Submission to the Nuclear Fuel Cycle Royal Commission

Dr Richie Gun MB BS FAFOM AO

Dr Philip Crouch BSc(Hons) PhD MARPS

Dr Richie Gun is a retired occupational physician. He is former Senior Lecturer in Occupational and Environmental Health in the Faculty of Health Sciences, University of Adelaide. He was principal investigator for the Mortality and Cancer Incidence Study of Australian Participants in the British Nuclear Tests in Australia, and is the author of several papers on occupational epidemiology in peer-reviewed journals.

Dr Philip Crouch has 35 years' experience in radiation protection, principally in radiation protection in mining and in the environment. He spent 22 years with the (then) Radiation Protection Branch of the South Australian Government, where he was heavily involved in the assessment and regulation of radiation aspects of uranium mining projects. He was also involved in the drafting of Australian Codes of Practice for radiation protection in mining. Since 2001 he has operated his own radiation protection consulting business, with projects including acting as Radiation Safety Officer at uranium mines and preparing EIS studies for projects, including assessing radiation exposures to workers, members of the public and environmental organisms. He has also participated in epidemiological studies of uranium miners and nuclear test veterans and has been involved as a consultant with the International Atomic Energy Agency on several projects.

Introduction

Uranium is a radioactive metal, meaning that it, and its decay products, emit ionising radiation. Thus all stages of the nuclear power cycle: mining, processing, enrichment, fuel fabrication, reactor operation, reprocessing, and waste management, have the potential for radiation exposure to workers and members of the public.

The finding of the International Agency for Research on Cancer (IARC) that ionising radiation is carcinogenic is non–contentious.[1] This has been shown to be true of ionising radiation in a variety of different circumstances. Excess cancers have been demonstrated in patients treated with X-rays for ankylosing spondylitis,[2] patients treated with radiation for cervical cancer[3,] patients treated with radiotherapy for benign gynaecological disease[4]and in Japanese atomic bomb survivors.[5] Many of these groups have been exposed to relatively high radiation doses, and at high dose rates. It is important therefore to establish the risk to workers in the nuclear fuel cycle who in general are exposed to lower doses of radiation and at a lower rate than in the above groups. The magnitude of such potential risks must be evaluated prior to commencing such operations.

Increased risks from radiation exposure in the nuclear fuel cycle have only been demonstrated for uranium mining and nuclear reactor operations, and are discussed below. These results are derived from studies of exposures received in previous decades, and current equipment and procedures are expected in many cases to result in exposure significantly less than those studied.

Extraction

This section of the submission addresses issue Question 1.8:
Bearing in mind existing arrangements, would an expansion in extraction activities give rise to new or different risks for the health and safety of workers and the community? If so, what are those risks and what needs to be done to ensure they do not exceed safe levels?

South Australia’s largest uranium mine is at Olympic Dam (Roxby Downs). It is an underground operation, which carries a risk of internal radiation exposure, the most serious consequence being lung cancer.

Uranium decays over time to a series of decay products, one of which is radon, which is a gas. The mining operation releases radon into the enclosed space of an underground mine. The products of radon decay (radon daughters), if inhaled, are likely to lodge in the lung, and their subsequent decay is accompanied by emission of alpha-radiation. This is a particulate exposure, and is 20 times more biologically potent than an equivalent dose of gamma-radiation. However there is also a component of gamma-radiation exposure in uranium mining.

Alpha-particles do not cause harm from external radiation. Unlike gamma- or X-rays, they cannot penetrate the skin beyond the outer keratinous layer, and cannot therefore damage the DNA of skin cells or of internal tissue. This inert layer is not present on the cells lining the respiratory tract, so that the emission of alpha-radiation following inhalation of radon daughters can have a harmful effect on the epithelium of the bronchial tree. That effect has been a raised incidence of lung cancer, demonstrated in many epidemiological studies of underground uranium miners.

The level of excess risk increases with the cumulative radiation exposure, which in uranium mining studies is measured in Working-Level Months (WLM). One WLM is the exposure accrued from 170 hours of exposure to a standard measure of energy from alpha-radiation (2.08 X 10^{-5} Joules/m^3). The International Agency for Research on Cancer (IARC) has reviewed 19 studies of underground miners exposed to radon (not all uranium mines), in which the cumulative exposure ranged from 7 to 822 WLM. A combined analysis of 11 of these studies resulted in an estimate of Excess Relative Risk (ERR) of lung cancer mortality of 0.0077/WLM.[1] Thus for example for a mining population with a mean cumulative exposure of 100 WLM, ERR would be 0.77: and if for example 100 lung cancer deaths were to be expected in an unexposed population of comparable size and age, 177 would be expected in the mining population with that level of exposure; and 77 of those deaths would be attributable to exposure.

No study has been attempted on death rates or cancer rates at Olympic Dam. The only available study from uranium mining in SA has been from the Radium Hill mine which operated from 1952 to 1961. Of those employees who could be followed up, lung cancer mortality was elevated 94% compared with the general population. Mean exposures were 7 WLM.[6]

Exposure levels at Olympic Dam have been significantly less than in the mining operations studied. The Environmental Impact Statement prepared for the proposed open-cut expansion (since lapsed), states that the average underground dose was <4 mSv/year, with the most exposed group at approximately 6 mSv/year: radon decay products accounted for approximately one-half of this. The International Commission on Radiological Protection estimates 1 WLM to be equivalent to 10 mSv. We understand that fewer than 10% of the potentially exposed workers remain for more than 5 years. Assuming a mean employment duration of 5 years, and a mean exposure rate of 2.5 mSv/year, the mean cumulative exposure would be 1.25 WLM, ie less than one fifth of the mean cumulative exposure at Radium Hill. The low exposure levels are probably due to (i) the efficient ventilation system with a time from surface of input through the mine to output of 15 minutes, (ii) the low grade of the uranium deposit, so that the gamma-radiation is correspondingly low, and (iii) a greater general awareness of the potential problem, with extensive monitoring and implementation of other control measures.

An important qualification is the evidence that some of the excess rise is due to a synergistic effect between radiation exposure and cigarette smoking. Indeed in studies where smoking information was available, there were small numbers of lung cancer deaths in non-smokers (only one in the Radium Hill study). It is therefore probable that the risk of lung cancer would be minimised if the underground workforce were non-smokers.

The recent proposal to expand the Olympic Dam mine would have converted the mine to an open-cut operation. Assuming that it were to become an open-cut mine, the risk of alpha-radiation exposure would be abated if it is converted to an open-cut operation, since any radon gas released would be rapidly dissipated. Thus for the open-cut operation at the Ranger deposit in the Northern Territory, doses are very low with the dose to "designated workers" (the most highly exposed group) averaging 2 mSv/year. In the mine the largest contribution is from gamma radiation (60%) with approximately equal contributions from radon decay products and dust (approximately 20% each). Gamma-radiation emission at Olympic Dam would be low since the ore deposit is of low grade relative to the Ranger mine. Therefore the conversion to open-cut mining which would accompany expansion at Olympic Dam would in fact reduce the cancer burden of the workforce.

Cancer risk from nuclear power generation

This section of the submission addresses issue 3.13: What risks for health and safety would be created by establishing facilities for the generation of electricity from nuclear fuels? What needs to be done to ensure that risks do not exceed safe levels?

This submission addresses health and safety issues of the workforce under normal operating conditions. It does not address health issues of residents in areas close to nuclear power plants, nor issues relating to system failure (eg Fukushima).

Unlike the case of underground uranium mining, the main source of exposure in nuclear power generation is external, from gamma-radiation. Ionising radiation can induce several types of cancer, and the cancer most strongly associated cancer type is leukaemia

As with alpha-radiation, the risk increases with radiation dose.

Two reports have appeared in which combined analyses have been undertaken of workers in nuclear power generation in several countries.

In 2005 a large study was published, presenting the results of a combined analysis of cancer mortality of nuclear industry workers in 15 countries. Altogether over 400 000workers were included in the study. The estimated mean cumulative exposure per subject was 19.4 mSv. For deaths from cancers other than leukaemia, there was a statistically significant trend in increased risk associated with increased exposure. The excess relative risk (ERR) per Sievert was 0.97, from which it was concluded that 1-2% of deaths were attributable to radiation.[7]

The ERR for leukaemia was estimated separately. The analyses excluded chronic lymphatic leukaemia (CLL), which has not been demonstrated to be radiogenic. The ERR for non-CLL leukaemia was estimated at 1.93/Sv. This trend was not statistically significantly different from zero, possibly because of smaller numbers; nevertheless the magnitude of the trend was similar to that of previous studies.[8,9]

More recently a follow-up study of the subjects from France, the US and the UK was published. Mean exposure per worker was 15.9 mGy. Risks for cancers other than leukaemia were not presented. For non-CLL leukaemia the ERR/Sv was estimated at 2.93, which in this case was statistically significant. On this basis, 25 of the 531 non-CLL leukaemias are attributable to radiation exposure.

The distribution of non-CLL leukaemia deaths suggests that most radiation-related deaths occurred in the 10% of subjects whose cumulative exposure was >50mGy.This suggests that the excess risk of non-CLL leukaemia could be largely eliminated if working-life exposure could be contained below this level.

Most excess leukaemia deaths of the excess risk in this study were from chronic myeloid leukaemia (CML). For CML the ERR/mSv was 10·45 (90% CI 4·48–19·65), compared with only 1.29 (90% CI -.82 – 4.28) for acute myeloid leukaemia (AML).[10]

It is worth emphasising that this study addressed mortality rates, not incidence rates. Cancer incidence rates are of course higher than mortality rates. (Interestingly, the follow-up period for this study ended in 2005, after which the mortality rate from CML in Australia halved, due to a breakthrough in treatment.[11])

Conclusion

While there is no doubt that exposure to radiation in occupational settings has in the past resulted in increased rates of cancer, doses and dose rates were in most cases significantly higher than those that would be expected from new projects, which employ new and improved technologies and are subject to greater regulatory controls. In particular the requirement that all radiation doses should be as low as reasonably achievable, taking into account economic and societal factors, has and will result in significant reductions in radiation doses. This requirement is included in South Australian legislation.

However, determining whether a particular project is justified and should go ahead, and in particular that the particular proposed operation and associated controls *will* be as low as reasonably achievable, will require a careful and detailed expert evaluation. In addition a similar high level of expertise will be required in order to maintain adequate regulatory oversight of the project while operating, and proper assessment and evaluation of the radiation exposures of workers, members of the public, and the environment generally. While such expertise currently exists within in the SA Government for the case of uranium mining (within the EPA), there is virtually no expertise available for the other potential projects, in particular nuclear power generation. Indeed there is very limited expertise on this subject anywhere in Australia. The development of a strong regulatory agency capable of effective oversight or radiation aspects of nuclear power would require a significant effort over a number of years.

References

1 International Agency for Research on Cancer. A Review of Human Carcinogens. D. Radiation. IARC Monographs on the Evaluation of Carcinogenic Risks to Humans. IARC Monographs Volume 100 (D). Accessed at www.iarc.fr

2 Weiss HC, Darby SC, Doll R. Cancer mortality following x-ray treatment for ankylosing spondylitis. Int J Cancer 1994;59:327-338

3 Boice JD, Engholm G, Kleinerman RA et al. Radiation dose and second cancer risk in patients treated for cancer of the cervix. Radiation Res 1988;116:3-55.

4 Inskip PD, Kleinerman RA, Stovall M et al. Leukaemia, lymphoma and multiple myeloma mortality after pelvic radiotherapy for benign disease. Radiation Res 1993;135:108-124.

5 Preston DL, Kusumi S, Tomonage M et al. Cancer incidence in atomic bomb survivors. Part III: Leukemia, lymphoma and multiple myeloma. Radiation Res 1994;137:S68-S97.

6 Woodard AJ, Roder DM, McMichael AJ, Crouch P, Mylvaganam A. Radon daughter exposures at the Radium Hill mine and lung cancer rates among former workers. Cancer Causes and Control. 1991 2:213-220

7 Cardis E, Vrijheid M et al. Risk of Cancer after low doses of ionising radiation: retrospective cohort study on 15 countries. BMJ, 2005 July 9;331(7508):77 Epub 2005 Jun 29.

8 IARC Study Group on Cancer Risk among Nuclear Industry Workers. Direct estimates of cancer mortality due to low doses of ionising radiation: an international study. Lancet 1994;344:1039-43.

9 Muirhead CR, Goodill AA, Haylock RGE, Vokes J, Little MP, Jackson DA, et al. Occupational radiation exposure and mortality: second analysis of the national registry for radiation workers. J Radiol Prot 1999;19:3-26

10 Leuraud K, Richardson DB et al. Ionising radiation and risk of death from leukaemia and lymphoma in radiation-monitored workers (INWIRKS): an international cohort study. www.lancet.com/haematology July 2015.

11 http://www.aihw.gov.au/acim-books/ 2015 Cancer Incidence and Mortality (ACIM) book for chronic myeloid leukemia.

Nuclear Fuel Cycle Royal Commission in. 2015 resulted in a detailed examination of the. potential for AustraliaËˆs expanded involvement. in the nuclear fuel cycle. Its terms of reference. included exploring opportunities that may lie. in the back end of the fuel cycle, as well as. the potential for generation of electricity from. nuclear reactors. The Royal Commission delivered ï¬ndings. in May 2016 (Nuclear Fuel Cycle Royal. Commission 2016). It ruled out any involveÂ the back end of the nuclear fuel cycle. Given the component parts of a compre-. hensive recycling solution to used fuel man The Nuclear Fuel Cycle Royal Commission released its tentative findings on the potential for further mining, electricity generation and storage of nuclear waste in South Australia last week. Although the commission found it would not be commercially viable to generate electricity from a nuclear power plant, it said South Australia did have certain attributes that meant it could offer safe, long-term disposal of used fuel.Â The Nuclear Fuel Cycle Royal Commission is currently taking submissions on its tentative findings, with a final report due for public release on May 6. charis.chang@news.com.au. trending in technology. â€¢ Nuclear fuel should be developed and nuclear reactors configured to enable the maximum burn up of fuel, thereby decreasing the attractiveness of plutonium in spent fuel for use in nuclear weapons. To be feasible, this needs to be consistent with efficient and economic operation. Recommendation 2: Nuclear governance (see chapter 5) â€¢ At the national level, regulation of nuclear.Â Fuel cycles could also be designed to facilitate the implementation of â€˜extrinsic barriersâ€™, relating to the political decisions and institutional arrangements governing the fuel cycle. These include international IAEA safeguards, other bilateral, regional or international verification measures, as well as import and export controls.