

 Eskom	Guideline	Technology
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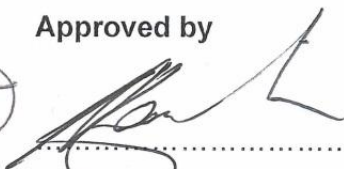
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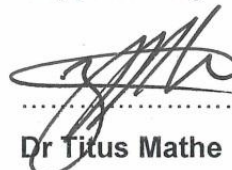
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PCM Reference: **Boilers**

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EXECUTIVE SUMMARY

On many Eskom Power Stations ID fans load losses have been incurred due to ID running out of volumetric capacity at times. This is common when unit controllers try to load the boilers to their maximum capacity rating (MCR) and furnace pressure cannot be controlled effectively, and to regain control of boiler, the loads have to be reduced. This document gives a guideline for troubleshooting all the contributory causes and an action list.

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1. INTRODUCTION

ID fans running out of capacity is very seldom a result of ID fan defects. It is mostly upstream process conditions that have changed to the point where the required flow and / or pressure rise across the ID fan is above the design duty point of that specific fan.

Most common reasons for ID fan (centrifugal and axial) overloading are:

- Air in-leakage on flue gas ducts and precipitators between oxygen control point and the ID fans
- Regenerative air heaters leakages
- Tubular air heaters leakages
- Boiler O2 control defects
- Blocked fabric filter plant bags
- Blocked regenerative and tubular air heaters
- Inefficient unit cycle efficiency caused by out of service HP heaters, LP heaters condenser related defects resulting in condenser pressure out of specification.
- Air in-leakage on flue gas ducts and precipitators between oxygen control point and the ID fans
- Inadequate soot blowing of regenerative air heaters
- Calorific value of coal being burnt lower than rejection value

Determining the root cause of ID fan overloading for a specific boiler can be a challenge and can require significant engineering effort to identify.

2. SUPPORTING CLAUSES

2.1 SCOPE

2.1.1 Purpose

The purpose of this document is to give plant users a guideline on how to avoid fan overloading and the subsequent UCLF

2.1.2 Applicability

This guideline is applicable to all radial and axial fans at coal fired Power Stations in Eskom Holdings Limited Divisions.

2.2 NORMATIVE/INFORMATIVE REFERENCES

Parties using this document shall apply the most recent edition of the documents listed in the following paragraphs. References to the following document(s) will enhance the understanding of the reader on the subject covered in this document. The requirements of these document(s) are, however, not an extension of this document.

2.2.1 Normative

- [1] ISO 9001 Quality Management Systems.
- [2] 240-53114002: Engineering Change Management Procedure
- [3] GGP 0464: Administration of Operations related ESKOM Regulations.
- [4] GGD 1447: Plant Asset Management Directive.

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2.2.2 Informative

- [5] 0363 EPRI 1009651 Forced Draft and Induced Draft Fan Maintenance Guide
- [6] 240-54041252: Standard for Boiler, Coal and Ash Plant Sizing on Ash Plant Sizing on Existing Power Stations
- [7] 36-680: Fossil Fuel Firing Regulations
- [8] 240-71273834: Standard for Coal quality specifications for Eskom power stations at Staithe/Silo inlet

2.3 DEFINITIONS

Definition	Description
Diff pressure	The difference between the air or gas pressure upstream and downstream of an item of plant such as the air heater or fabric filter.
Waiver	A waiver means permission of a temporary or permanent nature to be excused from a provision of this standard.

2.3.1 Disclosure Classification

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

2.4 ABBREVIATIONS

Abbreviation	Description
A/H	Air Heater
C&I	Control and Instrumentation
DHP	Dust handling Plant
DP	Differential Pressure
dT	Temperature Change
ECM	Engineering Change Management (process)
FD fan	Forced draft (secondary air) fan
FFP	Fabric filter plant
GO	General Outage
GT	Group Technology (department)
HP	High pressure
ID fan	Induced draft fan
IR	Interim Outage
IR	Infrared Camera
NDT	Non-destructive testing
OEM	Original Equipment Manufacturer
PA fan	Primary air fan

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Abbreviation	Description
PEI-C	Production Engineering Integration - Coal
PF	Pulverised fuel
PM	Preventive maintenance (maintenance philosophy)
RTS	Return to service
RVC	Radial vane control
SAP	Software maintenance management system
SSC	Submersed Scraper Conveyor
C&I	Control and Instrumentation
ECM	Engineering Change Management (process)
FFP	Fabric filter plant
GT	Group Technology (department)
PA fan	Primary air fan
PEI-C	Production Engineering Integration - Coal
PF	Pulverised fuel
PM	Preventive maintenance (maintenance philosophy)
A/H	Air Heater
IR	Infrared Camera
RFT	Remote Field Inspection
SAP	Software maintenance management system

2.5 ROLES AND RESPONSIBILITIES

This document is to be used by the draught plant system engineer and the station process engineering departments as a guideline in resolving ID fan maximum problems on the stations.

Each power station is responsible to develop a station specific procedure for the identification and correction of plant defects that contributes to ID fan reaching maximum capacity in order to ensure safe and reliable plant operation.

2.6 PROCESS FOR MONITORING

Compliance monitoring of this guideline will be via peer reviews and compliance audits

2.7 RELATED/SUPPORTING DOCUMENTS

The following documentation shall be produced as a result of this guideline;

The relevant PS shall compile and register an ID fan at maximum capacity guideline document as required.

The relevant PS shall maintain records of investigations done and corrective actions implemented.

2.8 Records

The relevant PS shall maintain records in SAP and on hyper wave that details the inspections and repairs that were completed. These include:

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- Description of the test and inspection performed.
- Dates of the tests and inspections.
- Name of the person(s) who performed the test and inspections.
- The plant code of the system inspected.
- Results of the tests and inspections
- Any abnormal operating conditions experienced.

3. ID FAN AT MAXIMUM CAPACITY

3.1 POSSIBLE CAUSES AND CONTRIBUTIONS

The intent of the table below is to serve as a guideline in determining the reason/s why ID fans runs out of capacity. A large amount of UCLF is currently booked under ID fans. In almost all cases it is not a true fan defect but rather overloading of the fan due to either above design flow rates or above design required pressure rise. As part of the standard practise in the root cause analysis the station should plot the operating point of the fan (pressure and vane position) on the fan characteristic curve and comparison with the fan design and normal operating points

Each Power Station is to develop a guideline which should encompass the following analysis on the table as a minimum

Investigation into the reasons for fans out of capacity should be done by the station Performance & Testing section and Process Engineering, assisted by the System Engineer and operating services

Corrective actions should be agreed on by the system engineer and the work must be planned on SAP maintenance (notifications outage scope of work, spares planning etc.)

Feedback as to the actual cause/s of ID fan out of capacity must be given to station production personnel for the correct allocation of UCLF, also for GPSS data capturing.

It is recommended to fill in column 5 – Normal Operating Parameters - and then compare the specific unit performance at the time to the normal operating conditions

Table 1: Table with Guidelines

<i>Item</i>	<i>Description – main cause</i>	<i>Typical problem areas</i>	<i>Corrective action</i>	<i>Normal Operating Parameters (At Full Boiler Load)</i>	<i>Actual Current operating Parameters</i>	<i>Notes</i>
1	Fan defects					
1.1		RVC defective	Check for defects, all RVC blades must be in same position. Check for free movement of RVC blades from 0% opening to 100% opening Check for links and			Inspect RVC lay-shaft, levers, push rods & ball joints. Check vane turnbuckle adjustment. Check for

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			turnbuckles to be correctly fitted and tight				smooth operation of the operating ring on the guide rollers. Ensure RVC is centred around the fan shaft
1.2		RVC and /or inlet / outlet damper stroke checking faulty	Re-do stroking, visually confirm damper position.				Pre & post Outage – also ensure RVC's are synchronised.
1.3		RVC or damper position feedback faulty	Compare control room indication to actual position on plant Inspect and test correct functioning of actuator positioners. Carry out proper plant commissioning and sign off and keep record for future reference				Do during commissioning. Adjust local indication levers where applicable
1.4		Excessive leakage on fan shaft seals	Inspect shafts seals and plan for replacement each outage Inspect dorsal fins and repair where needed and repair				Measure gap, must be concentric to shaft
1.5		Blade wear (axial flow fans)	Inspect blade thickness welds and fixtures, monitor the reduced stall limit				
1.6		Poor actuator (damper) response	Verify number of signal pulses it takes for dampers to operate Check the fans dead bands and adjust accordingly Measure the operating time and stroke length of the RVC actuators Check for looseness(backlash) in the operating leverage system				Pre & post outage - Check actuator linear mechanism, control link arms and ball joints for play

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			particularly when changing direction of actuator drive				
1.7		Fan runner & impeller	Inspect for flow obstructions such as loose liners and excessive fan blade wear				Inspect the mechanical structural integrity of the fans & repair
1.8		Suction cone	Inspect for damage or erosion wear, measure protrusion length and gap between cone and impeller.				Outage – replace damaged suction cone
<i>Item</i>	<i>Description – main cause</i>	<i>Typical problem areas</i>	<i>Measurement Method/s</i>	<i>Normal Operating Parameters (At Full Boiler Load)</i>	<i>Actual Current operating Parameters</i>		<i>Notes</i>
					L/h	R/h	
2	Air ingress – boilers						
2.1		SSC / wet ash hopper / dipper plates	Inspect for sealing / air ingress Clean the sealing trough at every opportunity where boiler is off load for more than 12 hours Repair all the damaged dipper plates Operating to make sure that the sealing trough is always filled with water and must be automated if not. Close all the sealing trough inspection doors Wet ash hopper doors to be closed and hoppers filled with water.				Pre & Post outage
2.2		Economiser expansion bellows	Inspect / measure O ₂ before and after Strip expansion joint lagging and cladding during				Pre-outage and post outage

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			GO or outage of suitable duration(not in abbreviations section)and inspect from inside where possible for leaks and replace leaking bellows				
2.3		Open boiler doors & seals	Inspect all the boiler doors for holes and proper closing of the doors, including proper gasket installation Repair all refractories to prevent fire damage to doors Carry out plant walks to ensure all doors are locked				Pre & Post outage
2.4		Soot blowers	Inspect for air ingress via gaps around soot blowers Check for removed soot blowers & if blanks are in place				Pre-outage Outage – install blanks where SB's are removed from boiler
2.5		Boiler skin casing and flue gas ducting	Inspect for leaks during forced cooling and repair. Utilise IR camera				Pre-outage - inspect Outage - repair
3	Air ingress – Secondary Air heaters						
3.1		Worn wear shoes / seals	Inspect and record (periphery can be inspected on-load).plan for replacement and carry out during opportunity Air heater leakages should be measured and trended The thermal performance of the air heater				Ensure new set of shoes, or at least properly matched shoes are replaced during short outages)

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			should be measured.				
3.2		Incorrect seal setting (hoods and collars)	Inspect seal setting and optimise the best settings with help of the maintenance crew. Optimise seal setting at every available opportunity				
3.3		Shaft or hood alignment out	Inspect the alignment and correct				
3.4		Too low flue gas inlet temperature, typically due to low boiler load or HP heaters out of service (de-cap the air heater rotors or stators)	Measure the inlet temperature and introduce HP heaters and investigate if periphery seal gaps have increased at lower loads				
3.5		Worn or ruptured Stainless steel expansion joint (Rothemuhle air heaters)	Inspect periphery and radial hood seals and replace if damaged off load				
3.6		Open internal hood doors (Rothemuhle air heaters)	High Air Flow and DP, Internal inspection and correct				
3.7		Worn or damaged axial seals (Lungstrom air heaters)	Inspect and replace if below specifications during off load				
<i>Item</i>	<i>Description – main cause</i>	<i>Typical problem areas</i>	<i>Measurement Method/s</i>	<i>Normal Operating Parameters (At Full Boiler Load)</i>	<i>Actual Current operating Parameters</i>		<i>Notes</i>
					L/h	R/h	
3.8		Radial seal wear	Inspect off load and replace				Make sure that they are level, that the hot and cold ends are

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							parallel and not worn in places.
3.9		Inspection doors not sealing correctly	Inspect on load and plan to repair defects offload				External inspection and access doors must be sealing properly.
4.0		Blocked element packs	Measure air heater differential pressure and if out of specification. Carry out HP cleaning with water				
4.10		Hood expansion rods defective (thermal compensator rods)	Check that Correct material used, Rods not damaged and are correctly installed				
5	Air ingress – Tubular Primary Air heaters						
5.1		Eroded or corroded tubes	Inspect the tubes for dew point corrosion/Fly ash erosion and extent of damage on tube continuity Carry out the RFI test and determine the accurate percentage of tubes blocked and eroded. If more than 30% blocked plan for replacement.				
5.2		Holed casings or ducts	Inspect on load – IR and mark out areas to be planned for repairs				Pre & Post outage
5.3		Open access doors	Inspect / measure flow and O ₂ ingress before and after the air heater and trend oxygen leakage and prepare scope for next opportunity				Pre & Post outage

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6 Air ingress – air heaters to Electrostatic Precipitators / Fabric Filter plant							
6.1		Holed ducts	Inspect – visually and with IR camera				Pre-outage
6.2		Worn expansion bellows or supple joints downstream of O2 control measurements	Inspect visually and with IR camera Strip cladding and lagging and inspect for light entering ducting from inside off load				Pre-outage
6.3		Open / leaking inspection doors	Inspect doors for proper sealing Measure flow and / or O2 before and after				Post and pre outage Ensure that inspection doors are properly closed and sealed.
6.4		Open FFP attemporation dampers due to temperature stratification in the gas stream	Investigate/Inspect Measure temperature before and after and repair defects				Post and pre outage
7 Air ingress – at Electrostatic precipitators or Fabric Filter Plant							
<i>Item</i>	<i>Description – main cause</i>	<i>Typical problem areas</i>	<i>Measurement Method/s</i>	<i>Normal Operating Parameters (At Full Boiler Load)</i>	<i>Actual Current operating Parameters</i>		<i>Notes</i>
					L/h	R/h	
7.1		Holed ducts	Inspect – visually and with IR camera Strip cladding and lagging and inspect for light entering ducting from inside during outage or an opportunity outage				Pre-outage
7.2		Worn expansion bellows or Flexible joints	Inspect – visually and with IR camera Strip cladding and lagging and inspect for light entering ducting				Pre-outage

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			from inside during opportunity outage				
7.3		Open inspection or access doors	Inspect doors for proper locking and sealing repair refractory where applicable				Pre & Post outage
7.4		Openings in DHP	Inspect and carry out repairs where required Check for poorly set , damaged or open hopper discharge valves				
7.5		Attemperation dampers not closed	Inspect for damage. Stroke check for proper operation where required				
7.6		DHP hopper discharge valves	Inspect and carry out OEM settings. Ensure proper commissioning is carried out				
8 Air ingress- Electrostatic precipitators / Fabric Filter Plant to Induced Draught fans							
8.1		Holed ducts	Inspect – visual and with IR camera immediately after forced cooling Strip cladding and lagging and inspect for light entering ducting from inside Measure flow and / or O2 before and after Measure temperature before and after				Pre & Post outage
8.2		Worn expansion bellows or supple joints	Inspect – visual and with IR camera Strip cladding and lagging and inspect for light entering ducting from inside				Pre & Post outage
8.3		Inspect ID Fan inspect doors	Bolts & packing to be replaced where				Pre outage - inspect

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		and seals	worn and loose				Outage - replacement
8.4		Open inspection doors	Inspect the internal for holed casing				Pre & Post outage
8.5		Open/faulty implosion dampers	Inspect (on-load) (also during outages – check for sealing)				
9 Too high flue gas inlet temperature							
9.1		At air heater inlet – over firing, inadequate boiler soot blowing	Measure – on plant instrumentation Poor combustion of the boiler should be improved and soot blowers made available Mill combinations with long burn out coal should be investigated				
9.2		After air heaters (air heater thermally ineffective) blocked or missing packs	Measure – on plant instrumentation Check the Differential pressures and initiate actions to bring differential pressure to acceptance values Ensure air heater recirculating damper to be the correct operational positions				
<i>Item</i>	<i>Description – main cause</i>	<i>Typical problem areas</i>	<i>Measurement Method/s</i>	<i>Normal Operating Parameters (At Full Boiler Load)</i>	<i>Actual Current operating Parameters</i>		<i>Notes</i>
					L/h	R/h	
10 Too low flue gas inlet temperature							
10.1		At air heater inlet – LP or HP heaters out of service,	Measure – on plant instrumentation Inspect and return				This will negatively affect air heater seal setting, resulting

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		severe air ingress etc.	HP heaters and LP heaters to improve the cycle efficiency				in high leakage rates This will also cause over firing to compensate for lost heat input to the boiler.
11	Excessive volume(Excess Air) -too high O2 content						
		Inaccurate O2 boiler control	Verify O ₂ measure and instrument calibration Fill the oxygen measurement matrix with water and check for leaks and open flanges to drain after Check the K factors on the Primary Air and secondary air duct with a flow verification checks Carry out boiler furnace air tightness checks to identify air ingress points				Pre & post outage
12	Too high Fan pressure rise required and Fan diff pressure higher than design						
12.1		Blocked air heaters	Measure air heater differential pressure and initiate scope to correct such as HP cleaning or better condition packs				Possible causes are operating air heaters in acid dew point condition, air heater soot-blowers not working etc.
12.2		Blocked FFP bags or precipitators houses (high ash levels)	Measure differential pressure and clear ash if full. Monitor hopper level alarms				
12.3		Partially closed dampers or ash build-up restricting flow	Inspect damper positions on load (shaft markings or level angles). Measure differential				Inspect on load, also during outages (for ash build-up) and during plant commissioning

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			pressure at various positions Proper commissioning				
12.4		Incorrect calibration or fault on furnace pressure control	Verify furnace pressure set point Assess flue gas pressure profile from furnace to ID fan and compare to design(very Important)				Pre & Post outage
<i>Item</i>	<i>Description – main cause</i>	<i>Typical problem areas</i>	<i>Measurement Method/s</i>	<i>Normal Operating Parameters (At Full Boiler Load)</i>	<i>Actual Current operating Parameters</i>		<i>Notes</i>
13	Uneven loading (between left/h and right/hand Induced draught fans) (LH and RH ID fans)						
13.1		One air heater blocked more than the other	Verify DP and temperatures across Air heaters and Carry out HP cleaning				Pre & Post outage
13.2		One air heater with free flow / missing packs	Consider maintenance history. Assess dP and dT across A/H .Replace missing packs or blank and plan for replacement				
13.3		RCV stroking incorrect	Compare ID fan amps, suction pressure, RVC positions				
12.4		RVC links broken or stuck	Visual inspection and replacement of links if broken				
13.5		Excessive air ingress on one duct or precipitators / FFP plant	Measure and confirm ingress and carry out corrective action				
13.6		Incorrectly applied fan biasing	Verify biasing pots control and zero point. Rectify if out of specification				Pre & Post outage
13.7		Ducting in-leakage / holes in ducts	Visual inspections during outages, smoke tests				

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		Ducting blockage (ash built up)					
14	Excessive gas flow rates (higher than design)						
14.1		Actual gas flow at ID fan	Traverse test to measure and validate				Pre & Post outage
14.2		Actual total measured primary air flow	PA flow venture actual and instrumentation check to verify Carry out boiler load line checks and ensure they follow control philosophy Conduct mill optimisation for better combustion				Pre & Post outage
14.3		Actual total measured secondary air flow	Calibrate SA flow venturi for better combustion				Pre & Post outage
14.4		Total air ingress	Calibrate Total air- (Primary Air Secondary Air) for better combustion				Pre & Post outage

15	Boiler Over firing and poor thermal/Cycle efficiency						
15.1		HP Heaters out of service HP Heaters Isolation valves	Carry out the Heat balance calculations to identify heat losses resulting to over firing to quantify the load loss Maintain valves during planned outages and to minimise risk of operating without HPH due to tube leaks or other defects. Repairs can be				The availability of HP heaters on the boiler cycle pulls back the firing and this on the overall will pull back the fans.

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			effected with proper isolation				
15.2		LP Heaters Out of service	Carry out the Heat balance calculations to identify heat losses resulting to over firing to quantify the load loss				
15.3		Main Turbine Vacuum(Condenser pressure) not in Design Specification	Carry out the Heat balance calculations to identify heat losses resulting to over firing Improve cooling tower performance Minimise back pressure situations on Turbine plant by arranging half load or off load condenser tube cleaning Maintain CW chemistry to minimise the risk of tube scaling Ensure that cooling tower screens are designed and operated as to avoid the risk of debris blocking condenser tubes Use the online condenser cleaning				

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			system whenever the conditions allow				
15.4		Condenser/Cooling Tower saturation temperatures out of design specification	Improve cooling tower performance Regular cleaning of heat exchanger tubes Carry out condenser tests that give condition of condenser and repair Re tube condensers that are more than 10% plugged Improve cooling water quality(remove ash and oil)				High cooling water inlet temperature(t1) leads to higher saturation temperatures and corresponding rise in condenser back pressure which results in over firing
15.5		Station Cooling Water not Adequately cooled to specification	Improve the efficiency of the water cleaning plant with regards to clarifiers or pre-treatment plants at the water plant that need to be available and operated according to design				
15.6		Mills not optimised	Carry out mill optimisation Check boiler load lines and ensure they				

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			are effective				
		Swinging furnace pressure	Blocked furnace pressure impulse lines; Partially blocked regenerative air heater element sectors; Blocked secondary air control pressure impulse lines; Cyclic fuel input; Cyclic air input; Cyclic load on turbine;				Steady state combustion is desirable though it is not always easy to achieve. If achieved. This allows the fans to run at higher vane opening without swinging between maximum opening and minimum.

4. AUTHORISATION

This document has been seen and accepted by:

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All	Boiler SCOT Committee
All	All Fossil Fired Power Station Managers
All	Group Technology Boiler Discipline Managers
All	All Fossil Fired Power Station Boiler Engineering Managers
All	All Fossil Fired Power Station Boiler Maintenance Managers

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5. REVISIONS

Date	Rev.	Compiler	Remarks
November 2015	A draft	H. Kleynhans	Updated to 240 document guideline, added additional inspection requirements.
November 2015	B draft	J. Eganza	Updated additional guidelines items on effect of over firing on ID Fan out of Capacity
February 2016	C Draft	J. Eganza	First Draft document for First Review
March 2016	0.1	J. Eganza	First Draft Document for Formal Comments Review
March 2016	0.2	J. Eganza	Final Draft Document for Formal Comments Review
April 2016	0.3	J. Eganza	Updated Final Draft after Comments Review Proces
April 2016	1	J. Eganza	Final Document for Authorisation and Publication

6. DEVELOPMENT TEAM

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

- Mike Lander (Senior Advisor, Draught Plant).
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