PEER REVIEW REPORT

BEYOND-DESIGN-BASIS ACCIDENTS

FOR NUCLEAR 1 ENVIRONMENTAL IMPACT ASSESSMENT

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1 INTRODUCTION

Dr C A R Bain Pri. Sci. Nat. Consultant was appointed by Gibb (Pty) Ltd. To undertake a peer review of specialist report "Beyond-Design-Basis Accidents" September 2015 (referred to subsequently as the Report) compiled by PSI Risk Consultants CC for the proposed Nuclear 1 Power Station project which covers three potential sites on the coast of South Africa.

2 SCOPE OF WORK

The scope of work as supplied by Gibb for this review study is the following:

1. Assess the document/ Report in terms of its fulfilment of its Terms of Reference set;
2. Consider whether the Report is entirely objective;
3. Consider whether the Report is technically, scientifically and professionally credible;
4. Consider whether the method and the study approach is defensible;
5. Identify whether there are any information gaps, omissions or errors;
6. Consider whether the recommendations presented are sensible and present the best options;
7. Consider whether there are alternative viewpoints around issues presented in the Report and if these are clearly stated;
8. Consider whether the style of the Report is written so as to make it accessible to non-specialists, technical jargon is explained and impacts are described using comparative analogies where necessary; and
9. Report on whether normal standards of professional practice and competence have been met.

3 REVIEW FINDINGS

3.1 Fulfilment of Terms of Reference

The terms of reference are covered in the Introduction and Scope section of the Report. The Report acts as additional support of accident discussions in the specialist report, “Assessment of the Potential Radiological Impact on the Public and the Environment” and is needed to give justice to the highly complex and emotive subject of nuclear accidents. The Report covers the full range of nuclear safety principles, the importance of rigorous methodology, concept of Defence-in-Depth and the deterministic and probabilistic accident analysis. The weaknesses of previous safety standards and design criteria is illustrated with discussions of past major nuclear accidents. This puts into context the criteria for Beyond-Design-Basis accidents for new Generation III reactors to avoid disasters of the past. The regulatory aspects and that of the International Atomic Energy Agency are described. The Report has successfully and clearly answered the question; when things go wrong how likely is a Fukushima-type accident now? In the context described it can be said that the Report fully meets the terms of reference set.

3.2 Report Objectivity

The Report under review does not address any matters directly concerning the three sites selected for possible nuclear power plants. It is within the EIA process to provide assurance how nuclear accidents at a proposed GEN III power plant (at any site) will be so constrained as to virtually remove any beyond-design-basis type accidents from occurring. The substance of the Report is to elucidate the inner workings of current safety analysis methodologies, the proper application of the defence in depth concept, the safety principles used and how they relate to national regulatory criteria and recommendations of the International Atomic Energy Agency and industry benchmarks. The Report objectivity is assured by the very nature of the methodologies followed and the benchmarks to be achieved. The new criteria for beyond-design-basis type accidents are put in perspective with discussion of past major nuclear accidents based on reports by US Nuclear Regulatory Commission and by the International Atomic Energy Agency and is reported objectively. However see section 3.7 of this review.

3.3 Technical, Scientific and Professional Credibility

The subject matter which is of an intricate technical and scientific nature is well summarised in a logical professional manner with numerous diagrams and illustrations. Copious references from respected international organizations and other sources further point to the Report’s credibility.

3.4 Defensibility of Methodology and Study Approach

The methodology encompasses painting a picture of the extensiveness of nuclear safety concepts and principles that are linked through safety analysis techniques and the proper use of defence-in-depth concept to establish design requirements for nuclear power plants. It is shown by reference to past major reactor accidents how safety analysis has evolved over time to produce the current GEN III design objectives that greatly curtail the consequences of a severe accident.

In discussing a beyond-design-basis-accident (BDBA) the concepts of risk, the design basis, its assessment and what events challenge the safety to cause significant health risk are outlined. A useful comparison of the changes in International Atomic Energy Agency (IAEA) safety standards and accident conditions for nuclear power plant design from year 2000 to 2012 is made. Design Base accidents now include the Design Extension Conditions of “no reactor core melt down” and the “severe core melt” accident. The GEN III type power plants that are proposed for the EIA project include all the main characteristics for design extension conditions which include improved resistance to external hazards such as aircraft crashes with full fuel load and extreme natural events. How the intended power plants are assessed to prevent BDBA is illustrated with the application of the five levels of defence in depth.

The actual safety analysis methodologies are presented which are needed in a safety case report to the National Nuclear Regulator for the nuclear license. These include deterministic and probabilistic safety analysis which have strengths and weaknesses. Used together these limitations are compensated for. The strong point of these methodologies is the large body of international experts that use them and that their findings are widely shared. Probabilistic safety analysis approach is used during both the design phase and life time of a power plant and considers frequencies of instrument failure, human fault, accident sequences and is carried out at three levels. These are, initiating events, accident phenomena of releases and public health risk. External events that may cause accident are assessed. Lessons learnt from the tsunami event at Fukushima have been incorporated into design protocols.

The overall complexity and extensiveness of safety analysis and safety provision for nuclear power plants from design to decommissioning is illustrated in a very detailed flowchart of safety principles that are applied (Fig 5-5)

Very insightful summaries of the major beyond-design-basis-accidents at Three Mile Island, Fukushima and Chernobyl and lessons learnt are given. The magnitude of the accidents are related to the International Nuclear Event Scale.

The role of the IAEA in the event of a nuclear accident, in promoting international best practice and providing publications to achieve this, contributes to the methodology of the Report. As is the role of the IAEA in establishing international conventions on Early Notification of Nuclear Accidents and the Convention on Assistance in the Case of a Nuclear or Radiological Accident. South Africa is a member of the IAEA and signatory to both these conventions. South Africa subjected

itself to an IAEA Review of nuclear infrastructure in 2013. The National Nuclear Regulator has promulgated its own regulations and criteria for safety in line with international safety. Western Europe has established initiatives to strengthen nuclear safety and accident criteria for GEN III power plants.

The references used are extensive and up-to-date. The study approach to outline the international accepted risk analysis and beyond-design-basis-accident methodologies and logically follow on to description of such accidents in the past is commendable. This is rounded off with the assurances and conclusion that proposed GEN III power reactor will meet the beyond-design-basis-accident criteria.

3.5 Information Gaps, Omissions or Errors

Typographical and Clarity: Generally small grammatical errors are not noted. The following few typographical, layout errors are noted.

P 5: The abbreviation SCC should be SSC. This error occurs twice on page 5 and on about 6 other pages in the Report

P 7: Layout error; Decay heat in Dose section, should be moved above Dose for alphabetic sequence

P 9: IEA to read EIA and move alphabetically

P 46 In Reference [1] the last word Vienna to be deleted.

Additions to Glossary and Abbreviations: The following could be considered for inclusion. None

Possible Gaps

This is a summary report based on a wide selection of literature. There are no obvious omissions. The Report does refer the reader to a Web address for further information.

3.6 Sensibility of Recommendations and Presentation of Best Options

The main finding of the Beyond-Design-Basis-Accident assessment for a Generation III type Nuclear Power Plant is that the new design has distinctive characteristics that allow for simpler design, more passive safety features, reduced failure probabilities of systems and components, provide mitigation to significantly reduce release to environment from core melt and have improved resistance to external hazards such as aircraft crash and extreme natural events. The design accident annual frequencies during a Beyond-Design-Basis-Accident for different types of GEN III Pressurised Water Reactors are given in the Report to vary from 5.1 E-07 to 4.6 E-06 (events per reactor year) which can be compared with the National Nuclear Regulator peak individual fatality risk of 5.0 E-06 per year. The Report concludes this means the GEN

III designs should meet the regulatory limits of the NNR. So to answer the earlier question qualitatively; the report gives the assurance that a Fukushima type accident will be extremely unlikely. In essence this is a sensible and only recommendation as it meets the findings of the methodology described according to best international practice.

3.7 Alternative Viewpoints Presentation and Clarity of Statement

There are no significant alternative viewpoints presented in the Report. The Report outlines the methodology used for beyond-design-basis-accident analysis as recommended by the IAEA. Summaries are presented of three major reactor accident reports as issued by international organisations and official reports. There are some dissenting opinions on the number of deaths from Chernobyl accident and levels of contamination associated with Fukushima accident. However the Report does not touch on these alternative views and just quotes the official reports.

3.8 Accessibility of Style of Report to Non-specialists

The style of the Report assures the non-specialist of the comprehensive, thorough and detailed manner in which the nuclear industry approaches the sensitive subject of nuclear accidents and their potential impact on man and the environment. There are copious photographs, diagrams and tabulations that cover the details of a complex topic. This is supported with a helpful glossary, list of abbreviations and units, detailed recent referencing. A particularly useful block diagram for the non-specialist is Figure 4-2 which compares the changes in International Atomic Energy Agency (IAEA) safety standards and accident conditions for nuclear power plant design from year 2000 to 2012. This shows that what is now included in Design Base accidents are the Design Extension Conditions of no reactor core melt and the severe core melt accident. Other useful illustrations include: Figure 5-1 for the different levels of protection in the defence-in-depth principle; Figure 5-5 for Safety Principles in lifecycle of power plants which reveals the extensiveness and complexity of safety analysis. The more advanced containment design with passive cooling is contrasted with the older standard reactor with more intricate cooling system dependent on electrical power and human intervention. The reader is also encouraged to refer to specific internet web pages for more information. Although there is a high technical content the non-specialist should benefit from this report and appreciate the conclusions.

3.9 Meeting of normal Standards of Professional Practice and Competence

The Report meets the normal standards of professional practice as reflected in the competent summary of a many facetted complex subject. The linking of past accident findings to the new design criteria was well thought out. Interfacing with the international criteria and local regulatory requirements and describing the

improvement initiatives of nuclear safety in Western Europe round off a competent report.

4 CONCLUSIONS

The review process has addressed all 9 points of the Scope of Work and concludes this is a satisfactory report.