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Load Rejection and Speed  
Control Verification Standard**

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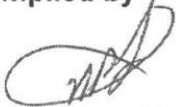
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Compiled by



NP Lecordier

Senior Consultant Turbines  
(Steam)

Date: 13 / 12 / 2012

Approved by



P Magner

Turbine COE Manager

Date: 2012/12/31

Authorised by



ZT Mathe

Senior Manager: Power Plant

Date: 07/01/2013

Approved by TDAC



D. Odendaal

TDAC Chairperson

Date: 30 / 4 / 2013

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### CONTROLLED DISCLOSURE

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## **1. INTRODUCTION**

The South African Grid Code (SAGC) requires that units contracted to island under the Ancillary Service Agreement need to perform islanding tests. The Code furthermore requires that routine islanding testing is to be done on an agreed interval or after modifications to plant that may affect unit islanding capability. Although the above satisfies the Transmission requirements from a Grid perspective, the additional benefits of testing to validate turbine governor systems have not been considered in SAGC. The revision of this standard stipulates the Generation requirements for testing of all units. A flowchart in Appendix A clarifies the different requirements for units contracted to provide an islanding service and those not contracted to island.

In case of conflict between the requirements of the South African Grid Code and this Standard, the South African Grid Code supersedes the Standard.

## **2. SUPPORTING CLAUSES**

### **2.1 SCOPE**

#### **2.1.1 Purpose**

This Standard has the following objectives:

- To stipulate the Eskom Generation requirements for islanding testing of steam driven turbo-generators to satisfy The South African Grid Code requirements;
- To define the minimum testing requirements for proving of turbine governor systems for units not contracted to island.

#### **2.1.2 Applicability**

This Standard is applicable to all operating steam turbine-generator units in Eskom which are contracted to island under the Ancillary Service Agreement. It is not applicable to combined cycle units.

### **2.2 NORMATIVE/INFORMATIVE REFERENCES**

The following documents contain provisions that, through reference in the text, constitute requirements of this document. These documents are subject to revision and users are responsible to ensure that the most recent edition of the documents listed below are used / referenced.

#### **2.2.1 Normative**

- [1] 240-56030556: Routine Overspeed Testing of Main and Boiler Feed Pump Steam Turbines.
- [2] 240-56030575: Steam Turbine Protection Functions - Requirements and Control Standard
- [3] South African Grid Code
- [4] ISO 9001 Quality Management Systems - Requirements

#### **2.2.2 Informative**

- [5] ISO 9004 Quality Management Systems – Guidelines for Performance Improvement

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## 2.3 DEFINITIONS

Definition	Description
Overspeed	Is a speed greater than the normal operating speed range of a prime mover when off load under normal turbine governor system control.
Turbine Governor System	Is the speed/load control loop for the turbine acting on the turbine steam admission valves which should not allow the turbine speed to increase above a predetermined maximum value. The turbine governor system includes the total system for speed/load control e.g. the electronic and hydraulic circuits, electronic-hydraulic converter, positioners, steam valve actuator and mechanical parts of the steam admission valves.
Steam valve hysteresis test	Is a valve stroke test recording hydraulic servomotor pressure vs. valve position for the subject valve, which is assessed for any indications of unacceptable valve response e.g. non-linearity, step changes, sticking action, etc.
Unit islanding	Is the ability of a generating unit suddenly to disconnect from the Transmission System by opening the HV breaker and to control all the necessary critical parameters automatically to a sufficient degree to maintain the turbine generator at speed and excited and supplying its own auxiliary load.
Load rejection	Is the separation of a unit from the Transmission System by the opening of the generator breaker after which the turbine returns to nominal synchronous speed.
Generator Breaker	Is the first electrical breaker in the export system after the generator terminals.
A unit	A steam generator, steam turbine-alternator and all the related equipment, including the step-up transformer, operated together to produce electricity.
Black Start	The provision of generating capacity that, following a total system collapse (black-out), is able to start without an outside electrical supply and energise a defined portion of the Transmission System (TS) so that it can act as a start-up supply for other capacity to be synchronised as part of a process of re-energising the TS.

### 2.3.1 Classification

**Controlled Disclosure:** Controlled Disclosure to External Parties (either enforced by law, or discretionary).

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## **2.4 ABBREVIATIONS**

<b>Abbreviation</b>	<b>Description</b>
AVR	Automatic Voltage Regulator
CV	Control Valve
ESV	Emergency Stop Valve
GO	General Overhaul
HV	High Voltage
MCR	Maximum Continuous Rating
OEM	Original Equipment Manufacturer
PEIC	Production Engineering Integration Coal
PS	Power Station
PSM	Power Station Manager
SAGC	South African Grid Code
SM	Senior Manager

## **2.5 ROLES AND RESPONSIBILITIES**

The relevant Power Station Manager (PSM) shall be responsible for ensuring that the requirements of this standard are implemented. Likewise, the PSM shall ensure that detailed test procedures are developed and followed to ensure the safety of personnel and plant during execution of the tests.

## **2.6 PROCESS FOR MONITORING**

The PEIC Turbine Care Forums are established to address the implementation of the respective standards. Monitoring and reporting form a part of the proceedings of these meetings to ensure effective management of compliance to the applicable standards.

## **2.7 RELATED/SUPPORTING DOCUMENTS**

This document supersedes GGS 0500 and 36-701, both entitled 'Standard for Steam Turbine Islanding, Load Rejection and Speed Control Verification.'

## **3. REQUIREMENTS**

### **3.1 STEAM INLET VALVE TESTING**

Adequate speed control and the prevention of turbine overspeed is greatly dependent on the correct response of the turbine governor system and operation and isolation of Emergency Stop Valves (ESVs) and Control Valves (CVs). This section prescribes testing to ensure that this is achieved.

- The isolation of all turbine ESVs on all relevant cylinders shall be tested in accordance with the requirements of the Steam Turbine Protection Function Standard [2].
- Where facilities exist for on-load valve stroking/testing, this shall be carried out in accordance with the requirements of the Steam Turbine Protection Function Standard [2].

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- c. Steam valve hysteresis tests shall be recorded five to six yearly or after any adjustment or maintenance work on the steam valve or the actuator. The relevant PS Turbine Engineering Manager approves the hysteresis test results before the unit's return to service.

### **3.2 ISLANDING TESTING**

Units contracted under the Ancillary Service Agreement to provide islanding capabilities as follows:

- a. During the first commissioning of new units that do not have black start capability;
- b. During re-commissioning of existing units after a major outage or modification or repair to all or part of the related plant, e.g. excitation, turbine governor system, unit control etc, that may affect islanding capability. This test is conducted within 60 days of achieving full load;
- c. At the first convenient opportunity after an incident of failure to survive a real unit Islanding condition but within 60 days of the unit's return to service;
- d. Islanding capability is tested on each unit per power station within 5 to 6 years (according to the GO cycle) after the previous successful test on that unit or the same time period after a successful real islanding incident on the particular unit. The real islanding incident will be regarded as a successful test if a generating unit is required to island, and the islanding takes place successfully, and the islanding condition is sustained as specified under Acceptance Criteria (par.3.1.5) or is called to synchronise and completes the synchronisation successfully;
- e. At the discretion of the Power Station Manager (PSM), to prove the capability of a unit in order to comply with a production contract;
- f. At the request of the national pool administrator, but subject to the conditions of the contractual agreement between the power station and pool administrator;
- g. At each new Power Station (PS), a once-off reference islanding test shall be conducted, on one unit only, as per the requirements of 3.1.2.1 to 3.1.2.4, but from 100% load for 120 minutes as per the South African Grid Code. Ensure complete documentation of the test (procedures and results).

#### **3.2.1 Islanding Test Procedure.**

- a. The unit is at steady state conditions above or at 60% of MCR.
- b. All protection systems and safety devices are in normal operating conditions.
- c. All plant shall be in the normal MCR operating status and configuration as far as possible. No extra auxiliary plant should be run or removed from service for the sake of a successful test.
- d. No special modifications to the plant for the purpose of the test are allowed, except the installation of monitoring equipment.
- e. The unit supplies its own electrical auxiliary load during the test.
- f. The AVR should be fully commissioned and in the Automatic mode.
- g. All operating within the first two minutes following the initiation of the test (HV breaker opening), shall be noted and the System Operator informed for approval.
- h. No additional operating staff above the normal quota is allowed at the control desk for the duration of the test.
- i. Islanding tests shall be carried out by the power station staff, assisted as required by contractors, or as stipulated in the contract in the case of new plant.

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### **3.2.2 Preconditions for islanding test**

- a. Within 60 days prior to performing an Islanding test, a satisfactory physical over-speed test is done in accordance with Standard 240-56030556 'Routine Overspeed Testing of Main and Boiler Feed Pump Steam Turbines' [1].
- b. Immediately prior to carrying out an islanding test, the overspeed protection is tested by oil injection or other appropriate simulation and all steam valves stroke checked (where this facility is available).
- c. Where applicable, the function of the bled steam non-return valves is confirmed before an islanding test is performed.
- d. The PSM ensures the availability of detailed procedures to ensure the safety of personnel and plant during the tests. These procedures shall include details such as the level and number of staff, limits, and special precautions necessary for the test.

### **3.2.3 Acceptance criteria**

- a. The turbine shall settle at or close to its nominal speed, supplying the entire unit's auxiliary load. The islanding condition shall be sustained for at least 20 minutes and the unit shall be re-synchronised and loaded to contracted output.
- b. The maximum turbine speed recorded during an islanding test should not exceed 106% of rated speed.

### **3.2.4 Unsuccessful Tests**

- a. In the event that an islanding test fails to meet the acceptance criteria, the reason for the failure shall be investigated and a report submitted to the PEIC SM and System Operator.
- b. The cause for the failed islanding test should be rectified and a repeat islanding test conducted within 60 days after the failed test.

## **3.3 TURBINE GOVERNOR SYSTEM RESPONSE VERIFICATION**

- a. Units not contracted to provide an islanding service verify turbine governor system response by means of one of the following three options:
  - Off load turbine governor system response verification tests (3.3.1),
  - Load rejection (3.3.2) or islanding tests (3.2) or
  - No testing, provided the turbine is controlled by an electronic governor and the requirements stipulated in section 3.3.3 are met.
- b. In addition to the above, the following units, when not contracted to island, must successfully complete a single (once-off) load rejection test as per section 3.3.2, but from 100% load:
  - New units;
  - Units returning to service after long term storage;
  - Units after replacement of the turbine governor system, in full or parts thereof, with new design.
- c. Turbine governor system response verification is performed as follows:

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- During re-commissioning of existing units after major modification or repair to all or part of the related plant, e.g. excitation, turbine governor system, unit control etc, that may affect turbine governor system response.
- At the first convenient opportunity after an incident of failure to survive a real or test load rejection condition but within 60 days of the unit return to service.
- This capability is tested on each unit per power station within 5 to 6 years after the previous successful test or the same time period after a successful real load rejection incident on the particular unit. The real load rejection incident will be regarded as successful if it meets the acceptance criteria given in section 3.3.2.2.

### **3.3.1 Off load turbine governor system response verification tests.**

- a. Simulation of turbine governor system speed/load input(s) will be required for this test.
- b. The testing procedure shall be approved by the PEIC SM. A typical testing procedure is described below, but similar procedures which achieve the desired proving may be considered:
  - The unit is off load with the main and reheat (where applicable) steam inlet governor valves in the fully open condition.
  - The turbine governor system response as a result of a sudden reduction in generator load or increase in speed, i.e. load rejection, is verified by simulation of the initiating condition.
  - The load rejection condition is simulated by either a step increase in turbine speed and/or a step reduction in generator load (underlined indicates simulated parameters).
  - The time period from the load rejection initiation to steam valve closed limit is accurately recorded. The results of this test are compared with previous test results from the same unit and any deviation will be investigated. Initially a once off actual load rejection test may be required to obtain a set of reference values. Acceptance criteria shall be developed from experience and documented by the PS.
- c. Results of tests shall be recorded and stored for history purposes.

### **3.3.2 Load rejection tests**

- a. The unit is at steady state conditions above 60% load.
- b. All protection systems and safety devices are in normal operating conditions.
- c. The actual turbine speed and steam valve position response is recorded during the test.

#### **3.3.2.1 Preconditions for load rejection tests**

- Within 60 days prior to performing a load rejection test, a satisfactory physical over-speed test is done in accordance with Standard 240-56030556 'Routine Overspeed Testing of Main and Boiler Feed Pump Steam Turbines [1].
- Immediately prior to carrying out a load rejection test, the overspeed protection is tested by oil injection/simulation and all steam valves stroke checked where this facility is available.
- Where applicable the function of the bled steam non-return valves is confirmed before a load rejection test is performed.
- The Power Station Manager provides detailed procedures to ensure the safety of personnel and plant during the tests.

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### **3.3.2.2 Acceptance criteria**

A test is regarded as successful if the turbo-generator's speed rise does not result in an automatic overspeed trip.

### **3.3.2.3 Unsuccessful tests**

- In the event that a load rejection test fails to meet the acceptance criteria, the reason for the failure shall be investigated and rectified and the test repeated within a 60 day period.
- Should the PSM decide to perform an islanding test instead, then this shall be performed as per section 3.2.

### **3.3.3 Electronic governor**

- a. Machines equipped with electronic speed control loops with internal verification functions may not be required to perform governor response testing provided that approval is obtained from the PEIC SM. This approval will be subject to the following:
  - The documented approval of the OEM is obtained and
  - The system is reviewed by the PEIC SM or his appointed representative, to ensure adequate integrity and reliability of testing and
  - The turbine speed control loops in these governors are continuously active and any failure would be immediately alarmed.
  - The testing procedure includes the proving of the complete Turbine Governor System, as a whole or in sections6      Waivers and variations

## **3.4 RECORDS**

- a. Should a condition arise whereby PSM considers it necessary to delay a test beyond the set period; approval shall be obtained from the PEIC SM or the duly appointed representative.
- b. A request for a waiver should be submitted by the PSM, detailing the justification for the proposed delay, include a brief history of the machine's previous performance, and including a proposed alternative date for the test.
- c. Detailed records and reports of unit islanding tests shall be kept by the PS. The reports must illustrate that all the key criteria were met, including the time period it took for the unit to stabilise.
- d. To enable meaningful analysis to be done of test results, the following minimum parameters are recorded:
  - Turbine speed or generator frequency
  - Generator voltage and current
  - Generator load
  - Exciter voltage and current
  - Anticipatory device position (where applicable).

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#### **4. AUTHORISATION**

This document has been seen and accepted by:

<b>Name</b>	<b>Designation</b>
L Joubert	Senior Engineer, Turbine CoE (Quality Rep)
	This Document has been approved by TDAC ROD 13 February 2013

#### **5. REVISIONS**

<b>Date</b>	<b>Rev.</b>	<b>Compiler</b>	<b>Remarks</b>
November 2012	0	NP Lecordier	Draft Document for review created from 36-701
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#### **6. DEVELOPMENT TEAM**

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

- N Lecordier

#### **7. ACKNOWLEDGEMENTS**

The author acknowledges the work of KR Mathwin in the development of the previous standard, upon which this document is based.

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## APPENDIX A: FLOWCHART FOR TESTING

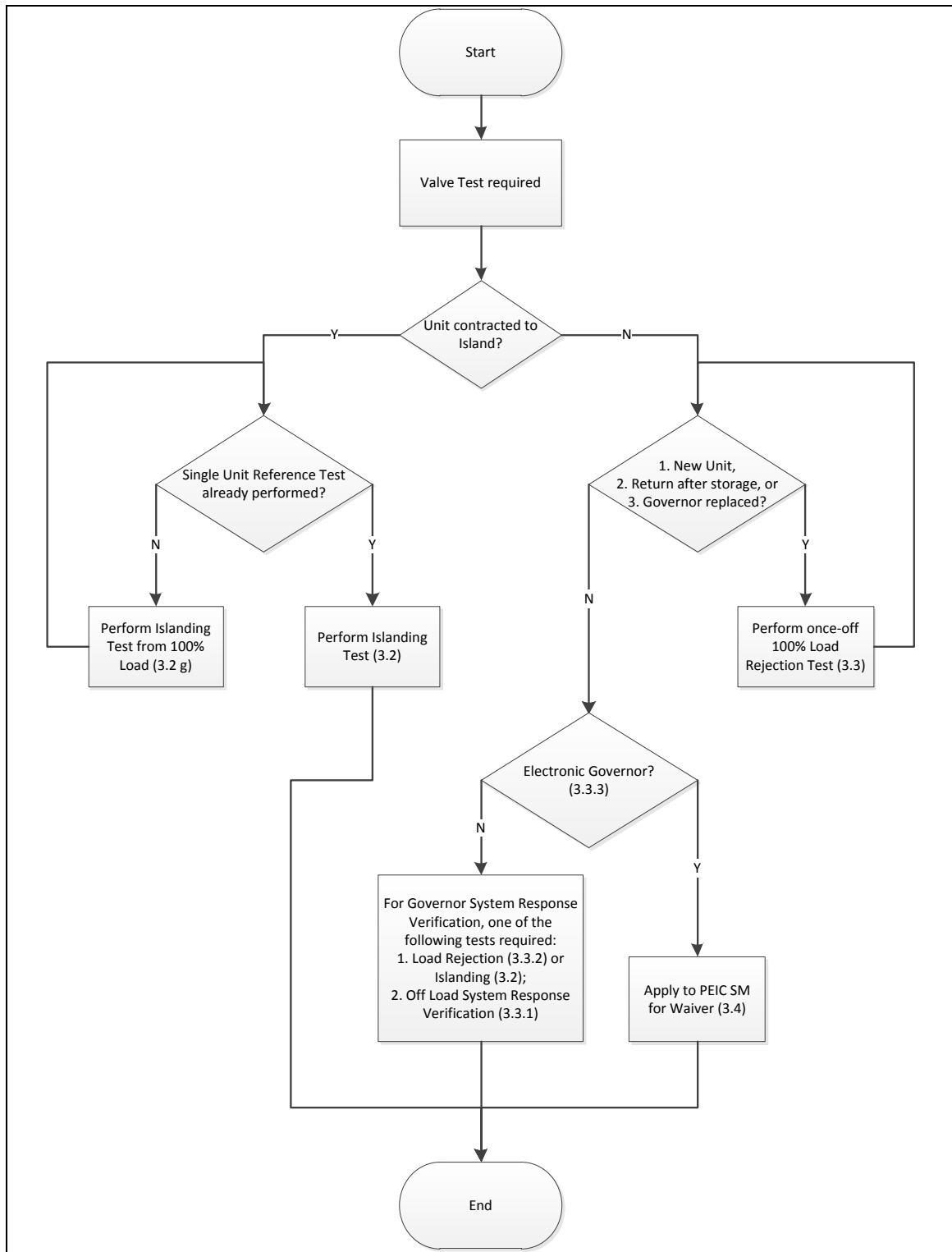


Figure 1: Testing Flowchart

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