NATIONAL NUCLEAR REGULATOR

LICENCE

DOCUMENT

No.	Title	Rev.
LD-1093	REQUIREMENTS FOR THE FULL SCOPE OPERATOR TRAINING SIMULATOR AT KOEBERG NUCLEAR POWER STATION	2

APPROVED: ______________________
CHIEF EXECUTIVE OFFICER

DATE APPROVED: 06/02/06

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1. INTRODUCTION

1.1 Purpose

This document defines the minimum functional requirements for the full scope simulator used for operator training at Koeberg Nuclear Power Station, the criteria for degree of simulation, performance and the functional capability of the simulated control room controls and instrumentation.

1.2 Scope

This licence document is applicable to the full scope simulator used in operator training at Koeberg Nuclear Power Station.

2. DEFINITIONS

Backtrack - Restoration of the simulator to a previous set of conditions that have been automatically recorded at designated time intervals.

Best estimate - Unit One plant response data, based upon engineering evaluation or operational assessment.

Computed values - Physical parameters calculated by the simulator mathematical models and stored in computer memory.

Critical parameters - Input parameters to safety systems and those parameters that require direct and continuous observation to operate the power plant under manual control.

Fast time - A condition whereby the dynamic simulation takes place at a speed greater that that of normal simulation.

Freeze - A condition whereby the dynamic simulation is interrupted and remains static until the simulator is taken out of the "freeze" mode, at which time dynamic simulation resumes.

Full scope simulator - A simulator incorporating detailed modelling of systems of Unit One with which the operator interfaces with the control room environment. The control room operating consoles are included. Such a simulator demonstrates expected plant response to normal and abnormal conditions.

Functionally simulated hardware - Hardware that has dynamic interface with the real time simulation.

Initialisation conditions - A set of data that represents that status of Unit One from which simulation can begin.

KIT - The plant process computing system.

Licence - The current variation of Nuclear Licence No. NL-1.

Licensee - The holder of the current variation of Nuclear Licence No. NL-1.

Malfunction - Failure or degradation in performance of plant equipment.

NNR - National Nuclear Regulator

NSSS - Nuclear Steam Supply System

Operational control panels - Panels that enable the operator to perform the required manual safety actions, equipment surveillance and to monitor normal and abnormal operating conditions of the plant.

Operator training - Training given to prospective and current licensed reactor and senior reactor operators.

Passive malfunctions - Those failures which do not become evident to the control room operator until the affected system is called upon to function.

Real time - Simulation of dynamic performance in the same time base relationships, sequences, durations, rates and acceleration as the dynamic performance of Unit One.

SG - Steam Generator

Snapshot - The instantaneous storage of existing conditions at any selected point in time. The stored condition then becomes a temporary initialisation point and may be called up repeatedly.

Unit One - "Unit One" refers to the reference plant, Unit One at Koeberg Nuclear Power Station.

3. REFERENCES

American National Standard ANSI/ANS-3.5 – 1998.

4. SCOPE OF SIMULATION

The simulator is to be used as a training and examination tool in support of initial and requalification licence training.

The degree of simulation shall be such that the actions taken by the operator on both the simulator and Unit One would be the same when evolutions or malfunctions, as listed in section 4.1 are performed.

4.1 Simulator Capabilities

The response of the simulator resulting from operator action, no operator action, improper operation action, automatic reference unit controls, and inherent operating characteristics shall be realistic and not violate the physical laws of nature, such as conservation of mass, momentum, and energy, and meet the accuracy requirements of Section 5, "Performance Criteria".

4.1.1 Normal Plant Evolutions

The simulator shall as a minimum, be able to perform the following normal operating evolutions:

1. Draining to mid loop level and refilling.
2. Maintenance Cold Shutdown with vessel head on.
3. Static and dynamic venting.
4. Normal Cold Shutdown, with vessel head on and the NSSS water solid.
5. Formation and collapse of a pressuriser bubble.
6. Plant heat up from cold shutdown to hot shutdown, and vice versa, plant cool down.
7. Reactor start up and shutdown.
8. Power escalation and reduction, (steady state conditions, extended low power operation, stretch-out).

4.1.2 Plant Malfunctions

The simulator shall as a minimum, be able to perform the following abnormal operating transients:

1. Loss of instrument air to various components, which affect plant performance.
2. Loss or degraded electrical power to the station, including:

   a) Loss of off-site power, with successful house load operation.
   b) Loss of emergency power; failure of emergency diesel generators.
   c) Loss of power to individual electrical distribution boards.
   d) Loss of power to the individual instrumentation boards (AC as well as DC) that provide power to control room indications or plant control functions affecting plant response.

3. Malfunctions affecting the reactor coolant pumps, including vibrations and seal failures.
4. Loss of forced reactor coolant flow due to single or multiple pump failure.
5. Loss of condenser vacuum.
6. Loss of the service water (SEC).
7. Loss of the component cooling (RRI) and leaks on the component heat exchangers inside and outside the containment.
8. Loss of normal feedwater, failures of pumps and valves affecting the feedwater system.
9. Failure of a train of the reactor protection system.
10. Control rod failures.
11. Inability to manipulate the control rods.
12. Fuel cladding failure.
13. Turbine and generator malfunctions.
14. Turbine trip; generator trip.
15. Failure of the following automatic control systems:

    a) Control rod control systems,
    b) Chemical and volume control system,
    c) Steam dump system,
    d) Feedwater control system.

16. Failure of the pressuriser pressure and level control system.
17. Reactor trip.
18. Failure of any nuclear instrumentation channel, with the possibility of simulating corrective actions such as channel bypass and placing the channel in the safe position.
19. Failure of any process instrumentation channel, alarm or control system, related to:

    a) Control rod system,
    b) Chemical and volume control system,
    c) Steam dump system,
    d) Feedwater pump and feedwater control system,
    e) Pressuriser pressure and level control systems,
    f) Turbine control system, and of any channel that has an input into the reactor protection system; with the capability of simulating corrective actions such as channel bypass and placing the channel in the safe position.

20. Leaks on the chemical and volume control system.
21. Leaks on the condensate, feedwater and steam system.
22. Passive failures in systems such as the engineered safety features and the auxiliary feedwater system.
23. Malfunction of any major component of those simulated systems directly affecting nuclear safety.
24. Loss of coolant:

    a) Significant SG tube leaks; single and multiple SG tube ruptures.
    b) Inside and outside containment (loss of re-circulation).

c) Small break LOCA, at different locations, showing natural circulation, two-phase natural circulation, phase separation and reflux, core uncovery and superheat, breaking of the loop seal, containment pressures, temperatures and activity.
d) Large LOCA showing containment pressures, temperatures, activity and humidity, core uncovery and cladding temperatures.
e) Failure of safety and relief valves.

25. Total loss of all AC power (offsite and onsite).
26. Complete loss of feedwater (normal and emergency), with the possibility of applying the feed and bleed method (opening of the pressuriser relief valves), to cool down the core.
27. Main steamline break as well as main feedline break, inside and outside containment.
28. Failure of the automatic reactor trip system.
29. Accidents causing a serious threat to the plant critical safety functions, such as:

    a) Return to criticality after a reactor trip.
    b) Failure of emergency core cooling systems during a LOCA, resulting in core exit thermocouple temperatures in excess of 650°C.
    c) Accidents inside containment that lead to containment pressures in excess of the design values and, hence, to containment failure.
    d) SG tube rupture, combined with a secondary side leak (stuck open safety valve), or combined with a loss of AC power.
    e) Loss of coolant accidents combined with instrumentation failure or drift.

30. Natural circulation cooldown with formation of a bubble in the vessel head.
31. Loss of natural circulation in one or more loops.

The scope of simulation shall be such that the control room instrumentation will reflect the effects of the malfunction-induced adverse conditions (pressure, temperature, activity). For example, erratic SG level readings in the case of a feedwater line rupture. The core exit thermocouple readings must all be displayed with failure capability in either direction.

4.2 Simulator Environment

The simulator shall duplicate Unit One control room. The control panels of the simulator shall be identical to those in the control room. The control panels shall have operational controls, alarms, labels, instrumentation, and other man-machine interfaces to ensure that an experienced control room operator does not distinguish differences between the control room and the simulator when performing the evolutions and malfunctions listed in section 4.1.

All the controls, alarms, instrumentation, operational aids, etc which are on the panels in Unit One shall be duplicated on the simulator. Items may be omitted from the simulation subject to justification based on a training needs analysis.

Maintenance shall be performed on the control panels to ensure that the reliability of controls, alarms, instrumentation etc. is equivalent to that of Unit One control room.

The simulator environment shall replicate Unit 1 with respect to flooring, walls, lighting, communication systems and other items of layout such as procedures, furniture etc.

4.3 Systems to be simulated and degree of completeness

The degree of simulation of the systems that are controlled from the control room shall be to the extent necessary to allow the operator to perform the evolutions described in 4.1.1 and to respond to the malfunctions described in 4.1.2. These systems shall be complete to the extent that the operator can perform these control manipulations and observe simulated unit response equivalent to Unit One.

Operations performed from outside the control room that provide inputs into the simulation models necessary to perform the evolutions and malfunctions listed in section 4.1 shall be simulated and performed from the instructor's console. The degree of simulation shall be such that the operator is able to interface with the remote activity being simulated in a manner similar to interface present on Unit One.

4.4 Simulator Training Capabilities

The simulator shall possess a minimum capacity of 99 initialisation conditions, of which 20 shall be available at any time on energising the simulator. These 20 conditions shall be at different plant states, at different stages in core life and at different poison concentrations.

It shall be able to insert and terminate the plant malfunctions listed in section 4.1.2. The simulator shall be capable of simulating those plant malfunctions expected to occur by either design or from operational experience. The introduction of a malfunction shall not alert the operator to the impending malfunction in any manner other than that which would occur in Unit One. Provision shall be made for incorporating additional malfunctions identified from plant experience and not listed in section 4.1.2.

The simulator shall have the capability of allowing simulation freezing, backtrack, snapshot, and replay. "Fast time" operation shall be available for models where parameters change slowly and slow time shall be available for demonstration purposes.

The simulator shall permit the instructor to act in the capacity of an individual performing local actions, external to the control room in support of 4.1.1 and 4.1.2.

4.5 KIT (ERF) SIMULATION

The degree of simulation for the KIT shall be such that while the simulator is running, an experienced control room operator does not distinguish differences between Unit One and the simulator when evolutions or malfunctions listed in section 4.1 are being performed. The simulation shall be such that when any of the actions listed in section 4.1 are performed then the KIT response will be the same with respect to simulated systems, i.e. on comparison between the instrumentation on the panels and the KIT there will be no difference.

5. PERFORMANCE CRITERIA

5.1 Steady State Operation

The accuracy of the simulator data shall be comparable to both full and intermediate power levels of the available data from Unit One. The parameters displayed on the control panels can have the instrument error added to the computed values. During steady-state testing, the accuracy of the computed values shall be determined from a minimum of three points over the power range:

1. The simulator instrument error shall not be greater than that of the comparable meter, transducer and related instrument system of Unit One;

2. The stability of the simulator-computed values for steady state, full power operation, with the control system in "AUTO" shall not vary by more than ± 2% of the initial values over a 60 minute period. As a minimum, the following parameters must comply.

   a) Net NSSS thermal power to generated electrical power;
   b) Reactor coolant system temperature and steam generator pressure;
   c) Feedwater flow to reactor thermal power;
   d) Mass balance of the pressuriser;
   e) Mass balance of the steam generator.

3. The simulator-computed values of critical parameters shall agree within ±2% of the Unit One parameters. As a minimum, the following parameters must comply:

   a) Reactor thermal power;
   b) Reactor hot and cold leg temperatures;
   c) Feedwater flow;
   d) Steam pressure;
   e) Generated electrical power;
   f) Re-circulation flow;
   g) Reactor coolant system pressures.

4. The simulator-computed values of non-critical parameters shall agree within ± 10% of the Unit One parameters.

5.2 Transient Operation

The simulator shall perform to the satisfaction of the NNR, during the evolutions and malfunctions listed in section 4.1. Performance tests shall demonstrate:

1. Both the simulator and Unit One responses to alarms and automatic actions are the same,

2. That the accident propagations produced by the simulator are in agreement with:

- data collected directly from the reference unit;
- data generated through engineering analysis with a sound theoretical basis;
- data collected from a plant which is similar in design and operation to the reference unit;
- data from subject matter expert estimates;

3. Compliance with Unit One periodic test acceptance criteria,

4. Comparable results to the Unit One plant commissioning test reports and the plant start up test procedures, where applicable.

5.3 Simulator Operating Limits

There shall be controls provided, to alert the instructor when certain simulator operating parameters approach values indicative of events beyond the implementation model or known plant behaviour.

5.4 Monitoring Capability

It shall be necessary for the simulator to provide hard copy transients data in the form of either plots or printouts for critical parameters during the evolutions and malfunctions listed in section 4.1. This monitoring capability shall provide time and parametric resolution to determine the compliance with the performance criteria listed in section 5.1 and 5.2.

6. SIMULATOR SOFTWARE CONTROL

The licensee shall have an approved process in place to ensure that software changes are carried out in a controlled manner.

6.1 Plant – Simulator Modifications

When it is determined that a modification is required on Unit One, a review shall be performed to determine the modification's impact on simulator training and the Licensee shall decide whether the modification is to be incorporated into the functionality of the simulator. The Licensee shall have standards in place to ensure the uniformity of the review process. This review shall be performed prior to the modification being implemented on Unit One. Simulator modification may precede plant modifications by a maximum of 6 months if required, based on the need for training prior to plant implementation.

The licensee shall retain evidence of plant modification reviews.

7. SIMULATOR TESTING

7.1 Annual Testing

The simulator shall be tested by the licensee every 12 months. (An allowance of 3 months is made for the planning of outages. That is, the simulator shall be tested within every 15 month period).

The tests to be performed are:

1. The accuracy of steady state operation at 100% power shall be verified by suitable comparison of simulated analogue sensor values with benchmark values. Simulated analogue sensor values shall not differ by more than the limits set out in paragraph 5.1 and 5.2.
2. A selection of 3 tests from section 4.1 that will comply with the criteria as per section 5.2 (The same 3 selected transients are to be repeated each time).

7.2 Modification Tests

If a modification is made to the simulator such that:

1. The modification has the potential to negatively affect simulator fidelity, capabilities or performance, the following shall be performed:

    a. New reference data shall be acquired.
    b. The test listed in 7.1.1 and the 3 transient tests selected in 7.1.2 shall be performed on the modified simulator whilst monitoring key performance data.
    c. The licensee shall conduct a review in order to reconcile any differences, between the newly captured performance data and the previous baseline data, to be predictable consequences of the modification. Reference data from the applicable source described in 5.2 must be used in order to reconcile performance differences.

2. The modification is such that it only affects individual systems or components then only performance tests on the affected systems and components and tests listed in section 7.1 needs to be performed.

8. DOCUMENT CONTROL

The following documents shall be available for the NNR to review:

8.1 The manufacturers design data.
8.2 Test reports for tests performed under section 7.
8.3 Performance data for tests conducted as part of section 7.
8.4 Reviews of plant modifications for consideration for inclusion in the simulator.
8.5 Administrative controls of simulator modification process.
8.6 Design data for simulator modifications.
8.7 Source code for any software modifications to simulation models.
8.8 Controls in place to satisfy section 6.

8.9 A list of the set of transients used in section 7 and the initial simulation conditions used at the start of such tests.

Records that demonstrate that the licensee meets the requirements of this document shall be maintained for the life of the simulator.

9. SUITABILITY OF THE SIMULATOR FOR TRAINING PURPOSES

9.1 In order to fulfil the requirements of LD-1081, it is necessary to demonstrate to the NNR the fitness for purpose of the simulator for the task at all times. This demonstration is dependent on the simulator tests, given in section 7, being carried out to the satisfaction of the NNR.

9.2 Should the simulator be considered by the NNR to be unsuitable for training purposes, its use as a training tool will not be recognised by the NNR for Licence purposes.

	Circular to the CEO OF THE NATIONAL NUCLEAR REGULATOR 31 JANUARY 2006	PAGE 1 OF 1

APPROVED
CHIEF EXECUTIVE OFFICER
06/02/01
DATE

1.0 Title of Circular

Approval request for NNR licensing document LD-1093 Rev 2: "Requirements for the full scope operator training simulator at Koeberg Nuclear Power Station"

2.0 Purpose

To obtain the CEO's approval of the document in order to issue the licence document to Eskom.

3.0 Discussion

As indicated in the Manco approval record the Koeberg training simulator was upgraded and as such the licence document LD 1093 required updating taking cognisance of the requirements of the updated American ANSI Standard of 1998 (updated from the 1988 standard) which was used to upgrade to simulator.

The changes are minimal and do not significantly change the requirements as currently indicated in Rev 1 of LD 1093.

The process for compiling and reviewing the document has been followed and is indicated in the attached Manco approval record.

4.0 Recommendation

It is recommended that the CEO approves the new licence document, LD-1093 Rev2 .

5.0 Financial Implication

No additional financial implication

6.0 Other Implications

None.

7.0 Quality Assurance Trail

See the attached MANCO approval record.

OFFICE OF THE
CHIEF EXECUTIVE OFFICER
RECEIVED 2006-02-01
RETURNED 2006-02-06

06 00284

Recommended for Approval By

Mr G Clapisson	[signature]	PRD: Senior Manager	31 January 2006
Name	Signature	Designation	Date

Approved for Implementation By

Mr M Magugumela	[signature]	Chief Executive Officer	06/02/06
Name	Signature	Designation	Date

APPROVAL RECORD (LD-1093, rev 2)

1. **TITLE OF CIRCULAR**

   Approval request for Revision 2 of the Licence Document, LD-1093, Requirements for the full scope operator training simulator at Koeberg Nuclear Power Station.

2. **PURPOSE**

   To obtain approval for the revisions to LD-1093.

3. **ISSUE**

   The Koeberg operating training simulator was upgraded by modification 99013. The upgrade was seen as an opportunity to review the applicability of the requirements contained in LD-1093.

4. **DISCUSSION**

   This simulator was upgraded to replace the computer hardware, primary system model, core model and the steam generator and steam supply system model. The vendor was the company CAE in Montreal, Canada. The upgrade was done in accordance with the latest American National Standard for Nuclear Plant Simulators for use in Operator Training and Examination, ANSI/ANS-3.5-1998. The licence document had to be reviewed as it was written with guidance from the older version of ANSI/ANS-3.5-1985. The review focussed on the applicability of the requirements contained in LD-1093 with the 1998 version of the standard. During the review process Eskom provided specialist assistance and input to the proposed changes. The changes turned out to be minimal and does not significantly change the requirements as currently found in Revision 1 of LD-1093.

5. **RECOMMENDATION**

   It is recommended that the NNR approve the new revision to LD-1093.

6. **FINANCIAL IMPLICATION**

   No financial implications.

7. **OTHER IMPLICATIONS**

   None.

8. **QUALITY ASSURANCE TRAIL**

Prepared By (Responsible Individual)

Name	Signature	Designation	Date
Ubert Coetzee	[signature]	Process Coordinator	06/09/2005

Reviewed for Technical Compliance By

Name	Signature	Designation	Date
Neil Fritz		Senior Regulatory Officer	06-09-2005

Reviewed for Legal Compliance By

Name	Signature	Designation	Date
R. ELK		SLA	30/1/06

Recommended for Approval By

Name	Signature	Designation	Date
R. ELK		CHAIRMAN: MANCO	30/1/06

Approved for Implementation By

Name	Signature	Designation	Date