HAZARD AND OPERABILITY (HAZOP) STUDY OF THE BOILER TRIP SYSTEM AT SEJINGKAT POWER CORPORATION (SPC)

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UNIVERSITI MALAYSIA SARAWAK

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.BISMILLAHIRRAHMANIRRAHIM.

BY THE NAME OF ALLAH, MOST GRACIOUS AND MOST MERCIFUL.

"THIS PROJECT IS DEDICATED TO MY MOTHER, BONDA ROKAYAH MOHIDI, MY AUNTIE, MARY MOHIDI, AND TO ALL MY FAMILY MEMBERS

&

ESPECIALLY TO SH. KHANIZAH"

"I LOVE YOU ALL"

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ABSTRACT

The objective of this study is to carry out hazard and operability (HAZOP) analysis, to determine the potential hazardous that can be activated by the Master Fuel Trip (MFT) and also to determine the hazard rating thus to verify the necessity of each trip signal of the Boiler Trip System. The study has been done at Sejingkat Power Corporation (SPC), at Bako area in Kuching. From the result, a HAZOP analysis system has been done in order to avoid potential hazards during the operation, and the required safeguard and action, have been developed to assure the safety of the boiler and also to the environment. The necessity of the each boiler tripping signals has also been analyzed using graphs based on the hazard rating. From the result, it has been determine that the loss of coding air fan trip signal can be neglected from the MFT. The most highest hazard rating consist of three signals which are the Induce Draft Fan (IDF) trip signal, Furnace Pressure High trip signal and less flow of air in furnace trip signals. Recommendations are included in form to enhance the efficiency of the system and can be used as future reference for similar system in other section or industries.

ABSTRAK

Tujuan projek ini dijalankan adalah untuk menganalisis kesan kemudaratan yang boleh berlaku semasa sesuatu operasi sedang dijalankan (*Hazard and Operability*) khasnya di dalam sistem pembakaran dan pendidihan (*Boiler*) yang terdapat di Sejingkat Power Corporation, iaitu sebuah loji penjana kuasa elektrik yang terletak di Bahagian Bako, Kuching. Kajian ini juga memfokuskan mengenai tahap keperluan sesuatu sistem petanda untuk memberhentikan sesuatu proses itu dengan serta merta (*Trip System*) yang terdapat pada sistem pembakaran dan pendidihan (*Boiler*) di kawasan yang sama. Daripada keputusan yang telah diperolehi, satu sistem untuk mengenal pasti kesan kemudaratan yang berpotensi untuk berlaku semasa proses dijalankan, langkah keselamatan dan tindakan susulan telah direka bagi memastikan tahap keselamatan ketika operasi dapat ditingkatkan. Tahap keperluan sesuatu sistem petanda untuk memberhentikan sesuatu proses itu dengan serta merta (*Trip System*) yang terdapat pada sistem pembakaran dan pendidihan (*Boiler*) juga dapat di kenal pasti dengan menggunakan graf berdasarkan tahap kesan kemudaratan yang mungkin berlaku ketika operasi dijalankan. Daripada keputusan yang diperolehi, didapati bahawa isyarat *Loss of Cooling Air Fan Trip Signal* boleh diabaikan daripada *Mester Fuel Trip (MFT)* kerana kesan kemudaratan yang rendah. Selain itu juga didapati terdapat 3 *Trip Signal* yang mempunyai kesan kemudaratan yang tinggi iaitu *Induced Draft Fan (IDF), Furnace Pressure High* dan *Total Air Flow < 25%*. Beberapa cadangan bagi meningkatkan operasi sistem pembakaran dan pendidihan (*Boiler*) juga telah disertakan untuk kemajuan sistem yang sama dan berkaitan pada masa depan.

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NOTATIONS

ASME	American Society of Mechanical Engineer
CAF	Cooling Air Fan
CCR	Centralized Control Room
ESD	Emergency Shutdown System
ESP	Electrostatic Precipitator
FDF	Force Draft Fan
GWh	Giga Watt per Hour
HAZOP	Hazard and Operability
HHH	High high high
HSH	High Temperature Superheater
IDF	Induced Draft Fan
IPP	Independent Power Producer
KJ/Kg	Kilo Joule per Kilogram
KWB	Kuching Water Board
LLL	Low low low
LSH	Low Temperature Superheater
MFT	Master Fuel Trip
PAF	Primary Air Fan
SECB	Sarawak Enterprise Corporation Berhad
SESCO	Sarawak Electricity Supply Corporation
SPC	Sejingkat Power Corporation

CHAPTER 1
INTRODUCTION

1.0 Introduction to the study

Nowadays, in Malaysia, there are a number of high-risk industries such as power plants, petrochemical plants, and etc., which operate successfully. Normally in these plants, there are several integrated equipment or components functioning to achieve one purpose of process. These components include boiler, steam turbine, gas turbine, generator, compressor, heat exchanger etc. In order to obtain smooth and efficient operation, a trip system is required as the supporting section. This trip system detects and analyzes the abnormal activities that may cause the malfunction of certain equipment. In the event of dangerous conditions the process will be tripped or shutdown to avoid damaged of other equipment that involved in the process as well as to avoid any hazardous conditions to the workers and environment.

The common parts in a trip system includes:

1. *Sensor*: An element that responds to a parameter to be measured and converts the response into a more usable form. Measured parameters such as temperature, pressure, water level and etc.

2. *Controller*: The components that computes the error signal and uses it to produce the control action.
3. *Actuator*: A control system component that provides the power needed to carry out the control action produced by the controller.

These three types of mechanism are important to avoid the unexpected hazard occurrence that may cause harm to the living things in the process area. It can be worst if the hazard occurs in a nuclear power plant. Imagine there is a high possibility of radioactive and poisonous material escape to the atmosphere and maybe explosion. These eventually will give bad impact to the environment and the living things.

Therefore, a study of a trip system becomes essential in order to maintain the efficiency and the integrity of the plant and provide safe working environment.

1.1 Background of the Study Location

Sejingkat Power Corporation Sdn. Bhd. (hereinafter know as SPC) was incorporated on 28th of September 1993 under the Companies Act 1965 primarily for the implementation of a 100 MW coal-fired power station in Kuching on the privatization concept of an Independent Power Producer (IPP). ***(Figure 1.1)***

Figure 1.1 Sejingkat Power Corporation Sdn. Bhd (SPC).
[Sejingkat Power Corporation Brochures (2000)]

The Sarawak Enterprise Corporation Berhad (SECB) and Sarawak Electricity Supply Corporation (SESCO) presently jointly own the corporation. SECB is also the holding company of SESCO.

Known as the Kuching Coal-fired Power Station, it is located on a 130-hectare land area situated by the side of the Sarawak River close to Kampung Goebilt in Muara Tebas. The traveling distance from Kuching City to the power station is 27 kilometers by road. The power station is designed to accommodate 4 units of 50 MW coal-fired steam turbine generators and to be developed in 2 phases. Phases 1, which has been completed, consist of 2 generating units and the common facilities such as pond, coal unloading wharf, coal storage yard, coal handling system and raw water cooling system, all of which are adequately sized to serve Phase 2 development in future.

The Kuching Coal-Fired Power Station is being operated as a base load station and the electricity is sold to SESCO.

In 1993, a feasibility study conducted by SESCO confirmed the technical and financial viability of setting up the thermal power station in Kuching using local indigenous coal as fuel. Beside energy generation, it plays a strategic role of assuring security of electricity supply to the Kuching area.

In May 1994, the contract for the implementation of the project was design for the commissioning in middle 1997. Sejingkat Power Corporation was granted an electricity generation license by the Tuan Yang Terutama for a period of 25 years, commencing on 1st of July 1997.

The 2 x 50 MW coal-fired generating plants were fully commissioned and entered initial trail operation from mid 1998. The dependable capacity of the station is 90 MW (2 x 45 MW) and the planned annual generation output 670 GWh at 0.85 plant capacity factor

1.2 General Process At Sejingkat Power Corporation (SPC)

The explanation of the general process in the following text is based on *Figure 1.2.* The systems have been classified into **six major** categories:

1. Boiler
2. Steam Turbine
3. Electrical System
4. Coal Handling
5. Chemical Treatment
6. Utilities

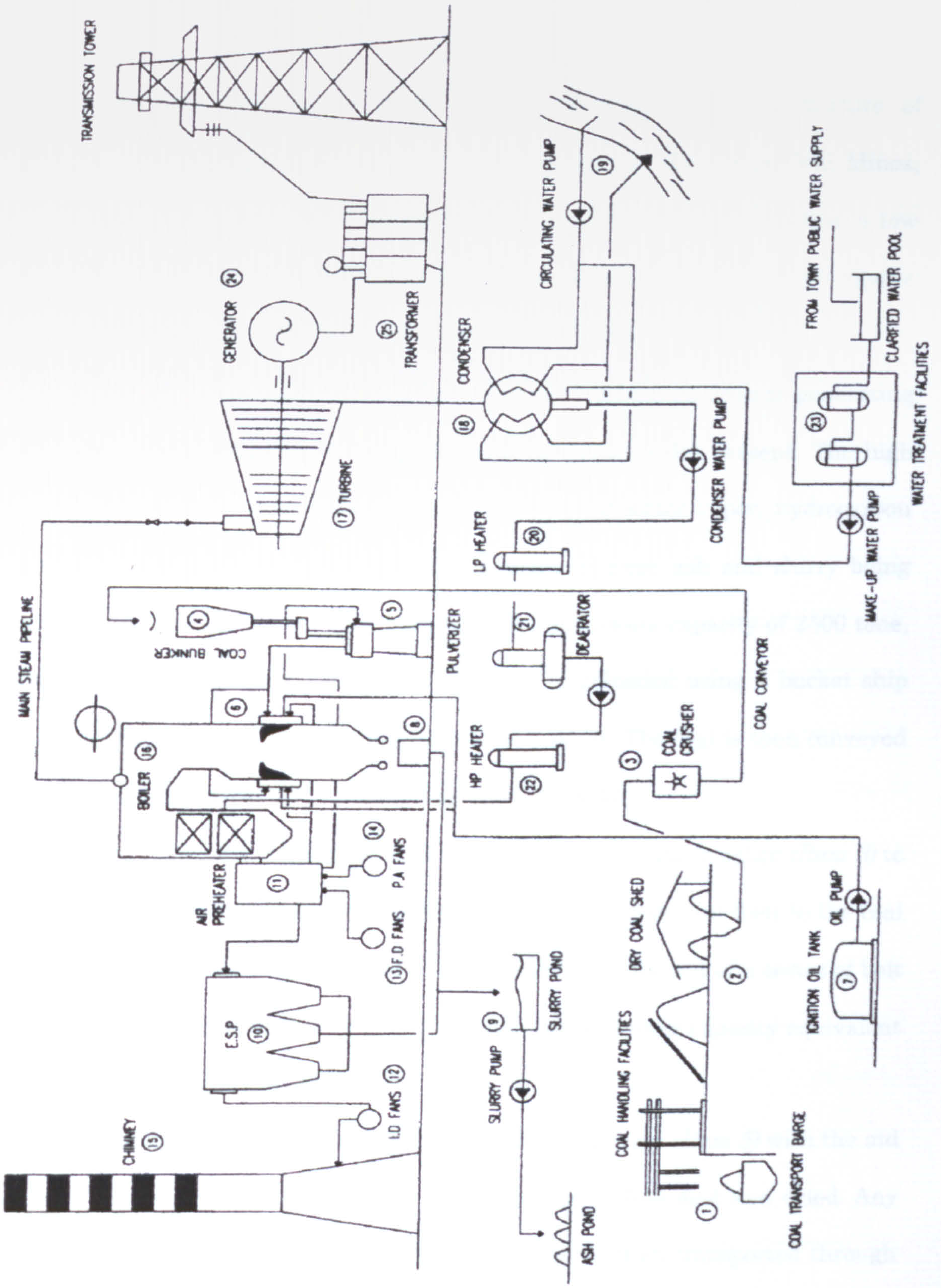

Figure 1.2 Overall Process Diagram of the Power Plant
[Sejingkat Power Corporation Brochures (2000)]

1.2.1 Coal Supply

The main fuel for the boiler furnace is predominately a mixture of bituminous and sub-bituminous coal, supplied from the Merit Pila Coal Mines, Kapit. It is referred to as the design coal having the following properties: a low heating value of about 20009 kJ/Kg, a low sulfur content of 0.096%, a high volatile matter content of about 36.8%, and a ash content of 10.2%.

The low sulfur content results in a cleaner combustion process generating less harmful gaseous emissions with fewer sulphurous oxides present. The high volatile matter content will result in the formation of water vapor, hydrocarbon gasses and tar. The high ash content will result in more ash and slurry being produced. The coal is delivered by barges, with a maximum capacity of 2500 tone, to the jetty *(Item 1). (See Figure 1.2).* The coal is unloaded using a bucket ship unloader of maximum handling capacity of 350 tone/hr. The coal is then conveyed to the coal storage yard and to the dry coal shed. *(Item 2).*

From the coal storage yard, coal is conveyed to the coal crusher *(Item 3)* to be crushed to manageable pieces of about 30mm in diameter and then to the coal bunker and feeder *(Item 4).* The coal is transported with the aid of a series of belt conveyors travelling at about 2m/s. Each bunker has a storage capacity equivalent to 11.5-hour fuel supply at MCR load.

From the coal bunker, the coal is fed to the pulveriser *(Item 5)* with the aid of a coal feeder. In the pulveriser, the coal is ground to fine dust and dried. Any ungrindable material is rejected. The pulverised coal is then transported through the burner pipes to the furnace and to the burners *(Item 6)* by preheated .air. The preheated air is supplied by the primary air fans *(Item 14).*

1.2.2 Combustion and Furnace

During start-up, diesel is used as fuel for the furnace since coal can only be used at comparatively higher loads. Once the load reaches 10 MW, coal firing is started and the oil guns are retracted. Diesel is also used as a standby fuel. The fuel is stored in two 265m tanks *(Item* 7) (See *Figure 1.2)* and is pumped to the furnace's oil guns. The fuel storage levels are monitored and alarms will activate if the oil level reaches the 2m low level.

The combustion process takes place in the furnace at an average maximum temperature of up to 980°C to 990°C. Combustion air is provided using forced draft fans *(Item 13).* The air is then preheated in the air preheater *(Item* 11) to up to 326°C. using heat from the hot flue gas (at about 368°C at MCR). The heat released from the combustion of coal is transferred to the boiler tubes through a combination of conduction, radiation and convection processes in the boiler *(Item 16).* The boiler consists of a boiler drum, firewalls, superheaters and economiser. It is capable of generating up to 220 tone/hr of superheated steam at 540°C. Boiler water is supplied via the feedwater system.

Inside the furnace, soot can accumulate on the boiler tubes. Soot build up can reduce the heat transfer efficiency from the fire to the water inside the boiler tubes. It can also create an obstruction to the gas flow inside the furnace. As such, sootblowing must be carried out to remove the soot built up on the heat-absorbing surfaces.

Low-pressure main boiler steam is injected into sootblowing lances as the cleaning medium. Auxiliary steam from the auxiliary boiler is used only when the main boiler is not in operation.

1.2.3 Steam-Condensate-Feedwater Cycles

The superheated steam is conveyed via the main steam pipeline to the turbine *(Item 17)* (See *Figure 1.2)* where it expands and produces useful work to turn the turbine. The low-pressure steam exhausted from the turbine is collected in the condenser waterbox *(Item 18),* Here the steam is condensed to water and recirculated back to the boiler. The rapid cooling effect creates a vacuum effect in the condenser section, which reduces the backpressure on the turbine and increases its output and efficiency.

The condensed steam, or the condensate, is pumped through a series of regeneration heaters. The first stage is a series of three low pressure heat exchanger heaters *(Item 20)* that heats the condensate to about 135°C. Low pressure steam tapped from the turbine low pressure extraction points provides the heat for the purpose.

The heated condensate is piped to the deaerator *(Item 21)* where dissolved oxygen and gasses are removed. The deaerated water (or feedwater) is stored in the adjacent $70m^3$ storage tank. From the tank the water is pumped by the boiler feed pump to two high pressure heaters arranged in series *(Item 22)* which raise the water temperature further to about 235°C. High pressure steam tapped from the turbine high pressure extraction points provides the heat for this purpose. The heated feedwater is then supplied to the boiler economiser and finally back to the boiler drum.

A good quality of the boiler feedwater must be maintained where it must has a very low concentration of minerals. Thus, a water treatment plant *(Item 23)* is used to treat the water before it is supplied to the boiler. The source of raw water supply for the water treatment plant is from the existing water mains of Kuching Water Board (KWB). The demineralisation system is used to remove dissolved minerals such as silica from the town water supply before enter the boiler and the hydrogen generation facility.

The system is capable of treating up to $26m^3$/hour of water through a series of activated carbon filters, cation exchangers, anion exchangers and mixed ion exchangers. Feedwater dosing is carried out to ensure that the water has the required quality. A number of chemicals such as phosphate, hydrazine and ammonia are used. Phosphate is injected into the boiler drum to prevent scaling. Hydrazine and ammonia are injected in the deaerator to remove residual oxygen in the feed water and to maintain the pH value of the water respectively. Both are used to protect the feed water piping and equipment from corrosion.

Daily periodic water analyses to determine the amount of dissolved oxygen, conductivity, pH, phosphate and sodium concentrations are carried out to ensure that they are within the prescribed safe working limits. The boiler water after demineralisation will still have a small concentration of minerals. With recirculation, the concentration of minerals in the boiler will build up due to evaporation losses. As such physical removal of part of the boiler water must be carried out. This process is called blowdown.

Continuous blowdown and periodic blowdown are carried out to remove part of the boiler water in circulation in the event of high mineral content in the feedwater. This is replenished by makeup water from the water treatment plant. Continuous blowdown removes a smaller quantity of the water continually whereas periodic blowdown removes a larger quantity of the water periodically. Both are carried out to maintain the boiler water quality. The makeup water also replenishes losses due to evaporation.