Canadian Nuclear Society Société Nucléaire Canadienne

CNS BULLETIN SNC

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Editorial

How Good Are The Data?

Reactor safety has always been a qualitative concern. Over the past twenty years quantitative methods have been used increasingly to demonstrate the level of safety involved. These *a priori* methods have led to the conclusion that the risk is very low, so low that it could never be verified using traditional statistical approaches.

A recent series of letters to the editor of *Nature* has re-opened this discussion, pointing out that there have been two serious accidents in 4000 reactor-years of experience. Most of the discussion in these letters has hinged on how such a small sample should be handled and what conclusions could legitimately be drawn from it. However, the correspondents have all made the point that the data appear to indicate that the design criteria for reactors are not being met in practice. One correspondent concludes that the risk assessment tools currently being used by the industry should be abandoned in favour of "risk assessment using observed data." Back to square one.

Whether or not it is correct, such a knee-jerk interpretation of "the data" is an obvious first approach. It would be a matter of concern if estimates of accident frequencies really were low by a factor of 10 to 50, as such a reading of "the data" might indicate. Obviously, a closer look at "the data" is required.

This task might be confronted at a fairly simplistic level by posing two questions:

- Is there any reason to suppose that the existing *a priori* estimates of reactor accident frequencies are greatly in error, or that a greater uncertainty is associated with them?
- Are the existing "data points" (i.e. TMI and Chernobyl) on reactor accidents acceptable as data points without qualification? If so, what do they tell us about reactor accident frequencies? If not, how can they be interpreted?

Factors that might serve to qualify, or even disqualify, either of these data points can be readily postulated:

- The reactor systems are different and are not built or operated to the same rules;
- The countries these reactors were operating in have different political, cultural, technical and philosophical outlooks;
- The 4000 reactor-year data base includes experience from other reactors and reactor systems, some of them different from either of the two which experienced the accidents and operating in countries which are yet again distinct.

However, without a clear game plan, all this can easily degenerate into a numbers game. Design criteria for accident frequencies were chosen not just because the numbers looked good but because it was and is felt that they represent some "acceptable" level of safety, that only some "tolerable" residual threat to life or welfare is being imposed. These criteria were first developed at a time when our supporting information on reactor safety issues was much less complete than it is now, when the hazard was conservatively over-estimated and possibly even thought to be unique. In the light of improved knowledge over the past 10-15 years, it is perhaps not too rash to assert that the perceived health risk from reactor accidents, as viewed by the technical community, is less now than it was then. Indeed, some people conclude from all this that reactors are already "too safe" from a public health perspective, that by increasing the level of safety further we are buying more and more expensive insurance against a relatively small hazard.

Technically this may be true but it can only be part of the answer. And the problem of interpreting these two data points is more than just academic for at least two reasons.

One is public perception. However irrational, uninformed, shortsighted or premature public judgments may be, they exist. They can't be ignored. If it's true that people fear what they don't understand and if there is any indication of undue hesitancy or uncertainty from the people in the nuclear industry on the facts of nuclear safety, then the King is already in check.

A second issue is economic impact. Nuclear accidents cost a lot of money. At some level of accident frequency they will cost too much money. The estimates of expense in the wake of the Chernobyl accident and the difficulties faced by investor-owned utilities in the U.S. following TMI are indication enough of the significance of this point, and should encourage one not to give way too readily to the natural human tendency to discount the future.

FYI

First Plasma at Varennes (Staff)

At 6:59 p.m. on March 25, Canada's fusion research facility, the Tokamak de Varennes, began producing its first plasma. This is the culmination of a federal-provincial initiative, begun in 1979, to launch Canada into a new phase of fusion research.

The Varennes Tokamak is a plasma device designed and built in Canada at a cost of about $56 million. It forms part of the overall national fusion program, which is managed by AECL. The Varennes project is jointly funded and managed by the National Research Council

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and Hydro Quebec, and the work is being carried out by IREQ, INRS-Energie, Université de Montréal, Canatom Inc., and MPB Technologies Inc. Of the $56 million project cost to date, $24 million represents equipment costs with the rest going to research, design and project management. More than 85% of the money spent on the project has been spent in Canada.

The area in which the Varennes Tokamak will excel is in plasma diagnostics. The machine's ability to produce long plasma pulses and its advanced diagnostic equipment were chosen to enable the facility to generate data more closely applicable to future fusion energy plants. The Tokamak de Varennes will provide the focus for a Canadian centre for fusion energy research, which is expected to be staffed by about 100 scientists, engineers and support staff from Canadian and overseas research organizations. Other areas of fusion research in which Canada is active include expertise in handling tritium, work on fusion reactor fuel systems and inertial confinement systems.

Bruce-8 Starts Up

(CANDU Update)

Ontario Hydro's Bruce unit 8 nuclear reactor achieved its first chain reaction on Sunday February 15. The 885MW unit should be available for commercial service in mid-May. Unit 8 is the final unit to start up at Bruce, completing the construction effort that began in 1969. The start up of Bruce 8 coincides with the granting of permission to construct a new power line south from the station to remove about 1,000 megawatts of "locked-in" power. The 8-unit Bruce station will produce about 6,800 MWe gross once unit 8 reaches full power.

Almost half of Ontario's electricity generation was provided by nuclear power last year. The increase of seven per cent from 1985, up to 49 per cent in 1986, was due to the completion of Pickering unit 8 and Bruce unit 7. Hydro-electric stations provided 31 per cent of the total power generated, followed by coal-fired stations at 20 per cent. Electricity demand in Ontario increased 3.9 per cent in 1986.

Uranium Production in Canada

(R. T. Whillans)

Uranium production in Canada in 1986 was an estimated 11,720 tonnes (t) of uranium (U), of which almost 60 per cent came from Saskatchewan. Canada continues to account for roughly 30 per cent of western world uranium supplies, producing annually more than its two largest competitors, South Africa and Australia, combined. Canada's position as the world's leading producer and exporter can be maintained for many years to come.

In 1986, shipments of Canadian uranium from ore processing facilities were estimated at 10,977 tU, valued at $C 924 million; final 1985 shipments were 10,441 tU, valued at $C 1,002 million.

Canada's uranium producers played an active role in 1986 in the international uranium market, with 30 new export contracts approved. Some 122,000 tU has been approved under export contracts since 1974, of which 62,000 tU is scheduled for future delivery. Forward domestic commitments exceed 73,000 tU.

In December 1986, the government of British Columbia announced that it will allow the 7-year provincial moratorium on uranium exploration and mining to expire as planned on February 28, 1987. The moratorium reportedly dampened the search for other minerals sometimes found in association with uranium.

Jennekens Appointed Head of IAEA Safeguards

(IAEA Newsbriefs)

The IAEA Director General has announced the appointment of Mr. Jon Jennekens as the Deputy Director General for the Department of Safeguards, effective July 1, 1987. Mr. Jennekens is currently the Chairman of the Board and President and Chief Executive Officer of the Atomic Energy Control Board in Canada. He will succeed Mr. Peter Tempus from Switzerland.

IAEA Expands Nuclear Safety Program

(IAEA Newsbriefs)

The IAEA Board of Governors has authorized an expansion of the Agency's program in nuclear safety and radiation protection for 1987. The expanded program would set in motion priority activities to heighten awareness of nuclear safety and to promote the "evolution of a safety culture" internationally. Approved activities generally are directed at measures incorporating lessons learned from the Chernobyl accident and pertain to, among other areas, operational safety of nuclear plants, radiological protection, emergency planning and preparedness, and human factors in nuclear power plant operations.

Overall, the program is designed to sustain the momentum built up over recent months in the development of the Agency's nuclear safety program. The expanded nuclear safety program will feature increased OSART and ASSET nuclear plant inspections, as was recommended by the IAEA's International Nuclear Safety Group (INSAG).

OSART Team to Visit Pickering

(Staff)

The International Atomic Energy Agency will send an Operational Safety Review Team (OSART) to Ontario Hydro's Pickering Nuclear Generating Station this May and June for an evaluation of operational safety procedures. The team, composed of IAEA experts, was requested by the Ontario Government and will provide its findings to Professor Kenneth Hare as part of his Ontario Nuclear Safety Review. OSARTs are becoming increasingly common as an international "auditing" process.

USSR Abandons Chernobyl-5 and -6

(Nucleonics Week)

Units 5 and 6 of the Chernobyl nuclear power station will not be completed, according to Andronik Petrosyants, chairman of the USSR State Committee for the Utilization of Atomic Energy (GKAE).

Petrosyants said also that unit 3 of the Chernobyl station, heavily contaminated by the accident at its twin unit 4, will be placed back in service "towards the end of this year." The GKAE head added that the three other RBMK units under construction, at Smolensk, Kursk, and Ignalino (the last a 1,500-MW unit) will be completed as planned.

Soviet officials have reiterated since the accident that no further RBMK units will be planned but have always insisted that Chernobyl-5 and -6 would be completed. Petrosyants offered no explanation for the change in policy. However, in an interview April 24 in the Paris newspaper Le Monde, Valery Legasov of the Kurchatov Atomic Energy Institute, a leader in the Chernobyl recovery effort, said that a decision on whether to pursue construction of the last pair of units at Chernobyl would "depend to a large extent on the quality of decontamination" possible on the construction site. Thus it can be deduced that the contamination was considered too problematic for the long-term presence of a large construction force at the site.

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CNS provides Canadians interested in nuclear energy with a forum for technical discussion. For membership information, contact the CNS office, a member of the Council, or local branch executive. Membership fee is $40.00 annually, $20.00 to retirees, $5.00 to students.

La SNC procure aux Canadiens intéressés à l'énergie nucléaire un forum où ils peuvent participer à des discussions de nature technique. Pour tous renseignements concernant les inscriptions, veuillez bien entrer en contact avec le bureau de la SNC, les membres du Conseil ou les responsables locaux. La cotisation annuelle est de $40.00, $20.00 pour les retraités, et $5.00 pour les étudiants.

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AECL Receives Space Shuttle Contract (CANDU Update)

Atomic Energy of Canada Ltd. Research Company has been awarded a $1.1 million contract to assist the U.S. space shuttle program by performing development tasks related to the qualification of a re-designed O-ring for the solid rocket booster which lifts the shuttle into space. Failure of O-ring seals is considered to have caused last year's "Challenger" accident. The contract award results primarily from AECL's long and successful experience in developing high performance, high reliability fluid sealing devices such as O-ring seals and pump seals for CANDU reactors.

The Crown corporation won the contract from Morton Thiokol Inc. of Chicago, the main supplier of solid rocket boosters to the space shuttle program. The rubber O-ring prevents escape of exhaust gases through joints in the rocket casing.

AECL Celebrates Anniversaries Throughout 1987 (AECL Labstracts)

This year marks important anniversaries at Chalk River, for Atomic Energy of Canada, the NRX and NRU reactors, and for the NPD reactor at Rolphton.

It was 35 years ago, on April 1, 1952, that a new Crown Corporation, Atomic Energy of Canada Limited, took responsibility for operation of the Chalk River nuclear site from the National Research Council. Dr. C.J. Mackenzie was the first President with Dr. W.B. Lewis Vice-President, Research and Development. At that time, the ZEEP reactor (Zero Energy Experimental Pile) had been running for seven years and NRX (the National Research X-perimental) reactor was five years old. NRX celebrates its 40th anniversary on July 22nd. For many years NRX had the highest neutron flux in the world.

Another important anniversary coming up in November 1987 will be the 30th for NRU (the National Research Universal) reactor which went critical on November 3, 1957. NRU is a versatile reactor capable of producing radioactive isotopes while providing ample space and neutron flux for scientific and engineering experiments.

Another event concerns the 25th anniversary of the Nuclear Power Demonstration reactor at Rolphton, Ontario. Built as a prototype for Canadian power reactors, NPD went critical on April 11, 1962.

"Stable" Isotopes Considered for Medicine (IAEA Newsbriefs)

Concern about radiation doses sometimes limits the use of radioisotopes as tracers in human nutritional and medical studies, even though only a very small dose is involved. In many advanced countries, attention has been shifting to the possible application of *stable* isotopes, such as deuterium, carbon-13, nitrogen-15 and oxygen-18, which are inherently so safe that they can be used even in studies of infants, children, and pregnant or lactating women.

As part of work in this field, the International Atomic Energy Agency is planning a new co-ordinated research program, which is due to start in 1987, on applications of stable isotopes in studies of human nutrition and nutritionally-related diseases. This is expected to focus on measurements of protein turnover and energy expenditure in selected population groups, mainly in developing countries.

WHO Supports Food Irradiation (IAEA Newsbriefs)

Long an active international supporter of food irradiation processing, the World Health Organization (WHO) believes that today's consumers may not be receiving accurate information about the technology.

"WHO is concerned that rejection of the process, essentially based on emotional or ideological influences, may hamper its use in those countries which may benefit the most," the organization stated in a recent fact sheet on food irradiation, a physical process whereby foods are exposed to controlled doses of gamma rays, X-rays, or electrons over a limited period of time. In urging "widespread information campaigns" to promote consumer acceptance, it encouraged countries, "regardless of their stage of development," to apply the process. Food irradiation "has the potential to increase safe food supplies, thus contributing to primary health care" and "has the advantage of reducing dependence on food treated with chemical substances," it said. The organization emphasized, however, that food irradiation is "not a miracle process" that can convert spoiled food into high quality food or be suitably applied on all foodstuffs. Its two main benefits, the organization said, are the destruction of certain food-borne pathogens, thus making suitably treated foods safer; and the prolongation of food shelf-life by killing pests and delaying the deterioration process, thus increasing supply.

In 1980, the International Joint Expert Committee on Food Irradiation of the Food and Agriculture Organization (FAO), WHO, and IAEA objectively assessed all available research findings on the wholesomeness of irradiated food. Its report, and the subsequent recommendation by the joint FAO/WHO Codex Alimentarius Commission (which sets international food standards) support the safety of food treated by ionizing radiation up to a specified dose level.

Hiroshima Researchers Devise Chernobyl Study (Nature)

The Soviet Union is planning a major survey of the medical consequences of the Chernobyl disaster based on a health monitoring program drawn up by the Radiation Effects Research Foundation at Hiroshima, Japan. A Soviet team of five, which spent 10 days in Japan recently at the request of the Soviet side, was presented with the monitoring program at the end of its stay.

The object of the program will be to monitor, and attempt the prognosis and treatment of, the long-term effects on those exposed to radiation around and near Chernobyl. As part of the program, an attempt will be made to determine the doses of radiation to which people were exposed.

A particular consequence of the accident now being brought to light is the possibility that 'micro-hotspots' consisting of small particles of radioactivity may have been more widely distributed after Chernobyl than first seemed possible. Although the amount of the fuel which 'relocated' in areas remote from the reactor site was only a minute fraction of the whole, 'micro-hotspots' were recorded as far afield as Sweden in the first reports of radioactivity after the accident.

Although the early Soviet medical work after Chernobyl concentrated on radioiodine and caesium, recent Soviet reports obliquely indicate that hotspot contamination is causing increasing concern. A Polish nuclear safety expert has indicated that whole-body monitoring suggests that as many as one in ten inhabitants of Warsaw has ruthenium hotspots in his or her lungs, while in Bialystok, close to the frontier of the Byelorussian SSR, the proportion may be as high as one in three.

CNS News

The following letter was sent on March 16 by Nabila Yousef, CNS President, to the Hon. Marcel Masse, federal Minister of Energy, Mines and Resources in Ottawa. The Minister replied in a letter of April 8.

Dear Minister Masse,

I am writing to you on behalf of the 31,000 Canadians working in the nuclear power industry in Canada today.

Over the past 2½ decades, we have dedicated our working lives to make the CANDU system the most successful option available in the world.

Since the end of the Second World War, the Government of Canada has invested approximately 3 billion dollars in the R&D required to develop this excellent system. This wise investment to date has led to the installation of approximately 25 billion dollars of nuclear plants in Canada, and probably as much as 40 billion dollars when mines and manufacturing facilities are included.

Already the investment of so little has meant the realization of the most cost effective reactor system in the world today. We have so far 156 reactor years of safe operation of CANDU reactors. The cost of electricity of this system is at least 25% cheaper than any other source in the western world – be it nuclear, coal, or oil – with few exceptions in specific geographic locations close to open-cast coal mines. Any

high technology system that has been successful consistently over the years requires not only the dedication of the people to make it work but also the support of their government. We ask the Government of Canada to continue its open and consistent support of the CANDU system, as any government representing any country will grow or fade by its export potential.
Your support should take the form of export financing, open lobbying of foreign governments, and ensuring the continuance of R&D funding to keep this technology at the forefront. There is an opportunity to develop a refinement of the CANDU system (300 MW CANDU) which could lead to a much greater export market for those countries only able to absorb smaller blocks of generated power at less overall cost.
Thirty-one thousand of us have done our job to the best of our abilities. We look forward to your continued support not only to ensure the existence of our jobs in the future but also the expansion of this industry to the benefit of many others in this great country of ours.

Yours truly,

N. Yousef
President of the
Canadian Nuclear Society

cc: The Rt. Hon. Brian Mulroney
The Honourable Michael Wilson
The Honourable David Peterson

Reply

Thank you for your letter of March 16, 1987, expressing support for the Canadian nuclear industry.
The present state of the nuclear industry and the risk of the demise of the CANDU concept indeed presents us with a serious challenge. I agree that we must do whatever is reasonable to ensure that the CANDU option is maintained. To that end, I have personally taken steps to advance discussions on the Lepreau 2 CANDU 300 project; my Department continues to work closely with Atomic Energy of Canada Limited in this direction. There are a number of hurdles yet to overcome before the project can be committed, but I am pressing to ensure that the issues are addressed in a timely manner.
One immediate issue to be addressed is the potential for the private sector to participate in the funding of Lepreau 2. This would provide an objective analysis of the risks and benefits of the project and would demonstrate that the private sector believes that Lepreau 2 is commercially viable. Private sector views on how we might work towards achieving this objective are now being sought.
Clearly, maintaining a viable nuclear power option in Canada is important, both for the immediate future and for following generations. The issue warrants cooperative initiatives by the government and the private sector.
I hope this information will be of assistance and thank you for bringing the perspective of your Society to my attention.

Yours sincerely,

Marcel Masse
Minister of Energy, Mines and Resources

Toronto Centre for Ethics and Corporate Responsibility

The Toronto Centre for Ethics and Corporate Responsibility will provide a resource to people and organizations when addressing critical social and ethical issues in business, based on an understanding of ethics and the part it can play in policy and decision making. The Centre proposes to bring together people of diverse religious and secular traditions to meet and share insights with business leaders, social scientists, ethicists, and clergy with a view to finding practical solutions to critical concerns, and to set standards which will serve as models for the business community. A practical, value-based approach to ethical analysis and a free exchange of ideas is considered to be essential to finding solutions to ethical problems.
For more information contact: Rev. Graham Tucker, King-Bay Chaplaincy, Box 175, Toronto Dominion Centre, Toronto, Ontario, M5K 1H6, (416) 366-2643.

PRV

The Need for CANDU PRA (II)

An earlier PRV column by David McArthur, which appeared in the November/December 1986 CNS Bulletin, argued for Probabilistic Risk Assessment (PRA) of all CANDU nuclear reactors. Here he continues arguments in favour of PRA. As always, views expressed in PRV are solely those of the writer.

The growing international interest in probabilistic methods and criteria for nuclear power plant safety is part of a fundamental shift from traditional deterministic nuclear safety criteria. In the words of the International Atomic Energy Agency, from its 1986 booklet "IAEA Activities in Nuclear Safety":
"The designers of nuclear installations seek to assure plant safety by arbitrarily assuming that certain events which could initiate an accident will occur, then designing safety features either to prevent the development of a given accident sequence, or to mitigate its effects. The deterministic criteria used are based in part on experience, and in part on engineering judgement. For modern, complex, large-scale technologies which have the potential for accidents with significant consequences, it is neither advisable nor possible to wait for statistical evidence of accidents to accumulate before re-evaluating deterministic criteria. Probabilistic safety analysis (PSA) has become a tool complementing deterministic criteria and substituting for statistical evidence.
PSA techniques use data on the failure rates of system components as the basis for the development of models of possible accident sequences, and the assessment of their probability. They help analysts to identify components, human acts or systems which could affect plant safety. Thirty (IAEA) Member States have active PSA programs, many of them supported by the IAEA. The Agency offers training courses for PSA experts . . . ".
The IAEA recognizes and supports PRA/PSA. It also notes that the numerical results give estimates of probabilities of accident sequences, core damage, radioactive releases and consequences to public health and the environment. However, probabilistic techniques and criteria promise to assimilate, even supercede traditional deterministic nuclear safety criteria, not merely complement it. Argentina has recently used Probabilistic Safety Criteria (PSC) to design its indigenous (pressure-vessel) Argos pressurized heavy water reactor. (Argentina also claims to have recently designed its own CANDU). The *IAEA Newsbriefs* newsletter (of March 5, 1987) reports that some IAEA member states already have adopted Probabilistic Safety Criteria while others are monitoring developments.
The IAEA has defined "Probabilistic Safety Assessment" (PSA) to be virtually the same as Probabilistic Risk Assessment (PRA) as it is known in the U.S. (See "Probabilistic Safety Assessment: Growing Interest," *IAEA Bulletin,* Autumn, 1985.) The difference between the words "risk" and "safety" isn't that great, although risk is always probabilistic. "Assessment" has also been replaced with the word "Analysis" in some literature, including that of the IAEA.
While PRA is PSA, PSA is not necessarily PRA. PRA (in the U.S.) is rigorous and well defined and part of a regime, whereas PSA, elsewhere, is not necessarily so. In other words, a PSA study might be sold as possessing all the merits and rigour of a PRA, while in fact, it may be a study less rigorous than a PRA. To complicate matters further, there is PSC.
A PRA could be poorly done, or inadequate, therefore there is a need for peer review. It should also be a full peer review, which would amount to an auditing of the PRA process by external parties. This is a need that is recognized in the United States, where the PRA developed and where the PRA regime is most advanced. While many things are not right with the nuclear program in the U.S., the use of PRA there is one thing that does lead the world. It would be reasonable for a country where the use of PRA is still developing to adopt the definitions and procedures of the U.S.
The U.S. Nuclear Regulatory Commission now requires PRA (or its equivalent) at all nuclear plants (there also are several levels of PRA analysis in the U.S.). The study of consequences is also a needed aspect of PRA.
PRA becomes a model of the way in which failures can occur in a nuclear reactor, or any complicated process. It can be as comprehen-

TECHNICAL SUPPLEMENT

CNS Bulletin May/June 1987 Canadian Nuclear Society

HUMAN PERFORMANCE IN ONTARIO HYDRO NUCLEAR STATIONS

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Abstract – *Ontario Hydro has always addressed aspects of human performance by the use of the Operational Safety Management Program. One means by which deficiencies in human performance are assessed is the Significant Event Report (SER) System. Over the past 25 years, and through operating experience, the SER system has been improved. New techniques in performance evaluation have evolved along with the SER system, the latest of which is the development of the Human Performance Evaluation System (HPES). HPES provides a systematic analysis of events and decisions that expose the causes of error in performance. This analysis is the basis of corrective action. The adoption of HPES by Ontario Hydro has improved the operating environment of its nuclear stations.*

INTRODUCTION

In this paper we present human performance evaluation in the context of the Operational Safety Management Program.

The operation of the nuclear generating stations in Ontario is the result of over 40 years of applied research and development. Today Ontario Hydro has 17 nuclear power reactors in operation. Four more are scheduled to be in-service by the early 1990s.

There are many reasons why Ontario Hydro's CANDU generating stations are safe. The two most important reasons are:

- the multiple barriers against radiation release built into the CANDU design; and
- the Operational Safety Management Program.

BARRIERS

These barriers can be visualized as shields between the radiation source and the public. These barriers are:

- The Nuclear Fuel: Ceramic uranium oxide has a high melting point so that most of the radioactive fission products are retained within the fuel pellet.
- The Nuclear Fuel Sheath: The Zircaloy fuel sheath is designed to withstand stresses resulting from expansion of the fuel, fission gas pressure, external hydraulic pressure of the heat transport fluid, and mechanical loads imposed by the fuel handling equipment.
- The Heat Transport System: The nuclear fuel is contained within the heat transport system. Fission products escape into the containment structure only through failure of this system. The heat transport system piping is designed to meet all relevant codes for a high pressure fluid boundary.
- The Containment Structure: The reactor and the heat transport system are located in the concrete, steel reinforced containment structure.
- The Exclusion Zone: No habitation is allowed within 914m of the station.

Although these barriers are formidable, they are required to function only in the last resort. Many other systems must fail before the barriers are needed.

All systems in a nuclear station are categorized into two broad groups. These are:

- Process systems being those systems used in the operation and control of plant equipment and processes; and
- Special Safety Systems, which are independent systems that perform one or more functions to prevent the accidental release of radioactive material following a process failure. The following systems are in this category:
  a) Reactor shutdown systems.
  b) Station containment systems.
  c) Emergency coolant injection systems.

The Process and Special Safety Systems *control* the nuclear reaction, *cool* the nuclear fuel, and *contain* the radiation. Therefore, they form additional barriers between the public and the radiation source.

THE OPERATIONAL SAFETY MANAGEMENT PROGRAM

To maintain these barriers and systems, Ontario Hydro's work program has four main objectives:

- To ensure that the process systems are reliable.
- To ensure that the special safety systems are reliable.
- To ensure that equipment and procedural faults are detected, assessed and promptly corrected.
- To develop highly-trained operating staff.

These objectives are the basis of the Operational Safety Management Program.

To focus the Program on problem areas an experience review system has been developed to:

- establish trends;
- establish the degree of compliance with standards; and
- determine the causes of poor performance.

There are many ways by which experience review takes place. Some are: In-Service Reports, Radiation Dose Reports, and Quality Assurance Audit Reports. For human performance evaluation, the primary method of experience review is the Significant Event Report.

THE SIGNIFICANT EVENT REPORTING SYSTEM

A significant event is an abnormal or unscheduled incident that causes or can cause an undesirable effect upon public or employee safety, product quality, environmental protection or product cost. The SER (see Figures 1a and 1b) describe the circumstances of the event reported and the corrective action. The SER system includes prompt reporting, a review, rigorous follow-up and cataloguing of all events on a database.

Examples of events that require SERs are a disabling injury, or a reactor trip.

The system is very broad in scope and covers almost every aspect of nuclear station operation. The system has been in operation from the beginning of Ontario Hydro's nuclear program. The effectiveness of the system has improved with experience.

OVERVIEW OF HUMAN FACTORS

The purpose of the SER system is to provide a logical basis for analyzing and correcting deficiencies that lead to error.

In spite of advanced technology and degree of automation of the CANDU design, mistakes and malfunctions do occur. Considerable effort has been made to prevent, or reduce, the incidence of error. For example, by improving the layout of instruments and annunciators in control rooms, information is more readily available to operators.

FIGURE 1a

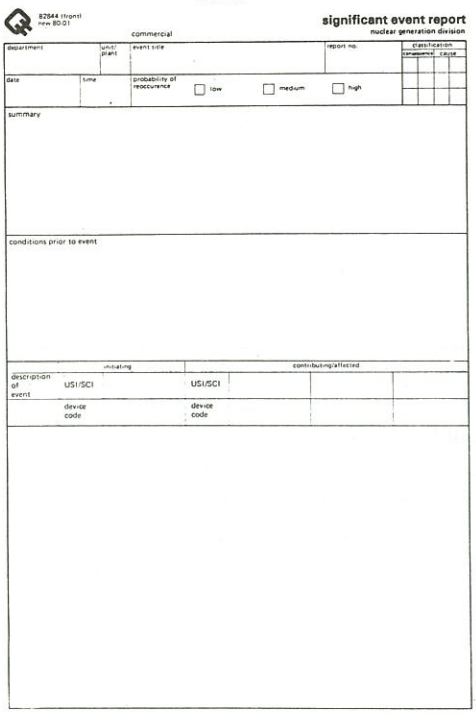

Figure 1a

FIGURE 1b

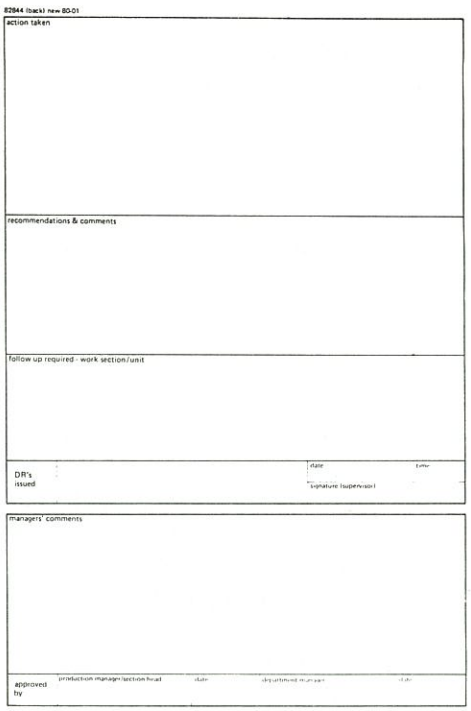

Figure 1b

Figure 1:
The Significant Event Report used by Ontario Hydro. Figure 1a (left) shows the front side, while Figure 1b (right) shows the reverse side of the form.

Equipment identification has also been improved by the use of colour codes and tagging. Well-written procedures are essential to the safety of equipment and personnel. Ontario Hydro places increasing emphasis on the use of clear procedures and well-developed quality assurance programs. Procedures must be verified to ensure that they are correct before they are issued.

As more reactors came into operation, Ontario Hydro increased the resources available to improve the human factor. We added safety system monitoring computers to reactor control rooms, and installed simulators for operator training. We found, however, that insufficient attention was being paid to the accumulation of human factor data. Then the Three Mile Island accident occurred in 1979.

The 1979 TMI accident focussed the attention of the international nuclear community on the human factor in nuclear operations.

In response, Ontario Hydro developed the Human Factors Reporting Form (see Figure 2). This form became part of the SER system, to ensure analysis of those operator actions that contributed to the event with the obvious intent of avoiding its repetition. The form is used throughout the Nuclear Generation Division for analysis. To record the human performance problems in addition to existing information the database had to be modified.

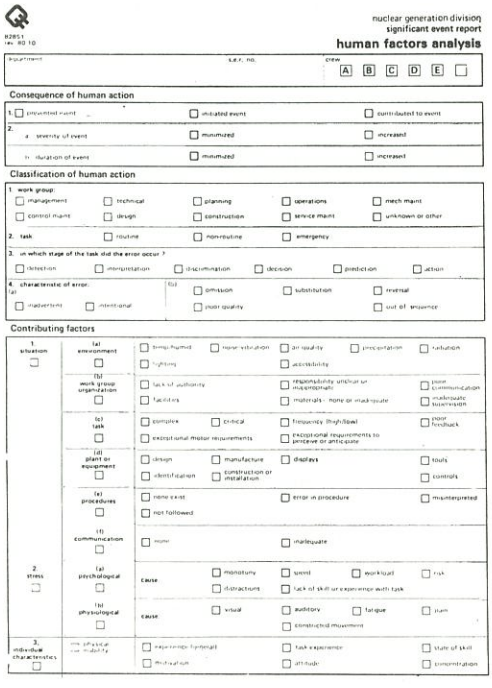

Figure 2:
The Human Factors Reporting Form used by the Nuclear Generation Division of Ontario Hydro.

As the need for further study of human factors became apparent, it was recognized that the SER System had limitations. Operating staff had neither the time nor the training to conduct detailed analyses. Problems which occurred on one shift may have originated on the previous shift or in other departments which work with the operating shift. This made it impractical for one person on shift – usually the Shift Supervisor – to gather all the facts needed to reach a conclusion as to the cause of the event.

Parallel to the Ontario Hydro experience in human performance analysis the Institute of Nuclear Power Operations (INPO) recognized similar shortcomings in the American reporting system. Consequently, INPO developed a system to analyze human error, called the Human Performance Evaluation System (HPES). A pilot program was launched in the USA in 1981. The pilot project was successful and because of this its application was extended to many utilities in the USA as well as the French national utility EdF.

HPES operates under the following axioms:

- People are not perfect.
- People want to perform well.
- Human error cannot be eliminated but it can be reduced.

The system has these objectives:

- To determine the causes of poor human performance.
- To specify and implement corrective action.
- To monitor the success of the corrections made and to modify them as necessary.

To encourage an open exchange of information, the system is anonymous and non-punitive. All data gathered during HPES evaluations is kept confidential.

Ontario Hydro joined the HPES program in 1984 and a HPES trial was set up at two Ontario Hydro nuclear stations: Bruce NGS-A, and NPD-NGS in Rolphton.

Bruce NGS-A is a four unit station located on the shore of Lake Huron approximately 250 km north-west of Toronto. Its net electrical output is 2960 MW.

The station is organized as shown in Figure 3. The major work groups are:

- The Production Section which operates and maintains the nuclear units.
- The Technical Section which provides work plans, technical procedures and guidance to the Production Section.
- The Quality Assurance Section which ensures that all legal and regulatory requirements are met. It also coordinates the human performance evaluation program.

The purpose of the trial was to determine if the HPES could improve the existing SER system. Selected personnel were trained by INPO. The training included human

Figure 3

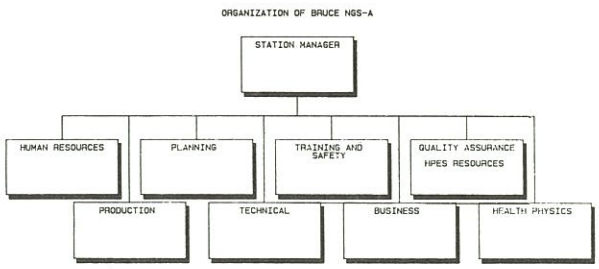

Figure 3:
Organization of Bruce NGS-A

performance theory, interviewing skills, a number of analytical techniques such as Energy Trace and Barrier Analysis. The 14 month HPES trial at Bruce NGS-A was an evaluation of 28 significant events using the SER System and the HPES. These events covered reactor and turbine trips, heavy water spills, the impairment of special safety systems and radiological hazards. HPES provided otherwise unobtainable information on the human factor. It produced more recommendations for corrective action than the SER system alone.

The use of HPES improves the evaluation of significant events as follows:

- The use of a trained HPES person improves the information gathering process. This makes it easier to identify problems. It also guarantees a detached and independent viewpoint.
- A neutral atmosphere and assurance of confidentiality makes information gathering easier.
- Analytical techniques such as Barrier and Energy Trace Analysis are used to determine the causes of the event under investigation.

The trial program ended in December 1985. In 1986 the HPES program was extended to all nuclear facilities. Resource people were appointed and trained and are capable of analyzing human performance.

Following is an example of how Bruce NSG-A management has applied the HPES:

> In the summer of 1986 the Atomic Energy Control Board required that the annulus gas system moisture detection for pressure tube leakage was to be operational before unit 2 was started.
>
> The unit was started with the moisture detector out of service.
>
> Management requested an evaluation of this event. It was concluded that there was a failure throughout the organization to communicate the AECB requirement.
>
> The answer to the problem was to improve the awareness of the station staff of good communication.

Other examples of how HPES recommendations have improved the operating environment are:

- Guidelines were prepared stating the minimum requirements for non-routine and post-maintenance testing.
- Signs were posted on equipment to identify specific hazards.
- Better tools have been purchased to do the job.

SUMMARY OF THE BRUCE NGS 'A' PROGRAM

Since 1984, 36 significant events have been analyzed using the HPES. This is only a small number of the total SERs issued over the same period. On average, 128 SERs are issued every year, of which 44 stem from human factors. The following indicates where the human performance problems may lie (see Figure 4). This data was compared with INPO's database which contains 132 evaluations from the seven participating utilities, including Ontario Hydro. Bruce NGS-A experience is comparable to international experience.

At BNGS 'A' the major causes ranked in order of frequency were:

Cause	Frequency (%)
Communications	19
Personnel Factors	17
Managerial/Supervisory	17
Workplace	16
Procedures	14
Work Organization	7
Training	6
Work Scheduling	2
Change Implementation	1
Third Party Requirements (e.g. AECB)	1
TOTAL	100

The top five categories account for 83% of the events analyzed and are summarized as follows:

Communications: failure to transmit information.
Personnel Factors: psychological and physiological factors such as work stress.
Managerial & Supervisory: inadequate supervision.
Workplace: displays or controls inadequate (e.g. Control room annunciation windows).
Procedures: missing information.

To correct problems arising from these causes we have applied Ontario Hydro's industrial safety philosophy, which is to eliminate the cause; and, where elimination is not possible, to control the hazard and protect plant personnel.

Figure 4

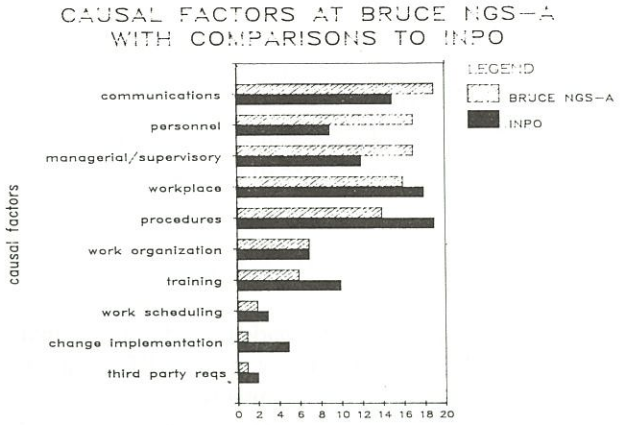

Figure 4:
Causal Factors at Bruce NGS-A, with comparisons to INPO

For example, Communication was identified as the most frequent cause of problems at Bruce NGS-A. A communication study was conducted for maintenance. Four problem areas were identified.

- Shift turnover: loss of information at shift turnover.
- Communication between work groups on the same shift crew.
- Work report: insufficient information on the maintainer's work report.
- Communication between the technical and production staff.

Communication was improved in two ways:

- Guidelines were issued to specify the minimum information to be given on shift turnover documents.
- Supervisor training sessions will emphasize communications skills.

Sixty additional recommendations for corrective action were made as a result of HPES analysis; 23 of these were implemented; 5 could not be justified. The remaining 32 were scheduled for future action. Most recommendations were small, inexpensive modifications to procedures or work methods. This demonstrates that improvements to the operating environment need not be costly.

COMBINING HPES AND THE SIGNIFICANT EVENT REPORTING SYSTEM

Combining the HPES with the SER system has led to the following program:

- Promoting the use of human performance evaluation by informing station staff of the increased attention the subject will be given.
- Monitoring HPES recommendations for effectiveness.
- Developing the expertise through HPES training and event evaluation.

PROGRAM PROMOTION

In 1985, a survey was made to find out how many of the Bruce NGS 'A' staff knew of the HPES trial and its goals. Only 15% of the personnel were aware of the program in spite of efforts made to publicize it. In 1986, program promotion, which included information seminars and a poster campaign was given high priority. The posters promoted training and communication. An article was published in the newsletter *BNPD Site News* describing the HPES program at BNGS 'A'. A station newsletter listing HPES recommendations and their status was also published. The response was good. Over 200 station staff attended the seminars and expressed opinions on the management system. For example, vacuum cleaning was noisy in the Main Control Room, irritating and distracting the unit operators. One operator asked for the problem to be investigated. Standards set for noise limits in the control room were exceeded. Research into the psychological effects of noise on personnel who must be vigilant indicated that the cleaning operation was a problem. We investigated the installation of a central vacuuming system.

The promotion campaign has made HPES evaluation easier. More people are aware of the system and its goals, and are more willing to cooperate. The campaign has dispelled the idea that HPES is a management tool to be used on workers. Involving workers, and soliciting recommendations from those who know the job best, has won acceptance from station staff of human performance evaluation.

MONITORING

Demonstrating the benefit of the program by improving the operating environment has been the key to the success of the HPES program. Actually getting work done, however, is much more difficult than getting agreement the work should be done. This has been due to the heavy maintenance and modification workload with which the station has recently had to cope. To ensure improvements take place, the HPES resource person has had not only to investigate events and make recommendations, but carry out those recommendations. For example, following one evaluation, a new procedure was recommended for the operators. Although the recommendation was accepted, no one had time to write it, so the person responsible for HPES studies wrote it. In another case, timing devices were recommended and agreed upon. The procurement of these devices was done by the HPES resource person.

DEVELOPING HUMAN PERFORMANCE EXPERTISE

To provide the expertise needed to evaluate human performance in the future, we have developed a two-tier training program. The first level, to be given to shift supervisors, will be included in existing safety courses. It will consist of human performance theory and case study. With training, shift supervisors will be able to analyze the human factor when investigating significant events.

The second level of training will be given to individuals selected from the Production and Technical Sections. This will be the HPES evaluator training given by INPO. In this way we will be able to isolate and resolve problems that may occur on one shift as well as having the resources to analyze more complex problems.

FUTURE WORK AT BRUCE NGS'A'

To date, the evaluation of human performance at Bruce NGS-A has been a reactive process. That is, an undesirable event occurs and resources are used to discover the whys so it doesn't happen again. For the HPES to be more beneficial it would be helpful to identify and rectify deficiencies before they result in operating or maintenance errors. We have had some success with this proactive approach through our poster campaign. Workers have made potential problems known, which have been remedied before trouble results.

At Bruce NGS-A we have considered adopting a proactive system. It would consist of a promotion campaign, a means of reporting human performance deficiencies, and a feedback system.

CONCLUSION

Human performance evaluation is an important part of the Operational Safety Management Program.

We have described how the SER system is used to evaluate human performance problems in Ontario Hydro. The HPES is a valuable improvement to the SER system. Systematic and rigorous evaluation has become an established feature of nuclear operations. The major benefit is the ability to identify shortcomings and strengthen the management system. Another is the integration of effort among the various work units.

REFERENCES

[1.] S. B. Harvey, "Ontario Hydro's Nuclear Operational Safety Management Program," RMEP-IR-03600-80, October, 1980.

[2.] R.W. Bartholomew, et al., "Ontario Hydro CANDU Operating Experience," NGD-9, 1985.

[3.] "The Safety of Ontario Hydro's Nuclear Reactors, Final Report," The Select Committee on Ontario Hydro Affairs, 1980.

[4.] I. Walker, B.N. Dick, "Human Performance Evaluation System Trial Program," BGA-IR-09053-6, February, 1986.

sive, as close to the reality, or as restricted as the people applying the PRA want to make it. PRA looks at possible accident events down to and including those less frequent than the design basis of the plant, below the deterministic criteria of 10^{-7} events per year in the case of many reactor systems. Deterministic safety criteria alone can give a false sense of security, as evidenced by TMI, Chernobyl and even the space shuttle accidents.

Canada needs to catch up to the U.S. in PRA, partly due to Canada's early (and world-leading) success at applying deterministic nuclear safety criteria, which followed its two nuclear research accidents in the 1950s. This early success may have resulted in institutional resistance to the later innovation of PRA.

PRA originally got off to a bad start, due to early over-optimistic and seemingly over-complex PRA used in the U.S. Rasmussen report. As a result, PRA was viewed with suspicion and generally misunderstood.

Now, however, those still rigidly in the deterministic school may need to do some catching up. Even the recent report by Sir Frank Layfield on the proposed Sizewell PWR in the UK revealed some confusion concerning the scope and directions of PRA.

In Canada, Ontario Hydro is completing the "Darlington Probabilistic Safety Evaluation" (DPSE) of the Darlington Nuclear Generating Station, the first study of CANDU which promises a full PRA approach, and which is being unveiled at the CNS annual conference this June. Terry Rogers, Frank King and others in Canada have championed PRA of CANDU reactors.

Full-fledged and peer-reviewed PRAs of all CANDU plants would make a lot of sense. It is to be expected that the earliest and longest-running plants would have the greatest overall risk of core damage accidents and would require PRA to identify the risk factors (not apparent by deterministic analysis or criteria) and correct them.

Towards establishing global PRA/PSA/PSC standards, the International Atomic Energy Agency has a committee studying the issue: the "IAEA Technical Committee on Prospects for the Development of Probabilistic Safety Criteria." The IAEA may set such nuclear safety criteria, and may also eventually audit it (witness OSART, ASSET) and perhaps, may even eventually enforce it. This would amount to a global nuclear safety regime, however, national nuclear regulatory bodies should adopt PRA approaches first.

Last year, calls for more PSA/PRA came from the IAEA's International Nuclear Safety Advisory Group (INSAG, of which Canada's Dan Meneley is a member), the USSR and the CEC, while responding to the Chernobyl accident. *IAEA Newsbriefs* also notes that the IAEA is now preparing a comprehensive report on the INSAG recommendations, which concentrate on PSC for nuclear safety functions and systems. The report also analyzes underlying principles, definitions and approaches taken by IAEA member states.

Another reason for PRA is that it may not simply aid in marketing nuclear reactors for export; it is now demanded by the more astute governments in their recent calls for reactor bids. If an export reactor has not had a full-fledged PRA, it may not be in the running.

Also, just as reactor performance is being considered for the determination of electricity rates in some jurisdictions, PRA performance may also have implications to nuclear liability as well as emergency planning.

D. McArthur

CNS Division Update

Results of the 1987 NSED Elections

The results of the 1987 NSED election have been tabulated and the successful candidates are:

B. Rouben (AECL)
W.J. Midvidy (OH)
R.C. Robinson (ANSL)

On behalf of the NSED, I would like to congratulate the successful candidates, and to thank all the candidates for their interest in standing for election. I hope this interest in the activities of NSED will continue, and that unsuccessful candidates will be willing to again stand for election in the future.

E. Young
NSED Returning Officer

CNS Branch Programs

Toronto Branch

On March 24, Mr. Ken Talbot, Commissioning Manager at Pickering Nuclear Generating Station, made a presentation to the Toronto Branch entitled "Pickering NGS Update: Retube, Restart and Future Expectations." The meeting was sponsored jointly with the University of Toronto, Centre for Nuclear Engineering.

Mr. Talbot began by outlining the history of nuclear energy in Ontario and briefly describing some of the design features of Pickering NGS CANDU units. He then launched into a detailed description of the G16 pressure tube break which ultimately resulted in the decision to retube Pickering units 1 and 2. A scale model of a section of the fuel channel showing the calandria tube, pressure tube, a fuel bundle and a "guilty" spacer (an out of place spacer which allowed the pressure tube and calandria tube to contact, leading to the failure) helped to illustrate both the events leading up to the rupture and the retubing process.

Mr. Talbot discussed the problems which have arisen during the retube project (such as carbon-14) and also the unique solutions which were implemented. Also discussed were other major jobs completed during the outage and future plans for the other Pickering reactors.

The presentation was very well received by a large audience of approximately 150 (the doughnuts ran out 15 minutes before the talk began!). The question period was lively and interesting.

The next issue of the *Bulletin* will report on Dr. David Mosey's review of two classic reactor accidents.

John Marczak
Eva Hampton

Central Lake Ontario Branch

On March 26, a meeting of the Central Lake Ontario Branch was held at the Pickering Information Centre. About 40 people were in attendance to listen to the two guest speakers, Nabila Yousef, President of the CNS and Dr. Tom Drolet, Program Manager of Isotope Sales and Services for Ontario Hydro. Ms. Yousef outlined the CNS plans aimed at informing the public of the benefits associated with nuclear energy through such means as the formation of a speakers bureau. She also called on industry members to speak out on the issues and to lobby their government representatives for continued support. Dr. Drolet outlined the present and future plans of Ontario Hydro's isotope marketing program including the sales of cobalt, heavy water and tritium. This was the first of the quarterly branch meetings to be held this year and was well organized by Dave Austin and George Wieckowski from Pickering. The next one is scheduled for June and will be held in Port Hope.

D.F. Meraw

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Book Review

Fallout from Chernobyl, L. Ray Silver, Deneau, 1987.

Ray Silver's title is somewhat misleading in that it understates, by a very considerable margin, the scope of his book. It is true that the Chernobyl accident and its aftermath form the central theme of the work, but as he recounts the events of April 26, 1986, he progressively widens the scope to provide the scientific and historical context for nuclear energy, to document the major role Canada has played in the evolution of nuclear science and engineering and her unique achievements in that field, and to show how media misinformation and political pusillanimity can combine to vitiate scientific and humanitarian endeavours.

Silver takes us back to the thirteenth century to Roger Bacon's formal documentation of a rational and systematic method of enquiry, to the sixteenth to identify the "mountain sickness" characterizing Joachimstahl in Czechoslovakia, the world's first "nuke town" and to the nineteenth and twentieth to follow the pioneering work of such as Becquerel, Curie, Roentgen and Rutherford. (It is a small point, but one wonders whether the characterization of ions as "jolly little beggers," ascribed to Rutherford, has not received some tasteful editing in the form of a vowel change to the third word, when one remembers Sir Ernest's reputation for pungent expressions).

In style, scope and achievement Silver's book is closest to the work of the great eighteenth century essayists. There is the same erudition, the same extraordinarily broad intellectual scope, the same scathing wit and the same passionate conviction. Indeed Silver can erupt in positively Johnsonian indignation as he recounts the "tea and sympathy" dispensed by the Canadian Department of External Affairs. And he exhibits a Johnsonian delight in exposing cant, exploding myths and exploiting linguistic infelicities (particularly those of the news media) for their comic (not to say salacious) effects – his identification on page 153 of what may well be the twentieth century's most sustained unwitting double entendre is worth the price of admission alone.

Of course, this does not make the task of the reviewer an easy one. Since the book truly reflects the nature of human intellectual experience and is an elegantly crafted radiating network, the linear approach ("In his opening chapters the author . . . ") is as appropriate as using a measuring rod to check the metre of a sonnet. Perhaps the answer is to identify Silver's main themes. A most important one is that of the magnitude and nature of the hazards of nuclear energy – as Silver reiterates, "so long as the sun shines and the rivers run, energy would cost sweat and tears and sometimes blood. There was no free lunch." Placing the 31 deaths at Chernobyl in a mortality perspective, Silver notes:

> "Ten times that many died of stomach infection in Angola that May; ten times as many died of cancer in Britain that month . . . a gun happy American killed half as many fellow workers in an Oklahoma post office one afternoon that summer. All were irrevocably removed from society, yet none of them became post-mortem celebrities."

In fact, Silver establishes the human cost of Chernobyl as being that of a very serious industrial accident – tragic in that any lives were lost, but of modest cost in comparison to such real catastrophes as Bhopal. The point he leads to is not that nuclear energy is OK because it doesn't kill as many people as other technologies (including other energy technologies) – although this is a factor worthy of consideration – but that until Chernobyl, nuclear energy was repeatedly faced with the same question – "what if . . . ". Now, Silver establishes, we've seen "if" since it is difficult to conceive of a more disastrous reactor accident. The sky has not fallen. The accident was costly but not unmanageable. And the "doomsayers" are facing a credibility gap.

One of Silver's major achievements in his book is to open to us what was, until Chernobyl, a closed society. Closed, one might add, by ourselves rather than the Soviet Union. That we had little, if any, understanding of the Soviet nuclear power program on April 26 was certainly not due to Russian secrecy – as this reviewer can attest, our libraries were well stocked with articles and conference papers on all aspects of the various Russian reactor systems but few people had bothered to read them. Such unawareness of one of the world's largest nuclear energy programs is hard to justify. Even harder to justify is the treatment of the accident by the western news media, where apocalyptic stories appear to have received little discouragement from the scientific community. A *New York Times* headline screamed, "Mass Grave for 15,000 Nuke Victims" while, uncharacteristically, the *Toronto Sun* made the more modest claim of 2,000 dead. Much coverage was made even more repellent by thinly veiled gloating, reminiscent of the worst that Fleet Street's scumbuckets can dredge up. It reflects lasting discredit on the western scientific community that few, if any, voices were raised to counter what were clearly science fiction stories – and not very good science fiction at that. Early in May (around the 6th) a Torontonian would have been presented with a choice of three views of the Chernobyl accident from the print media: "Reactor Fire Out Say Soviets," "Nuke Fire Rages On" and "Second Reactor Begins to Melt Down" – and this from people dedicated to reporting the *facts!* For the Canadian news media's treatment of the accident, Silver reserves his strongest criticism for the CBC – and rightly so. On the Sunday morning following the accident the wireless program *Sunday Morning* broadcast what purported to be an emergency measures announcement relating to a nuclear accident at Pickering. To designate this "puerile play-acting" the height of irresponsibility is to be too kind, but stronger language would probably alarm the publisher's lawyers.

It was not just the news media, Silver argues, who were irresponsible. Politicians seem to have been equally culpable, and Silver notes with some irony that at the very time the heads of seven nations at a Tokyo conference were calling for the Soviet Union to start providing information, IAEA Director-General Hans Blix had already arrived in Moscow (at the Soviets' invitation) for a detailed technical briefing on the accident. Political and media response to the Chernobyl accident was too often, Silver argues, informed by cold-war attitudes and, at times, virtually amounted to "red-baiting."

Silver's own account of the accident and its aftermath is detailed enough to give the lie to any accusations of Soviet secrecy. And to any Soviet official, Silver's book would be ample vindication of the *Glasnost* policy since he pays generous (and thoroughly deserved) tribute to the prompt, effective and heroic efforts made to contain the accident and protect the population. Indeed, Silver suggests that Soviet concern, for example, for the psychological impact of the accident and evacuation of children contrasts strongly with the total indifference to the psychological trauma inflicted on 41 children living in Malvern. Slight levels of radioactive contamination were discovered there in November 1980. The resultant media ballyhoo was fanned by nuclear critics and self-appointed experts who, in actions which can only be described as despicable, questioned the adequacy of medical examinations of children and misrepresented the results of those examinations.

Canada's expertise in all aspects of radioactive decontamination and reactor repair is another important theme in *Fallout From Chernobyl.* Silver carefully documents the development of Canadian experience in these areas from the NRX accident recovery to the retubing of Ontario Hydro's Pickering reactors. Special attention is paid to major decontamination achievements in the form of the clean-up of a seriously contaminated Toronto building in the mid 'seventies and the recovery of the fragments of the Cosmos-954 satellite in 1978 – the latter a particularly spectacular demonstration of Canadian expertise. Could not, Silver suggests, this reservoir of experience be put to use in establishing an international team of specialists under the auspices, say, of the International Atomic Energy Agency, to provide assistance in decontamination and accident recovery? Silver points out that formation of such a "nuclear safekeeping" group would provide a strong focus for the development of increased international cooperation and mutual assistance in nuclear matters and would be in the tradition of this country's leadership role in establishing international cooperation on the peaceful uses of atomic energy. The idea is so manifestly sensible that clearly its chances of adoption by the politicians are correspondingly small.

(continued on page 7)

Conferences & Meetings

27th Annual International Conference of the CNA and 8th Annual Conference of the CNS

To be held **June 14-17, 1987** in Saint John, New Brunswick. For information contact **CNS Office,** (416) 977-6152.

International Workshop on Mechanisms of Irradiation Creep and Growth

Sponsored by AECL, UKAEA, Ontario Hydro and CNS, to be held **June 22-25, 1987** on Hecla Island, Manitoba. For information contact: **Dr. C.H. Woo, Whiteshell Nuclear Research Establishment, Pinawa, Manitoba, R0E 1L0,** (204) 753-2311, ext. 2255.

International Workshop on Nuclear Robotic Technologies and Applications, Present and Future

Sponsored by UK Dept. of Trade and Industry, CESTA (France) and MITI (Japan), to be held **June 29-July 1, 1987** at University of Lancaster, UK. For information contact: **N. Burtnyk, National Research Council of Canada, Ottawa, Ontario, K1A OR8.**

International Topical Conference on Probabilistic Safety Assessment and Risk Management

Sponsored by SNS, ENS, ANS, CNS et al., to be held **Aug. 30-Sept. 4, 1987** in Zurich, Switzerland. For information contact: **PSA '87, c/o ENS, P.O. Box 2613, CH-3001, Berne, Switzerland,** or F. King, (416) 592-7597.

International Meeting on Nuclear Power Plant Operation

Sponsored by ANS, CNS, ENS and Atomic Energy Society of Japan, to be held **Aug. 31-Sept. 3, 1987** in Chicago, Illinois. For information contact: **Norman Wandke, Commonwealth Edison Co., P.O. Box 767, Chicago, IL 60690,** or Ken Talbot, (416) 839-1151.

3rd McMaster University Symposium on Nuclear Science and Engineering

Sponsored by McMaster University and CNS, to be held **Sept. 30-Oct. 1, 1987,** in Hamilton, Ontario. For information contact: **Dr. J.-S. Chang, Dept. of Engineering Physics, McMaster University, Hamilton, Ontario, L8S 4M1,** (416) 525-9140, ext. 4924.

Second Workshop on Advanced Topics in CANDU Reactor Thermalhydraulics

Sponsored by McMaster University, to be held **Oct. 1-2, 1987** in Hamilton, Ontario. For information contact: **Dr. J.-S. Chang, Dept. of Engineering Physics, McMaster University, Hamilton, Ontario, L8S 4M1,** (416) 525-9140, ext. 4924.

1987 International Decommissioning Symposium

Sponsored by U.S. DOE, IAEA and OECD NEA, to be held **October 4-8, 1987,** in Pittsburgh, Pennsylvania. For information contact: **Kristie Edwards, P.O. Box 1370, Richland, Washington 99352.**

Chernobyl: Implications for Illinois

Conference sponsored by Illinois Dept. of Nuclear Safety, to be held **October 22-23, 1987** in Chicago. For information contact: **Gail Melson, Illinois Dept. of Nuclear Safety, 1035 Outer Park Drive, Springfield, Illinois 62704,** (217) 546-8100.

Symposium on the Transportation of Radioactive Materials

Sponsored by the Canadian Nuclear Association, to be held **October 29-30, 1987** in Toronto, Ontario. For information contact: **Canadian Nuclear Association, 111 Elizabeth St., 11th Floor, Toronto, Ontario, M5G 1P7, (416) 977-6152.**

International Conference on CANDU Maintenance

Sponsored by Canadian Nuclear Society and Canadian Nuclear Association, to be held **November 22-24, 1987** in Toronto, Ontario. For information contact: **D.F. Meraw, Darlington N.G.S., P.O. Box 4000, Bowmanville, Ontario, L1C 3Z8,** (416) 623-6606, ext. 4218.

1987 International Waste Management Conference

Sponsored by ASME and IAEA, cosponsored by ANS, CNS et al., to be held **Nov. 30-Dec. 5, 1987** in Kowloon, Hong Kong. For information contact: **L.C. Oyen, Sargent & Lundy, 55 E. Monroe St., Chicago, Illinois 60603,** or Tom Carter, (416) 592-6024.

International Conference on the Man-Machine Interface in the Nuclear Industry

Sponsored by IAEA, OECD NEA and CEC, to be held **Feb. 15-19, 1988** in Tokyo. For information contact: **IAEA, Vienna International Centre, P.O. Box 100, A-1400 Vienna, Austria.**

Safety of Next Generation Power Reactors – Call for Papers

Sponsored by the American Nuclear Society and the U.S. Department of Energy, in cooperation with the European Nuclear Society, the Atomic Energy Society of Japan, the Canadian Nuclear Society, the International Atomic Energy Agency, and the OECD/NEA's Committee on the Safety of Nuclear Installations. To be held **May 1-5, 1988** in Seattle, Washington. The principal purpose of the conference is to assess how new work in nuclear safety might help revitalize the nuclear power industry in the United States. Papers are solicited that address safety aspects of advanced reactors of commercial interest to designers and utility owners/operators, including water-cooled, liquid-metal-cooled, and gas-cooled reactors. The conference will focus on the progress made in power reactor designs that emphasize passive safety, enhanced engineering safety systems, or improved operability and maintainability. Any papers that have a direct relationship to these topics are encouraged. Deadline for submission of three copies of 1000-word summary and 100-word abstract: **September 30, 1987.** Author notification: **December 30, 1987.** Summaries and abstracts should be submitted to **Alan E. Waltar, Technical Program Chairman, Westinghouse Hanford Company, P.O. Box 1970, Richland, Wash. 99352.** (509) 376-5250.

Third Topical Meeting on Tritium Technology in Fission, Fusion and Isotopic Applications

Sponsored by Canadian Nuclear Society, co-sponsored by American Nuclear Society, to be held **May 1-6, 1988** in Toronto, Ontario. For information contact: **C.D. Burnham, CFFTP, 2700 Lakeshore Rd. W., Mississauga, Ontario, L5J 1K3.** (416) 823-6364.

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It was, Silver notes, the federal government who put the mockers on direct Canadian technical assistance to the Soviet Union immediately after the Chernobyl accident. Silver's recounting of the bureaucratic arabesques at the Department of External Affairs should certainly give the scriptwriters for the TV program *Yes, Minister* much useful material, and does show that the descendants of Tite Barnacle are alive and flourishing in Ottawa. Whether the bureaucratic and political distaste for nuclear trade with the Soviet Union sprang, as Silver suggests, from the new "colonial reflex" of not offending our southern neighbours or simply from the fundamental resistance of any politician (or politician's lackey) to actually *do* something is less important than the fact that when timely assistance could have been made available, it wasn't. Silver argues compellingly that increased international nuclear co-operation and assistance is not just desirable because it means good business, or because, following a Chernobyl-type accident, it's simple humanitarianism, but because in a world balancing uneasily on the macabre uncertainty of Mutual Assured Destruction, increased cooperation is a *necessity.*

That is Silver's culminating theme. Speaking with the perspective of a Bomber Command airman with first-hand experience, Silver argues passionately that we cannot allow the horrors of World War II bombing offensives to be repeated on an unimaginably vaster scale. " . . . The nuclear weapons tests persist," he points out, and "there had been 1580 bomb tests before the Chernobyl accident. That accident exposed Canadians *once* to a fraction of the fallout they still get *every year* from past nuclear weapons testing". Focus our nuclear fears where they belong, says Silver, on the weapons – "Turning off the furnace will not disarm a single bomb. And there is such a multitude of bombs to be defused."

Fallout from Chernobyl is necessary reading for anyone involved in any way with nuclear energy. Against the shrill posturing of the critics and the costive ruminations and patronising pap of the nuclear industry, Silver's book stands out in welcome contrast. But further, the book is *pleasurable* reading for anyone. Firmly in the tradition of the great eighteenth century essayists, he marshals his arguments with erudition, wit and elegance and fires them with passionate conviction. Ray Silver has been writing about the Canadian nuclear energy endeavour for thirty-five years, although *Fallout from Chernobyl* is his first book. Let's hope the second one comes along soon.

David Mosey

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The Unfashionable Side

A bas les clochards!

The cellular telephone had been installed in the Lagonda for less than a week when already it began to pay off. One of the first important calls was from a long standing acquaintance at Hydro Québec, Michel Blaireau.

"Allô, Georges? C'est moi, Michel. Nous avons un problème très urgent ici à Gentilly."

"Parbleu! Est-ce que c'est la neige dans le congélateur encore une fois?" Not bad, I said to myself, for someone who lives in the heart of Angloland. The phrases rolled off my tongue with all the grace and euphony of a rusty anchor chain.

"Quoi? Ah, je comprends. Non, ce n'est pas les crabes de neige dans le condenseur. On les a mangés il y a longtemps, comme tu l'avais conseillé."

"Alors, mon vieille, c'est quelle sorte de difficulté contre laquelle tu luttes, aujourd'hui?", I articulated fluently.

"Ah, c'est une affaire beaucoup plus délicate cette fois. Nous devons en discuter, mais pas au téléphone. Pourrais-tu venir à Trois-Rivières demain matin, chez moi?"

Cherchez la femme, I said to myself. After promising to meet him all the same, I raced back to my pad, put the nose bag on the Lagonda, grabbed a handful of essentials and caught a late afternoon flight. Annoyingly, the galley was fresh out of Barsac, which would have nicely rounded out my meal of snow crab sandwiches. At Quebec City, I shunned the Hilton, accepting instead a modest suite in the Château overlooking the St. Lawrence.

The dawn came up next morning like thunder out of Lévis and in no time I was in Trois Rivières, still wondering what kind of amorous tangle Michel had got himself into. It was more complicated than I had imagined, judging from his explanation, which I really didn't understand all that well, I must admit. The woman's name was McCrae, oddly, but there was also something about an incomprehensible inspector and his bums. "Et voilà! Le problème, c'est que je ne comprends pas ce McCrae," Michel concluded despondently as we approached the site.

It was so delicious; I had to chuckle. "Tu sais bien, ma vieux, que les écossaises sont difficiles et dangereuses. Pourquoi veux-tu chasser une jeune Picte?"

He suddenly became impatient for some reason. "Quelle tête de . . . Non, Georges! Ecoute-moi. Ce McCrae, il est venu ici d'Ottawa, je crois, pour régler un problème quelconque . . . mais il refuse de parler l'anglais. Et nous ne comprenons pas du tout la langue qu'il écorche, avec son accent affreux de Cabbagetown, ou Saskatoon, ou je ne sais pas d'où. C'est pour ça que je t'ai invité ici. Peut-être deux anglais peuvent se comprendre. Le monde est plein de surprises."

Now I had it. There was no woman, sadly, and McCrae and the anatomically irregular inspector were one and the same. I asked Michel to lead me to this Gaullist Caledonian and we'd soon sort him out. We pulled into the car park at Gentilly and, escorted by a platoon of Michel's troops, made our way to the Station Manager's office. McCrae was there alone, looking around imperiously as we came in. I took in the main items at a glance: shortish fellow, thinning sandy hair, grey suit, asymmetric eyebrows, top button missing from his shirt, and a bumper sticker on his briefcase which read "J'aime Lunenburg en hiver."

"Laissez-moi avec lui," I said to the others and they left wearing relieved expressions.

I turned to him and introduced myself. "Georges Bauère," I said in a sonorous Touraine accent.

"Extasié," he replied, and I immediately questioned the wisdom of sending the others away. We spoke in a vaguely orthogonal way for some minutes. He seemed not to notice that he wasn't making the least bit of sense; on the contrary, he had the air of one who was humouring a lesser being. Eventually I found out quite by accident that he was from Red Deer, that he had acquired what he thought was faultless French by associating with an unemployed typist in Blackburn Hamlet and that he had been sent to determine why Gentilly appears to be such a collection point for tramps, down-and-outs, and vagabonds.

I was completely confused by this time. "Pourquoi est-ce que vous cherchez des clochards ici, à une centrale nucléaire?"

"Parce qu'ils sont partout ici," he said emphatically, becoming quite incensed. "Dans chaque document concernant cette centrale, on discute des clochards: clochards du réacteur, clochards de puissance, clochards neutroniques. C'est dégoûtant, honteux."

Transients! Of course! The answer leapt up before me and fifteen minutes later we emerged smiling, joking and shaking hands. Michel was astounded and after McCrae had driven off purposefully, he turned on me grimly.

"Georges, qu'est-ce que tu as fait?"

"Elémentaire, mon petite. Toute cette affaire résulte d'une faute de traduction, probablement au bureau de McCrae lui-même. Alors, je l'ai envoyé à Pickering."

"Quoi? Tu es fou . . . "

I was enjoying myself. "Comme le renard, Michel. Je lui ai suggéré une approche plus logique. S'il pense qu'il y ait un problème ici, engendré par *un* réacteur, ça devrait être encore plus sévère à Pickering, où il y en a *huit*. Alors, logiquement c'est là où il faut commencer."

That night they all took me out on the town and the toasts rang out one after the other: I was Hercule Poirot, Arsène Lupin, traducteur extraordinaire, diplomate, maudit anglais, con, ivrogne.

George Bauer