021623000	4	12 pc's
	3.Purifier Unit	F021901100	1	3 sets
	4.Filter element	H435126-01	4	12 pc's
	5.Gas Filter	F021100400	8	24 pc's
T-2-5	Cylinder Gases 1. 90ppm of NO in nitrogen 10 liter cylinder: TAIYO-TOYO SANSO 2. 45ppm of SO_2 in nitrogen 10 liter cylinder: TAIYO-TOYO SANSO 3. Two Stage Pressure Controller: CROWN Inlet 250kg/cm^2, Secondary Stage 5 kg/cm^2 Output Joint RC 1/4 T joint(for Teflon tube)			6 cylinders 6 cylinders 7 pc's
T-2-6	Sampling Fitting for NOx and SO_2 - KASAI GUM 1. Teflon Tube: 6×8mm 2. Polypropylene Funnel 3. Silicon Tube: 7×12mm x 5m			 50 m 15 pc's 1 set
T-2-7	Wind Vane and Anemometer-KOSHIN-MVS-320 - AC 100 V, Propeller type, including 1. Flange: for 4 inch 2. Cable: 50m 3. Down Transformer 4. Data converter module 5. Sensor with connecting tools			3 sets

<table>
<tr><th>ITEM</th><th>SPECIFICATION</th><th>No. of Req'd</th></tr>
<tr><td>T-2-8</td><td>Data Logger-HORIBA DL-360
No. of Channel: 8
Analogue DC Input: Selectable of 0-1 V, 0-10V, 0-16mA, or 4-20mA
Resolution: 12bits
Accuracy: ±0.5% or within ±1 digit, to be isolated
Data File: 3.5 inches floppy
Recordable-Hourly data for more than 1 month/floppy
Record Frequency-every hour on the hour
Data: binary
Watch: year to second(auto calendar)with power failure compensation
Memory Back-up: When power failure, set values and data to be backed up with automatic recovery system upon power supply
Data Processor - (HORIBA) Artist P166ATX :
CPU pentium MMX 166 MHHz, Memory 32 MB, HDD 1.8 KB
Printer - (HORIBA) HP DESKJET 690 C
Monitor - (HORIBA) Belinea 17 inch
Power Supply: 220VAC, 50-60Hz
Consumable: Floppy disk
Printer paper</td><td>3 sets

60 pc's
3 sets</td></tr>
<tr><td>T-2-9</td><td>6 Points Recorder-YOKOGAWA uR-1800-437006
Input Signal: DC 0-100mV, 0-1V
Recording Paper Speed: 1-1500 mm/hr(1 mm/hr step)
Effective Paper Width: 180 mm
Power: 100VAC, 50Hz,Consumption 29 VA
Consumable Spare Parts
<table>
<tr><th>Name</th><th>Code</th><th>Req'd No./set</th></tr>
<tr><td>-1. Ribbon Cassette</td><td></td><td>3</td></tr>
<tr><td>-2. Chart Paper</td><td></td><td>60</td></tr>
</table></td><td>3 sets

9 pcs
180 vols</td></tr>
</table>

ITEM	SPECIFICATION	No. of Req'd
T-2-10	Miscellaneous Auxiliaries for Automated Analyzers	
	-1. Equipment System Rack-HORIBA APMS-360, including	3 sets
	Cylinder Rack for 2 cylinders	
	Cable and Piping	
	-2. Automatic Voltage Regulator(SVC-1030-A) - HORIBA	3 sets
	Input: single phase 220VAC,48Hz-62Hz	
	Input Variation: ±15%(187-253V)	
	Output: 220VAC, Accuracy±(1.0-1.5)%	
	Capacity: 3.0KVA	
	Response Speed: within 1.0 sec to 10% of abrupt change of input voltage	
	-3. UPS (Un-interrupted Power Supply) - HORIBA	6 sets
	Input: 230VAC, 50Hz	
	Output: 230VAC ±3%, 700w	
	Back up time: 8-12min	
	-4. Lightning Arrester(RP-200, Mfg No.59920804M) - HORIBA	3 sets
	Input: single phase 220VAC	
	Output: single phase 220VAC	
	Capacity: 3KVA	
	Including: Power cable x 2 piece	
	Earthing cable: 305 m x 1 piece	
	Joint x 2 pieces	
	Teflon tube x 1 piece	
	Pipe x 1 piece	
	-5. English Manuals	each 3 sets
	for Items T-2-3, T-2-4, T-2-7, T-2-8, T-2-9	

ITEM	SPECIFICATION	No. of Req'd
T-2-11	Low Volume Air Sampler · SHINTAKU S-2 Components: Filter holder, Flow meter, Suction pump, and Centrifugal separator Collecting characteristics: Limit size of particles to be 10 μm Continuous sampling: maximum for 30 days. Suction Pump: Rotary type Suction Flow Rate: 20 liter/min Standard Filter Size: 110 mmϕ	3 sets
	Consumable and Spare Parts	
	1. Quartz filters (110 mmϕ) — Code: — Req'd No./set: (100 sheets)/ 1	3 boxes
	2. Glass fiber filters for back up (110 mmϕ) — Code: — Req'd No./set: (10 sheets)/ 1	3 sets
	3. Gas tube (5m) — Code: — Req'd No./set: 1	3 pc's
	4. Piston — Code: — Req'd No./set: 1	3 pc's
T-2-12	Deposit Gauge · SHIBATA Receiver: Polyethylene bottle placed in wire frame - Capacity 20 liters Funnel: Material: Pyrex glass Dimensions 275 millimeters in diameter	3 sets
	Consumable and Spare Parts	
	-1.Extra 20 liter Polyethylene bottle — Code: — Req'd No. set: 1	3 sets
T-2-13	Tools and Miscellaneous Parts:	
	-1. Tool Kit: HOZAN S-45	1 set
	-2. Adjustable Wrench for Gas Cylinder, 300mm	3 pcs
	-3. Holder Band: 100mm, 100pcs/case	3 bags
	-4. Holder Band: 140mm, ditto	3 bags
	-5. Holder Band: 180mm, ditto	3 bags
	-6. Gum Tape: 50mm×25m	3 pcs
	-7. Vinyl Tape: 19mm×10m	10 pcs
	-8. Teflon Seal Tape: 0.1mm×13mm×15m	5 pcs
	-9. Instant Bond: ARON-ALFA, 2g, 5 tubes/box	3 sets
	-10. Bond: Two Chemicals Type, 30g (MOS 7-200)	3 pc's

ITEM	SPECIFICATION	No.of Req'd
T-2-13 cont'd	-11. Saw	1 piece
	-12. Saw Blade	15 pcs
	-13. Portable Electric Drill	1 piece
	-14. Drill Blade: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10mm diameter	1 set
	-15. Silicon Sealing Compound: White, 330ml/pcs	3 pcs
	-16. Pipe Wrench: 300mm	1 piece
	-17. Electric Wire Terminal Set: 3 kinds / set	2 sets
	-18. Digital Tester	1 set
	-19. Wire Terminal Crimping Tool with Wire Stripper	1 piece
	-20. Wire Terminal Crimping Tool	1 set
	-21. Precision Screw Driver set	1 piece
T-3	Ambient Simple Method OS LAB Co. MM Method -1. SO_2, NO, NO_2 Passive Sampler Sampling method: Molecular diffusion system -2. Collecting Filter: Filter paper (47mmΦ) impregnated with adsorbent Analyzing method: to be analyzed with ion-chromatography Detective level: SO_2 - 0.5 ppb, NO-NO_2 - 0.8 ppb -3 to -7 blank	500 sets
	-8. Shelter and Pole for setting outside Pole: OS Lab's standard, 2 m in length x 25 mm in diameter, Aluminum Shelter: OS Lab's standard, Polyethylene	75 sets
	-9. Manuals: English Instruction Manual	4 sets

ITEM	SPECIFICATION	No.of Req'd
T-4	Surface Meteorology	
T-4-1	-1. Wind Vane and Anemometer-KOSHIN MVS-320, Propeller type Data Transmission: wind direction by photoencorder, wind speed by photointerrupter	1 set
	-2. Coupling Flange: for 4 inch pole	1 set
	-3. Cable 50m	1 set
T-4-2	-1. Thermometer-KOSHIN-FT-S: Platinum resistance thermocouple	1 set
	-2. Cable 2p, 3p, 50m each ×1	1 set
T-4-3	-1. Pyranometer-EIKHO-MS-43F: Electric pyranometer with a thermocouple covered by a glass dome	1 set
	-2. Flange: for 2 inch pole	1 set
	-3. Cable 2p, 50m	1 set
T-4-4	-1. Net Radiometer-EIKHO-MF-11 : with two sets of thermocouple covered by polyethylene dome	1 set
	-2. Fixture: for 2 inch pole	1 set
	-3. Cable 2p, 50m×2	1 set
T-4-5	Surface Meteorology Observation Parts	
	-1. Data logger: HORIBA DL-360	1 set
	Data Processor - (HORIBA) Artist P166ATX : CPU pentium MMX 166 MHHz, Memory 32 MB, HDD 1.8 KB	
	Printer - (HORIBA) HP DESKJET 690 C	
	Monitor - (HORIBA) Belinea 17 inch	
	-2. Pen-recorder: KOSHIN MVS-320	1 set
	-3. Pen-recorder: KOSHIN EH-800	1 set
	-4. Data Converter: KOSHIN—KANTAM	1 set
	-5. Unit Case: 2000 x 570 x 500*	1 set
	-6. Stable Power Supply: MEISEI with 2kv-step down transformer	1 set
T-4-6	Consumable and Spare Parts-KOSHIN	
	-1. Recording Chart (wind vane and anemometer Recorder)	18 rolls
	-2. Recording Chart (6 point recorder)	18 rolls
	-3. Recording Pen	36 pcs
	-4. polyethylene dome, etc.	1 set

ITEM	SPECIFICATION	No.of Req'd
T-5	Upper Layer Meteorology	
T-5-1	Pilot balloon observation	
	-1. Theodolite: M.T. PRECISION-KDT-3	1 set
	-2. Cable: M.T. PRECISION 30m	1 set
	-3. Hose with counter weight: HAIJIMA: Rubber hose 5 m	1 piece
T-5-2	Pilot Balloon Consumable and Spare Parts	
	-1. Pilot Balloon: TORTEX rubber, 20 g in weight	1000 pcs
	-2. Battery: MEISEI-PA-80	500 pcs
	-3. IC Card: M.T. PRECISION for KDT-3	1 set
	-4. Recording Chart: M.T. PRECISION for KDT-3	20 vols
T-5-3	Low level Radio Sonde Observation	
	-1. Sonde Receiver: MEISEI-SAR-4	1 set
	-2. Portable Antenna 1673 MHz: MEISEI	1 set
	-3. Data Processor: NEC - PC-9821Xb10, Software - MEISEI	1 set
	Printer: NEC - PC-PR201/40	1 set
	-4. Sonde Calibrator: MEISEI	1 set
	-5. UPS: MEISEI	1 set
	-6. Stable Power Supply: MEISEI, with 2 KV down transformer	1 set
	-7. Assman type Psychrometer: MEISEI, YS-1D	1 set
	-8. Aneroid type Barometer: MEISEI, 8A	1 set
	-9. Cable: 50m	1 set
	-10. Hose with counter weight: MEISEI, hose length 5 m	1 set
T-5-4	Low Level Radio Sonde Consumable and Spare Parts	
	-1. Low Level Radio Sonde: MEISEI, JWA-94w	270 pcs
	-2. Battery: MEISEI, PA-80	140 pcs
	-3. Data Disk: 3.5" Floppy disk	1 piece
	-4. Recording Chart: MEISEI	1 set
T-5-5	Helium for Pilot balloons and Radio Sondes: Roham Gas	
	Minimum 99.996% purity gas in 50 liter cylinder at 180 bar: 9 m^3N in a cylinder	
	Requirement including spare: 9 x 28 = 252 m^3N for each power plant	504 m^3N
	Cylinders - 16 pieces for each of Tabriz and Esfahan power plant	32 pieces
	Pressure Regulator - Inlet Pressure 200 bars and Outlet less than 10 bars	1 piesce

ITEM	SPECIFICATION	No. of Req'd
E-2	Ambient Air Monitoring	
E-2-1	Automatic SO_2 Analyzer-HORIBA APSA-360 Method: Ultraviolet Fluorimeter Range: 0-0.1/0.2/0.5/1.0ppm(changeable automatically & manually) Detection Limit: 0.5ppb Zero Drift: ±1.0ppb/ 24hrs or ±2.0 ppb/week Span Drift: ±1.0% of full scale/24 hrs or ±2.0% of full scale/week Analogue output: Selectable of 0-1 V(DC),0-10 V(DC),or 4-20mA(DC) Two Outputs: Current and summation (or average)values Data Memory: 1000 data of 1 hr value(equiv. to 1.5 months data) Light source: Long life xenon lamp Power: Supply-220VAC,50Hz,Consumption-150A	3 sets

Consumable and Spare Parts

Name	Code	Req'd No./Analyzer	
1. Filter Element	F021434400	4 (24pc's/ set)	12 sets
2. Diaphragm	9022002900	1	3 pc's
3. HC Cutter	9022003700	1	3 pc's
4. Xenon Lamp	9022003800	1	3 pc's
5. Air Filter	H443672-02	1	3 pc's
6. Filter Element	F021565700	1	3 pc's
7. CAT Pipe Unit	U800885000	1	3 sets
8. O-ring	U801150900	1	3 pc's
9. Pump Unit(110 V,50Hz)	9022003400	1	3 sets

ITEM	SPECIFICATION	No. of Req'd
E-2-2	Automatic NOx Analyzer HORIBA APNA-360 Method: Chemiluminesence Range: 0-0.2/0.5/1.0/2.0ppm(Changeable automatically & manually) Detectable Limit: 0.5ppb Zero Point Adjustment: Automatic Zero Drift: ±1.0% of Full scale/24hrs or±2.0% of full scale/week Span Drift: ditto Analogue Output: Selectable 0-1 V(DC),0-10 V(DC),4-20 mA(DC) Two Outputs: Current and summation (or average) values Data Storage: 1 hr summation value-1000 data (equiv. to 1.5months) Sensitivity: Zero drift free,0.1 ppm sensitivity, High stability Power: Supply 220VAC,50Hz;Consumption less than 200VA	3 sets

Consumable and spare Parts

Name	Code	Req'd No./Analyzer	
1. PPD capillary	U801200600	2	6 pc's
2. Air Filter	H443672-02	1	3 pc's
3. DO Unit	U801154200	1	3 pc's
4. Filter element	F021434400	1	3 sets
5. O-ring	F020223700	1	3 pc's
6. F-Packing	H457606-02	1	3 pc's
7. UV-Lamp Unit	U800952700	1	3 sets
8. UV liner	H533781-01	1	3 sets
9. CAT pipe Unit	U800694300	1	3 sets
10. Diaphragm	9022002900	2	6 sets
11. Silica gel	F022298500	1	3 bottles
12. Pump Unit	U801145900	1	3 pc's
13. Solenoid Valve	U801163300	3	9 pc's

<table>
<tr><th>ITEM</th><th>SPECIFICATION</th><th>No. of Req'd</th></tr>
<tr><td>E-2-3</td><td>SO_2 Span Gas Generator-HORIBA SGGU-514
Blank Gas: Air to be purified in the generator
Purity-SO_2 less than 0.01 ppm
H_2O saturation at 0℃
Stabilized within 5min
Span Gas: SO_2 gas dilution with purified air by regulated flow ratio
Dilution Ratio Indication: ±5%;Accuracy ±2% of indicated dilution
Span Gas Concentration: 0.045 ppm of SO_2 in purified air
Span Gas Flow Rate: 2.5l/min (overflow at 500ml/min)
Span Gas Pressure: 10mmAq Gauge
Span Gas Stabilization: within 10 min
Power: AC 220VAC,50Hz,Consumption-200VA

Consumable and Spare Parts
<table>
<tr><th>Name</th><th>Code</th><th>Req'd No./Generator</th><th></th></tr>
<tr><td>1. Silica gel</td><td>F020902900</td><td>8</td><td>24 bottles</td></tr>
<tr><td>2. Charcoal, 500 g</td><td>F021623000</td><td>4</td><td>12 pc's</td></tr>
<tr><td>3. Purifier Unit</td><td>F021091100</td><td>1</td><td>3 sets</td></tr>
<tr><td>4. Filter Element</td><td>H435126-01</td><td>4</td><td>12 pc's</td></tr>
<tr><td>5. Gas Filter</td><td>F021100400</td><td>8</td><td>24 pc's</td></tr>
</table></td><td>3 sets</td></tr>
<tr><td>E-2-4</td><td>NOx Span Gas Generator-HORIBA SGGU-514
Blank Gas: Air to be purified in the generator
Purity-NO less than 0.01 ppm
H_2O saturation at 0℃
Stabilized within 5min
Span Gas: NO gas dilution with purified air by regulated flow ratio
Dilution Ratio Indication: ±5%;Accuracy ±2% of indicated dilution
Span Gas Concentration:0.09ppm of NO in purified air
Span Gas Flow Rate:2.5 l/min (overflow at 500 ml/min)
Span Gas Pressure:10mmAq Gauge
Span gas Stabilization: within 10 min
Power: AC 220VAC,50Hz,Consumption-200VA</td><td>3 sets</td></tr>
</table>

ITEM	SPECIFICATION			No. of Req'd
E-2-4 cont'd	Consumable and Spare Parts			
	Name	Code	Req'd No./Generator	
	1.Silicagel	F020902900	8	24 bottles
	2.Charcoal	F021623000	4	12 pc's
	3.Purifier Unit	F021901100	1	3 sets
	4.Filter element	H435126-01	4	12 pc's
	5.Gas Filter	F021100400	8	24 pc's
E-2-5	Cylinder Gases			
	1. 90ppm of NO in nitrogen 10 liter cylinder - TAIYO-TOYO SANSO			6 cylinders
	2. 45ppm of SO_2 in nitrogen 10 liter cylinder - TAIYO-TOYA SANSO			6 cylinders
	3. Two Stage Pressure Controller - CROWN			7 pc's
	Inlet 250kg/cm^2, Secondary Stage 5 kg/cm^2			
	Output Joint RC 1/4 T joint(for Teflon tube)			
E-2-6	Sampling Fitting for NOx and SO_2 - KASAI GUM			
	1. Teflon Tube: 6×8mm			50 m
	2. Polypropylene Funnel			20 pc's
	3. Silicon Tube: 7×12mm x 5m			1 set
E-2-7	Wind Vane and Anemometer-KOSHIN-MVS-320 - AC 100 V, Propeller type, including			3 sets
	1. Flange: for 4 inch			
	2. Cable: 50m			
	3. Down Transformer			
	4. Data converter module			
	5. Sensor with connecting tools			

ITEM	SPECIFICATION	No. of Req'd
E-2-8	Data Logger-HORIBA DL-360 No. of Channel: 8 Analogue DC Input: Selectable of 0-1 V, 0-10V, 0-16mA, or 4-20mA Resolution: 12bits Accuracy: ±0.5% or within ±1 digit, to be isolated Data File: 3.5 inches floppy Recordable-Hourly data for more than 1 month/floppy Record Frequency-every hour on the hour Data: binary Watch: year to second(auto calendar)with power failure compensation Memory Back-up: When power failure, set values and data to be backed up with automatic recovery system upon power supply Data Processor - (HORIBA) Artist P166ATX : CPU pentium MMX 166 MHHz, Memory 32 MB, HDD 1.8 KB Printer - (HORIBA) HP DESKJET 690 C Monitor - (HORIBA) Belinea 17 inch Power Supply: 220 V AC, 50-60 Hz Consumable: Floppy disk Printer paper	3 sets 60 pc's 3 sets
E-2-9	6 Points Recorder-YOKOGAWA Ur-1800-437006 Input Signal: DC 0-100mV, 0-1V Recording Paper Speed: 1-1500 mm/hr (1 mm/hr step) Effective Paper Width: 180 mm Power: 100 V AC, 50 Hz, Consumption 29 VA Consumable Spare Parts	3 sets

Name	Code	Req'd No./set	
1.Ribbon Cassette		3	9 pcs
2.Chart Paper		60	180 vols

ITEM	SPECIFICATION	No. of Req'd
E-2-10	Miscellaneous Auxiliaries for Automated Analyzers	
	-1. Equipment System Rack-HORIBA APMS-360, including	3 sets
	Cylinder Rack for 2 cylinders	
	Cable and Piping	
	-2. Automatic Voltage Regulator(SVC-1030-A) - HORIBA	3 sets
	Input: single phase 220VAC,48Hz-62Hz	
	Input Variation: ±15%(187-253V)	
	Output: 220VAC, Accuracy± (1.0-1.5)%	
	Capacity: 3.0KVA	
	Response Speed: within 1.0 sec to 10% of abrupt change of input voltage	
	-3. UPS (Un-interrupted Power Supply) - HORIBA	6 sets
	Input: 230VAC, 50Hz	
	Output: 230VAC ±3%, 700w	
	Back up time: 8-12min	
	-4. Lightning Arrester(RP-200, Mfg No.59920804M) - HORIBA	3 sets
	Input: single phase 220VAC	
	Output: single phase 220VAC	
	Capacity: 3KVA	
	Including: Power cable x 2 piece	
	Earthing cable: 305 m x 1 piece	
	Joint x 2 pieces	
	Teflon tube x 1 piece	
	Pipe x 1 piece	
	-5. English Manuals	each 3 sets
	for Items E-2-3, E-2-4, E-2-7, E-2-8, E-2-9	

ITEM	SPECIFICATION	No. of Req'd
E-2-11	Low Volume Air Sampler · SHINTAKU S-2 Components: Filter holder, Flow meter, Suction pump, and Centrifugal separator Collecting characteristics: Limit size of particles to be 10 μm Continuous sampling: maximum for 30 days. Suction Pump: Rotary type Suction Flow Rate: 20 liter/min Standard Filter Size: 110 mmϕ	3 sets
	Consumable and Spare Parts	
	1. Quartz filters (110 mmϕ) — Code: — Req'd No./set: (100 sheets)/ 1	3 boxes
	2. Glass fiber filters for back up (110 mmϕ) — Code: — Req'd No./set: (10 sheets)/ 1	3 sets
	3. Gas tube (5m) — Code: — Req'd No./set: 1	3 pc's
	4. Piston — Code: — Req'd No./set: 1	3 pc's
E-2-12	Deposit Gauge · SHIBATA Receiver: Polyethylene bottle placed in wire frame - capacity 20 liters Funnel: Material: Pyrex glass Dimensions 275 millimeters in diameter	3 sets
	Consumable and Spare Parts	
	1.Extra 20 liter Polyethylene bottle — Code: — Req'd No. set: 1	3 sets
E-2-13	Tools and Miscellaneous Parts:	
	-1. Tool Kit: HOZAN S-45	1 set
	-2. Adjustable Wrench for Gas Cylinder, 300mm	3 pcs
	-3. Holder Band: 100mm, 100pcs/case	3 bags
	-4. Holder Band: 140mm, ditto	3 bags
	-5. Holder Band: 180mm, ditto	3 bags
	-6. Gum Tape: 50mm×25m	3 pcs
	-7. Vinyl Tape: 19mm×10m	10 pcs
	-8. Teflon Seal Tape: 0.1mm×13mm×15m	5 pcs
	-9. Instant Bond: ARON-ALFA, 2g, 5 tubes/box	3 sets
	-10. Bond: Two Chemicals Type, 30g (MOS 7-200)	3 pc's

ITEM	SPECIFICATION	No.of Req'd
E-2-13	-11. Saw	1 piece
cont'd	-12. Saw Blade	15 pcs
	-13. Portable Electric Drill	1 piece
	-14. Drill Blade: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10 mm diameter	1 set
	-15. Silicon Sealing Compound: White, 330 ml/pcs	3 pcs
	-16. Pipe Wrench: 300mm	1 piece
	-17. Electric Wire Terminal Set: 3 kinds	2 sets
	-18. Digital Tester	1 set
	-19. Wire Terminal Crimping Tool with Wire Stripper	1 piece
	-20. Wire Terminal Crimping Tool	1 set
	-21. Precision Screw Driver set	1 piece
E-2-14*	Mini pump for bag sampling: Model-603T	2 sets
E-3	Ambient Simple Method OS LAB Co. MM Method	
	-1. SO_2, NO, NO_2 Passive Sampler	500 sets
	Sampling method: Molecular diffusion system	
	-2. Collecting Filter: Filter paper (47mmΦ) impregnated with adsorbent	
	Analyzing method: to be analyzed with Ion-chromatography	
	Detective level: SO_2 - 0.5 ppb, NO-NO_2 - 0.8 ppb	
	-3 to 7 blank	
	-8. Shelter and Pole for setting outside	75 sets
	Pole: OS Lab's standard, 2 m in length x 25 mm in diameter, Aluminum	
	Shelter: OS Lab's standard, Polyethylene	
	-9. Manuals: English Instruction Manual	4 sets

ITEM	SPECIFICATION	No. of Req'd
E-4	Surface Meteorology	
E-4-1	-1. Wind Vane and Anemometer-KOSHIN MVS-320, Propeller type Data Transmission: wind direction by photoencorder, wind speed by photointerrupter	1 set
	-2. Coupling Flange: for 4 inch pole	1 set
	-3. Cable 50m	1 set
E-4-2	-1. Thermometer-KOSHIN-FT-S : Platinum resistance thermocouple	1 set
	-2. Cable 2p, 3p, 50m each x 1	1 set
E-4-3	-1. Pyranometer-EIKHO-MS-43F : Electric pyranometer with a thermocouple covered by a glass dome	1 set
	-2. Flange: for 2 inch pole	1 set
	-3. Cable 2p 50m	1 set
E-4-4	-1. Net Radiometer-EIKHO-MF-11 : with two sets of thermocouple covered by polyethylene dome	1 set
	-2. Fixture: for 2 inch pole	1 set
	-3. Cable 2p 50m×2	1 set
E-4-5	Surface Meteorology Observation Parts	
	-1. Data logger: HORIBA DL-360 Data Processor - (HORIBA) Artist P166ATX : CPU pentium MMX 166 MHHz, Memory 32 MB, HDD 1.8 KB Printer - (HORIBA) HP DESKJET 690 C Monitor - (HORIBA) Belinea 17 inch	1 set
	-2. Pen-recorder: KOSHIN MVS-320	1 set
	-3. Pen-recorder: KOSHIN EH-800	1 set
	-4. Data Converter: KOSHIN—KANTAM	1 set
	-5. Unit Case: 2000 x 570 x 500*	1 set
	-6. Stable Power Supply: MEISEI with 2kv-step down transformer	1 set
E-4-6	Consumable and Spare Parts-KOSHIN	
	-1. Recording Chart (wind vane and anemometer Recorder)	18 rolls
	-2. Recording Chart (6 point recorder)	18 rolls
	-3. Recording Pen	36 pcs
	-4. polyethylene dome, etc.	1 set

ITEM	SPECIFICATION	No.of Req'd
H-1	Data Management system; to be set up at Tehran	
H-1-1	1) Personal Computer Type: COMPAQ-Japan, DESKPRO 4000 5200X2400/CD Processor: Pentium 166MHz User Memory: 16MB Hard disk storage: 2.5GB Diskette storage: 3.5"1.44MB-FD Others: equipped 105 type key board also Mouse function	1 set
	2)Printer (included in the Personal Computer set)* Type: Epson, MJ-930C Resolution: 300DP Max paper size: A4 Cable: Connecting cable Power: 1KVA	1 set
	3) Consumable and Down Transformer	1 set
H-1-2	Software: OS LAB Co., Eco-Das-32 and DL-360* Software for data management, such as SO_2, NO, NO_2, WD, WV, SUN, NETR, HUM, and data from the Data Logging System Operating System: PS-DOS Main Function: Processing Data from FD recorded by HORIBA logger : Edit Hourly, Daily, Monthly & Annual reports by keyboard : Output Report: Daily, Monthly and Annual Reports : Graphic Output: Hourly Variation (Multiple Stations and Items) Daily Variation (Multiple Stations and Items) Monthly Variation (Multiple Stations and Items) Wind Rose Diagram Pollution Rose Diagram Histogram Scatter Diagram (Regression, Multiple Stations) Scatter Diagram (Regression, Multiple Items) Special Function: Data File Information : Data Backup and Re-store	1 set

JICA Equipment: Agents (A) or Manufacture (M)

Code in Equip. List	A or M	Company Name and Address	Postal Code	Country	Telephone	Fax
EIKHO	M	Eikho Instrument Trading Co.: 6th Fl. Sasazuka Center Bldg., 1-6, Sasazuka-2, Shibuya, Tokyo	151-0073	Japan	81-3-5352-2911	81-3-5352-2917
HORIBA	A	Bisan Pars Co., Ltd.: Apt. #5, No.7, Leili St., Khodami Ave.,Vanak Sq., Tehran	19946	Iran	021-879-1269	021-879-6233
KOSHIN	M	Koshin Electric Industry Co., Ltd.: 20-19, Jiyuugaoka-1, Meguro, Tokyo	152-0035	Japan	81-3-3717-0101	81-3-3718-0101
MEISEI	M	Meisei Electric Co., Ltd.: Sasaki Bldg., 5-7, Koishikawa-2, Bunkyo, Tokyo	112-8511	Japan	81-3-3814-5123	81-3-3813-9774
OS LAB	M	OS Lab Co., Ltd.: 14-12, Nishi-Kanagawa-1, Kanagawa, Yokohama	221-0822	Japan	81-45-322-1011	81-45-322-3133
NIGORIKAWA	M	Nigorikawa Rika Industry Co., Ltd.: 4-7, Naka-Juujo-1, Kita, Tokyo	114-0032	Japan	81-3-3906-2511	81-3-3906-5050
M. T. PRECISION	M	M.T. Precision Co., Ltd.: 15-3, Chuo-8, Ohta, Tokyo	143-0024	Japan	81-3-3753-6557	81-3-3753-6551
ROHAM GAS	M	Roham Gas Co.: 10 Jahankoodak Blvd., Tehran	--	Iran	021-686-470	021-888-4781
SHIBATA	A	Perse SANCO Ltd.: 129 Ave. Somayeh, Tehran	--	Iran	021-830-206	021-882-5887
SHIMADZU	A	Mahzad Kala Co., Ltd.: 152 Ostad Motahari Ave. Parsa Cross Rd., Bank Melli Bldg. Tehran	15787	Iran	021-884-6182	021-884-6185
SHINTAKU	M	Shintaku Kikai Co., Ltd.: 9-30, Higashi-Nanba-4, Amagasaki, Hyougo	660-0892	Japan	81-6-401-0276	--
YOKOKAWA	M	Yokokawa: Musashino Center Blgd., 19-18, Nakamachi-2, Musashino, Tokyo	180-0006	Japan	81-422-36-5851	--

Appendix 1-4

Mothball Manual for Ambient Air Monitoring Instruments

Take the following precautions when storing, moving or transporting ambient air monitoring instruments to avoid damaging the instruments and to ensure safe.

1. General in Storage and Transportation

- Do not dismantle each instrument from a set of equipment (do not disconnect tubing and wiring connecting each instrument) and do not remove the equipment from its shelf.
- Cap with cotton balls all the inlets and outlets to/from ambient of the equipment set.

2. Storage

- Store the instrument set a sturdy, level, vibration-free, flood-free, and dust-free location.
- Avoid direct sunlight and radiant heat sources. Avoid direct contact with air conditioned or heated air. Avoid areas where rain or water might fall on the instruments. Make sure that the temperature of the storage never rises above 40 ℃ or fall below 10 ℃ and the humidity never also rises above 85 %.

2. Transportation

- Do not turn the instruments on their side (keep upright as it is now) when transporting or moving the instruments. Make sure that it is not subjected to unnecessary shocks or rough handling. Avoid direct sunlight, radiant heat sources and rain.
- When transporting a container, secure the instruments with appropriate bands or supports to fix them in the container and to prevent them from falling over in the container. Again, make sure that it is not subjected to unnecessary shocks or rough handling. Avoid direct sunlight, radiant heat sources and rain.

Precautions in Handling, Storing and Transporting Gas Cylinders

High-pressure gas handling, safety procedures, etc. are closely regulated in all countries through laws and regulations. For this reason, be sure to handle the cylinders in the manner regulated by laws, etc. In general, the following precautions should be followed.

- Place the gas cylinders in an area with good ventilation, and not subject to direct sunlight.
- Make sure that the temperature of the gas cylinders never rises above 40℃. In addition, do not allow fire within 2 meters of a cylinder.
- Secure the cylinders with appropriate bands (chains, etc.) to prevent them from falling over and rolling.
- When the gas is completely used, immediately cap the cylinder.
- Check the functions of the pressure meter at least once every three months.

Appendix 3-1

General Data of Iran Power Plants
as of April 1999

Steam Power Plants

Power Plant	Place	No. of Units	Nominal MW	Date of Installation	Note
Shahid Firoozy	Tehran	4	50	1958	
Besat	Tehran	3	247.5	1967-1968	
Shahid Montazer Qaem	Karaj	4	625	1970-1972	
Esfahan	Esfahan	2	75		
		1	120		
		2	640		
	Total	5	835	1969-1980	
Shahid M. Montazeri	Esfahan	4	800	1983-1988	
		4	800	1998-1999	7)
	Total	8	1600		
Shahid Beheshti	Loshaon	2	240	1972	
Shahid Salimi	Neka	4	1760	1980-1982	
Ramin	Ahwaz	4	1260	1980-1984	
		2	630	1999-2000	5, 7)
		2	630	planning	5)
	Total	8	2520		
Shahid Madhaj	Ahwaz	2	290	1974	
Bandar Abbas	Bandar Abbas	4	1280	1980-1985	
Zarand	Kerman	2	60	1972	
Tabriz	Tabriz	2	736	1985-1988	
Shahid Rajaei	Qazvin	4	1000	1990	
			1000	planning	2)
	Total		2000		
Beesotoon	Kermanshah	2	640	1992	
Mofatteh-e-Qarb	Hamedan	4	1000	1992	
Sahand	E. Azerbayjan	2	650	2002-	1)
Shazand Arak	Arak	4	1300	designing	2, 5)
Alkam Pareh Sar	Gilan	1	460	designing	2)
Mashhad	Mashhad	1	13	1967	
		2	120	1973	
	Total	3	133		
Toos	Mashhad	4	600	1985	
Iranshahr	Iranshahr	4	256	1995 - ?	3)

Gas Power Plants

Power Plant (CC = combined cycle)	Place	No. of Units	Nominal MW	Date of Installation	Note
Besat	Tehran	2	120	1973	
Montazer Qaem, CC	Tehran	6	696	1990	
Ray	Tehran	6	192	1977-1978	
		18	424.4	1977-1978	
		7	224	1978	
		3	255	1978	
		6	144	1978	
	Total	40	1243.4		
Tabriz	Tabriz	2	64	1978	
Kermanshah	Kermanshah	2	64	1977	
Soofian	Tabriz	4	96	1983-1984	
Gilan, CC	Rasht	6	862.8	1991	
Shahid Beheshti	Loshan	2	120	1977	
Shahid Salimi	Neka	2	275	1990	
Booshehr	Booshehr	3	71.1	1974-1975	
		4	94.8	1973-1974	
	Total	7	165.9		
Kangaan	Kangaan	1	25	1995	
		1	18.5	1995	
	Total	2	43.5		
Shahid Madhaj (Zargaan)	Ahwaz	3	96	1975	
Orumieh	Orumieh	2	60	1989	
Shiraz	Shiraz	3	42	1967	
		2	51	1974	
		1	12	1965	
		1	21.5	1973	
		1	60	1981	
	Total	8	186.5		
Abadeh	Abadeh	2	16.2	?	
Bandar-Abbas	Bandar-Abbas	2	46	1993-1996	
Qom, CC	Qom	4	512	1993	
		2	200	planning	6)
	Total	6	712		
Shahid Zanbag	Yazd	4	94.8	1977-1979	
Dorood	Dorood	2	60	1977	
Hassa	Shahin-Shahr	3	96	1989	
Kazeroon, CC	Kazeroon	2	256	1993	
Shahid Rajae, CC	Qazin	6	740.4	1993	
Fars, CC	Shiraz	5	617	1995	
		1	123.4	construction	5)
	Total	6			
Aslavieh	Aslavieh	6	8.4	1995	
Biram	Biram	1	1.4	1995	
Mashhad	Mashhad	2	37	1974-1984	
		2	158	1978	
		1	24	1982	
	Total	5	219		
Shirvan	Shiran	6	142.2	1982-1984	
Shariatti	Mashhad	6	142.2	1983-1984	

Gas Power Plants - continued

Power Plant (CC = combined cycle)	Place	No. of Units	Nominal MW	Date of Installation	Note
Shariatti, CC	Mashhad	2	232	1993	
Neishaboor, CC	Neishaboor	5	617	1996-1998	
		1	123.4	construction	5)
	Total	6	740.4		
Qaen	Qaen	3	71.1	1987	
Toos	Mashhad	1	8	1977	
Cha-bahar	Cha-bahar	6	142.2	1978	
Zahedan	Zahedan	3	71.1	1987	
		1	30	1995	
	Total	4	101.1		
Khoy, CC	Azerbayjan	2	246.8	1998-	5, 6)

Hydroelectric Power Plants

Power Plant	Place	No. of Units	Nominal MW	Date of Installation	Note
Dez Dam	Andimesk	8	520	1962-1973	
Shahid Abbaspour	Masjed-Soleiman	?	1000	1977	
		?	1000	planning	3)
	Total		2000		
Masjed-Soleiman and Karkheh	Masjed-Soleiman	3	400	2000-	5, 8)
		?	400	2005	3)
	Total		800		
Amir Kabir Dam	Karaj	2	91	1961	
Sefidrood Dam	Manjil	5	87.5	1964	
Latian Dam	Latian	2	45	1969-1987	
Zaiandehrood Dam	Abbe-Shinder	3	55.5	1970	
Aras Dam	Jolfa	2	22	1971	
Mahabad Dam	Mahabad	2	6	1972	
Golan Dam	Tehran-East	3	115.5	1988	
		1	35	2005	3)
	Total	4	150.5		
Doroodzan Dam	Shiraz	2	10	1989	
Saveh & Forghan Dam	Saveh	2	10	1986	
		2	5	1986	
	Total	4	15		
Jannat-e-roodbar Dam	Jannate-e-roodbar	1	1	1996	
Gheshlagh Dam	Gharb	2	6	1996	4)
Jiroft Dam	Kerman	2	30	1993	4, 5)
Shoote Moghan Dam	Azebayjan	2	13	1995	4)
		2	13	2005	3, 5)
	Total	4	26		
Kohrang Dam	Esfahan	3	27	1995	4, 5)
Karoun 3	Khoozestan	8	2000	construction	3, 5)
Karoun 4	Khoozestan	4	1000	2010	3, 5)
Maroon	Khoozestan	?	74	2005	3, 8)

Note: Source - #85 other than noted

1) #99, 12/27/98, 2) #101, 3) #102, 4) #23, 5) #25, 6) #104, 7) #105, and 8) #106

Appendix 3-2

Power Plant Operational Data

Name of Power Plant : TABRIZ POWER PLANT

Unit No. : 1

Munth : 98.8.17~98.9.18 14:00

		Unit	Design Data	Date 8/17	18	19	20	21	22	23	24	27	28	29	30	31	9/1	2	3	4	5	6	7	8	9	11	12	13	14	15	16	17	18
1	Power Generation Output	MW	368	347	346	349	350	349	347	350	350	345	345		343	320	330	350	345	350	350	350	350	350	349		348	350	349		349	350	348
2	Fuel Comsumption (Heavy Oil or Bz)	t/h		80	77	80	79	80	79.5	80	79.5	79.5	79		81	83	78	84	82	84	78	79	79	79	79.5		79.5	80	79		80	78	78.5
3	Feed Water to ECO	t/d		1100	1100	1100	1105	1120	1110	1110	1110	1120	1100		1090	1010	1030	1130	1080	1100	1080	1100	1080	1090	1100		1120	1130	1100		1140	1080	1100
4	Combustion Air Flow Rate	t/d		940	900	940	930	930	940	940	925	905	915		930	880	870	930	935	930	910	920	900	920	905		910	930	920		910	915	915
5	Main Steam Temperature Entering Turbine	℃	538	538	538	538	538	539	538	538	538	538	538		538	535	538	538	538	538	538	538	538	538	538		538	539	538		538	538	538
6	Reheat Steam Temperature Entering Turbine	℃	538	534	531	530	537	535	535	537	532	533	538		540	534	538	535	539	538	538	537	534	537	535		540	539	537		537	539	537
7	Discharged from Air Preheater	℃	160	220	218	221	225	200	218	220	212	219	212		210	207	208	210	205	200	202	203	205	205	205		200	202	200		202	210	210
8	Atmopheric Air Temperature at Force Draft Fan (in the shade)	℃																															
9	O2 or CO2 Concentration Discharged from Economizer	%	1	0.9	0.2	0.4	0.4	0.2	0.1	0.2	0.2	0.1	0.1		0.8	0.1	0.2	0.1	0.2	0.2	0.2	0.1	0.2	0.2	0.05		0.4	0.7	0.5		0.4	0.6	0.4
10	Water Temperature Entering Condenser	℃	21.6	33	30	30	30	30	29	28	24	30	23		29	29	30	29	29	28	28	29	28	29	21		29	29	28		27.5	29	55
11	Water Temperature Discharged from Condenser	℃	29.6	44.5	42	45	45	43	45	46	44	46	42		43		45	45	44	42	43	44	45	43	41		42	41	41		43	44	43
12	Condenser Vacuum Pressure or Absolute Pressure	mmHg	38.0	65	62	68	57	69	65	63	58	53	52		52	50	56	50	52	56	51	52	50	52	54		60	59	55		53	56	
13	Condensate Flow Rate	t/h		97	97	99.5	98	98	97	99	98	97	96		96	93	93	98	98	97	98	98	97	99	97		98	98	98		97	97	98
14	Steam Temperature Entering Condenser (A)	℃		47	47	47	45	47	45.5	46	45	44	44		45		45	44	44	45	43	43	43	43	44		45	45	44		44	45	44
15	Steam Temperature Entering Condenser (A)	℃		44	44	46	44	45	43	44	43	42	42		42		44	44	42	43	41	42	42	41	41		42	44	43		443	44	44
16	Steam Temperature Entering Condenser (B)	℃		44	44	46	44	44	42	44	43	42	42		42		44	44	43	43	41	41	41	41	41		42	43	42		43	44	44
17	Steam Temperature Entering Condenser (B)	℃		44.5	44	46	44	44	43	45	43	42	42		42		44	44	43	43	41	41	41	41	41		42	43	42		43	44	44

Power Plant Operational Data

Name of Power Plant : ESFAHAN POWER PLANT

Unit No. : 4

Month : 98.7.23~98.8.21 14:00

		Unit	Design Data	Date 7/23	24	25	26	27	28	29	30	31	8/1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1	Power Generation Output	MW	320	310	250	230	220		320	280	320	300	310	310	310	310	315	240	270	310	210	270		210	280	250			220	270	210	220	270
2	Fuel Comsumption (Heavy Oil or Bz)	t/h	66.4	25	28	22	14		38		37	32	34	35	35	37	55	28	36	45	37	29		14	28	27			23	38	33	38	36
3	Fuel Comsumption (Natural Gas)	m³/h	75000	46000	27500	30000	32000	35500	35000	32000	35500	36000	35000	35000	34500	36000	25000	26000	24000	25000	20500	32000		36000	35500	32000			36000	29000	26000	32000	25000
4	Combustion Air Flow Rate	m³/h	930	990	800	795	570	870	1020	910	1010	950	990	980	1000	1010	1000	800	780	1000	780	930		720	900	860			720	875	680	810	890
5	Main Steam Temperature Entering Turbine	°C	538	540	540	540	540	540	540	540	540	540	540	540	540	540	540	540	540	540	540	540		540	540	540			540	540	540	540	540
6	Reheat Steam Temperature Entering Turbine	°C	538	540	540	540	540	540	540	540	540	540	540	540	540	540	540	540	540	540	540	540		540	540	540			540	540	540	540	540
7	Discharged from Air Preheater	°C	170	184 171	166 157	166 153	165 150	165 150	180 170	181 166	188 172	180 165	188 170	180 165	187 170	183 175	180 165	168 158	170 160	188 169	175 160	180 160		155 150	181 160	172 160			155 155	178 160	157 147	155 150	179 165
8	Atmopheric Air Temperature at Force Draft Fan (in the shade)	°C	20																													
9	O₂ or CO₂ Concentration Discharged from Economizer	%	0.5																													
10	Water Temperature Entering Condenser	°C	33	31	30	32	32	30.5	32	31	32	33	32.5	33	32	33.5	33	31	31	32		32		30	31	32.5			30	31.5	30.5	32	30.5
11	Water Temperature Discharged from Condenser	°C	44.8	41	36	42	38	40	42	40	43	43	42.5	44	41	43	43	39.5	40	42		42		46	40	42			38.5	41	37.5	43	41
12	Condenser Vacuum Pressure or Absolute Pressure	mmHg	580.0	550	570	540	570	575	575	560	550	550	550	555	560	550	550	570	555	550		560		560	560	555			570	560	575	560	560

Appendix 3-3 Energy Saving Measures

Energy saving should be tried where there are large energy loss anticipated. In the power plants, a condenser, stack gas, and turbine are three major parts energy is wasted. Table 1 points out how to save those wasted losses.

Table 1 Major Energy Saving in Power Plants

Measures	Contents
Reduce the released energy loss of condenser	It is essential to control and keep the vacuum degree of a condenser at approximately the designed value. Among several causes that deteriorate the vacuum degree, the most influential factor is fouling of the cooling tubes. It can be cleaned off by brushes or sponge balls as well as a "backwash" method.
Reduce the stack gas energy loss of boiler	It is important to lower both the excess air ratio and the stack gas temperature. That is, it is necessary to lower the excess air ratio as lower as possible within the limit that could maintain a good condition of combustion. It is also desirable to lower the stack gas temperature by recovering the stack gas heat as much as possible under the condition that sulfur corrosion of the low temperature zone should be limited.
Lower the mechanical energy loss of turbine	It is also effective measures to install high efficient blades and appropriate steam seals, in facility aspect, and also take a variable pressure operation at the time of partial load operation, in operational aspect.

Respecting the above-mentioned measures for energy saving, it is required to implement the following specific measures.

(1) Energy Saving Measures by Operational Management

Specific measures by operational management are conceived as in **Table 2.**

(2) Energy Saving Measures by Improvement and Reformation of Facilities

Specific measures by improvement and reformation of existing facilities are conceived as in **Table 3.**

(3) Energy Saving Measures by Installation of New Facilities

Measures with installation of new facilities are usually applied in such a case as existing equipment and facilities are operated fully over durable years and should be abandoned or replaced. Two measures given in **Table 4** are conceived depending on the concept.

Table 2 Energy Saving by Operational Management

Facilities	Measures
Boiler and devices concerned	1) Proper keeping and management of the steam temperature and pressure 2) Improvement of the air ratio (i.e. lowering the excess air percentage) 3) Lowering the stack gas temperature from an air heater (it may require some appropriate treatments such as injection of ammonia). 4) Reinforcing the thermal insulation of boiler, and prevention of gas leak 5) Proper maintenance of air heater 6) Removing ash adhered to the wall of boiler tube (in case of using heavy oil as a fuel) : (Proper operation of soot blowers)
Turbine and devices concerned	7) Keeping the vacuum degree of a condenser at the designed one 8) Improvement of deterioration in the operating efficiency of a cooling tower 9) Repairing corroded and worn part of turbine blades, and proper maintenance of steam seals
Plant in General	10) Resolving poor maintenance of instruments and gauges, and also implementing repairs of facilities. 11) Saving number of devices at work, such as feed water pumps, cooling pumps, air blowers etc., at the time of low load operation 12) Prevention of steam leak 13) Totally economizing other in-house energy consumption in the plant

Table 3 Energy Saving by Improvement and Reformation of Facilities

Facilities	Measures
Boiler and devices concerned	1) Preventing air leak from boiler (i.e. frequent repair and maintenance of air heater are recommended.) 2) Improving the thermal conductivity elements of air heater
Turbine and devices concerned	3) Adopting high efficient blades for steam turbine 4) Improving the controlling system for valves of steam turbine 5) Improving the cleaning method for thin tubes of condenser 6) Installing steam ejectors and vacuum pumps as air extractors of condenser
Plant in General	Economizing in-house energy consumption in the plant, by adopting variable blade system

Table 4 Energy Saving Measures by Installation of New Facilities

	Measures
By keeping basic process	1) Installation of new equipment and facilities with high efficiency 2) Scrap and build
Changing basic process	Adoption of combined cycle power generation system, in cases where natural gas is available as a fuel.

Appendix 3-4

Various Air Pollutant Control Measures at Thermal Power Plants

Main reference 1) Flue Gas Clean-up Technologies in the World by Junpei Andou (J)
2) Stationary Source Control Manual at Developing Countries by JEA (J)

1. Measures against Sulfur Oxides

(1) Implementation of Fuel Measures

This measure is to reduce an emission rate of sulfur oxides from a thermal power plant by converting its fuel to one of lower sulfur contents, such as, diesel oil, naphtha, NGL, natural gas.

(2) Implementation of Facility Measures

This is a measure that sulfur oxides are removed directly from flue gas by means of flue gas desulfurization plants. **Table 1** shows major desulfurizing methods.

Table 1 Kind of Flue Gas Desulfurization Processes

Processes		Chemical Agents	Byproduct
W E T	Limestone-Gypsum	limestone or lime slurry for absorption, and air for oxidation	calcium sulfate particles for recovery or throwaway
	Limestone-Sludge	limestone or lime slurry for absorption	calcium sulfite sludge for throwaway
	Wellman Lord	sodium carbonate solution	concentrated sulfur dioxide
	Magnesium Throwaway	magnesium carbonate solution	magnesium sulfite solution throwaway
D R Y	Lime Slurry Spray	slurry sprayed to dryer vessel or duct	calcium sulfite collected with soot
	Limestone Injection	limestone slurry injected to furnace	ditto
	Active Carbon Adsorption	active carbon moving bed	concentrated sulfur dioxide
	Limestone Fluidizing	with coal combustion in fluidized bed	calcium sulfite collected with ash

The plant by-producing concentrated sulfur dioxide needs a sulfur or sulfuric acid plant nearby. There are many other processes, commercialized or under development, in the world. Varieties are from contact methods of flue gas and chemical agents, and types of chemical agents.

(3) Wet Limestone Desulfurization Processes

The most commonly used in the power industry are wet limestone processes. The basic flow scheme of this process (**Figure 1**) is as follows: 1) sulfur dioxide (SO_2) in flue gas is absorbed in a slurry containing limestone in a contacting device, such as a spray tower, 2) calcium sulfite produced in the slurry is completely oxidized with air in order to get gypsum (calcium sulfate), and 3) after free

water is separated from the gypsum, it will be taken out as a by-product.

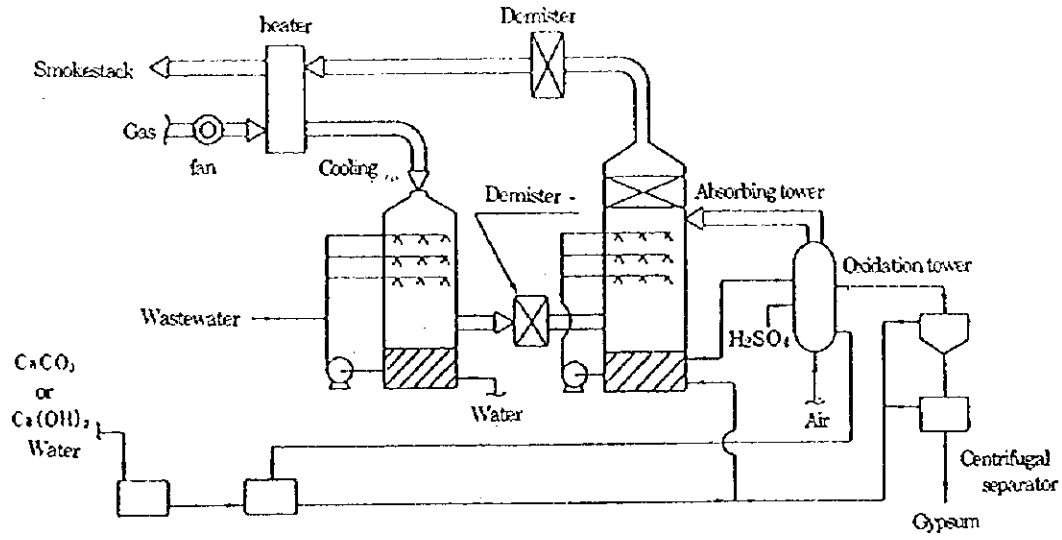


Figure 1 Flow Diagram of Limestone Desulfurization Process

A key variation of the above process is an elimination of air oxidation and accordingly of gypsum production. The process is called a limestone sludge throwaway process. By this variation, there was a problem of hard scale deposits in the absorption tower in the past. However, the problem has overcome by an addition of chemicals (oxygen scavenger) in the absorption slurry.

One another variation of the limestone process is the CT-121 process (**Figure 2**) which uses the JBR (jet bubbling reactor) contacting device instead of the absorption tower. All chemical processes, absorption, oxidation, and neutralization, are carried out in one JBR. This process is simple and revolutionary, because of less number of facilities, smaller area where such plant is installed, easier operation, and competitive construction and operation costs.

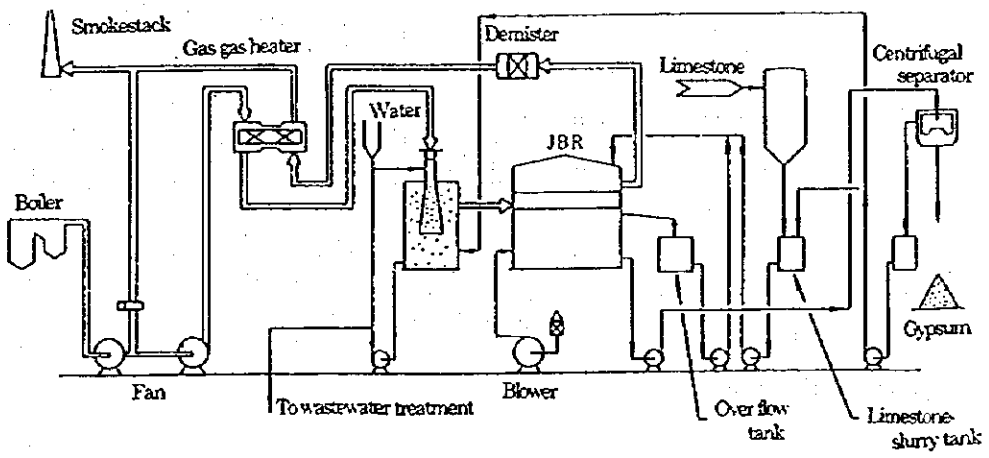


Figure 2 Flow Diagram of CT-121 Process (One of Limestone Desulfurization Processes)

(4) Basis for Adoption of Wet Limestone Desulfurization Process

Generally a desulfurization process for a large power plant should be selected based on following considerations, besides ordinary economical and technical feasibility studies: a) process history - one year continuous operation by more than 100MW capacity, b) no secondary pollution by plant operation including throwing away of by-products, c) easiness of operation by power plant operators, d) availability of chemical agents and spare parts locally, e) easiness of maintenance, and f) market of by-product, if salable.

The limestone desulfurization process has the following characteristics, and is widely employed in power plants because it is the most reliable and the economical one from the general point of view.

1) Its process is relatively simple and high SO_2 removal efficiency can be obtained.
2) Its plant operation is stable and easy for power plant operators. Long continuous operation is possible. Its plant can withstand severe load changes.
3) The plant equipment is easy to maintain.
4) Limestone is found in abundance, costs low, and is safe for handling.

Further, if gypsum is by-produced,

5) It can be sold as raw material of cement, gypsum boards etc., or can be stored relatively easily without further pollution.
6) Any secondary pollution is not generated.

(5) Construction and Operation Costs

In the case of installation of the wet type limestone gypsum flue gas desulfurization plant of 90% SO_2 removal efficiency, its construction cost is in the range of ¥ 7,000 - 15,000/kW in Japan, or around 10% of the corresponding thermal power plant cost itself. For the plant to be built in a power plant of 500MW rated capacity, the construction cost ranges from 3.5 billion to 7.5 billion yen.

Operating cost is different from local prices of electricity, limestone, water, wage of operators, and maintenance, and also policy of depreciation. Each consumption for rough estimation of the operating cost of the limestone gypsum process of 90% SO_2 removal is as follows:

Electricity	0.7 - 1.0 % of the rated capacity of the corresponding power plant
Limestone	1.64 tons of $CaCO_3$ (as 100%) per 1 ton of SO_2 to be removed
Water	0.5 - 0.8 tons/day for 1 MW rated capacity: if 500 MW, it is 250 - 400 tons/day; practically it should be calculated from an evaporation rate of water contacting with flue gas (temperature and water vapor contents at the outlet of a gas-gas heat exchanger) to cool it to its water

saturation temperature. The requirement is the sum of the above evaporation rate and the water discharge rates with byproducts and else.

Operators: 2 operators/shift

Maintenance: In case of the limestone gypsum plant, it can be annually 2% of the plant construction cost as a practical and safe estimation.

(6) Cost-down of Limestone Flue Gas Desulfurization Plant

The limestone process is the most advantageous selection in the power industry, if circumstances allow so. However, the cost of its plant construction and operation is not the cheapest among others in general. Therefore, research and development are being carried out by cutting down expenses sharply by simplifying processes and plants as much as possible. Generally, reduction of the cost is achieved with the items shown in **Table 2.**

Table 2 Measures to Cut Down Construction Cost of Flue Gas Desulfurization Plants

Item	Description	User Side's Consideration
Decrease of engineering time	New planning and designing should not be conducted each time.	Selecting the plant with standardized arrangement, capacity, and specifications
Simplification of equipment/ machines comprised the plant	Cutting down of design surplus, Development of new design.	Lowering request of desulfurization efficiency within the acceptable ranges in view of environmental preservation.
Re-evaluation of construction materials of equipment and machines	Conversion from high-grade materials to low-priced materials.	Supporting with a regular check and maintenance plan.
Simplification of processes	Development of a process which constituent equipment/ machines can be omitted or integrated.	Lowering demanded levels of peripheral matters such as qualities of the by-product.
Omission of some of constituent equipment and machines by simplifying the control method		Adopting a minimum automatic control process required.

(7) Operation and Maintenance

In many cases, flue gas desulfurization plants in thermal electric power plants are operated automatically with instrumentation control systems. However, since full automation from starting to stopping is difficult from the viewpoint of safety and economy, there are some left to operators' judgement. Therefore, it is important to educate operators so that they can cope with exactly whatever kinds of events occur.

The serious requirement for flue gas desulfurization plants, especially in thermal electric power plants, is the capability of continuous operation for 1 - 2 years. Reliability of long continuous operation should be emphasized from the beginning of the process selection. Also, the point to stress is the importance of the regular plant inspection and maintenance. By organizing of a special group, to be established is the maintenance system including prediction of repair, replace, or reinforce requirements of the plant equipment, purchase of spare and consumable parts, establishment of a cooperation system with venders concerned, following to the inspection and trouble shooting manual.

(8) Tendency of Future Technologies

The limestone gypsum flue gas desulfurization process has a history of about 35 years, and is completed as the one to be used practically with satisfaction in full. However, there is a possibility of further improvement on the process and plant and introduction of technology to eliminate waste water discharge (non-draining).

There are under going of another kinds of flue gas desulfurization process development. **Table 3** shows noteworthy flue gas desulfurization technique. The electron beam method has materialized at a Japanese electric power company with a capacity of 225MW. Its uniqueness is to by-produce fertilizer (mixture of ammonium sulfate and nitrate). The seawater desulfurization method is not used in Japan because of low desulfurization efficiency and uncertainty of secondary pollution in seas. However, there are applications in England, Norway, India, etc.

Table 3 Toward the Future of Flue Gas Desulfurization

Name etc.	Description	Problems etc.
Electron beam method	Method to convert NO_x and SO_2 to mixture of ammonium nitrate and sulfate by irradiating flue gas with electron beam under the existence of ammonia. Because temperature of gas does not fall much, there are advantages such as no cost of re-heating and no waste water discharge. It is said that construction and operation costs of this method can comprehensively compete with those of the limestone gypsum method.	Though by-products can be used as fertilizer, they are subject to a market size and distribution methods. Power consumption is about 2.5% of the rated power plant capacity.
Seawater desulfurization method	Method to desulfurize by Ca/Mg contained in seawater. Used seawater is treated and discharged. As a large quantity of seawater is required, it is necessary that a power plant is adjacent to the seashore.	Assessment regarding sea pollution.

There are also development of dry lime or limestone processes and dry simultaneous SOx and NOx

removal processes in the world.

2. Measures against Nitrogen Oxides

For emission reduction of nitrogen oxides (NOx), there are three methods; fuel measures, combustion improvement and installation of flue gas denitrification facilities. NOx is generated from nitrogen in air and in fuel. The former NOx is called as thermal NOx and the latter as fuel NOx.

(1) Fuel Measures

This measure is to restrain the fuel NOx by burning lighter fuels, such as naphtha, NGL, natural gas, etc. having less amount of nitrogen.

(2) Combustion Improvement

As to thermal NO_x, the higher combustion temperature inside a furnace is, also the higher O_2 concentration is, and the longer retention time in high temperature is, the more thermal NO_x is generated. So the quantity of NO_x generation can be restrained by reducing O_2 concentration in combustion zone by restraining excess air. This is possible by the low excess-air combustion method, the two stage combustion method, the exhausted-gas mixture method, and the process employing a low NO_x burner.

1) Two-Stage Combustion

Two-stage combustion is a method based on the following procedures: 1) air supply to the lower part of a furnace is restrained to produce reduced atmosphere for combustion, and 2) subsequently the sufficient amount of air is added from the upper part of the furnace to complete the combustion, and as a result generation of NO_x is restrained. Although this is effective, observation and care are required because the combustion is likely to be unstable and there are tendencies of increased unburned combustibles in ash and of more soot generation, particularly for coal combustion.

There is another measure which takes one more step forward. Fuel is blown into the upper part of combusting flames in furnace, in order to be burned in reduction atmosphere and reduce NO_x generation., and then further additional air is blown into furnace to make complete combustion. With this variation, NO_x can be reduced by around 50%. This method called as Furnace Denitrification, Three-Stage Combustion or Re-burning process requires a little higher height of a furnace, and is difficult to be applied for existing furnaces.

2) Flue Gas Recirculation

The flue gas recirculation is a method to reduce NO_x by returning a part of flue gas of around 350 to 400℃ to the vicinity of a burner and mixing it with combustion air so as to lower combustion temperature and O_2 concentration during burning.

Although much volume of recirculated flue gas is effective for reduction of NO_x, the more volume of recirculated flue gas exists, the poorer combustion occurs. Therefore, the volume of recirculatied flue gas is limited to be 20 - 30 % of that of combustion air.

3) Low-NO_x Burner

Low-NO_x burners have the structure to promote burning under the optimum conditions by forming two combusting areas with concentrated fuel and with lean fuel in the burners so as to make premixed combustion and diffusion controlled combustion in each burner. With this structure, generation of NO_x is reduced by lowering combustion temperature and oxygen concentration in the burners and shortening the retention time of combustion gas.

4) Measures for Reduction of NO_x by Combination of Combustion Improvements

It is possible to further reduce emission of NOx with synergetic effect of combination of combustion improvement measures. In many cases in small-sized plants, NOx is decreased by 20 - 40 % by changing fuel from residual oil to kerosene or by using low NOx burners. In the large-sized plants, NOx is decreased by up to around 60 - 70% by combining low NOx burners, two stage combustion, flue gas recirculation, etc.

NOx at an exit of a burner is decreased to 150 - 300 ppm in the case of a coal burner, and to 80 - 200ppm, 60 - 100ppm and 40 - 80ppm in the cases of residual oil, kerosene and gas respectively. NOx emission standards can be generally cleared with these combustion improvements.

However, in Japan, as emission is regulated severely with the local regulations and agreements, various kinds of deeper denitrification is necessary. Measures of NOx reduction by means of combustion improvement are as shown in **Figure 3** and **Table 4**.

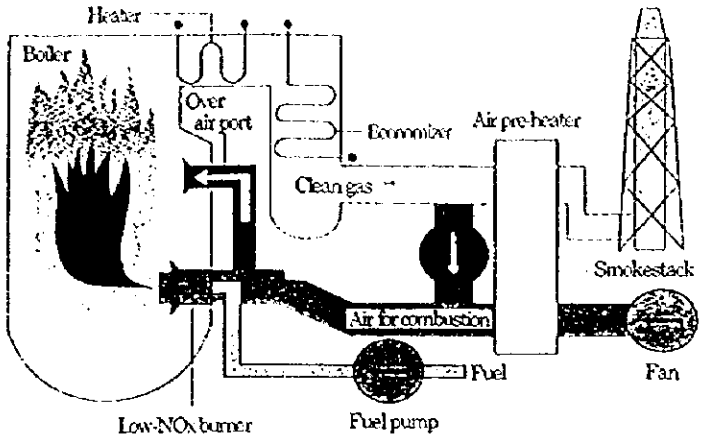


Figure 3 Measures for Reduction of NO_x by Combustion Improvement

Table 4 Reduction of NO_x by Combustion Improvement

(Unit: NO_x ppm)

Fuel		Coal	Residual oil	Kerosene	Gas
N(%) in Fuel		0.7~3	0.1~0.5	0~0.3	0
Oxygen in Flue Gas (%)		6	4	4	5
①	Standard combustion	550~800	400~500	350~450	300~400
②	Excess air	600~900	500~600	400~500	350~450
③	Low oxygen combustion	450~650	300~400	250~350	200~300
④	③+ Two stage combustion	300~500	200~300	150~250	150~200
⑤	③+ Flue gas recirculation	350~550	200~300	150~250	150~200
⑥	④+ Flue gas recirculation	200~400	200~300	100~150	80~120
⑦	⑥+ Low NO_x burner	150~300	80~200	60~100	40~80

(3) Flue Gas Measures

Kinds of direct flue gas denitrification processes are given in **Table 5.** Among the given processes, the dry process is exclusively applied, because higher reactivity in comparison with wet absorption processes. In the dry process, a method to reduce NO_x to N_2 is employed. Ammonia is generally used as a reducing agent which reacts selectively with NO_x.

Table 5 Kinds of Flue Gas Direct Denitrification

Dry method	Wet method
• Selective catalytic reduction process • Non-selective catalytic reduction process • Non-catalytic reduction process • Catalytic cracking process • Adsorption process • Electron beam irradiation process	• Gas-phase oxidation absorption process • Liquid-phase oxidation absorption process • Complex-salt-generating absorption process

1) Process

The denitrification processes can be classified into two methods as given below, according to installation places of denitrification reactor. Either method should be determined upon a practical plant plan, with comprehensive study.

① High-soot Denitrification Process

This is a process where flue gas from boiler is introduced directly to denitrification facilities and soot is later removed by an Electrostatic Precipitator. This is generally adopted to boilers burning low ash contained fuel, such as natural gas, or residual oil.

② Low-soot Denitrification Process

This is a process to denitrify after soot removal. An Electrostatic Precipitator is installed in the upper stream of denitrification facilities. It is sometimes used for denitrification of gas containing a large amount of soot such as flue of coal.

2) Denitrification Catalyzer

① Required characteristics of denitrification catalyzers :

a. High denitrifying capacity in the temperature range where it is used
b. Few side reaction such as conversion from SO_2 to SO_3
c. Sufficiently long life
d. Sufficient mechanical strength and heat resistance
e. Abrasion resistance, in the case of flue gas containing soot likely to cause abrasion

Several kinds of catalyzers which satisfy the above, are put to practical uses now. For main ones, porous ceramic such as titanium or aluminum is used as a carrier, to which several kinds of metal oxide compounds, etc. are given as active components.

② Selection of Denitrifying Catalyzers

Catalyzers are required to have capabilities according to properties of flue gas.

In case of clean flue gas by burning natural gas as a fuel, catalyzers only with heat resistance should be selected because flue gas does not contain soot nor SO_x which causes deterioration. For dirty flue gas burning residual or crude oil, or coal, it is necessary to consider soot and SO_x contained in the gas.

Table 6 shows variety of boiler fuel and points to be duly considered for selection of catalyzers. **Figure 4** shows the vertical view of the boiler unit having denitrification of catalytic reduction with ammonia.

Table 6 Boiler Fuels and Points for Selection of Catalyzers

Kinds of Fuel		Points to be Considered
Gas		High activity, heat-resistance
Residual/Crude Oil		High activity, heat-resistance, resistance to suffering from soot poison, SO_x resistance, Low SO_3 conversion rate
Coal	Low-soot Denitrification	Ditto
	High-soot Denitrification	Ditto, abrasion resistance

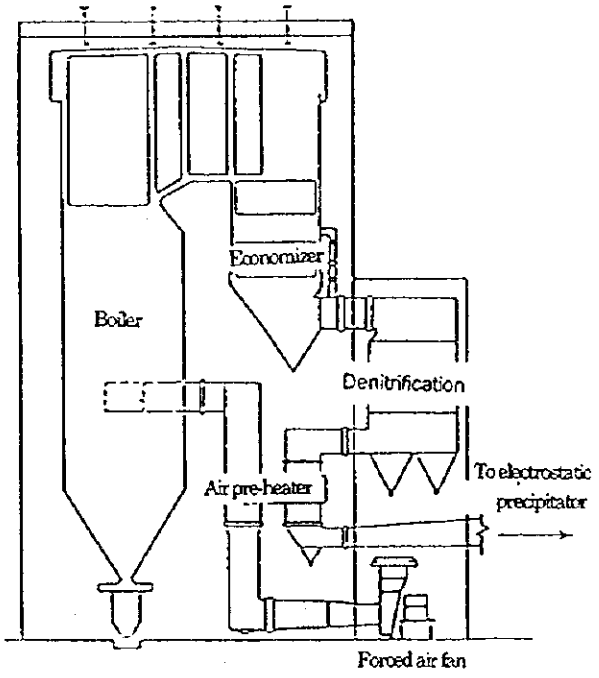


Figure 4 Vertical View of Boiler with Catalytic Denitrification with Ammonia

3) Construction Cost of Denitrification Facilities

Construction cost of denitirification facilities largely differs according to types of fuel and demanded performances. For example, cost of denitrification facilities with the 0.8 - 1.0 of ammonia injection mol ratio and the 80 % of denitrification rate is roughly estimated as follows:

Boiler burning residual or crude oil : ¥4,000 - 5,000/kW

Boiler burning coal : ¥6,000 - 7,000/kW

The cost of a storage tank occupies largely of whole cost of an ammonia injector facility necessary for denitrification. It is roughly ¥ 4,000 - 5000/tank capacity (m^3). All of above-mentioned facilities costs exclude foundation work cost.

For reference, an example of cost of denitrification facilities for thermal power plants (in 1981) is shown in **Table 7.**

Table 7 Example of Cost of Denitrification Facilities

Method	Invest-ment cost	Operation cost	Rem oval	Operation Difficulty	Applicat-ion Range	Use	Mainten-ance Difficulty
Condition	¥1000 / m^3 / H	¥1000 / m^3 / H ①NO_x concentration ②Utilization factor ③Cost of ammonia	%		gas volume Nm^3/H	applicable facilities	Difficult/ Average/ Easy
Ammonia catalytic reduction process	0.6 - 7.0	0.3 - 2.8 ①60-400ppm ②70% utilization ③¥60,000/t	<90	Average	70,000 ~3 million	·Boiler ·Gas turbine ·Diesel ·Garbage incinerator ·Heating furnace	Average
Ammonia non-catalytic reduction process	0.7 - 1.0	≧0.8 ①100-150ppm ②70% utilization ③¥60,000/t	<40	Easy	570,000 ~1 million	·Garbage incinerator ·Heating furnace ·Boiler	Easy

3. Measures for Control of Soot Emissions

(1) Fuel and Operational Measures

Unburned carbon is mainly generated in case of residual or crude oil combustion and fly ash mainly in case of coal combustion. As for measures against soot emissions, there are two approaches; 1) fuel measures that decrease generation of soot by using high quality fuel, and 2) operational measures that restrain soot by improving combustion control.

(2) Facility Measures

There are also soot removal processes using gravitational force, inertia force, electrostatic force, etc. Various kinds of these facilities which adopt such forces for soot collection are shown in **Table 8.**

Table 8 Various Soot Collecting Facilities by Acting Forces

Name	Gravi-tational force	Inertial force	Centri-fugal force	Thermo dynamic force	Diffu-sion force	Electro static force	Sonic force
Gravitational soot collector	◎						
Inertial soot separator	○	◎	○				
Centrifugal soot collector	○	○	◎	△			
Scrubbing soot collector	○	◎		△	◎	△	
Filter soot separator	○	◎			◎	△	
Electrostatic precipitator	○	○			○	◎	
Sonic precipitator	○		○				◎

Note: Marks ◎ and ○ show mainly acting forces for collection, and the △ marked forces are to accelerate aggregation of fine particulates.

1) Kinds and features of soot collectors/precipitators

Kinds and features of each collector/precipitator are shown in **Table 9.**

2) Summary and features of main collectors/precipitators

① Centrifugal soot collector

The equipment gives rotational flow to gas, and separates and collects particles in gas by centrifugal force acted on particles. A cyclone separator is the typical centrifugal soot collector.

a. There is a method to use several cyclones in a series. However, pressure loss is increased with this method, while further improvement of collection efficiency is not expected.

b. Small cyclones in parallel arrangement is called multicyclone or multiclone. Gas flow velocity is 10 to 25m/s. **Figure 5** illustrates one example of the multicyclone.

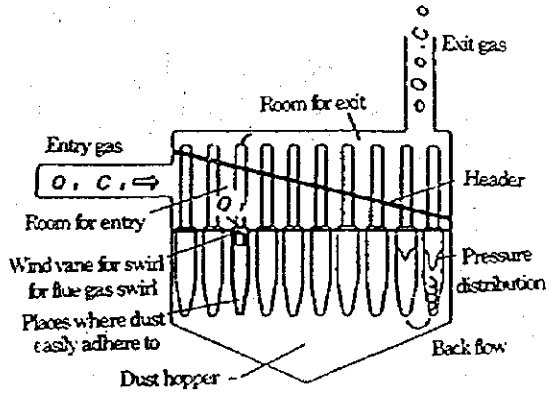


Figure 5 Axial-flow Reaction Type Multicyclone

Table 9 Kinds and Features of Soot Collectors/Precipitators

Equipment *1)	Feature	Type	Diameter of Soot Particle μ m	Apparent electric resistance rate of soot	Operating Temperature ℃	Removal level	Pressure loss mmH_2O	Typical flow rate m/s	Facility cost	Operating cost
Gravitational soot collector	To separate soot from the gas by free fall with gravitational force.	Settling chamber	50≦	No limit	Dew point or higher ～400	Collection efficiency 40～60%	10～15	1～3	Low	Low
Inertial soot separator	To separate soot using inertia by colliding against baffles with sudden changes of the gas flow direction.	Louver type	10≦	No limit	Dew point or higher ～400	Collection efficiency 50～70%	30～70	15～	Low	Low
Centrifugal soot collector	To separate soot from the gas by giving centrifugal force.	Cyclone	3≦	No limit	Dew point or higher ～400	To several $10mg/m^3$	50～150	Around 10	Middle	Middle
Scrubbing soot collector	To collect soot by scrubbing the gas with spray or film of liquid (water) to make soot adhere and flocculate to larger sizes.	Venturi scrubber	～0.1	No limit	No limit	To around $20mg/m^3$	300～800	60～90	Middle	High
Filter soot separator	To filtrate soot by passing the gas through the body of cotton, wool, synthetic and glass fiber, etc.	Bag filter	～0.1	No limit	Dew point or higher ～200	To less than $5mg/m^3$	100～200	0.01～0.03	Middle～High	Middle～High
Electrostatic precipitator	To separate corona-charged soot in the gas by discharging on grounded electrodes.	EP	～0.03	10^4～10^{11}	Dew point or higher ～400 *2)	To less than $5mg/m^3$	10～20	0.5～1.5	High	Low～Middle

Note *1) There is a sonic precipitator also. However, it has not yet been for practical use.

*2) In case of the wet type process, the upper limit of temperature is approximately 80℃.

Generally given values represent an outlines and differ from types and applications.

② Filter soot separator

There are two types of filter soot separator. One is the bag filter which employs surface filtration method to separate and collect soot on the surface of relatively thin filter cloth, and the other is the packed bed filter type which employs internal filtration method to separate and collect soot inside of the filter bed with filter medium. The bag filter is more popular.

Advantages and disadvantages of filter soot separator are shown in **Table 10.**

Table 10 Advantages and Disadvantages of Filter Soot Separator

Advantages	*Enables to collect sub-micron particles in high efficiency. *Not influenced by electric resistance of soot. *Removal efficiency is less affected by the fluctuation of the inlet gas temperature.
Disadvantages	*Pressure loss is high. *Improper for processing gas at dew point or lower. *Improper for hygroscopic soot and high adhesive soot. *Not suitable for high temperature gas processing because of filter material. *Regular replacement of filter cloth is required.(every 2 to 3 years) *Even one part of breakage at filter cloth causes large decrease in collection efficiency.

③ Electrostatic precipitator (EP)

EP charges soot particles in gas with corona and collects them by discharging on grounded parts. EP is adopted mostly to the boiler for electric power generation, because 1)EP is loss affected by properties of gas and soot, 2)the pressure loss is low, 3)collects fine particles easily, and 4)enables to collect soot in high efficiency.

a. Principle of collection

For electrostatic precipitation, several forces such as electric, diffusion, inertia, gravitational, etc. are utilized as collecting action force, but the main one is electric force.

As shown in **Figure 6**, the discharge electrode of core wire is negative and the collecting electrode of flat plate is positive. High voltage direct current power is applied to the charge. As electric field strength is risen, corona discharge is occurred. It is negative corona and is composed of large quantity of negative ion. The negative ion and the free electron move to the collecting electrode. If gas including soot is blown into here at this moment, particles in the gas are charged instantly. The charged particles are moved by Coulomb force (electric force) to the collecting electrode, and separated and collected.

The collected particles on the collecting electrode are peeled off/removed by hammering impact, etc.

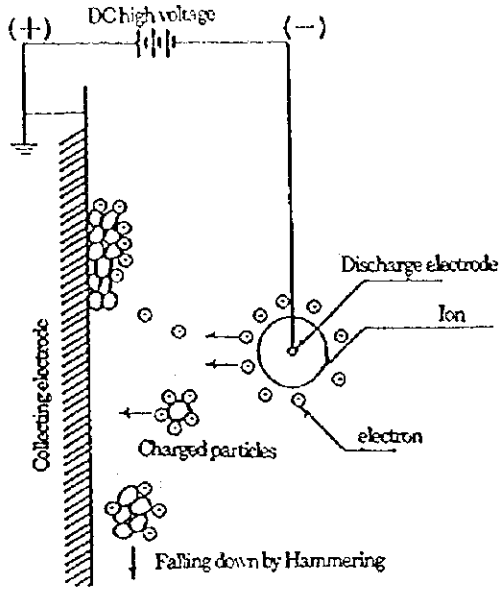


Figure 6 Principle of Electrostatic Precipitation

b. Structure of EP

As shown in **Figure 7**, EP is composed of the following parts.

- Gas distribution board which help to smooth our inlet flow and distribute it evenly across entire cross-section
- Discharge electrode wires or rods
- Collecting electrode plates
- Direct current high voltage generator.
- Hammering apparatus for peeling off soot adhered to the collecting electrode.
- Ash handling system which delivers collected soot.

3) The latest development of electrostatic precipitators

The largest development of the electrostatic precipitators is aimed to overcome back-ionization phenomenon, in order to maintain and improve collecting performance against high-resistant soot such as coal ash. Those precipitators for high-resistant soot already had been developed and used practically.

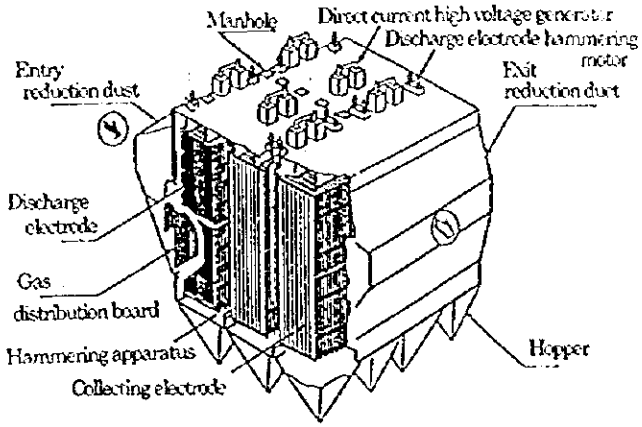


Figure 7 Structure of Electrostatic Precipitator (EP)

① New charging type

It is necessary to turn down electric current to restrain back-ionization in the normal direct current charging method of the ordinal electrostatic precipitators. Accordingly, the applied voltage is dropped and the electric field strength in the precipitator is also dropped. It causes reduction of soot charging activity because of non-uniformity of corona current from the discharge electrode, and further deterioration of EP performance.

However, short-time application of high voltage to the discharge electrode in pulse makes uniform distribution of corona current. In addition, changing the voltage, the amplitude, and the frequency of applied pulse permits to obtain higher peak voltage than that at direct current charging. Hence, improvement of soot collecting performance is permitted.

② Wet type

Wet type EP has been used as industrial particulate separators for a long time. In an electric power plant where a wet type desulfurizer is installed, the wet type EP is the most suitable to collect carried-over soot and mist at outlet of the wet type desulfurizer.

The basic structure of the wet type EP is the same as that of dry type. Major difference is that water is spraying through spray nozzles from the upper part of the collecting electrodes and is washing down the collected soot constantly. The wet type EP permits high flow rate of gas and accordingly has a compact system in size, because it is never affected by electric resistance of soot and free from re-fly of soot. However, it requires not only large quantity of water and a treatment unit for collected soot slurry, but also corrosion resistant material for construction because of lowering of gas temperature up to water saturation temperature.

③ Higher temperature EP

Adoption of higher temperature EP started in 1970's for coal thermal power plants. It is placed in the flue gas flow duct between an economizer and a gas-gas heat exchanger. Since the higher temperature EP collects soot at the temperature range of higher than 300℃ where electrical resistivity of soot drops, it can collect soot which can not be collected by conventional EP.

However, the following points must be considered for adoption; 1)volume of processing gas increases because of the high temperature range, 2)the structure should resist high temperature, and 3)heat loss should be prevented.

4) Advantages and disadvantages of electrostatic precipitator - see **Table 11.**

Table 11 Advantages and Disadvantages of Electrostatic Precipitator

Advantages	* Suitable for gas processing in large capacity. * Enables to collect sub-micron particles in high efficiency. * Has excellent durability, and maintenance is simple and also its cost is low. * Permits processing of high temperature gas. * Has also wet type and it enables to collect mist. * Relatively resists fluctuation of operating condition.
Disadvantages	* Costs for electric charging facility, control system, etc. are high. * Collection efficiency is affected by electric resistivity of soot, and it is lowered at $10^{4}\ \Omega \cdot$ cm or less and also at $10^{11}\ \Omega \cdot$ cm or higher. * System is large in size. * High manufacturing accuracy is required.

5) Cost of soot collector

Cost of soot collector largely differs in accordance with the types. In addition, it also depends on kinds of soot, required collection efficiency, and system size. **Table 12** lists construction and annual operational costs. The construction cost largely differs depending on specification of additional facility and range of estimation. The annual operation cost is estimated as operation in 6100 hours annually and the cost of electric power is ¥14/kwh. The higher required collection efficiency is, the higher annual operation cost is, in any type.

Table 12 Costs of Soot Collectors

Type	Construction cost (¥1,000/Nm^3/h)	Annual cost (Conditions) ①Operation rate 70% ②Cost of power ¥14 / kWh (¥1,000/yr /Nm^3/h)	Efficiency (%)	Difficulty of Operation	Application Range Gas Volume (Nm^3/h)	Maintenance Difficulty (Difficult / Average / Easy)	Remarks: Size of subjected particle (μ m)	Remarks: Pressure loss (mmH_2O)
Centrifugal	0.3~2.2	0.1~1.0	50~99	Easy	3,000~580,000	Easy	3~100	50~150
Filtration	0.3~2.1	0.3~1.1	93~99.9	Average	3,000~2,400,000	Average	0.1~20	100~200
Electrostatic	0.4~4.4	0.1~1.0	50~99.9	Easy	18,000~2,160,000	Easy	0.05~20	10~20

Appendix 3-5

General Waste Water Treatment Scheme

See numbers in the attached flow diagram.

1) Oil/Water Separator: The plates inclined to 45° separate oiling water.

2) Neutralization Basin

Waste waters of demineralizing plant and of boiler chemical cleaning are received and neutralized in the basin. Neutralized waste water is transferred to a retention basin.

3) Retention Basin

The basin is to equalizing properties of the waste waters for further treatment. Blow-down water of the boiler and another clear processed waste waters are added to the streams from the neutralization basin and the oil / water separator.

4) pH Adjustment Tank

The $FeCl_3$ coagulant is added to the waste waters from the retention basin. The water pH is adjusted by acid and caustic.

5) Coagulation Tank

Polymer coagulant is added to the waste waters. It helps to make flocs in the tank larger.

6) Clarifier

The generated flocs are settled on the bottom and are collected to the center-well by the scraper. The collected sludge is periodically pumped to the drying bed for drying. The clarified water is overflowed through a trough and transferred to the treated water tank.

7) Filter

Overflowed fine flocs from the clarifier are filtrated out by the pressure filter which is packed with sand and anthracite.

8) Filter Treated Water Tank

9) Neutralization Tank

The waters is finally neutralized in the tank before discharge. Only H_2SO_4 is injected in the tank because pH is alkaline after the coagulation process.

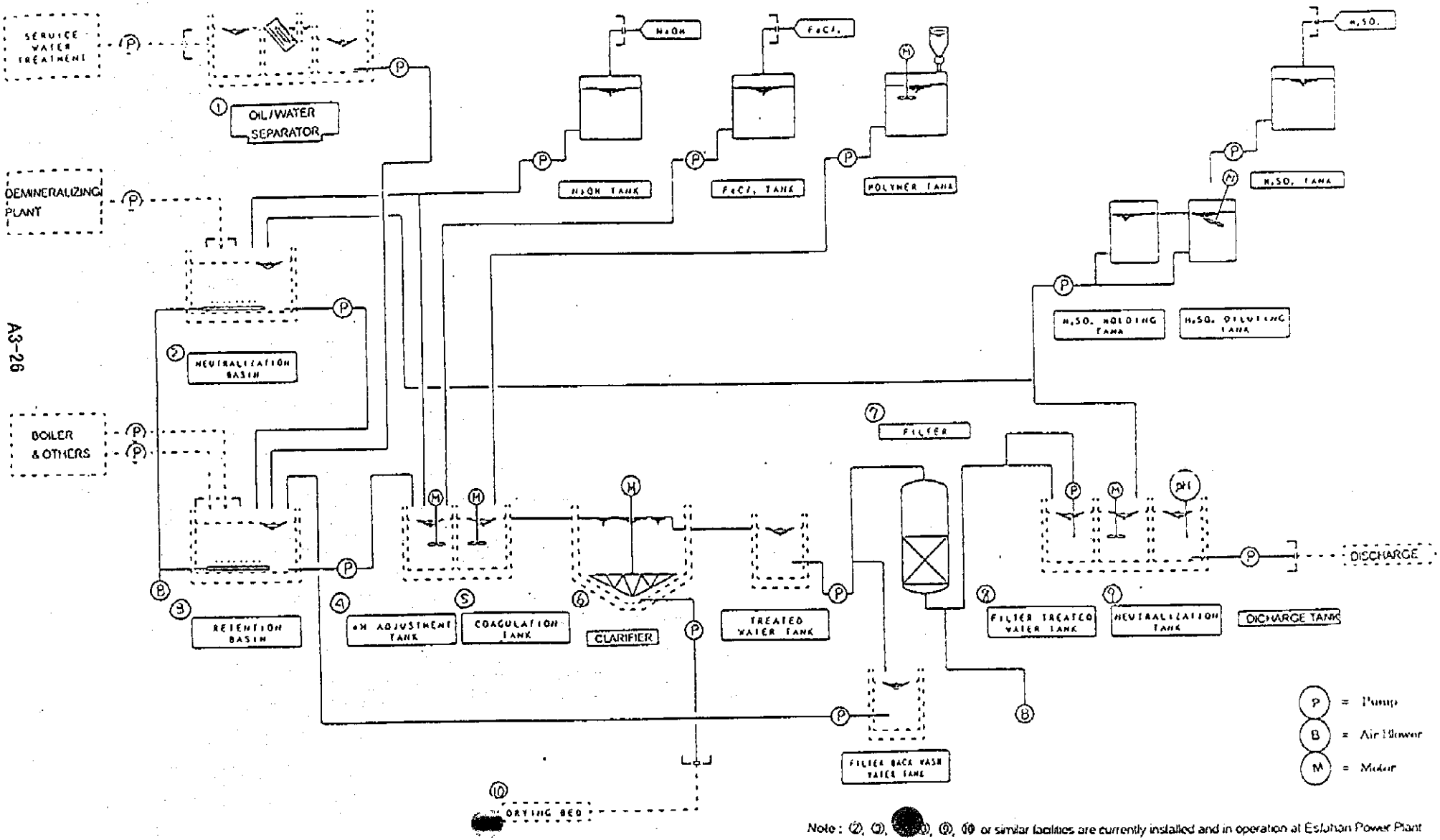
10) Drying Bed

Accumulated sludge from the clarifier is sent for natural-drying on a gravel bed. Dried crud is accumulated and discharged periodically.

Construction Cost of Power Plant Wastewater Treatment Facilities

Construction cost of power plant waste water treatment facilities, in case that an hourly treatment capacity is 80 tons, is roughly estimated to be US$ 25,000,000 and an annual operation cost would be US$120,000 except depreciation and wages. All of the facilities costs exclude foundation work cost.

WASTE WATER TREATMENT



Note : ②, ③, [redacted], ⑨, ⑩ or similar facilities are currently installed and in operation at Esfahan Power Plant

Appendix 5-1

THE TECHNICAL GUIDE TO THE AEROLOGICAL OBSERVATION WITH THE JWA-94W RADIO SONDE SYSTEM AND A BALLOON THEODOLITE

1. Equipment for the observation and data processing procedure

Equipment for the observation of temperature and humidity with the JWA-94W radio sonde system and the pilot balloon observation of wind are as follows. A flow of processing of the data derived from these observations is also shown below.

1-1 Equipment for the observation

① Radio sonde observation (for temperature, humidity and pressure)

JWA-94W radio sonde system

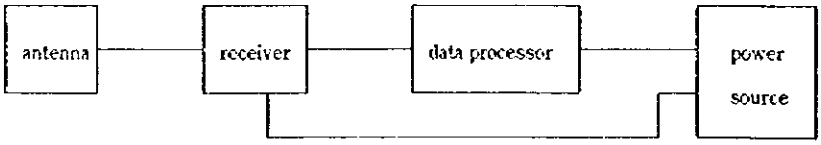
- Radio sonde
- Receiver
- Antenna
- Data processor (personal computer)
- Base line checker

② Pilot balloon observation (for wind direction and speed)

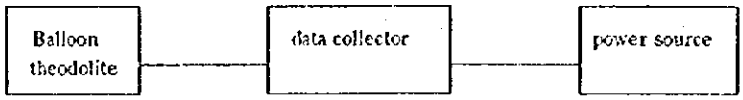
- Balloon theodolite (data collector is attached)
- Tripod
- Data processor (personal computer)
- Data collector
- Card reader

1-2 Connection of the observation system

① JWA-94W radio sonde system



② Pilot balloon observation system



1-3 Data processing procedure

① Processing procedure of the derived data by radio sonde (temperature, humidity and pressure)

In each observation, the data that is derived every 0.5 second and transmitted from radio sonde are taken into the data processor. Then the original data is processed by the observation data processing program as required into a data set of 50m intervals (the standard level data).

② Processing procedure of the pilot balloon observation data(wind direction and speed)

The data obtained by theodolite is temporarily stored in the optional data collector. Copy the data file from the data collector into the personal computer. Then the original data is processed into the standard level data by the observation data processing program.

2. Flow of the observation

The following show the flow of the observation. The indicated times should be considered simply as a kind of criterion. The procedures especially before balloon release are suggested to be made earlier, until the observation members become proficient at.

The instruction manual attached to the equipment would be helpful to know the detailed procedure of operation.

2-1 Observation with JWA-94W radio sonde

① 20 minutes before balloon release

[indoor operations]

* Unpack a radio sonde.

*Take the battery out of the package box.

*Dip the battery in water for one minute in order to activate it. It is advised that water temperature should be 15 – 25 ℃ for the best result.

*Do not wet the connector.

*Take the battery out of the water and shake it off excessive moisture.

*Return the battery to the package box.

*Connect the battery to the voltmeter and wait until the meter indicate 9V or more.

*In the case that the voltage of the battery does not reach 9V in 15 minutes, change it for another one.

* In the night observation, prepare one more battery for a miniature bulb that is used as a guide in the dark.

② 15 minutes before balloon release

[outdoor operations]

* Prepare a balloon

Fill up the balloon with helium gas.

* Moisten the wet bulb of the Assmann aspiration psychrometer and switch on its fan.

[indoor operations]

* Connect the battery to the radio sonde.

* Set the radio sonde sensor in the base line checker.

* Switch on a fan of the base line checker for homogenizing the inside air.

* Turn the antenna toward the radio sonde.

* Listen to the "za-za-za..." sound out of the receiver.

If it does not make a sound, tune the frequency to do so.

* Select "94W observation program" on the display of the data processor.

* Select "start of processing for observation" on a main menu.
* The data processor makes a self--diagnosis of the system condition and takes in sonde coefficients. Wait a while.
* Press "f1" key. Take notes of readings of the barometer and the thermometer which are attached to the base line checker. Input these base line data, pressure and temperature to the first place of decimal. Remember, input always "33.0%" for humidity because the base line checker is supposed to be maintained this constant humidity .
* Press "f5" key. The system gives a decision whether the condition is OK or not.
* All of 3 items are OK, press "f10" key. If there is any NG, we cannot go ahead and we are made to return to "f1". Check the data, and try again. In the case that OK is not gained in spite of a couple of trials, change the sonde for the new one. Keep the old sonde in custody with comments on inferiority and date.
* In the night observation, fit the radio sonde with miniature bulb that is used as a guide in the dark.

③ 2 minutes before balloon release

[outdoor operations]

* Turn the antenna toward the direction that is expected the balloon blown off.
* Tie a parachute and the radio sonde to the balloon. Then, stand by for release.

[indoor operations]

* Input observation number. The display screen changes for data monitoring.

④ 30 seconds before balloon release

[outdoor operations]

* Pull out the pin of sonde timer. Then, the frame counter on the monitoring screen is reset.

[indoor operations]

* Check whether the data (altitude, temperature, humidity, pressure, frame counter) are normal.

⑤ Balloon release

[outdoor operations]

* Release the balloon.
* Turn the antenna toward the direction of sonde by manual operation.
* Handle the antenna to make it track the sonde normally. In the case that the sonde is not seen, adjust the direction of antenna with reference to the sound out of the receiver and intensity of the signals.
* Take notes of readings of the dry and wet bulbs at Assmann aspiration psychrometer almost simultaneously with the balloon release.

[indoor operations]

* Flip on the start switch connected to data processor simultaneously with the balloon release.

⑥ After the balloon release

[outdoor operations]

* Check whether the antenna is tracking the sonde normally. If it isn't, adjust the direction of antenna with reference to the sound out of receiver and intensity of the signals.

[indoor operations]

* Check whether the data (altitude, temperature, humidity, pressure, frame counter) are normal and continue the observation.
* When the sonde reaches the objective altitude (this time 1,650m), press the ESC key : finish the observation.
* There is no necessity for inputting memo. Press the return key.
* Data processor makes a data file automatically.
* Run the observation data processing program. For the details, read the chapter 4.

2-2 Pilot balloon observation

① Setting of theodolite for the observation

* Check the switch positions of the theodolite and the data collector.
* Flip on the power switch of the data collector.
* Set elevation to zero by passing the telescope manually through the horizontal position.
* Aim at the standard object and flip the set switch.
* [Setting of the azimuth standard] Turn the mode switch to H-SET. Flip the set switch to begin setting. Turn the rotary switch on the side of the theodolite to set the standard value. At first, set the value on the each digit of integer indicated by a cursor. Flip the set switch then the cursor move to the decimal fraction, set the value in the same way. After the setting is finished, turn the mode switch to MEAS.

② Setting of data collector for the observation

* [Setting of time interval] Turn the mode switch to TIM and set the present time by ENT/INC switch. Press the ENT switch, then a cursor appears under the tens digit. For increment of the number, press the INC switch. After the required number is set, press the ENT switch to fix it and the cursor slides to the next digit. Do the same operation to complete setting of time interval. Turn the mode switch to TI.
* [Delete contents of internal memory of a data logger before each observation] Turn the mode switch to MEM. Press the CLR switch. Press the CLR switch again for long to delete the previous data. Turn the mode switch to TI.

③ Observation

* Check the mode switch set to TI.
* Flip on the switch of the theodolite to start simultaneously with the balloon release.
* The data collector takes in the data automatically according to the setting time interval, and writes it on the internal memory.
* In the case that the balloon goes out of view at the measuring time, flip on the ERR switch of the theodolite to mark the missing data. After the observation, the marked data should be corrected appropriately on the balloon trajectory in the processing program.
* When the balloon reaches the objective altitude(1500m : 465sec), flip on the switch of the theodolite to stop.
* In the case that the balloon tracking is impossible by any reason, for example the balloon enters into clouds, flip on the switch of the theodolite to stop and terminate the observation.
* After the observation, aim at the standard object by telescope and check the discrepancy of elevation and azimuth. Take notes of the discrepancy, if any.

④ Data processing

* The data file obtained by each observation is recorded on the internal memory of the data collector. Turn the mode switch to MEM, and press WRT switch, then press WRT switch one more time for long to write the data file on the memory card. Turn the mode switch to TI.
* Transfer the data file to the personal computer through the exclusive card reader by inserting the memory card.
* Run the observation data processing program to calculate wind direction and speed. For the details, read the instruction manual of pilot balloon data processing system.

3. Observation notes

[File the observation note] Fill in the blanks of JWA-94W observation note; observation number, date, time of balloon release, sonde number, name of observer, whether there is needed to check the data again, rough draft of track of sonde, surface meteorology (temperature, humidity and pressure).