NATIONAL NUCLEAR REGULATOR

For the protection of persons, property, and the environment against nuclear damage

INVESTIGATION REPORT

REPORT ON NNR INVESTIGATION FOLLOWING
THE RADIOLOGICAL EVENT AT
THE NTP RADIOCHEMICALS FACILITY ON THE NECSA PELINDABA SITE
ON 02 NOVEMBER 2013

NTWP-INV-2013-0001

APPROVAL RECORD

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1. INTRODUCTION

At approximately 10H37 on 02 November 2013, the NNR received notification that the Necsa Emergency Control Centre (ECC) had been activated following a radiological event at the NTP Radiochemicals Complex – Building P1701 on the Necsa Pelindaba site. In response to the notification the NNR dispatched representatives to the Necsa ECC. The NNR representatives arrived at the Necsa ECC at 12H00.

On arrival at the Necsa ECC the NNR representatives were informed that –

- there had been an incident in Cell 19 within the NTP Radiochemicals Complex resulting in a release of radioactivity into the building.
- the Necsa ECC was activated shortly before 10H00.
- elevated levels of radiation were detected in the facility and workers in the facility had been evacuated.
- there had been a release of iodine and noble gasses to the environment via the P-1701 stack.
- all personnel on site had been ordered to remain indoors.
- a team wearing safety equipment including breathing apparatus had entered the facility and confirmed that the top alpha window in Cell 19 had broken.
- field teams had been dispatched but had not detected any radioactivity in the surrounding area.
- based on estimates of dose projections, there was no need to activate the off-site emergency plan.

The NNR conducted preliminary dose evaluations and confirmed that the impact to persons off the Pelindaba site was low and posed no immediate danger.

The NNR issued a press release –

- confirming that notification of an event had been received from Necsa.

- while there had been a release of noble gas and iodine, there was no need to activate the Necsa off-site emergency plan.

Notwithstanding the fact that the off-site impacts were low, the NNR viewed the event as representing a breakdown or degradation of nuclear safety at the facility. The NNR therefore undertook an investigation into the event. Operations in the facility were suspended and resumption of operations will not be permitted pending the outcome of the NNR investigation.

2. NNR INVESTIGATION TEAM

The NNR investigation team comprised the following members –

Name	Designation
T Pather (Team Leader)	Manager: NTWP
S J Mosoeunyane	Chief Inspector: NTWP
A Singh	Functional Coordinator: Operational Safety
A Joubert	Principal Specialist: ERP
M Mpundu	Principal Specialist: Design Safety
H van Graan	Senior Specialist: ERP

3. PURPOSE

The purpose of this report is to detail the NNR findings from the investigation into the event that occurred at the NTP Radiochemicals facility on the Necsa Pelindaba site on 02 November 2013.

4. INVESTIGATION METHODOLOGY

The sources of information for the investigation included the following –

- reviewing the investigation conducted by the holder;
- reviewing video footage of the event;
- facility walkthrough;
- interviewing management and operating staff;
- interviewing specialists at the facility (design and chemistry);
- reviewing maintenance records;
- reviewing various procedures related to production activities;
- analysing production records;
- reviewing Necsa ECC documentation;
- review of the Initial Notification of the occurrence;
- review of Holder Investigation Report and Action Plan.

5. INVESTIGATION FINDINGS

The NNR investigation findings are presented below and were grouped into the following areas –

- Quantification of Radiological Impact to Workers and Members of the Public;
- INES Rating of the Event;
- Management Approach and Nuclear Safety Culture;
- Safety Case Documentation;
- Handling of Event;
- Findings Related to the Cell;
- Ventilation System;
- Evaluation of Holder Investigation Report and Action Plan.

5.1. Quantification of Radiological Impact to Workers and Members of the Public

5.1.1. Radiological Impact to Workers

The investigation team noted that –

i. whilst elevated dose rates of approximately 3 mSv/h were recorded in the facility red area (area immediately behind Cell 19), no personnel were in this area at the time of the event. All workers were conducting activities in the facility blue area (area in front of the hot cells).

ii. shortly after identification of the event (within 5 minutes of the event) all workers were evacuated from the facility.

iii. the first responders to the event were provided with safety equipment including protective overall and breathing apparatus prior to their entry into the facility.

iv. all personnel that were present within the facility at the time of the incident were subjected to a whole body count on Monday 04 November 2013.

Review of the worker doses recorded on both the TLDs and Electronic Personal Dosimeters (EPDs) worn by the workers in the facility showed no accumulation of dose that would approach the dose limits or the worker dose constraints. Furthermore the results of the whole body counts undertaken showed no exposure of the workers.

The TLD and EPD results as well as whole body counts are detailed in Table 1 below –

Table 1: Results of Worker Doses as Recorded on EPD and TLD as well as Results of Whole Body Counts

Personnel that were Present in the Facility During the Event		EPD (mSv)		TLD (mSv)	Whole Body Count (mSv)
		HP10	HP07	13/10/28 13/11/02	
Name	Necsa Employee Number				
Malefo, D	0174041	0.002	0.003	0	0.0005
Manyediwane, M	0425796	0.001	0.001	0	0
Mnizi, V	0425753	0.005	0.008	0	0
Molokoane, TS	289876 R	0.000	0.000	0	0.0008
Netshandama, A	281328	0.003	0.004	0	0
Ngubeni, L	0403113	0.004	0.005	0	0
Seeme, LR	0267953	0.002	0.003	0	0.00056
Sekgodi, CM	406120	0.002	0.001	0	0
First Responders					
Rootman JP	1875787	0.008	0.013	0	0
Wortmann HG	1837591	0.002	0.001	0	0

5.1.2. Radiological Impact to Members of the Public

5.1.2.1. Quantification of radiological releases

In quantifying the total activity of iodine released the investigation team considered the qualitative data available from the Facility SCADA and LAB Impex systems as well as the quantitative evaluation of the stack maypack systems which was undertaken by the Necsa Radioanalysis Laboratory in Building P-1600.

The release of noble gas was quantitatively determined from the results in the Facility Lab Impex system.

The release were therefore quantified as follows –

Iodine 5.379E09 Bq

Noble Gas 1.280E12 Bq

5.1.2.2. Meteorological data

The investigation team reviewed the hourly averaged and per minute meteorological data collected at Pelindaba for the day in question. Based on the qualitative data from the Facility Lab Impex system the investigation team assumed that the release occurred within the first twenty minutes of the event and the per minute data for the period in question was (07H40 – 08H00) was averaged and used in the subsequent dose predictions.

5.1.2.3 Dose predictions

Predictions of public doses were undertaken using –

i. HotSpot ver 3.0.1 dispersion software developed by Lawrence Livermore National Laboratories in the USA.

ii. PC Cosyma accident consequence assessment software developed jointly by National Radiation Protection Board (NRPB) in the UK and Kernforschungszentrum Karlsruhe GmbH (KFK) in Germany

The iodine source term was assumed to all be iodine -131 and the noble gas release was all assumed to be xenon-133. This approach is considered as being conservative as these nuclides have the highest dose conversion factors per unit release.

The release was assumed to have occurred over a twenty minute period (07H40 – 08H00) and the average wind speed for the duration of the release was determined to be 1.85 m/s from a SSE direction (158.9 degrees)

The two models gave similar results. The maximum dose predicted by both software codes are presented in Table 2 below –

Table 2: Predicted Maximum Whole Body Doses and Dose to Thyroid

Code	Maximum Total Effective Dose (Sv)	Maximum Dose to Thyroid (Sv)	Distance from release point (km)
PC Cosyma	1.79E-07	3.07E-06	0.2
HotSpot ver 3.0	2.60E-07	4.3E-06	0.3

Further the results from the HotSpot modelling are presented graphically in Figure 1 and Figure 2 below –

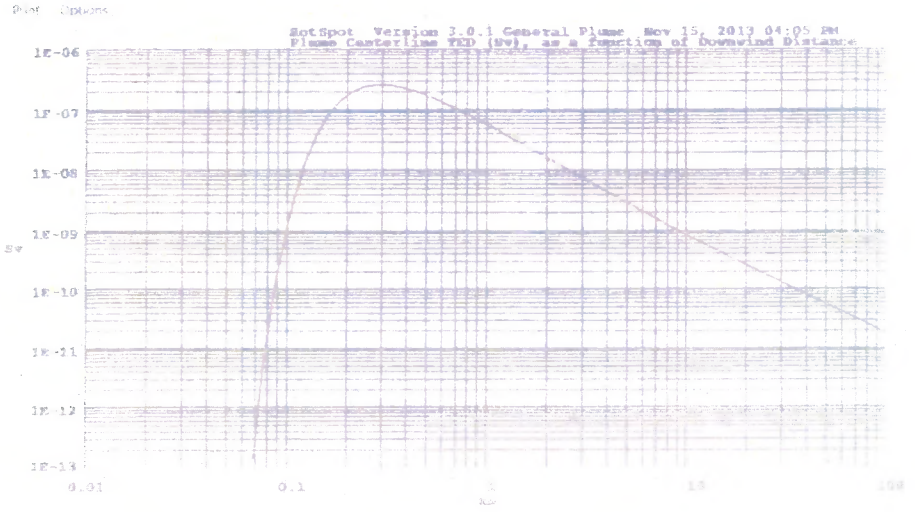

Figure 1: Plume Centreline Total Effective Dose (TED) as a Function of Downwind Distance

to keep the public, as well as nuclear authorities, accurately informed on the occurrence and potential consequences of reported events.

In accordance with the procedure for INES ratings, an event is evaluated against the criteria of impact on –

i. People and the Environment
ii. Radiological Barriers and Controls at Facilities
iii. Defence in Depth

The overall INES rating is then taken as being the highest rating from the three individual ratings.

Following the event, Necsa conducted an initial INES rating of the event and concluded that the rating was Below Scale / Level 0 for all three evaluation criteria. Consequently Necsa provisionally rated the event as Below Scale / Level 0.

The NNR investigation team conducted an independent rating, using the methodology prescribed in the 2008 INES User's Manual, of the event against the INES scale and concluded as follows –

Table 3: Determination of INES Rating

Criteria	Rating	Explanation
People and Environment	0	1) Activity released was quantified as being – a) Noble gas 1.28 TBq; b) Iodine 5.379 GBq; 2) Release was less than tens of GBq I-131 equivalent; 3) Public dose was quantified as being below 1 µSv/a and; 4) Worker doses showed no exposure of workers in excess of statutory limits or dose constraints.

Radiological Barriers and Controls at Facilities	0	1) Event resulted in contamination of an area not expected by design; 2) Total Iodine equivalent released was less than a few tens of GBq.
Defence in Depth	1	Although more than 1 layer of safety barrier existed after the event, which could warrant a Level 0, the INES grading was increased to a Level 1 considering, amongst others, the following – 1) The safety assessment did not adequately consider all hazards associated with chemicals used in the cell; 2) The event invalidated safety arguments related to facility ventilation; 3) Inadequate safety culture based on, amongst others a) inadequate procedures for cell cleaning; b) failure to respond to alarms; c) operating outside of prescribed operating limits and conditions; d) delayed reporting of an in-facility event to the ECC.

Based on the above the investigation team rated the event as a Level 1 on the INES scale.

5.3. Management Approach and Nuclear Safety Culture

The most significant group of findings relate to the management approach and nuclear safety culture which has been defined as "an assembly of characteristics and attitudes in organisations and individuals which establishes that, as an overriding

priority, protection and safety issues receive the attention warranted by their significance."

F1. Management approach appears to be highly production orientated and due consideration to safety management is not always evident.

a. In establishing the investigation team the NTP Production Manager (Mr J Selome) was included in the investigation team and not the Executive Manager: Compliance (Mr G Wortmann). It was noted however that Mr Wortmann attended some sessions as an observer.

b. During the investigation the NNR was informed that Necsa has ordered a replacement top alpha window from a supplier in the UK. Further at the same time, it was learned that Necsa was making alternate arrangements for the procurement of the top alpha window from a French supplier, who had a window available, but of a different size (larger). The NNR is concerned with Necsa management bypassing procurement processes and non-compliance with RD-0034 requirements, e.g. –

i. it is unclear what process was followed to qualify the French supplier.

ii. it is unclear how Necsa has determined that the window to be purchased from the French supplier is fit for purpose and meets the required design specifications, particularly as the event may require a design review of the top alpha window.

iii. noting that the window to be procured from the French supplier is not of the requisite size, it is unclear what oversight Necsa has had of the process to cut the window to the requisite size.

c. With Cell 11 being unavailable since March 2013, NTP did not adequately evaluate the impact on safety of the continuous use of Cell 19 for production, which is not in compliance with the operating regime described in the Safety Case of the facility.

d. The impact of the crack on the front window of Cell 19 was superficially monitored and not thoroughly investigated. It is noted that this issue is still under investigation.

e. The investigation team noted that in some instances operations in Cell 19 proceed even if the cell differential pressures are outside the limits specified in the facility OTS.

f. The management structure at NTP is inconsistent with other Necsa facilities, where the NFM is the primary person responsible at the facility, including nuclear safety and production.

g. Furthermore from the responses received during the interviews with management and staff, it is not clear who is responsible for nuclear safety within the facility. In some cases safety personnel deferred safety related questions to staff in the Technology Development Department.

5.4. Safety Case Documentation

During the course of the investigation the following findings related to the Safety Case of the facility were identified –

F2 From the discussion held with the Safety Case preparers, the safety assessment did not consider the possible interactions of process chemicals and cleaning chemicals. As a result, all possible combinations of chemicals that could be present in the cells were not evaluated.

F3 The current Safety Case claims that removal of the top alpha window would not result in spread of contamination from purple area to red area. The event on 02 November 2013, has invalidated this claim and Necsa is required to re-evaluate the design and operation of the facility ventilation system.

F4 This event and another event in October 2013 resulted in spread of radioactivity from within the Hot Cell to the red area. It was noted that the ventilation in the red area is not equipped with charcoal filters to trap any iodine that may be released into the red area.

5.5. ACTIONS TAKEN IMMEDIATELY AFTER THE EVENT

The following findings were noted by the investigation team related to actions taken immediately after the event –

F5. Immediately following the event, workers did not evacuate the facility – this was only done approximately 5 minutes later.

F6. The facility did not provide prompt notification of the event to the Necsa ECC.

F7. The Executive Manager: Compliance contacted the Senior Manager: Safety and Licensing Department, who then activated the Necsa ECC. This was approximately two hours after the event in the facility.

F8. The sudden atmospheric release of radioactive nuclides was not timeously notified to the Necsa ECC.

F9. The facility was not able to provide quantitative data with respect to the releases to the Necsa ECC.

F10. The facility does not have adequate ability to quantify releases to the environment in real time. This led to the ECC not being able to accurately predict the evolution of the event and subsequent consequences.

F11. The installed iodine monitoring in the red area was not linked to the Lab Impex System or it was inoperable at the time of the event.

5.6. IN CELL ACTIVITIES

Following a facility walk down and examination of documentation related to in-cell activities and processes, the following findings were identified –

F12. The currently approved procedure related to cleaning of the cells, Document RAD-SOP-3058 (Rev 0) is vague and does not address all actions related to cleaning in the cells.

F13. An update of the cleaning procedure Document RAD-SOP-3058 (Rev 1) was developed in 2011 but was not approved for implementation.

F14. During cleaning, the operators dry the contents of the 6 litre waste container by placing it on the uranium residue containers (It has become a common practice). This is not addressed in either revision of the cleaning procedure nor the facility Safety Case.

F15. The problems experienced prior to this event with the sliding cover of the uranium residue waste pots in the cell was not adequately investigated and rectified.

F16. The reported increase in the need to replace the in-cell filter was not adequately investigated.

F17. The set-points for the alarms for the pressures for the cells were found to be not in accordance with the Operating Technical Specifications.

F18. The blockage of the in-cell filter played an important role in the release to the atmosphere, and in this case it was not a fail-safe system.

F19. Continuous use of Cell 19 for production resulted in an increased rate of waste generation and build-up of consumables in the cell.

5.7. VENTILATION SYSTEM

The ventilation system for the NTP Radiochemicals Facility provides "dynamic containment" by means of keeping the process atmosphere (purple) at a lower pressure than the maintenance area (red) and the operator area (blue). The purple area has the lowest pressure, followed by the red area and then the blue area. The blue area is still at a lower pressure than the white area (P1701 Control Room) which is maintained at normal atmospheric pressure. The following findings relating to the ventilation system were identified –

6. RECOMMENDATIONS

Necsa is required to provide an action plan addressing the findings listed above. However, the following recommendations must be prioritised –

R1. Re-evaluate the management structure to ensure that the prime responsibility for nuclear safety resides within the management structure at an adequate level with the necessary authority and influence.

R2. Conduct a facility-wide safety culture audit and propose actions to improve safety culture in the facility.

R3. Re-evaluate the ventilation system and justify the lack of charcoal filters in the red ventilation system.

R4. Reassess the safety arguments presented in the Safety Case, to ensure consideration of hazards associated with the interaction of all potential combinations of chemicals in all cells.

R5. Implement a system which allows for the quantification of releases to the environment on a real time basis. Such a system must have the capability to record such information and be available to the Necsa ECC.

R6. Revise and implement the cleaning procedure based on a hazard assessment that must be performed on the cleaning processes within the cell.

R7. Correct the set points for the alarms for all the parameters to ensure compliance to the OTS and relevant procedures.

R8. Re-evaluate the Safety Case of Cell 20, in light of this event and submit said evaluation to the NNR.

R9. Considering the cleaning procedure that was revised but never implemented, NTP is required to review their change management process and identify deficiencies.

R10. Noting that practices in the facility is not in line with some procedures and in some instances outside of OTS requirements, NTP is required to institute on job observations in line with current best practices and establish records of all important plant parameters.

R11. The continuous use of Cell 19 for production led to additional quantities of nitric acid and other cleaning chemicals being required to be used in the cell, thereby creating conditions conducive for the event to occur. Necsa is required to review the in cell housekeeping requirements including revised waste limitation in the cell.

R12. Considering operational experience over the past year and the events that have occurred in the facility, Necsa must justify why there should not be limitations on production activities in the dissolver cells.

R13. The top alpha window of the cell failed in its containment function, and Necsa is required to re-evaluate the assumptions made in its safety argument stating that it is designed to fail without the contents of the cell being released to the environment.

7. CONCLUSION

Whilst the direct impact to the workers, public and the environment were very low, the event and subsequent investigation highlighted the breakdown and degradation of nuclear safety in the facility.

The most significant of the findings relates to the nuclear safety culture of the facility management and staff. This is further exacerbated by the high emphasis on production in the facility.

Another area of concern is that the Necsa ECC was not able to make timeous and accurate predictions of the event consequences due to unavailability of information with regard to the release to the atmosphere from the facility.

The nuclear authorisation holder must review aspects related to the facility design, safety evaluation and operational procedures and update the facility Safety Case.