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1. INTRODUCTION

Adequate boiler draught plant protection is essential to safeguard the plant and prevent major damage and shall always be available on demand. However, the benefits of such protection must be balanced against the inevitable reduction in reliability associated with the protection equipment and systems. This Standard strives to achieve such a balance, and to ensure the documentation and control of the protection requirements and settings at each relevant Eskom fossil fired Power Station.

The document content has been compiled jointly by a working group of boiler draught plant and C&I engineers from Group Technology and representative PS's, incorporating input from the 1991 Plant Reliability Study and the consideration of protection philosophies and systems already existing on respective fossil fired boilers.

2. SUPPORTING CLAUSES

2.1 SCOPE

This document covers the minimum protection requirements for the draught plant. The main components of the draught plant are:

- primary and secondary air heaters
- PA, FD and ID fans and –motors
- primary air, secondary air and flue gas duct systems and
- associated auxiliaries such as dampers, lubrication systems, drive motors and actuators.

2.1.1 Purpose

The purpose of this document is to prevent loss of life or major plant damage by ensuring that fossil fuel fired boiler draught plant are not operated beyond safe limits. This is achieved by:

- Defining the minimum protection functions for all fossil fired boiler draught plant.
- Ensuring that each Power Station has a protection philosophy document detailing the specific plant protection functions, setting values and testing requirements.

The protection functions as defined in this document should be supplemented by appropriate control setpoints, process limiters, alarms, sequential tripping, automatic load reduction and/or manual operator interventions.

2.1.2 Applicability

The defined requirements shall apply to the draught plant within all Eskom coal fired boilers.

2.2 NORMATIVE/INFORMATIVE REFERENCES

2.2.1 Normative

- [1] ISO 9001 Quality Management Systems.
- [2] 240-53114002: Engineering Change Management Procedure.
- [3] 36-680: Fossil Fuel Firing Regulations (currently under revision)
- [4] 240-56241288: Fossil Fired Boiler Protection Function Standard

2.2.2 Informative

- [1] VGB-R 117 C: Guideline for Power Plant Equipment Protection

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- [2] GGP 0464: Administration of Operations related ESKOM Regulations.
- [3] IEC 61508: Functional Safety of Electrical/Electronic/Programmable Electronic Safety Related Systems.
- [4] IEC 61511: Functional Safety Instrumented Systems for the Process Industry Sector.

2.3 DEFINITIONS

Definition	Description
Protection functions	All those functions that will trip the boiler draught plant, or initiate actions to prevent major plant damage, in the event of a predetermined process level being exceeded in terms of the plants defined operating envelope.
Boiler master trip	Boiler master trip means a device which will, either automatically or by means of a manual push button, stop all fuel input into a boiler furnace.
Waiver	A waiver means permission of a permanent nature to be excused from a provision of this standard.
Exemption	Exemption means permission of a temporary nature to be excused from a provision of this standard.
	Note: Where applicable definitions were taken from FFR 36-680

2.3.1 Disclosure Classification

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

2.4 ABBREVIATIONS

Abbreviation	Description
ARP	Alarm Response Procedure
BPS	Boiler Protection System
C&I	Control and Instrumentation
FD fan	Forced draft (secondary air) fan
FFP	Fabric Filter Plant
GT	Group Technology (department)
ID fan	Induced draft fan
OEM	Original Equipment Manufacturer
PA fan	Primary air fan
PEI-C	Production Engineering Integration - Coal
PF	Pulverised Fuel (milled coal)
PS	Power Station
PSM	Power Station Manager
RT&D	Research Test and Development
SM	Senior Manager

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2.5 ROLES AND RESPONSIBILITIES

Each PS is responsible to develop and implement the requirements described in this Standard to ensure that the boiler draught plant protection systems installed are managed such that the integrity of the equipment is ensured, and that it is available on demand to prevent major plant damage and loss of human life.

2.6 PROCESS FOR MONITORING

Compliance monitoring to this Standard will be via peer reviews and compliance audits.

2.7 RELATED/SUPPORTING DOCUMENTS

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

- The relevant PS shall compile a boiler draught plant protection philosophy document as required.
- The relevant PS shall maintain records that certify that proof tests and inspections were completed as required.

3. REQUIREMENTS

3.1 BOILER DRAUGHT PLANT PROTECTION PHILOSOPHY DOCUMENT

Each relevant PS shall compile and maintain a boiler draught plant protection philosophy document with the following content;

3.1.1 Front Cover

The cover shall include;

- The name of the PS.
- The relevant units at the PS. Where boiler draught plant on the same PS incorporate different protection philosophies, a separate document shall be compiled and authorised for each group of boiler draught plant. Where boiler draught plant use different trip limit values for the same protection function, both shall be specified and highlighted in the document.
- Acceptance, approval and authorisation signatures.
- Revision status of the document.

3.1.2 Protection Functions Implemented at the Subject PS

This section shall include all installed protection functions, which include the following information per protection function;

- Protection function description.
- Alarm and trip limit values, including any time delays applied.
- Testing requirements and frequency, both on- and off-load where applicable.
- Brief summary of the protection logic formation, actions initiated and degree of redundancy used to implement the protection function.
- Test reporting/recording requirements.
- The section may be in the format of tables, functional logic diagrams, descriptive text or any other suitable means to adequately display the necessary information.

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3.1.3 Plant information

Supporting information, for example OEM descriptions, drawings and other information may at the discretion of the PS Management be attached to the document as an Appendix.

3.2 BOILER DRAUGHT PLANT PROTECTION PHILOSOPHY DOCUMENT CONTROL

- The boiler draught plant protection philosophy document shall be compiled by the relevant PS Engineering department, approved by the PS Manager and authorised by the subject matter expert (Eskom draught plant specialist).
- Modifications to the PS boiler draught plant protection philosophy or trip limit value changes contained in the document shall be controlled as per ECM process for Level 1 classified components.
- Modifications to alarm limit values of the respective protection functions may be revised through the relevant ECM process; however these changes shall be recorded by amending the boiler draught plant protection philosophy document.
- Temporary changes to trip limit values shall be approved by the relevant PS Manager, but authorised by the subject matter expert (Eskom draught plant specialist) in terms of its Level 1 classification status. Implementation is controlled via the relevant ECM emergency and out of normal processes.
- Temporary changes to alarm limit values shall be approved by the PS Engineering department with concurrence from the subject matter expert (Eskom draught plant specialist) and controlled by the relevant PS out of normal process and the ECM process.
- The alarm and trip limit values, protection function mechanisms and levels of redundancy initially entered in the document shall be those existing on the plant at the time of compiling the boiler draught plant protection philosophy document. Any modification to this shall be processed only after authorisation of the initial document, through the above defined process.
- There may be individual isolated cases where existing plant does not require the stipulated protection function due to specific design characteristics. In this case the relevant PS Manager shall provide written motivation for non-compliance to the Group Technology SM (PEI-C). This will then be reviewed and authorised by the Group Technology SM (PEI-C) by means of a waiver.
- Where modification to existing equipment is required to meet the requirements of this Standard, a programme to implement will be agreed between the Group Technology SM (PEI-C) and the relevant PS Manager. The Group Technology SM (PEI-C) will issue an exemption for compliance as per the agreed programme.

3.3 GENERAL ASPECTS OF PLANT OPERATION

Each protection function listed in this Standard shall incorporate predetermined values for alarm and boiler draught plant trip value limits. The alarm limit values should be set such that the warning functions shall direct the operator's attention towards the plant condition requiring timely assessment and response.

The following alarm management principles should be followed;

3.3.1 Alarms

- Each alarm shall alert, inform and guide the operator.
- Every alarm shall have a defined response (alarm response procedure).
- Every alarm presented to the operator shall be useful and relevant to the operator.
- Adequate time shall be available for the operator to carry out the defined alarm response.

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3.3.2 Monitoring and Control Functions

All measurement and control functions shall have documented planned maintenance schedules for measurement calibration verification and correct functioning testing. These schedules shall be used as a framework within which each PS shall establish maintenance, test and commissioning instructions, which must take local conditions and equipment technologies into account.

The boiler draught plant protection system is integrated with the unit control and automation system.

3.3.3 Control Limits

All control limits shall have documented maintenance, inspection and test instructions for operational integrity verification and setting validation. These instructions shall be used as the framework within which each PS shall proof test and commission the draught plant.

The draught plant control limits functions are provided within the unit control and automation system.

3.4 PROTECTION FUNCTIONS

The draught plant protection functions are provided within the unit control and automation system. Appropriate response time and redundancy levels shall be incorporated with due consideration of OEM recommendations and specific safety integrity requirements.

Local indications shall be independent (dedicated process taps) and diverse from the remote and control process measurements. These measurements shall be installed within line of site of the fan or heater.

Protection measurements and functions shall be implemented independently from the remote measurements, control functions, control limits and alarm functions.

As far as possible all measurements shall have their own process tap.

In designs where level switches are used to provide the required level protection functions, a redundant remote level measurement shall be provided.

The protection system shall accept plant protection input signals in a 2oo3, 2oo2, 1oo2 or 1oo1 selection configuration, depending on the measurement loop installation constraints and criticality requirements. It is important to note that the boiler draught plant is integrated with the boiler master trip. This philosophy will ensure that the fuel supply to the boiler has been effectively isolated and prevents the possibility of disastrous furnace conditions.

Each source of operation of the boiler draught plant trip shall actuate a “cause of trip” indication that informs the operator of the initiating cause of the tripping impulse.

Appropriate measurement diversity shall be applied to safe guard against common mode failure.

All process measurements shall be installed such that it can be maintainable on load.

Note that for the requirements of Para 3.4 immediate changes or modifications on current station installations are not required, but stations must comply when their C&I system get upgraded or replaced.

The following represents the minimum protection functions for fossil fired boiler draught plant. It further provides supportive information by capturing the intent and requirement of the respective protection functions;

3.4.1 Boiler protection function impacting on draught plant:

Furnace pressure protection

Both ID fans off

Both FD fans off

Both air heaters off

All mills tripped – then the PA fans shall trip

Air heater fire protection

Primary air, secondary air and flue gas ducts protections

3.4.2 ID Fans

Motor protections – recommended to have an alarm on motor winding temp only. Earth faults, phase unbalance etc. is covered under motor protections

3.4.2.1 Fan Lubricating oil pressure < minimum;

Intent: To protect the fan bearings and shaft journals against loss of lubrication.

Requirement: Initiate ID fan trip, which in turn shall initiate a draught group trip.

3.4.2.2 Fan bearing temperature > maximum (fan and fan motor);

Intent: To protect the fan- and motor bearings and shaft journals against damage.

Requirement: Initiate ID fan trip, which in turn shall initiate a draught group trip

3.4.2.3 No flue gas flow path protection;

Intent: To protect the furnace and fan ducting from pressure disturbances due to a total loss of flue gas extraction.

Requirement: Initiate ID fan trip, which in turn shall initiate a draught group trip.

3.4.2.4 FD Fan off;

Intent: To protect the furnace and fan ducting from under pressurisation due to a total loss of combustion air supply. Further to protect the air heater against overheating.

Requirement: Initiate ID fan trip, which in turn shall initiate a draught group trip.

3.4.2.5 ID Fan bearing vibration protection;

Intent: To protect the ID fan rotating components against damage.

Requirement: Initiate ID fan trip, which in turn shall initiate a draught group trip.

3.4.2.6 ID fan stall protection (axial flow fans)

Intent: To prevent structural damage of ID fans due to high frequency blade vibrations (stall). This requirement should also incorporate surge protection with fabric filter plant.

Requirement: Initiate ID fan trip, which in turn shall initiate a draught group trip

3.4.2.7 ID fan inlet gas temperature > maximum;

Intent: To prevent damage to ID fans and air heaters, flue gas cleaning plant, FFP's and ducting due to over temperature conditions.

Requirement: Trip associated draught group, but not the air heaters.

3.4.3 FD Fans

Motor protections – recommended to have an alarm on motor winding temp only. Earth faults, phase unbalance etc. is covered under motor protections

3.4.3.1 Fan Lubricating oil pressure < minimum;

Intent: To protect the fan bearings and shaft journals against loss of lubrication.

Requirement: Initiate fan trip, which in turn shall initiate a draught group trip.

3.4.3.2 Fan bearing temperature > maximum (fan and fan motor);

Intent: To protect the fan- and motor bearings and shaft journals against damage.

Requirement: Initiate FD fan trip, which in turn shall initiate a draught group trip

3.4.3.3 FD Fan bearing vibration protection;

Intent: To protect the ID fan rotating components against damage.

Requirement: Initiate ID fan trip, which in turn shall initiate a draught group trip.

3.4.3.4 FD fan stall protection (axial flow fans)

Intent: To prevent structural damage of FD fans due to high frequency blade vibrations (stall). This requirement should also incorporate surge protection with fabric filter plant.

Requirement: Initiate FD fan trip, which in turn shall initiate a draught group trip

3.4.3.5 No secondary air flow path protection;

Intent: To protect the furnace and fan ducting from pressure disturbances due to a total loss of secondary air supply.

Requirement: Initiate FD fan trip, which in turn shall initiate a draught group trip.

3.4.3.6 ID Fan off;

Intent: To protect the furnace and fan ducting from over pressurisation due to a total loss of flue gas extraction. Further to protect the air heater against temperature excursions.

Requirement: Initiate FD fan trip, which in turn shall initiate a draught group trip.

3.4.4 PA Fans (PA fan per draught group)

Motor protections – recommended to have an alarm on motor winding temp only. Earth faults, phase unbalance etc. is covered under motor protections

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3.4.4.1 All mill motors off;

Intent: To prevent fan stall and prevent PF build-up

Requirement: If all mills are off, the PA fans are pulse tripped.

3.4.4.2 Fan lubricating oil pressure < minimum;

Intent: To protect the fan bearings and shaft journals against loss of lubrication.

Requirement: Initiate PA fan trip, which in turn depending on boiler status shall initiate a boiler capability operation.

3.4.4.3 Fan bearing temperature > maximum (fan and fan motor);

Intent: To protect the fan and –motor bearings and shaft journals against damage.

Requirement: Initiate PA fan trip, which in turn depending on boiler status shall initiate a boiler capability operation.

3.4.4.4 No primary air flow path protection;

Intent: To protect the PA fan against extended operation with no flow/stall conditions and to protect mill against PF build-up.

Requirement: Initiate PA fan trip, which in turn depending on boiler status shall initiate a boiler capability operation.

3.4.4.5 Fan bearing vibration protection;

Intent: To protect the fan rotating components against damage.

Requirement: Initiate PA fan trip, which in turn depending on boiler status shall initiate a boiler capability operation.

3.4.5 PA fans (Dedicated PA fans)

Motor protections – recommended to have an alarm on motor winding temp only. Earth faults, phase unbalance etc. is covered under motor protections

3.4.5.1 Associated mill motor off;

Intent: To prevent PF carry-over/isolate fuel flow and structural damage in primary air ducting.

Requirement: Mill off, trip associated PA fan and close associated dampers.

3.4.5.2 Fan lubricating oil pressure < minimum;

Intent: To protect the fan bearings and shaft journals against loss of lubrication.

Requirement: Initiate PA fan trip, which in turn depending on boiler status shall initiate a boiler capability operation.

3.4.5.3 Fan bearing temperature > maximum (Fan and fan motor);

Intent: To protect the fan and –motor bearings and shaft journals against damage.

Requirement: Initiate PA fan trip, which in turn depending on boiler status shall initiate a boiler capability operation.

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3.4.5.4 Fan bearing vibration protection;

Intent: To protect the fan rotating components against damage.

Requirement: Initiate PA fan trip, which in turn depending on boiler status shall initiate a boiler capability operation.

3.4.5.5 No primary air flow path protection;

Intent: To protect the PA fan against extended operation with no flow/stall conditions and to protect mill against pf build-up.

Requirement: Initiate PA fan trip, which in turn depending on boiler status shall initiate a boiler capability operation.

3.4.6 Air Heater

3.4.6.1 Loss of air heater bearing lubrication;

Intent: To protect the air heater bearings against loss of lubrication.

Requirement: Initiate a low flow alarm in the unit control room and an air heater trip if the alarm is not cleared within an hour. The air heater trip in turn shall initiate a draught group trip.

Note: The alarm and trip functions may be based on low lubrication pressure or flow

3.4.6.2 Air heater bearing temperature > maximum;

Intent: To protect the air heater bearings and shaft journals against damage.

Requirement: Initiate a high temperature alarm in the unit control room and a very high temperature air heater trip which in turn shall initiate a draught group trip.

3.4.6.3 Air heater no rotation protection;

Intent: To protect the air heater and downstream flue gas path against overheating due to due to no heat exchange taken place in the air heater.

Requirement: Initiate ID fan trip, which in turn shall initiate a draught group trip.

Note: The trip function can be achieved by a no rotation signal or gas outlet temperature high signal. Where rotation sensors are used a time delay of max.10 minutes before trip may be used.

3.4.6.4 Air heater fire detection

Intent: To prevent major air heater damage due to fires.

Requirement: Critical Alarm

Note: In most cases the protection settings and philosophies will be those of the relevant OEM at the time of construction.

4. TESTING

4.1 PROOF TESTING AND INSPECTION

- The relevant PS shall prepare and implement a plan for the routine testing of the boiler draught plant protection system and respective protection functions, such that it cover the following aspects;
- Validation of the alarm and trip devices and settings: Alarm and trip value settings and device calibration shall be validated as part of the off load simulated functional tests.
- Off load simulated functional testing: A full off load simulated functional test shall be performed as part of the re-commissioning of the protection system after a major outage or modification or repair to all or part of the boiler draught plant protection system. The periodicity of such tests shall however not exceed six years.
- Inspections: The protection system and devices shall be periodically visually inspected to ensure the integrity of the system and that there are no simulations, unauthorised modifications and no observable deterioration (for example, missing bolts or instrument covers, rusted brackets, open wires, broken conduits and missing insulation).

MAINTENANCE AND TESTING REQUIREMENTS

Maintenance, test and inspection plans shall be prepared to ensure sustainable and reliable operation. The minimum maintenance activities and their respective intervals are captured below;

- **Damper and vane stroke testing:** Draught plant damper and vane operation shall be verified by means of stroke testing at intervals defined in the plant maintenance strategies. The periodicity of such stroke checking shall however not exceed three years.
- **Instrumentation calibration:** Instrumentation calibration shall be verified at intervals defined in the plant maintenance strategies. The periodicity of such calibrations shall however not exceed six years.
- **Validation of the alarm and protection settings:** Alarm and protection settings shall be validated as part of the off load functional tests.
- **Off load functional testing:** A full off load functional test shall be performed as part of the re-commissioning of the draught plant system after a major outage or modification to all or part of the system. The periodicity of such tests shall however not exceed six years.
- **Inspections:** The draught plant shall be periodically visually inspected to ensure the that there are no simulations, unauthorised modifications and observable deterioration (for example, missing bolts or instrument covers, rusted brackets, open wires, broken conduits and missing insulation) of the monitoring, control and protection system.
- **Repairs:** A full off load functional test shall be performed as part of the re-commissioning of the draught plant system after plant repairs to all or part of the system. This shall include damper and valve stroke checking.

Testing Intervals

The time intervals for the defined maintenance, tests and inspections are recommended on the basis of the “time intervals” below;

Interval 1 every three months

Interval 2 once a year

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Interval 3 every three years a year

Interval 4 during general overhaul (GO) but not exceeding six years

Interval 5 after repairs

Test	Interval				
	1	2	3	4	5
Simulation and modification review	X			X	X
Inspections		X		X	X
Verification of damper and vane stroke checking			X		X
Validation of Alarm, and Protection Settings				X	
Off Load Functional Testing				X	
Repairs					X
Instrument Calibration				X	

4.2 DOCUMENTATION OF PROOF TESTS AND INSPECTIONS

The relevant PS shall maintain records in SAP that certify that proof tests and inspections were completed as required. These records shall include the following information as a minimum;

- 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 loop or system tested.
- Results of the tests and inspections.

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6. REVISIONS

Date	Rev.	Compiler	Remarks
January 2015	0.1	H. Kleynhans	Updated to 240 document standard, added protection for fan stall conditions, high flue gas temperature protection and air heater fire detection.
February 2015	0.2	H. Kleynhans	Draft Document for Comments Review
March 2015	1	H. Kleynhans	Final Document for Authorisation and Publication

7. DEVELOPMENT TEAM

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8. ACKNOWLEDGEMENTS

None

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