Eskom	Scope of Work	Kusile Power Station

Title: **Kusile Power Station Reheater Drying Scope of Work**

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Introduction

To limit Unplanned Capability Loss Factor (UCLF) associated with Boiler Tube Failures (BTFs) due to pitting corrosion, Kusile Power Station requires a reheater drying system to be designed and implemented to evacuate steam and replace it with dry air, prior to condensation.

2. Supporting Clauses

2.1 Scope

2.1.1 Purpose

The purpose of this document is to give high level scope of work for the sourcing of Professional Engineering Services from an Engineering Consultant, for the provision of Professional Engineering Services including supervision during construction supervision and issuing of Professional Engineering Certificates for the design of a reheater drying system.

2.1.2 Applicability

This strategy document will apply to the technical evaluation team appointed for the process drain sump modification project.

2.1.3 Effective date

This document will be effective from the date of its authorisation.

2.2 Normative/Informative References

Parties using this document shall apply the most recent edition of the documents listed in the following paragraphs.

2.2.1 Normative

[1] 150527 Reheater Drying Final Report

[2] 240-57127944 Preservation of Power Plants During Shutdowns Guideline

[3] RTD/MAT/15/142 Prevention of Pitting Corrosion in Reheater Tubes Through Effective Reheater Drying.

[4] 240-127549136 Boiler Tube Failure Reduction Standard

2.2.2 Informative

[5] 240-142811581 ROC Reheater Drying Report

[6] 366-357602 Concept Design Kusile Reheater Drying Project

[7] 366-324526 SRD End of Phase Kusile Reheater Drying Project.

2.3 Definitions

Definition	Description
Employer	Kusile Power Station.
Appointed Consultant	A consultant specializing in engineering and provides engineering advice and technical solutions on the reheater drying project.
Professional Engineering Services	An engineering service that requires, or is based on, the application of engineering principles and data – to a design relating to engineering, or. to a construction, production, operation or maintenance activity relating to engineering.

2.4 Abbreviations

Abbreviation	Description
BOQ	Bill of Quantities
BTF	Boiler Tube Failure
ECC	Engineering and Construction Contract
ECN	Engineering Change Notification
ECSA	Engineering Council of South Africa
KPS	Kusile Power Station
NEC	New Engineering Contract
PEC	Professional Engineering Certificate

2.5 Roles and Responsibilities

The Employer is required to:

1) provide access to Kusile Power Station for site investigations and/ or meetings;
2) ensure safety by performing the relevant safety inductions prior to any site visits;
3) provide the requested information to the *Consultant* necessary for completion of the design *works*;
4) organise and participate in meetings on a regular basis to ensure all information relating to standards and/ or operational requirements are being fulfilled; and to prevent delays on the schedule.
5) arrange meetings with SCCC and presentations for the approval of designs;

The Consultant is required to:

1) review all existing available information and previously compiled reports.
2) perform the necessary site inspections prior to commencement of the works.
3) provide adequate resources for the required works.
4) ensure that the design scope is carried out in full.
5) ensure compliance to the various design codes
6) provide costs and a scheduled time frame of the works.
7) provide daily feedback on the status of the works as requested.
8) coordinate the inputs/designs from all Eskom disciplines where required.
9) comply with all Eskom specific policies, procedures and guidelines.
10) adhere to all applicable South African governing legislation.
11) produce all deliverables for the works
12) takes full accountability and liability for design changes and provides design assurance of the works.

2.6 Process for Monitoring

Regular progress meetings will be held between the Consultant and Eskom. The Eskom Design Review procedure (240 – 53113685) will be followed to verify and validate the designs or design changes.

2.7 Related/Supporting Documents

Not applicable

3. Scope of Work

3.1 Description of the services

The Kusile boiler is equipped with a three-stage superheater and two-stage reheater. According to the Benson principle, the entire supplied feed water is evaporated above the Benson point and after superheating in the convection heating surfaces supplied as superheated live steam to the HP section of the turbine. After first expansion, the steam flows through the reheat section and is passed to the IP section of the turbine. There are no provisions made for reheater drying for the Kusile boiler.

During normal operation of the boiler, steam flows through the tubes and pitting will not initiate, thus initiation occurs only during shutdowns or outages when the steam in the reheater and superheater tubes is allowed to condense. A proven pro-active requirement to eliminate and prevent this failure mechanism is drying the reheater tubing during extended shutdowns or layup (i.e. outages).

The service required at this stage is the design, drafting and sizing of Reheater Drying System which consists of utility air pipelines and compressors. The parameters of the scope of work are defined in this document.

BTF due to pitting corrosion have been on the rise across the entire Eskom Power Stations. These failures contribute to high UCLF and impacts the availability of electricity to the consumer and the country at large.

It is therefore imperative to guard against pitting corrosion by implementing Reheater Drying System. It calls for qualified Consultant to provide KPS with complete design that will successfully alleviate/reduce significantly the BTF due to pitting corrosion.

The SOW entails the following:

1) This project aims to size new compressors and design new pipelines connecting from the compressors to header where provision had been made for the connection. Currently an alternative method is used to preserve reheater section of the boiler to avoid failures due to pitting corrosion.
2) The project has been structured by the products to be easily identified, new and existing connection points, utility air pipelines and compressors. Each system requires both modification and as built.
3) Approved for construction drawings must be issued and updated to as built after construction.
4) EOJ (End of Job) documentation must be issued to the Employer at the end of the job.

The project will be conducted within the below phases and deliverables:

Phase 1	• Air Compressor sizing and selection report. • P&ID & PFDs in editable (CAD, MicroStation etc) and pdf format. • Hydraulic Analysis of the piping system (Design report).
Phase 2	• Basic and Detail Design Development (2 options) • Piping stress analysis (Piping design package and certificate of design). • 3D model of the design for reviews. • Electrical Design of the system.
Phase 3	• Basic & Detailed Design Reports • End-of phase documentation and reports. • Technical/Equipment Specification. • Mechanical Bill of Quantities. • Civil Bill of Quantities.

3.2 Plant Description

Kusile Power Station (KPS), located approximately 20 km from Bronkhorstspruit in the Mpumalanga Province, is a coal fired Power Station currently under construction. The first unit was commissioned in December 2016 and the last unit planned for June 2023. The Kusile boiler is a supercritical once-through boiler of the Benson tower type with an evaporator designed as membrane wall, a three-stage superheater and a two-stage reheater. According to the Benson principle, the entire supplied feed water is evaporated above the Benson point (38% BMCR) and after superheating in the radiant and convection heating surfaces supplied as superheated live steam to the High Pressure (HP) section of the turbine. After first expansion, the steam flows through the reheat section and is passed to the Intermediate Pressure (IP) and Low Pressure turbine.

The boiler has 30 opposed, vertical staggered arranged burners and is fired by pulverized coal with fuel oil being used for start-up and support firing. The back end of the boiler is equipped with two regenerative air heaters and two fabric filters followed by two induced draft fans.

The plant sub-systems and major equipment include:

High pressure system:

a) Economiser (HAC),
b) Evaporator (HAD)
c) Superheater (HAH)

Low Pressure System:

a) Reheater 1 (HAJ)
b) Reheater 2 (HAJ)

Boiler Auxiliaries:

a) Circulation system (HAG)
b) Drains and Vents (HAN)
c) Condensate system (LCL)
d) HP Bypass Control Valves

Attemparation System:

a) Superheater spray water
b) Reheater spray water
c) HP Bypass spray water

The following systems are affected:

a) KKS: HAH, HAJ, LBA, LBB, LBC, MPR
b) Name: Boiler Superheater, Reheater, Main Steam and Reheat Piping, Turbine Forced Air Cooling.
c) RH, SH, MS, FAC

Boiler tube failures (BTF) are one of the leading causes of plant downtime and may carry substantial repair costs. One of the mechanisms of BTF is pitting corrosion on the steam side of the reheater and superheater tubes.

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Pitting corrosion is a localized part-wall or through-wall dissolution (corrosion) of a tube by which cavities or "small holes" are produced in the material. It is more dangerous than uniform corrosion damage as it is more difficult to detect, predict and design against. It can result from, firstly, poor shutdown practices leaving stagnant oxygen rich water within the tube, secondly, from the mechanical carryover of calcium sulphate (Ca2SO4) and/or sodium sulphate (Na2SO4) in the steam to the metal surface during operation which will combine with the moisture from the condensing steam during shutdown and initiate pitting, and lastly, from improper chemical cleaning.

Pits tend to initiate at surface irregularities such as dislocations, grain boundaries, or locations of non-metallic inclusions. Once initiation has begun continued growth of the pit will occur during each unprotected shutdown, this mechanism is only active during off load conditions and requires the presence of oxygen rich water. During operation, a protective oxide film is formed on the tube side against the metal preventing pit initiation and growth.

The only recognised way of controlling this mechanism is by preventing the formation/accumulation of water during the shutdown of a unit. This requires the evacuation of steam from the reheater and superheater circuits before tube temperatures reach saturation for the condition inside the tube.

Table 1: Reheater 1 Elements indicating tube material Flow

Material Flow	Size	Material
A	48.3 x 4	P265GH
B	48.3 x 4	13CrMo4-5
C	48.3 x 4.5	10CrM9-10

Table 2: Reheater 2 Elements indicating tube material Flow

Material Flow	Size	Material
A	57 x 3.6	X10CrMoVNb9-1
B	57 x 3.6	TP347HFG

3.3 Specification and description of the services

The scope of work entails the following:

1) Comprehensive review of the existing boiler design to cater for RH drying.

2) Amends the design as required after incorporating RH drying design. The amendments are to be presented to the relevant change management committees within Eskom.
3) Prepare and present at least 2(two proposed solutions to address the current challenge of RH dryness
4) Taking design liability for any changes in the design as a result of queries during the design and construction period.
5) Take full accountability for all design clarification updates or changes
6) Attend to technical queries including review and acceptance of Method Statements, Risk Assessments, Data Packs and inspection plans.
7) Independent verification testing (Required ADHOC – verification of required dryness to prevent pitting, sample acquisition and review of results);
8) Signoff of the Works and issuing of Professional Engineering Certificates (PECs) and all handover requirements.
9) Consultant to do all necessary testing/verifications/inspections/design reviews to ensure there are no issues related to professional sign off and accountability upon completion of the project.
10) Preparation and issuing of as-built drawings and handover documentation.
11) Design (conceptual & detailed) and further studies.
12) Design, obtain licensing/approvals/permissions from relevant authorities for permission to create a new intersection or amendment to the pressure envelope or pressure parts.
13) Conduct follow up technical studies to confirm the current site conditions and suitability of the modification as well as best/suitable locations to connect to the boiler circuit

3.3.1 Stage 1 Preparation

The Eskom intends to appoint an external *Consultant* for professional engineering services incl. design clarifications and technical oversight/supervision during construction.

The appointed *Consultant* develops basic and detailed designs. The *Employer* reviews the designs for completeness and constructability and proposes value-adding changes where applicable. The Consultant takes design liability for any design changes and issues Professional Engineering Certificates for the works upon completion.

The appointed *Consultant* conducts all designs, sizing, equipment required and further studies, compiles specifications and quantifies the *works* required to implement the Reheater Drying. The *Consultant* provides construction supervision and professional engineering services for the *works*

3.3.2 Stage 2 Concept

The Consultant is required produce two preferred options that adequately address the reheater drying requirements.

The chosen design concept report must cater for all units at Kusile power station. The Consultant must establish a complete design, i.e., to produce all the component specifications, engineering drawings and other design documentation for procurement, fabrication, installation, construction and commissioning.

3.3.3 Stage 3: Design development

The Consultant is required to perform a due diligence review of two selected options, the design (incl. investigative reports) for the Reheater Drying Facilities including all supporting infrastructure

This assessment is performed by means of a comprehensive review of the following receivables:

1) All related design reports.
2) Investigation reports
3) Mass Energy Balance
4) Design drawings (detailed design report);
5) Bills of Quantities.
6) Works Information and Specifications.
7) Operating and Maintenance Manuals.
8) Construction Quality Assurance Plans.
9) DWS checklists.
10) DWS technical advisory notes.

3.3.4 Stage 4: Production information

The new compressor and dryers need to be sized to achieve a minimum of fifteen Reheater volume exchanges prior to the boiler flue gas temperature reducing to 150 C. This needs to happen within an hour. Considering the size of Kusile boilers the required levels of “dryness” cannot be achieved using existing compressors on site.

Therefore, the request is for an external contractor to design a new system that utilizes the forced drying method. The compressor is nonproduction and will only be operated during unit shutdown.

A new tapping point is required to introduce air into the steam circuit. This will be installed on the cold reheat piping, LBC12, or hot reheat piping, LBB12. The cold reheat pipeline and hot reheat pipeline material and dimensions are as follows respectively:

Main line material: BS EN 10216 – 16Mo3

Size: 720ID x 28WT

Main line material: BS EN 10216 – 16Mo3

Size: 526ID x 18WT

The system is only operated during boiler shut down after the pressure has been released. However, during normal unit operation, the system will experience cold reheat or hot reheat conditions and thus the following design conditions have been selected:

Pressure: 70 bar

Temperature: 577°C

During the detail design, the following base parameters should be utilised for the tapping point and valve arrangement to allow for a degree of standardisation:

Material: BS EN 10216 – 16Mo3

Size tubing: 88,9OD X 5,6WT

Size valve: Weld-in DN80 Globe and Gate valves

3.4 Documentation

Project deliverables must at a minimum include the following documentation:

1. Air Compressor sizing and selection report.
2. Hydraulic Analysis of the piping system.
3. Piping stress analysis to ensure code compliance thus covering nozzle loads, pipe routing and piping support details
4. Electrical Design of the system.
5. Isometric drawings, P&ID & PFDs in editable (DWG, DGN) and pdf format.
6. 3D model of the design (DGN/PDF) for reviews or squad checks.
7. Basic & Detailed Design Reports.
8. End-of phase reports.
9. Technical/Equipment Specification.
10. Mechanical & Civil Bill of Quantities.
11. All relevant mechanical & electrical drawings.
12. Operational & maintenance manuals

3.5 Performance Guarantees

The effectiveness of the drying method is determined by measuring the moisture content at the end of the drying. The design must make provision for installation of suitable test points at the outlet flow of the drying process to allow for independent verification testing when required.

3.6 Spares and Tools Requirements

Not applicable

4. Acceptance

This document has been seen and accepted by:

Name	Designation

5. Revisions

Date	Rev.	Compiler	Remarks
January 2022	2		New Document
May 2022	1		Document updated.

6. Development Team

7. Acknowledgements

None