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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.

By design these air heaters are prone to leakage from the air stream/s to the flue gas stream. Excessive leakage however contribute to PA, FD and ID fans running at maximum capacity, increased fly ash erosion, dust removal plant ineffectiveness and flue-gas back-end temperature control problems.

This document discusses the most common causes of excessive regenerative air heater leakage, consequences of excessive leakage and corrective actions to be implemented to minimise leakage.

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# 1. INTRODUCTION

This document covers the most common causes of excessive air heater leakage and strive to give guidance to plant personnel on how to identify these. Guidance is also provided on how to correct the identified defects.

# 2. SUPPORTING CLAUSES

## 2.1 SCOPE

This document covers plant defects and plant process conditions that influences air heater leakage.

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 excessive air heater leakage, and rectify these defects.

### 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

[2] 240-56241933 Control of Welding during Construction, Repair and Maintenance Activities Standard

## 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 |
| 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 |
| PEIC | Production Engineering Integration Coal |
| QCP | Quality control plan |
| SCOT | Steering Committee of Technologies |
| SOW | Scope of Work |

## 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 PEIC- Boilers.

## 2.6 RELATED/SUPPORTING DOCUMENTS

Not applicable.

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# 3. AIR HEATER LEAKAGE GUIDELINE

## 3.1 ROTHEMULE (STATIONARY MATRIX, ROTATING HOOD DESIGN) AIR HEATERS

| 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)<br>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<br>1.1.2. Check spring stiffness and free movement on spring pin assembly<br>1.1.3. Check condition and setting of seal frames and seal frame articulation joints<br>1.1.4. Check condition and setting of thermal compensators<br>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<br>1.2.2. Correctly set shaft and hood alignment<br>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 air heater fire incident)<br>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.<br>1.3.3. Check setting of hood thermal compensators |
| 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<br>2.2.2. Check wear on rubbing rings and cover plates<br>2.2.3. Check wear and looseness on drag links and tensioner spring assemblies, including shoe link plates<br>2.2.4. Check tensioner spring assembly and functionality<br>2.2.5. Check for worn or loose bolts on the drag links and shoe link plates |

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| Itm | Leak area / contributor | Result of defect/s | Possible causes for leak / contributor | Corrective actions |
|---|---|---|---|---|
| 3. | Stainless steel bellows (on main seal frames) | Increased leakage area | 3.1. Erosion wear / mechanical damage | 3.1.1. Replace worn sections<br>3.1.2. Revise outage SOW (inspection and replacement philosophy)<br>3.1.3. Install erosion wear protection where practically possible<br>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<br>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 |
| 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<br>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<br>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<br>5.3.2 Investigate reason for low temperature and rectify |
| | | | 5.4 Stator distortion | 5.4.1 See 1.3 above |
| | | | 5.5 Incorrect Shaft/Hood alignment | 5.5.1 Check HE and CE stator periphery sealing surfaces are parallel<br>5.5.2 Ensure correct shaft alignment<br>5.5.3 Ensure hoods are not loose relative to shaft (especially for horizontal shaft heaters – ie Arnot U1) |

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| Itm | Leak area / contributor | Result of defect/s | Possible causes for leak / contributor | Corrective actions |
|---|---|---|---|---|
| 6. | Blocked air heater elements | Cause increased air heater differential pressure and -higher leakage) | 6.1 See guideline for reducing air heater fouling document no 240-119862303 | 6.1.1 See guideline for reducing air heater fouling document no 240-119862303<br>6.1.2 Consider installing element plates of a different design (more open profile) |
| 7. | Abnormal high primary air / secondary air / flue gas pressure | Increased leakage (as a result of higher differential pressures) | 7.1 Pressure set point on primary air or secondary air controls incorrect | 7.1.1 Check set point against design, correct if feasible<br>7.1.2 Verify instrument accuracy |
| | | | 7.2 Incorrect boiler $O_2$ 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 |
| | | | 7.5 Blocked Element Packs | 7.5.1 See 6 above |
| 8. | Abnormal high primary air / secondary air / flue gas pressure | Increased leakage (as a result of higher differential pressures) | 8.1 Partially closed air heater air outlet damper/s or obstruction | 8.1.1 Correct damper position if required, remove obstruction/s |
| 9. | Abnormal high primary air / secondary air / flue gas flow rates | Increased leakage | 9.1 Flow measurement incorrect | 9.1.1 Check flow against design, correct if feasible<br>9.1.2 Check and calibrate instruments |
| | | | 9.2 Pressure set point on secondary air duct incorrect | 9.2.1 Check and calibrate instruments, including $O_2$ control<br>9.2.2 Revise maintenance philosophy on instruments |
| 10. | Abnormal high flue gas inlet temperature | Affects air heater capping and as such air heater seal setting | 10.1 Inadequate sootblowing in boiler furnace, superheaters and reheaters | 10.1.1 Optimize sootblowing in the boilers (frequency and effectiveness) |
| | | | 10.2 Changes in combustion and / or coal quality | 10.2.1 Consult with Process Engineering |

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| Itm | Leak area / contributor | Result of defect/s | Possible causes for leak / contributor | | Corrective actions | |
|---|---|---|---|---|---|---|
| 11. | Abnormal low flue gas inlet temperature | Affects air heater capping and as such air heater seal setting | 11.1 | Out of service LP or HP heaters, condenser issues low boiler loading | 11.1.1 | Investigate cause/s and rectify |
| 12. | Air in leakage at air heater ducting (including rotating hoods) | Direct increased leakage | 12.1 | High localised fly ash erosion | 12.1.1<br>12.1.2<br>12.1.3 | Reinstate duct condition during outage<br>Revise SOW for outages<br>Consider installing erosion wear protection |
| 13. | Air in leakage at primary air, secondary air and / or flue gas duct expansion bellows | Direct increased leakage | 13.1 | Wear / inadequate protection plates / incorrect bellow material | 13.1.1<br>13.1.2<br>13.1.3<br>13.1.4 | Replace failed bellows<br>Revise outage SOW for outages<br>Make sure all air heater duct components can expand and contract freely as per design intent – check all expansion bellows and duct supports / hangers<br>If bellows keep on failing, investigate root cause and rectify |
| 14. | Air heater inspection and –access doors (internal and external) | Direct increased leakage | 14.1 | Left open after last inspection / access | 14.1.1<br>14.1.2 | Close after fitting new door seals<br>Door closing activity must be a hold point on air heater maintenance QCP |
| | | | 14.2 | Opened during operation due to inadequate closing / locking | 14.2.1<br>14.2.2 | Revise sealing mechanism (lock pin installation)<br>Door closure and –sealing activity must be a hold point on air heater QCP |
| | | | 14.3 | Door seals blown out | 14.3.1 | Maintain door frames, use correct sealing material |

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## 3.2 LJUNGSTROM (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<br>1.2.2 Review maintenance philosophy |
| | | | 1.3 Worn sector plate sealing area | 1.3.1 Inspect and refurbish worn parts<br>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<br>1.7.2 Correctly set shaft alignment |
| | | | 1.8 Moveable sector plate adjustment (where fitted) not optimised | 1.8.1 Optimise seal setting (including auto adjustment where fitted) |
| | | | 1.9 Where adjustable sector plates are fitted – damaged seals behind sector plate | 1.9.1 Inspect and repair |

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| Itm | Leak area / contributor | Result of defect/s | Possible causes for leak / contributor | Corrective actions |
|---|---|---|---|---|
| 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.<br>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<br>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 |
| 3. | Blocked air heater elements | Increased air heater leakage (causes increased air heater differential pressure which in turn causes higher leakage) | 3.1 See Air Heater Fouling Prevention guideline 240-119862303. | |

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| Itm | Leak area / contributor | Result of defect/s | Possible causes for leak / contributor | Corrective actions |
|---|---|---|---|---|
| 4. | Abnormal high primary air / secondary air / flue gas pressure | Increased leakage (as a result of higher differential pressures) | 4.1 Pressure set point incorrect | 4.1.1 Check setpoint against design, correct if feasible<br>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 | 4.4.1 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<br>5.1.2 Check and calibrate instruments |
| | | | 5.2 Faulty control instruments | 5.2.1 Check and calibrate instruments, including $O_2$ control<br>5.2.2 Revise maintenance philosophy on instruments |
| 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 | 7.1.1 Investigate cause/s and rectify |
| | | | 7.2 Low boiler loading | 7.2.1 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<br>8.1.2 Revise SOW for outages<br>8.1.3 Consider installing erosion wear protection |

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| Itm | Leak area / contributor | Result of defect/s | Possible causes for leak / contributor | Corrective actions |
|---|---|---|---|---|
| 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<br>9.1.2 Revise outage SOW for outages, allow for bellow inspection<br>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<br>9.1.4 If bellows keep on failing, investigate root cause and rectify |
| 10. | Air heater inspection and – access doors | Direct increased leakage | 10.1 Left open after last inspection / access | 10.1.1 Close after fitting new door seals<br>10.1.2 Door closing activity must be a hold point on air heater QCP |
| | | | 10.2 Door seals blown out | 10.2.1 Maintain door frames, use correct sealing material |

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## 4. AUTHORISATION

This document has been seen and accepted by:

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| All | All Fossil Fired Power Station Boiler Engineering Managers |
| All | All Fossil Fired Power Station Boiler Maintenance Managers |

## 5. REVISIONS

| Date | Rev. | Compiler | Remarks |
|---|---|---|---|
| October 2016 | 0 | H. Kleynhans | Compiled guideline for use by Station personnel. |
| November 2016 | 0.1 | H. Kleynhans | Incorporated comments from document reviewers |
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| October 2017 | 1.0 | N. Rust | Final Document for Official 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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- Jesse Eganza – PEIC
- Nico Rust – PEIC
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## 7. ACKNOWLEDGEMENTS

- Herman Kleynhans for his valued input over the years

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