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CONTENTS

Page

EXECUTIVE SUMMARY **3**

1. INTRODUCTION **4**

2. SUPPORTING CLAUSES **4**

2.1 SCOPE 4
2.1.1 Purpose 4
2.1.2 Applicability 4
2.2 NORMATIVE/INFORMATIVE REFERENCES 4
2.2.1 Normative 4
2.2.2 Informative 4
2.3 DEFINITIONS 4
2.3.1 Disclosure Classification 4
2.4 ABBREVIATIONS 4
2.5 ROLES AND RESPONSIBILITIES 5
2.6 RELATED/SUPPORTING DOCUMENTS 5

3. AIR HEATER FOULING PREVENTION GUIDELINE **6**

3.2 ROTHEMULE (STATIONARY MATRIX) TYPE AIR HEATER 8
3.1 LJUNSTROM (ROTATING MATRIX DESIGN) AIR HEATERS 13

4. AUTHORISATION **16**

5. REVISIONS **16**

6. DEVELOPMENT TEAM **16**

7. ACKNOWLEDGEMENTS **16**

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EXECUTIVE SUMMARY

Regenerative rotating air heaters are used on all the Eskom coal-fired power stations to recover heat from the flue gas stream leaving the boiler.

Air heater element pack fouling results in reduced air heater and boiler efficiency, premature and expensive element pack replacements, increased fly ash erosion rates and fans running at maximum capacity.

This document discusses the most common causes of regenerative air heater fouling and recommends corrective actions required to prevent fouling.

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1. INTRODUCTION

This document identifies the various causes of regenerative air heater fouling, and recommends corrective actions to be implemented to avoid fouling.

2. SUPPORTING CLAUSES

2.1 SCOPE

This document covers plant defects and plant process parameters that influences air heater fouling.

Both types of air heaters used in Eskom, namely the rotating matrix (Ljungstrom design), and stationary matrix (Rothemule design) are covered in this document.

2.1.1 Purpose

This document strive to give guidance to plant personnel on how to identify causes of air heater fouling, and implement corrective actions to prevent fouling.

2.1.2 Applicability

This document shall apply to Eskom Generation – all coal-fired power stations, and Group Technology PEIC boilers.

2.2 NORMATIVE/INFORMATIVE REFERENCES

2.2.1 Normative

[1] ISO 9001 Quality Management Systems.

2.2.2 Informative

N/A

2.3 DEFINITIONS

Definition	Description
Approved by	The accountability of the Approver of the document is equivalent to the specified role of Functional Responsible/Owner as identified in 240-53114186 and 32-6 for Documents and Records Management.

2.3.1 Disclosure Classification

Controlled Disclosure: Controlled Disclosure to external parties (either enforced by law, or discretionary).

2.4 ABBREVIATIONS

Abbreviation	Description
FD fan	Forced draught fan
FFFR	Fossil fuel firing regulations
HP	High pressure
ID fan	Induced draught fan
LP	Low pressure
O_2	Oxygen

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Abbreviation	Description
PA fan	Primary air fan
PEI-C	Production Engineering Integration - Coal
QCP	Quality control plan
SOW	Scope of work
SSC	Submersible scraper conveyor

2.5 ROLES AND RESPONSIBILITIES

Responsibility for implementation at Station level: System Engineers, Maintainers, Process Engineers and Performance & Testing

Responsibility for maintaining and updating this document: Group Technology PEI-C boilers.

2.6 RELATED/SUPPORTING DOCUMENTS

Not applicable.

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3. AIR HEATER FOULING PREVENTION GUIDELINE

Itm	Main fouling contributor	Possible causes for fouling / contributor	Corrective actions
1	Too low cold end element plate temperature / acid dew point formation	1.1 Too low flue gas air heater inlet temperature	1.1.1 Compare gas inlet temperature to design value, if lower investigate why. 1.1.2 Check for excessive air in-leakage in the boiler, boiler outlet flue gas ducts and air heater ducts. can be done on load by means of air leakage tests and / or thermography tests can be done during outages by means of visual inspection and by pressurising the boiler and flue gas ducts to facilitate leakage identification 1.1.3 Ensure there is a good water seal at the SSC / coarse ash hoppers 1.1.4 Mal-distribution of flue gas flow between primary and secondary air heaters 1.1.5 Ensure the combined temperature❶ control system is functioning (where applicable), must control >85°C.
		1.2 Too low air heater flue gas outlet temperature	1.2.1 Refer to Air Heater Leakage Guideline document no. 240-119862281. 1.2.2 Actions as in 1.1 above 1.2.3 Ensure the combined temperature❶ control system is functioning (where applicable), must control >85°C. 1.2.4 Ensure correct operation of flue gas recirculating system / air heater bypass system (where applicable)
		1.3 Too low air heater air inlet temperature	1.3.1 Ensure steam air pre-heaters are in use and functioning (where applicable) 1.3.2 Ensure correct operation of flue gas recirculating system / air heater bypass system (where applicable) 1.3.3 Ensure the combined temperature❶ control system is functioning (where applicable), must control >85°C.
		1.4 Too low flue gas flow rate (this will also cause a drop in air heater flue gas outlet temperature)	1.4.1 Check flue gas distribution between primary and secondary air heaters (where applicable). Can be a temperature control error or damper malfunctioning. 1.4.2 Check flue gas distribution between left-hand and right-hand air heaters 1.4.3 Check if ID fans are not overly biased

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Itm	Main fouling contributor	Possible causes for fouling / contributor	Corrective actions
		1.5 Too high air flow rate entering the air heaters (cooling the air heaters as it upsets the flue gas / air heat balance)	1.5.1 Check correctness of air flow control (air pressure and/or flow measurement error) 1.5.2 Check for excessive air leakage at air heaters or air ducts 1.5.3 Compare air flow rate to design values, if higher investigate why. (This applies to primary air and secondary air where twin flow air heaters are used) 1.5.4 Ensure O_2 levels at the boiler outlet is controlled as required by station operating standards and FFFR regulations 1.5.5 Check if FD fans are not overly biased

❶ Combined temperature = $\frac{\text{air heater air inlet temperature + air heater gas outlet temperature}}{2}$

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3.2 ROTHEMULE (STATIONARY MATRIX) TYPE AIR HEATER

Itm	Leak area / contributor	Result of defect/s	Possible causes for leak / contributor	Corrective actions
1	Main seal sealing system (between rotating hoods and stator surface) Hot and cold end	Increased leakage area	1.1 Incorrect pre-setting	1.1.1 Optimize seal setting procedure by pre-outage on-load inspections and adjustment during outages 1.1.2 Check spring stiffness and free movement on spring pin assembly 1.1.3 Check condition and setting of seal frames and seal frame articulation joints 1.1.4 Check condition and setting of thermal compensators 1.1.5 Adjust seal gap on load (only possible on cold end at some stations)
			1.2 Incorrect shaft-and hood alignment	1.2.1 Check guide bearings condition 1.2.2 Correctly set shaft and hood alignment 1.2.3 Check if top and bottom rotating hoods are aligned vertically (horizontally for Arnot unit 1)
			1.3 Stator, air heater casing and / or hood distortion	1.3.1 Check stator flatness (could be bent due to thermal excursions or an air heater fire incident) 1.3.2 Make sure all air heater duct thermal components can expand and contract freely as per design intent – check all expansion bellows and supports / hangers on the ducts and air heaters. 1.3.3 Check setting of hood thermal compensators
			1.4 Erosion wear	1.4.1 On wear shoes and seal frames. Refurbish. 1.4.2 On stator radial plates and -periphery flanges – inspect, measure. Refurbish / fit U-channel sealing

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Itm	Leak area / contributor	Result of defect/s	Possible causes for leak / contributor	Corrective actions
2	Collar seal system (hot and cold end)	Increased leakage area	2.1 Incorrect pre-setting	2.1.1 Check seal setting including drag links and minimum seal width locating pins
			2.2 Erosion wear on seal assembly	2.2.1 Check wear shoe width 2.2.2 Check wear on rubbing rings and cover plates 2.2.3 Check wear and looseness on drag links and tensioner spring assemblies, including shoe link plates 2.2.4 Check tensioner spring assembly and functionality 2.2.5 Check for worn or loose bolts on the drag links and shoe link plates
3	Stainless steel bellows (on main seal frames)	Increased leakage area	Erosion wear / mechanical damage	3.1.1 Replace worn sections 3.1.2 Revise outage SOW (inspection and replacement philosophy) 3.1.3 Install erosion wear protection where practically possible 3.1.4 Consider reverse installation direction of bellows (so that the bend face the air side of the hood and not the gas side)
4	Cast iron wear shoes excessively worn	Increased leakage area	4.1 Incorrect (too tight) seal setting	4.1.1 Refer 1 above 4.1.2 Avoid using shoes of different thickness
			4.2 Operating boilers at varying load (affects stator capping and sealing as such)	4.2.1 Compensate for changes in boiler load and the subsequent air heater capping / seal arrangement changes by re-adjusting seal setting (more open setting)
			4.3 Failure of seal frame spring assemblies	4.3.1 Revise maintenance philosophy on seal frame spring assemblies

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Itm	Leak area / contributor	Result of defect/s	Possible causes for leak / contributor	Corrective actions
5	Air heater stator surface unevenly worn	Increased leakage area, difficult to seal	5.1 Incorrect (too tight) seal setting	5.1.1 Refer 1 above 5.1.2 Avoid using shoes of different thickness
			5.2 Excessive fly ash erosion	5.2.1 Install U-channels to re-instate surface flatness and reduce leakage 5.2.2 Clean or replace element packs (if this contributes to high localized erosion)
			5.3 Too low air heater gas inlet temperature (reduce stator capping and cause hot end wear shoe wear)	5.3.1 See 4.2.1 above 5.3.2 Investigate reason for low temperature and rectify
			5.3 Stator distortion	See 1.3 above
6	Blocked air heater elements	Cause increased air heater differential pressure and -higher leakage)	6.1 Incorrect element pack selection. 6.2 Failed soot-blower system component 6.3 Failed soot-blower system process control	6.1.2 Consider installing element plates of a different design (more open profile) 6.2.1 Investigate and resolve soot-blower system component failure 6.3.1 Investigate and resolve soot-blower system process failure 6.3.2 Check functioning of soot-blower system moving actuator
7	Abnormal high primary air / secondary air / flue gas pressure	Increased leakage (as a result of higher differential pressures)	7.1 Pressure setpoint on primary air or secondary air controls incorrect	7.1.1 Check setpoint against design, correct if feasible 7.1.2 Verify instrument accuracy
			7.2 Incorrect boiler O2 controls	7.2.1 Verify accurate measurement and control setpoint
			7.3 Faulty control instruments	7.3.1 Check and calibrate instruments
			7.4 Partially closed air heater gas inlet damper/s or obstruction	7.4.1 Correct damper position if required, remove obstruction/s

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Itm	Leak area / contributor	Result of defect/s	Possible causes for leak / contributor	Corrective actions
			7.5 Partially closed air heater air outlet damper/s or obstruction	7.5.1 Correct damper position if required, remove obstruction/s
8	Abnormal high primary air / secondary air / flue gas flow rates	Increased leakage	8.1 Flow measurement incorrect	8.1.1 Check flow against design, correct if feasible 8.1.2 Check and calibrate instruments
			8.2 Pressure setpoint on secondary air duct incorrect	8.2.1 Check and calibrate instruments, including O2 control 8.2.2 Revise maintenance philosophy on instruments
9	Abnormal high flue gas inlet temperature	Affects air heater capping and as such air heater seal setting	9.1 Inadequate sootblowing in boiler furnace, superheaters and reheaters	9.1.1 Optimize sootblowing in the boilers (frequency and effectiveness)
			9.2 Changes in combustion and / or coal quality	9.2.1 Consult with Process Engineering
10	Abnormal low flue gas inlet temperature	Affects air heater capping and as such air heater seal setting	10.1 Out of service LP or HP heaters, condenser issues 10.2 Low boiler loading	10.1.1 Investigate cause/s and rectify
11	Air in leakage at air heater ducting (including rotating hoods)	Direct increased leakage	11.1 High localised fly ash erosion	11.1.1 Reinstate duct condition during outage 11.1.2 Revise SOW for outages 11.1.3 Consider installing erosion wear protection

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Itm	Leak area / contributor	Result of defect/s	Possible causes for leak / contributor	Corrective actions
12	Air in leakage at primary air, secondary air and / or flue gas duct expansion bellows	Direct increased leakage	12.1 Wear / inadequate protection plates / incorrect bellow material	12.1.1 Replace failed bellows 12.1.2 Revise outage SOW for outages 12.1.3 Make sure all air heater duct components can expand and contract freely as per design intent – check all expansion bellows and duct supports / hangers 12.1.4 If bellows keep on failing, investigate root cause and rectify
13	Air heater internal inspection and –access doors	Direct increased leakage	13.1 Left open after last inspection / access	13.1.1 Close after fitting new door seals 13.1.2 Door closing activity must be a hold point on air heater maintenance QCP
			13.2 Opened during operation due to inadequate closing / locking	13.2.1 Revise sealing mechanism (lock pin installation) 13.2.2 Door closure and –sealing activity must be a hold point on air heater QCP
			13.3 Door seals blown out	13.3.1 Maintain door frames, use correct sealing material

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3.1 LJUNSTROM (ROTATING MATRIX DESIGN) AIR HEATERS

Itm	Leak area / contributor	Result of defect/s	Possible causes for leak / contributor	Corrective actions
1	Sector plate sealing areas	Increased air heater leakage	1.1 Incorrect pre-setting	1.1.1 Correct seal setting by continued monitoring and adjustment
			1.2 Worn radial sealing plates on rotor	1.2.1 Inspect and refurbish worn parts 1.2.2 Review maintenance philosophy
			1.3 Worn sector plate sealing area	1.3.1 Inspect and refurbish worn parts 1.3.2 Review maintenance philosophy
			1.4 Mechanical damage on seals or seal area	1.4.1 Inspect and repair
			1.5 Distorted rotor surface	1.5.1 Inspect for distortion on radial plate surface (temperature excursions, possible air heater fire incidents)
			1.6 High leakage by design	1.6.1 Consider installing VN mod and / or brush seals (if not done already)
			1.7 Incorrect shaft alignment	1.7.1 Check guide bearings condition 1.7.2 Correctly set shaft alignment
2	Axial seals (on rotor periphery)	Increased air heater leakage	2.1 Incorrect seal pre-setting	2.1.1 Correct seal setting by continued monitoring and adjustment
			2.2 Worn seals or sealing area	2.2.1 Refurbish / replace seals. 2.2.2 Review maintenance philosophy
			2.3 Mechanical damage on seals or seal area	2.3.1 Inspect and repair
			2.4 High leakage by design	2.4.1 Consider improving seal arrangement
			2.5 Incorrect shaft alignment	2.5.1 Check guide bearings condition 2.5.2 Correctly set shaft alignment
			2.6 Rotor distortion on periphery (out-of-roundness)	2.6.1 Do run-out test to check roundness, rectify if required
			2.7 Air heater outer casing distortion	2.7.1 Check dimensionally, rectify if required

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Itm	Leak area / contributor	Result of defect/s	Possible causes for leak / contributor	Corrective actions
3	Blocked air heater elements	Increased air heater leakage (causes increased air heater differential pressure which in turn causes higher leakage)	3.1 Incorrect element pack selection. 3.2 Failed soot-blower system component 3.3 Failed soot-blower system process control	3.1.1 Consider installing element plates of a different design (more open profile) 3.2.1 Investigate and resolve soot-blower system component failure 3.3.1 Investigate and resolve soot-blower system process failure 3.3.2 Check functioning of soot-blower system moving actuator
4	Abnormal high primary air / secondary air / flue gas pressure	Increased leakage (as a result of higher differential pressures)	4.1 Pressure setpoint incorrect	4.1.1 Check setpoint against design, correct if feasible 4.1.2 Verify instrument accuracy
			4.2 Incorrect boiler O_2 controls	4.2.1 Verify accurate measurement and control setpoint
			4.3 Faulty control instruments	4.3.1 Check and calibrate instruments
			4.4 Partially closed air heater gas inlet damper/s or obstruction	5.4.1 Correct damper position if required, remove obstruction/s
			4.5 Partially closed air heater air outlet damper/s or obstruction	4.5.1 Correct damper position if required, remove obstruction/s
5	Abnormal high primary air / secondary air / flue gas flow rates	Increased leakage	5.1 Flow measurement incorrect	5.1.1 Check flow against design, correct if feasible 5.1.2 Check and calibrate instruments
			5.2 Faulty control instruments	5.2.1 Check and calibrate instruments, including O_2 control 5.2.2 Revise maintenance philosophy on instruments

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Itm	Leak area / contributor	Result of defect/s	Possible causes for leak / contributor	Corrective actions
6	Abnormal high flue gas inlet temperature	Affects air heater capping and as such air heater seal setting	6.1 Inadequate sootblowing in boiler furnace, superheaters and reheaters	6.1.1 Optimize sootblowing in the boilers (frequency and effectiveness)
			6.2 Changes in combustion and / or coal quality	6.2.1 Consult with Process Engineering
7	Abnormal low flue gas inlet temperature	Affects air heater capping and as such air heater seal setting	7.1 Out of service LP or HP heaters, condenser issues 7.2 Low boiler loading	7.1.1 Investigate cause/s and rectify 7.1.2 Consider installing an auto seal setting device to cater for changes in gas temperatures
8	Air in leakage at air heater ducting	Direct increased leakage	8.1 High localised fly ash erosion	8.1.1 Reinstate duct condition during outage 8.1.2 Revise SOW for outages 8.1.3 Consider installing erosion wear protection
9	Air in leakage at primary air, secondary air and / or flue gas duct expansion bellows	Direct increased leakage	9.1 Wear / inadequate protection plates / incorrect bellow material	9.1.1 Replace failed bellows 9.1.2 Revise outage SOW for outages, allow for bellow inspection 9.1.3 Make sure all air heater duct components can expand and contract freely as per design intent – check all expansion bellows and duct supports / hangers 9.1.4 If bellows keep on failing, investigate root cause and rectify
10	Air heater– access doors	Direct increased leakage	10.1 Left open after last inspection / access	10.1.1 Close after fitting new door seals 10.1.2 Door closing activity must be a hold point on air heater QCP
			10.2 Opened during operation due to inadequate closing	10.2.1 Revise sealing mechanism (lock pin installation) 10.2.2 Door closure and –sealing activity must be a hold point on air heater QCP
			10.3 Door seals blown out	10.3.1 Maintain door frames, use correct sealing material

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5. REVISIONS

Date	Rev.	Compiler	Remarks
Oct 2016	0	H. Kleynhans	Compiled guideline for use by Station personnel.
Nov 2016	0.1	H. Kleynhans	Incorporated comments from document reviewers
January 2017	0.2	H. Kleynhans	Final Draft Document for Comments Review
October 2017	1.0	N. Rust	Final document for publication
October 2017	1	N. Rust	Final Document for Authorisation and Publication

6. DEVELOPMENT TEAM

The following people were involved in the development of this document:

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- Herman Kleynhans

7. ACKNOWLEDGEMENTS

- Herman Kleynhans for his valued input over the years

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