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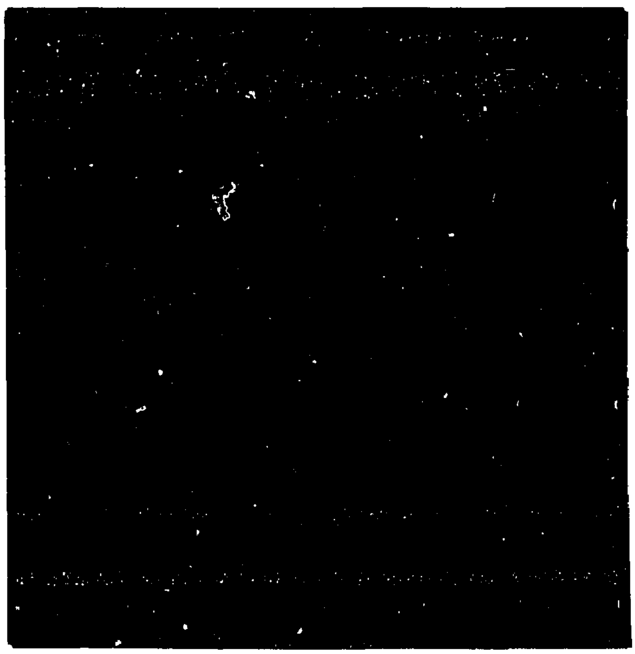
REPORT



RAPPORT

Atomic Energy Control Board
Commission de contrôle de l'énergie atomique

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REPORT

AECB Staff Annual Assessment of the Pickering A and B Nuclear Generating Stations for the Year 1994

Atomic Energy Control Board
Ottawa, Canada

June 1995

Atomic Energy Control Board
Commission de contrôle de l'énergie atomique

Canada

The Atomic Energy Control Board is the independent federal agency that controls all nuclear activities in Canada. Our mission is to ensure that the use of nuclear energy in Canada does not pose undue risk to health, safety, security and the environment.

A major use of nuclear energy in Canada is electricity production. We have an office at every nuclear generating station, and we monitor the stations on a day to day basis. Specialists in our Ottawa head office work with the on-site staff to accomplish our mission.

We assess every station's performance against legal requirements, including the conditions in the operating licences we issue. To do this, we review all aspects of a station's operation and management, and we inspect each station.

SUMMARY

This report is the Atomic Energy Control Board staff assessment of safety at the Pickering Nuclear Generating Stations (PNGS-A and PNGS-B) for 1994. Our on-site Project Officers and Ottawa based specialists monitored the stations throughout the year.

The stations operated safely in 1994. The performance of all special safety systems was very good. Ontario Hydro continues to meet its commitments to us regarding capital projects to improve plant safety.

Compared to 1993, the number of times Ontario Hydro failed to comply with the stations' Operating Licences conditions decreased in 1994. None of these reported non-compliances had any direct impact on safety. No violation of the Atomic Energy Control Regulations occurred during 1994.

Releases of radioactive material from the stations were well below the legal limits for public safety.

Ontario Hydro management successfully introduced a process that encourages employees to report, besides actual events, events that are considered near misses.

It also delivered required training to new and redeployed safety analysts. With the relocation of safety analysts to the site, we did notice an improvement in the timeliness of their support to operating staff. Station management is trying to improve the control of equipment maintenance at the two stations with a new preventive maintenance program.

As compared to 1993, in 1994 there was an increase in the whole body dose to the workers in spite of programs to reduce it. However, no worker received radiation exposure greater than the legal limit. Ontario Hydro still needs to improve on the contamination control aspects of its radiation protection program.

Ontario Hydro management needs to devote more attention to the people aspects of improving safety. There were still a significant number of human performance-related events.

Housekeeping and work planning activities require more management action to sustain the gains and the improvements that have already been made.

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INTRODUCTION

The Pickering *Nuclear Generating Station* (PNGS) is located on the north shore of Lake Ontario, about 32 km east of downtown Toronto. It consists of two stations, PNGS-A and PNGS-B. Each station contains four reactor units. PNGS-A consists of Units 1 to 4, while PNGS-B consists of Units 5 to 8. Each unit can generate about 540 megawatts of electricity. All eight units are located within a single enclosure. Ontario Hydro's Pickering Nuclear Division has assigned one Station Director with authority over both stations, but each station has its own organization. We issue a separate operating licence for each station.

This report presents the Atomic Energy Control Board staff assessment of the Pickering stations' safety performance in 1994 and other aspects that we consider to have significant impact on nuclear safety. We based our conclusions on our observations, audits, inspections and review of information that Ontario Hydro submits to us as required by the station Operating Licences.

Throughout this report we include tables and charts with more detailed information to compare yearly station performance on selected topics. Although we use similar terms to describe the safety performance of each of the nuclear generating stations in Canada, many of them have different contexts. Readers should be aware that direct comparison between nuclear stations is difficult, and often not appropriate.

The nuclear industry uses many technical terms. To help our readers, we have provided a glossary at the end of the report and have *italicized* glossary words when they first appear in the report.

At our head office in Ottawa, the public can consult all documents related to the licensing process of nuclear facilities. Our public library also contains an important collection of documents, available on request. Apart from the Atomic Energy Control Board annual report, we publish research reports, communiqués, information bulletins, notices and pamphlets. Board members' minutes of meetings are also available. Our address is:

280 Slater Street,
Ottawa, Ontario, Canada.

Written requests for information should be mailed to:

Atomic Energy Control Board,
Office of Public Information,
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We can also be reached by telephone at 613-995-5894 or 1-800-668-5284.

OPERATIONAL SAFETY

COMPLIANCE WITH THE ATOMIC ENERGY CONTROL REGULATIONS

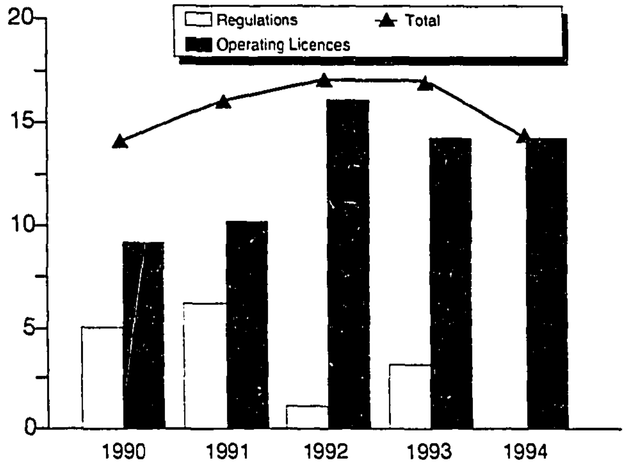
We conclude that Ontario Hydro's compliance with the *Atomic Energy Control Regulations* in 1994 was fully satisfactory. We require Ontario Hydro to operate PNGS according to the legal requirements governing the nuclear industry in Canada. These requirements come from the *Atomic Energy Control Act* and regulations made under the Act. The regulations directly applying to Ontario Hydro Pickering Nuclear Division are the *Atomic Energy Control Regulations*, the *Physical Security Regulations*, the Transportation Packaging of Radioactive Materials Regulations and the Cost Recovery Fees Regulations. The Atomic Energy Control Regulations contain rules to ensure the safety of nuclear activities.

As shown in Figure 1, there was no violation of the Atomic Energy Control Regulations in 1994, as compared to three in 1993.

COMPLIANCE WITH THE OPERATING LICENCES

We conclude that Ontario Hydro's compliance with the operating licences in 1994 needs improvement. The operating licences

Figure 1: ***REGULATIONS AND LICENCES NON-COMPLIANCE (Number of Violations vs Year)***



we issue to Ontario Hydro contain conditions that it must observe. *Operating Policies & Principles* and the Ontario Hydro *Radiation Protection Regulations* referred to in the licence also govern the operation of the stations.

In 1994, there were 14 instances where Ontario Hydro did not comply with the licence conditions. We reviewed each of these events and concluded that none of them directly affected nuclear safety. We concurred with the actions Ontario Hydro had taken to correct the non-compliances. Figure 1 shows a comparison of the number of non-compliances to the operating licences for the last four years.

Of the 14 instances, seven involved failure to observe the Operating Policies & Principles compared to the 12 instances that occurred in 1993. The other seven involved failure to follow licence conditions. None of these incidents was deliberate, but Ontario Hydro could have avoided all these non-compliances. Therefore, we believe that Ontario Hydro can make improvements in this area.

On May 6, 1994, the Unit 7 authorized nuclear operator became ill and had to be taken to the hospital. This resulted in only five authorized staff on shift, instead of the six required by licence conditions. For 20 minutes the station was placed in the "quiet mode", with the licensed Shift Operating Supervisor attending the unit. This event was a non-compliance of an operating licence condition.

On July 20, 1994, Unit 5 was shut down due to the *moderator* cover gas concentration exceeding the Operating Policies & Principles limits. Ontario Hydro changed the operating procedures to minimize this kind of event being caused by human performance errors and omissions.

On October 10, 1994, two tankers of spent solvent from *boiler* chemical cleaning were shipped out of the station without the necessary documentation and transfer permits. It was a non-compliance of Ontario Hydro Radiation Protection Regulations. Immediate measures were put in place to minimize a recurrence of this event.

On October 31, 1994, Ontario Hydro reported to us that they could not submit the PNGS-B *Safety Report* Volume 1 revision. This is reportable as a non-compliance of the operating licence.

The other non-compliance instances are described in the appropriate sections of this report.

COMPLIANCE WITH THE PHYSICAL SECURITY REGULATIONS

We conducted a security assessment of the Pickering stations and found compliance with these Regulations to be good. The Physical Security Regulations define the security measures that Ontario Hydro must maintain at the stations.

To validate the security procedures, Ontario Hydro security staff conducted periodic security drills throughout the year. In addition, the stations' security staff conducted a small-scale joint training exercise with the stations' operations staff and the Durham Regional Police. Ontario Hydro continues to update its equipment to maintain a high level of security system availability.

WORKER RADIATION SAFETY

We judged the radiation doses received by workers to be acceptable. Although there were two *reportable events* related to radioactive *contamination*, no worker received a radiation dose greater than the legal limit of 50 *millisievert* (mSv). Table 1 summarizes the *whole body dose* distribution at Pickering in 1994.

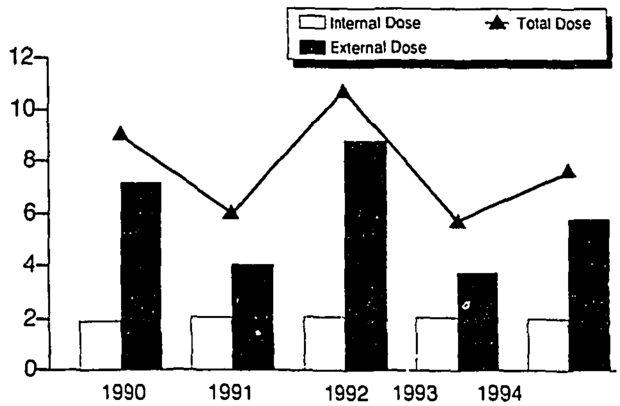
Figure 2 shows the distribution of whole body dose for all workers and the history for the last five years. The figure shows that whole body dose for all workers increased in 1994, as compared to 1993, in spite of programs to reduce it. This suggests that worker radiation exposures may not be *as low as reasonably achievable.* Ontario Hydro should continue to actively seek ways to further control and minimize worker radiation exposure. In particular, we believe Ontario Hydro staff needs to use personal protective equipment more effectively in order to reduce the internal dose.

Table 1: *SUMMARY OF WHOLE BODY DOSE DISTRIBUTION FOR EQUIVALENT CALENDAR YEAR PERIOD ENDING IN 1994*

	Number of Individuals		
Dose in mSv	PNGS-A*	PNGS-B	Total
No dose	963	109	1072
< 5	1011	292	1303
> 5 to 10	300	59	359
> 10 to 15	32	0	32
> 15 to 20	19	0	19
> 20 to 25	7	0	7
> 25 to 30	3	0	3
> 30 to 35	1	0	1
> 35	0	0	0

* Ontario Hydro staff reported under PNGS-A, doses for those working on both stations.

Figure 2: ***TOTAL WHOLE BODY DOSE FOR WORKERS (Sieverts vs Year)***



non-compliance of licence condition. Also, as required by the Ontario Hydro Radiation Protection Regulations, a contaminated worker needs to be decontaminated before leaving the radiation area. Fortunately, this incident did not result in any significant radiation dose to the worker.

On July 14, 1994, Ontario Hydro reported that the coveralls worn by three construction workers were contaminated by tools that had been improperly stored. The Atomic Energy Control Regulations require that contaminated material must be stored in areas with clearly and prominently displayed radiation hazard signs. Fortunately, this incident did not result in any significant radiation dose to the worker.

For 1994, the total whole body dose of 7.51 person-Sv is more than the previous year's total of 5.60 person-Sv. *Tritium* exposure accounted for about one quarter of this total dose. The total whole body dose for workers can vary from year to year, depending in part on the type and amount of work that must be completed during the unit outages.

Table 2: ***MEASURES OF PNGS-A PERFORMANCE: RELEASES FROM THE STATION***

Average Percent Derived Emission Limit for the Year	1992	1993	1994
Airborne tritium	0.22	0.16	0.14
Airborne noble gas	0.32	0.45	0.40
Airborne iodine-131	<0.01	0.01	<0 .01
Airborne particulates	<0.01	<0.01	< 0.01
Airborne carbon-14	0.08	0.02	0.01
Waterborne tritium	0.49	0.06	0.06
Waterborne gross beta/gamma activity	0.14	0.35	0.38

On March 24, 1994, we received a report that an employee had fixed contamination on the left thumb. The event was reported to station senior staff two days after the contamination was discovered. Untimely reporting of a reportable event is a

Table 3: ***MEASURES OF PNGS-A PERFORMANCE: RELEASES FROM THE STATION***

Number of Times Weekly Percent Derived Emission Limit Target Exceeded:	1992	1993	1994
Airborne tritium	0	0	0
Airborne noble gas	0	0	0
Airborne iodine-131	0	0	0
Airborne particulates	0	0	0
Airborne carbon-14	0	0	0
Number of Times Monthly Percent Derived Emission Limit Target Exceeded:	**1992**	**1993**	**1994**
Waterborne tritium	1	0	0
Waterborne gross beta/gamma activity	2	0	0

Table 4: ***MEASURES OF PNGS-B PERFORMANCE: RELEASES FROM THE STATION***

Average Percent Derived Emission Limit for the Year:	1992	1993	1994
Airborne tritium	0.07	0.07	0.07
Airborne noble gas	0.20	0.25	0.26
Airborne iodine-131	<0.01	<0.01	<0.01
Airborne particulates	<0.01	<0.01	<0.01
Waterborne tritium	0.01	<0.01	0.01
Waterborne gross beta/gamma activity	0.01	0.05	<0.01

During the year, we continued to find poor control over contaminated materials. Clean-up during and after a unit *outage* often resulted in contaminated material being left in places where no proper contamination control is taken. There were instances where loose contamination was found outside "rubber areas". Rubber areas are temporary areas set up to control, contain and prevent the spread of loose contamination in the station and are generally established during unit outages. We found the spread of contamination beyond the boundaries of these areas. This indicates poor control and lack of compliance with the Radiation Protection Procedures. We will continue to monitor for improvements in contamination control.

PUBLIC RADIATION SAFETY

Ontario Hydro's control of radioactive effluent releases from the stations was satisfactory during the year. The operation of the Pickering stations did not result in undue radiological risk to the public or the environment.

Table 5: *MEASURES OF PNGS-B PERFORMANCE: RELEASES FROM THE STATION*

Number of Times Weekly Percent Derived Emission Limit Target Exceeded:	1992	1993	1994
Airborne tritium	0	0	0
Airborne noble gas	0	0	0
Airborne iodine-131	0	0	0
Airborne particulates	0	0	0
Number of Times Monthly Percent Derived Emission Limit Target Exceeded:	**1992**	**1993**	**1994**
Waterborne tritium	0	0	0
Waterborne gross beta/gamma activity	0	0	0

We assess radioactive effluent releases from the stations in terms of *Derived Emission Limits* and Pickering stations operate to a target of one percent of these limits. Ontario Hydro reports the liquid releases to us monthly; the airborne releases are reported weekly. To establish these limits, the annual limit is divided into 12 equal parts to provide the monthly limit and into 52 equal parts for the weekly limit. Each of the *radionuclide* groups has its own Derived Emission Limit.

Tables 2 to 5 show a breakdown of station releases over the past three years. These tables also show the number of times the releases exceeded weekly and monthly targets. In 1994, the annual average gaseous and liquid emissions did not exceed the one percent of Derived Emission Limits. The amount of radioactive material released from the stations were comparable to the level released during previous years.

Ontario Hydro regularly measures the concentration of radioactive material in the environment around the Pickering stations. It uses this information to assess the radiation dose that people living near the stations get from routine operation of the stations. We considered the radiological impact of the operation of the Pickering stations on the surrounding population to be insignificant for 1994.

During 1994, as in past years, Ontario Hydro detected very low levels above background of tritium in air, rain and snow, drinking water, milk and in local produce. It also detected very small amounts of above background *carbon-14* in fruits, vegetables and milk from the nearby area. Table 6 summarizes the measurements for 1994 and compares them with the previous year's values.

By analyzing environmental samples and using historical emission-to-dose ratios, Ontario Hydro calculates the maximum annual radiation dose to members of the public at places where it expects the exposure from releases to be highest. That is, at the station boundary. We call this the *critical group* dose. From the Pickering stations, an adult in this critical group would have received a dose of

Table 6: *MEASURES OF PICKERING NGS-A & NGS-B PERFORMANCE: PUBLIC & ENVIRONMENT DOSES*

Environmental Measurements	1992	1993	1994
Average boundary dose rate external (nGy/hour)	42.7	42.7	39.3
Average boundary tritium in air(Bq/m3)	12	8	6.4
Average boundary tritium concentration in precipitation(Bq/L)	1080	620	650
Average boundary gross beta in precipitation and dry deposition (average over all measurement sites) (Bq/m2/month)	27.9	24.7	21
Average tritium in milk (Bq/L)	39	26	36
Average C-14 in milk (Bq/kg carbon)	429	422	445
Average I-131 in milk (Bq/L)	<0.15	< 0.13	< 0.14
Average tritium in drinking water at the Ajax water supply plant (Bq/L)	27	16	15
Average gross beta/gamma in drinking water at the Ajax water supply plant (Bq/L)	0.11	0.12	0.12

Table 7: *MEASURES OF PICKERING NGS-A & NGS-B PERFORMANCE: CRITICAL GROUP DOSE*

Estimated dose to critical group (mSv)	1992	1993	1994
Infant	0.0224	0.0152	0.0137
Adult	0.0231	0.0157	0.0141

0.0141 mSv during 1994. For a six-month old child in this group, Ontario Hydro calculated the dose to be 0.0137 mSv. We judged these doses to be insignificant when compared to our legal limit of 5 mSv per year and the 3.6 mSv per year that people normally receive from sources other than the nuclear station.

Table 7 shows the estimated critical group doses. The results show that there were further reductions in the 1994 values, as compared to 1993 and 1992.

PERFORMANCE OF PICKERING NGS-A SAFETY SYSTEMS

In 1994, the three *special safety systems* performed very well. As in 1993 and 1992, they performed within the targets we set for *availability* of special safety systems.

Each unit in PNGS-A has three special safety systems. These three systems are:

- the *shutdown system*,
- the *emergency core cooling system*, and
- the *containment system*.

We require each one to be fully available 99.7% of the time. To meet this requirement, the time for which each system does not meet its requirements must not be more than 26.4 hours a year. This time is called the *unavailability* of the system.

Ontario Hydro measures both how well special safety systems have performed in the past and how they are expected to perform in the future. This is done on the basis of actual operating experience and on tests performed on the systems and components. The results are expressed as actual past unavailability and predicted future unavailability. The smaller the actual past unavailability and predicted future unavailability are, the better the performance of the system. Table 8 shows the special safety system actual past unavailability and predicted future unavailability.

Table 8: *PNGS-A SPECIAL SAFETY SYSTEM UNAVAILABILITY*

Special Safety System:	Actual Past Unavailability (hours/year)	Predicted Future Unavailability (hours/year)	System Target Unavailability (hours/year)
SDS Units 1-4	0	16.6	< 26.4
ECCS Unit 1	0	24.4	< 26.4
Unit 2	0	24.9	< 26.4
Unit 3	0	24.4	< 26.4
Unit 4	10.3	24.4	< 26.4
Containment:			
Units 1-4	0	14.0	< 26.4

❑ Shutdown System Enhancement

As ordered by the Board, Ontario Hydro began to upgrade the shutdown capability and reliability for PNGS-A reactors. It began to install changes under a shut-down system enhancement design process. The PNGS-A operating licence requires all four reactors to have the enhancement system installed and available by the end of 1997. If this target is not met, any reactor that does not have the change completed will have to be shut down.

Installation of the enhancement system was progressing on schedule. Certain work can only be done when a reactor is shut down. Ontario Hydro expects that each reactor will be shut down for about 180 days for this installation. Ontario Hydro staff is continuing to work on safety assessment work in support of the enhancement. At years' end, analysis work in progress covers loss of reactor control and large *loss of coolant accident* events.

We have reviewed the enhancement's Safety Design Requirements relating to the installation of the in-core neutron overpower system and its supporting analysis. We agree with the design and are now reviewing the supporting documents.

❑ Emergency Core Cooling System

In response to the December 10, 1994 heat transport liquid relief valve failure on Unit 2, some water from the high pressure emergency core cooling water storage tank was injected into Unit 2 heat transport system. As a result, the storage tank water level fell below the limit of 10.8 m. As this water supply is common to all PNGS-A units, Unit 4, the only operating unit at that time, experienced an unavailability of 10.3 hours for the emergency core cooling system. This is less than the system target unavailability limit of 26.4 hours.

This was the first time in the history of CANDU reactors that there has been a real need for the emergency core cooling system to operate. The system operated successfully.

PERFORMANCE OF PICKERING NGS-B SAFETY SYSTEMS

In 1994, the four special safety systems performed very well. As in 1993 and 1992, they performed within the targets we set for availability of special safety systems.

Each unit in Pickering NGS-B has four special safety systems. These four systems are:

- the *shutdown system 1*,
- the *shutdown system 2*,
- the emergency core cooling system, and
- the containment system.

We require each one to be fully available 99.9% of the time. To meet our requirement, the time for which each system does not meet its performance requirements must not be more than 8.8 hours a year. Table 9 shows the PNGS-B special safety systems actual past unavailability and predicted future unavailability.

Table 9: *PNGS-B SPECIAL SAFETY SYSTEM UNAVAILABILITY*

Special Safety System:	Actual Past Unavailability (hours/year)	Predicted Future Unavailability (hours/year)	System Target Unavailability (hours/year)
SDS1 Units 5-8	0	0.3	< 8.8
SDS2 Units 5-8	0	1.0	< 8.8
ECCS Units 5-8	0	1.7	< 8.8
Containment:			
Units 5-8	0	6.8	< 8.8

There were two reportable events that involved the special safety systems in 1994. Both of these instances did not directly affect system performance.

On May 9, 1994, Ontario Hydro reported that it found incorrect size packing springs had been installed on shutdown system 2 valves. The use of incorrect springs had the potential of impairing the proper operation and response of the shutdown system 2. However, subsequent review of test results showed that the spring would still meet the technical requirements and not affect the valve performance. Ontario Hydro will, however, replace all these springs to conform with the technical requirements.

On June 28, 1994, Ontario Hydro reported that it found improper pressure switches had been installed on the shutdown system 2 of all four units. These switches had been in service since 1983. This was reported to us because use of incorrect components has the potential to render the system unavailable. Review of the component showed that although the installed switches were rated below the design requirements, the pressure retaining part of the switch was rated above the maximum system operating pressure. Also, the switch had been tested at a much higher pressure. Therefore, it was concluded that there was minimal safety implication. Ontario Hydro will, however, replace all these switches to conform with the design requirement. An Equipment Parts Engineering Unit is now in place to improve material control.

We reviewed both of these events with Ontario Hydro staff and concurred with their conclusions and replacement strategy. There continues to be a need for tighter control of replacement parts so that only qualified parts are installed in the plant.

EVENTS REPORTED TO THE AECB

In 1994, Ontario Hydro reported a total of 65 events to us for both stations, 17 events less than those reported in 1993. Event reporting was on time. Human errors accounted for 26 of these events. Human error was an important factor in reactor safety. Non-compliance of operating licences conditions accounted for 14 of these reported events. The remaining events were attributed to other causes such as component failures. Of these 65 events, 39 events came from PNGS-A and 26 came from PNGS-B.

A significant number of the human errors are attributed to situations where Ontario Hydro's staff failed to follow approved procedures. We consider procedural compliance important to the safe operation of a nuclear station. For example, one event occurred at the start of a unit outage when shutdown system 2 power level setpoints were not lowered correctly as required by the procedure. Another event occurred when a cable for each of the three channels required removal, but only one cable was taken off. Eventually, the cables were all removed. Fortunately, failure to remove all three cables did not affect the overall performance of the safety system as there are other trip signals in place to provide adequate protection for accident conditions that can happen during a shutdown state.

Figures 3 and 4 show a comparison of the number of reportable events for the last four years. There has not been much improvement in the reduction of human performance-related events over the last two years. We believe that significant improvements are needed in this area and have requested Ontario Hydro to implement a program to address this problem.

We received nine analyses and follow-up reports which were related to reportable events from the previous year. By year-end, they had either been reviewed or were in the process of being reviewed by our staff.

Figure 3: ***PNGS-A REPORTABLE EVENTS INCLUDING THOSE COMMON TO BOTH PNGS-A & -B (Number of Events vs Year)***

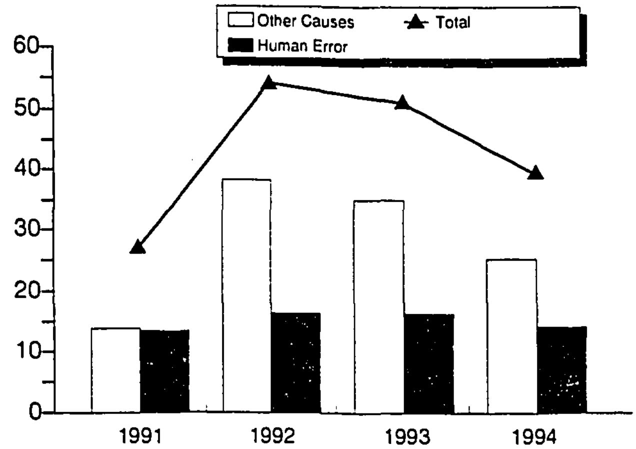
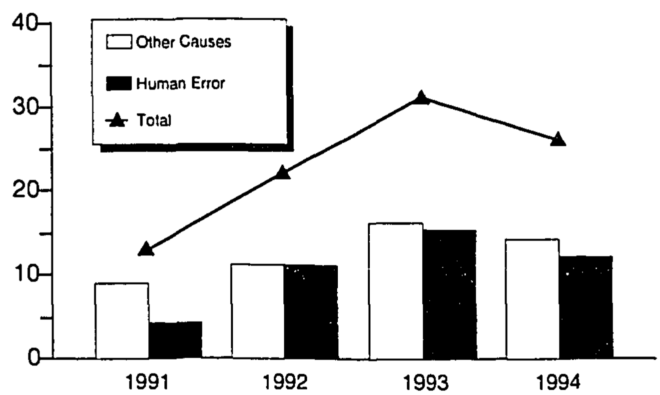


Figure 4: ***PNGS-B REPORTABLE EVENTS (Number of Events vs Year)***



❑ Radioactive Effluent Compliance Monitoring

In 1994, Ontario Hydro reported seven events that were related to sampler failures on compliance monitors. Of these seven, four came from PNGS-A and three came from PNGS-B. This is a significant improvement over 1993 when there were 25 events due to monitor failures.

We do not consider these events to have any direct impact on public, reactor or personal safety as all monitors on critical streams are duplicated. Also, Ontario Hydro can confirm the quantity of radioactive material releases from the stations by reviewing data that it routinely collects through environmental monitoring. However, we will continue to follow up the progress to the resolution of the monitor failures.

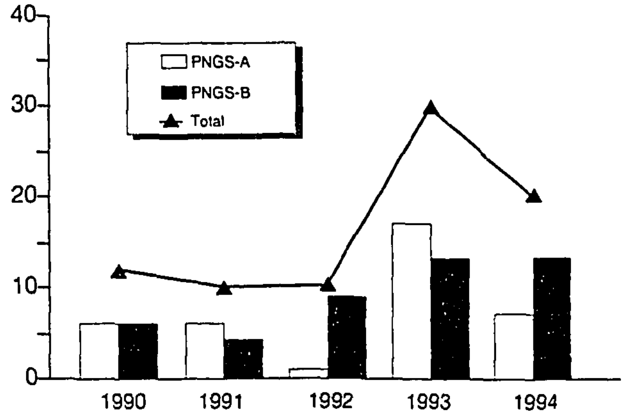
❑ Reactor Trips

Reactor *trips* occur when certain reactor operating conditions reach preset limits. This is to ensure that a reactor remains within a safe operating envelope. We therefore prefer to see few reactor trips.

There were 20 reactor trips reported for both stations in 1994, 10 less than in 1993. PNGS-A experienced seven and PNGS-B had 13 reactor trips. Figure 5 shows the number of reactor trips and the trends for PNGS-A and PNGS-B since 1990.

Equipment failures or abnormal unit conditions initiated 16 trips while the remaining four trips could be attributed to human performance deficiencies. Of these four, one was caused by electrical interference from an incorrectly issued portable radio

Figure 5: ***REACTOR TRIPS (Number of Trips vs Year)***



and another trip occurred as a result of an incorrectly installed connector screw on a meter terminal. These events are due to poor material and procedures control.

Another human performance related event was due to maintenance induced electrical interference that resulted in a reactor trip while the unit was in *guaranteed shutdown state*. A fourth event occurred when an operator incorrectly closed a boiler feed valve and initiated a reactor trip on low boiler water level.

Spurious electrical signals seen by detectors in the trip circuits accounted for nine of the trips while the units were in a shut down state. Ontario Hydro staff continues to investigate the cause of these spurious trips. They have installed special equipment to monitor and analyze the trip circuit signals whenever a reactor is shut down.

❑ Fires

In 1994, Ontario Hydro staff reported 12 fire related incidents at PNGS. We found 10 to be minor with no significant impact on plant or worker safety. The other two, however, had the potential for serious consequences.

There was a fire in the Unit 5 *control equipment room* in January, 1994. The control equipment room is outside the Unit 6 *reactor building* and next to the *main control room*. Even though a floor penetration above the room had been covered, welding sparks went through a small opening around a support beam and ignited some paper material left in the control equipment room following some housekeeping activities. The resulting fire occurred in close proximity to the reactor control system wiring racks. More strict control over welding practices has been put in place by Ontario Hydro and we would not expect to see a similar event in the future.

In March of 1994, there was a fire on a temporary access platform to a *pressure relief duct* seal outside the reactor building. A tarpaulin, used to protect equipment, was ignited by a heater used to keep the equipment warm. Fortunately, there was no damage to the relief duct *expansion joint seal* or nearby safety system cables. The fire occurred in the off hours and went undetected and burnt itself out. Following the event, Ontario Hydro put in place procedures to ensure better fire safety practices and awareness in this area.

As reported last year, we had a consultant review the status of fire protection at the stations. To follow up, we did a fire safety inspection of the stations with Ontario

Hydro staff in 1994. We found that Ontario Hydro, although tardy, made progress in addressing the fire safety issues that we and our consultant identified. However, the number and nature of the fires reported during the year showed that workers in both stations still lack fire hazard awareness.

❑ Security

There were no significant security events in 1994.

OPERATIONS AND MAINTENANCE

❑ Jumpers

The total number of *jumpers* at the stations remained unchanged for 1994. There was a notable increase in the number of jumpers for PNGS-A. However, we do not believe that this increase has safety implications. Unit 1 was in an outage for more than six months during the year.

Ontario Hydro staff uses jumpers to record temporary changes. Therefore, we expect to see the number of jumpers increase when units are shut down, as jumpers are used to record and authorize temporary conditions which are required during maintenance. Most of these jumpers are removed after the outage and before the unit returns to power. However, for safety reasons, it is important to keep the number of outstanding jumpers low.

Figure 6: ***JUMPERS***
(Number of Jumpers vs Year)

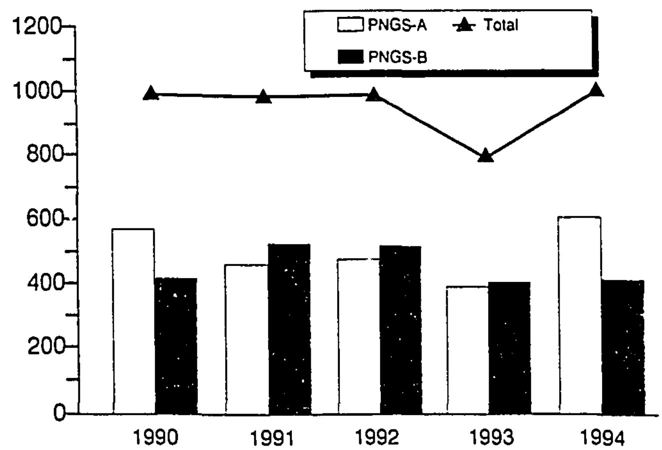


Figure 6 shows the total number of jumpers active for longer than six months in the years 1990 to 1994. The figure indicates that the number increased to 998 in 1994 from only 780 in 1993. Table 10 gives the 1994 distribution of jumpers associated with special safety systems, safety support and safety-related systems and other systems for both PNGS-A and PNGS-B.

Table 10: ***JUMPERS ACTIVE FOR MORE THAN SIX MONTHS***

System:	PNGS-A	PNGS-B
Special safety systems	3	13
Safety support and safety-related process systems	59	19
Other systems	539	365

❑ Relicensing of Pickering NGS-A & B

In December 1994, the Board renewed the operating licences for PNGS-A and PNGS-B. These renewals attracted much public attention. Interested persons and groups requested the Board to call for public review by a panel before renewal of the licences.

The Board took all presentations and submissions from interested parties into serious consideration. As the stations' performance continued to be acceptable, the Board agreed with its staff's recommendation to renew the operating licence for both stations. However, because of a loss of coolant accident on Unit 2 in December, the Board ordered that all four units at PNGS-A remain in an assured shutdown state until the cause of the Unit 2 event has been fully analysed and corrective action taken on all the units. This was taken to prevent a similar occurrence. Also, start up of any PNGS-A unit will require prior approval of the Board itself.

❑ Preventive Maintenance and Call-ups

A good preventive maintenance program is essential to the safe operation of the station. Proper preventive maintenance on plant equipment will minimise or eliminate equipment breakdown. The new Pickering management has taken steps toward better management of maintenance. Management is now tracking station performance in *preventive maintenance* by recording percentage completion of all identified *call-ups*. It also tracks the ratio of preventive maintenance completed to the amount of corrective maintenance completed during the same period.

In 1994, Pickering stations' operating preventive maintenance call-up completion was 62 percent. The Pickering management targets to attain a 100 percent call-up completion rate by the year 2000. Also, the preventive-to-corrective maintenance ratio was 15 percent. The stations' present target is 50 percent with the goal of achieving 70 percent by the year 2000.

This shows less time was being spent on preventive maintenance than on corrective maintenance during 1994 and that the stations' target for preventive maintenance is not being met. Ontario Hydro's performance in this area needs considerable improvement. We will continue to monitor the stations progress on improving their management of maintenance.

OPERATIONS AND MAINTENANCE OF PICKERING NGS-A

❑ Operation

In 1994, the PNGS-A net capacity factor was 71 percent. Although this did not meet Ontario Hydro's corporate target of 80 percent, Ontario Hydro had anticipated it to be lower. The cause was mostly due to the longer than planned maintenance outage of Unit 1, required for boiler cleaning in order to extend the boiler life. New boiler cleaning techniques were developed and used on Unit 1. A complete shutdown of all four units following the loss of coolant accident on Unit 2 also contributed to the lower net capacity factor for the year. However, we noted that Units 2, 3 and 4 operated at an average net capacity factor of 90 percent. Table 11 compares the net capacity factor for PNGS-A with the past year's performance.

Table 11: ***PNGS CAPACITY FACTORS***

	1991	1992	1993	1994
PNGS-A	55%	61%	80%	71%
Unit 1	67%	65%	77%	19%
Unit 2	72%	91%	95%	86%
Unit 3	34%	90%	76%	91%
Unit 4	47%	0%	74%	89%
PNGS-B	89%	73%	81%	84%
Unit 5	63%	29%	85%	68%
Unit 6	99%	89%	60%	89%
Unit 7	94%	82%	98%	82%
Unit 8	99%	93%	81%	96%

The net capacity factor is the ratio of the power actually delivered to the grid by the generator to the power the generator is capable of producing. A high plant net capacity factor shows that:

- Process systems are functioning well;
- Maintenance is such that systems can be operated satisfactorily to meet requirements;
- Process systems are able to be tested and the availability of equipment can be verified under operating conditions;
- Safety system testing can be performed to verify the system and equipment availability.

❑ Process Systems

There was one serious process failure in PNGS-A during 1994. On December 10, 1994, the failure of *a heat transport system liquid relief valve* and the subsequent failure of the *bleed condenser* relief valve pipe resulted in a small loss of coolant accident. The reactor automatically shut down, as designed. The emergency core cooling system also automatically started and provided cooling water to the reactor.

The unit remained shut down at the end of the year. Ontario Hydro staff continued to clean up Unit 2 through into early 1995. They need to make design changes and do inspection of the unit. We will assess these changes and inspection results before making a recommendation for returning the PNGS-A units to service.

❑ Chemistry

The PNGS-A station Chemistry Performance Index was 94 percent in 1994. This is an improvement over the 92 percent achieved in 1993 and is above the Ontario Hydro standard of 90 percent. Ontario Hydro had, over the years, increased the Chemistry Performance Index target towards 93 percent. Ontario Hydro has been successful in exceeding its self-imposed yearly targets since 1990. This is good, as the Chemistry Performance Index is a measure of achievement compared to the Ontario Hydro's chemistry specifications, process equipment standards and laboratory performance standards. Maintaining good chemistry control is important for worker and public safety, as well as for station reliability.

❑ Unit 1 Boiler Chemical Cleaning

Early in the year, Ontario Hydro staff found cracks in *boiler tubes* after being removed from Unit 1. After their extensive inspection of the unit's boiler tubes, they reported to us that the cracking was due to the method used to pull the tubes. A new method has since been developed. To extend the boiler's life and enhance safe operation, they also cleaned the boiler tubes and plugged pitted boiler tubes.

As in previous years, we reviewed Ontario Hydro's submissions to assure that this cleaning and plugging would not affect reactor safety. Through the Atomic Energy Control Board Environmental Assessment Review Process, we confirmed also that the chemicals used for boiler cleaning would not be hazardous to the environment.

OPERATIONS AND MAINTENANCE OF PICKERING NGS-B

❑ Operation

In 1994, the PNGS-B net capacity factor was 84 percent, an improvement from 81 percent achieved in 1993. Ontario Hydro achieved this by good planning and control of maintenance outages on Units 5 and 7.

Table 11 shows the capacity factors attained by the PNGS-B units. The shut down of Units 5 and 7 for planned outages in 1994 lowered the capacity factors for these units. Ontario Hydro completed the required pressure tests of the reactor building on both units during these outages. The leak rates measured from both units were well below target, showing that the reactor buildings are well sealed and will assure continued safe operation.

❑ Process Systems

There were no serious process system failures in 1994.

❑ Chemistry

Chemistry control at PNGS-B continued to improve through 1994. PNGS-B achieved a total Chemistry Performance Index of

96 percent in 1994 compared to 93 percent in 1993. This is good as it is better than the station target of 93 percent.

The boiler Chemistry Performance Index exceeded the station targets for most of the year. Introduction of preventive maintenance for condenser tubes and tighter chemical control of boiler water contributed to this improvement. More frequent boiler blowdowns by operators to remove impurities also contributed to the improvement. Maintaining good boiler chemistry control is important for safety, as well as for station reliability. Ontario Hydro also replaced the main steam *turbine* condenser tubes and feedwater system heaters to allow for better chemistry control.

In 1994, Ontario Hydro continued to install an oxygen addition system in the *annulus gas system* on the PNGS-B units. The addition of oxygen in the annulus gas system maintains a protective oxide layer on the outside surface of the *pressure tubes* which extends their life.

❑ Maintenance

In 1994, Ontario Hydro did major maintenance on Unit 5 and Unit 7 during planned outages. During the Unit 5 outage, Ontario Hydro inspected the boiler tubes and the turbine, and replaced the moderator *heat exchangers*, condenser bundles and feedwater heaters. During the Unit 7 outage, Ontario Hydro inspected the boiler tubes and replaced the moderator heat exchangers and *shutdown cooling system* heat exchangers. These inspections and replacements are required to ensure continued safe operation.

❑ Unit 5 Boiler Tube Inspection and Electrosleeving

During 1994, as part of the boiler cleaning program, Ontario Hydro staff inspected Unit 5 boiler tubes. Out of over 10,000 tubes inspected, they did not detect any tubes that needed repair. Last year, we reported that Ontario Hydro had successfully sleeved many tubes in the laboratory.

To show if the *electrosleeving* process is acceptable for future use, Ontario Hydro formed 18 sleeves in Unit 5 boiler tubes. As the test results of four sleeved tubes removed from the boiler were favourable, we approved Ontario Hydro's request to leave 14 sleeved tubes in service. To leave the sleeves in service, Ontario Hydro did show that the sleeves are as good as or better than the original material. Ontario Hydro will also examine the conditions of the sleeved tubes when Unit 5 is shut down for planned maintenance in 1995. From our Environmental Assessment Review Process, we established that the chemicals used to form the sleeves would not be hazardous to the environment.

OPERATIONS AND MAINTENANCE OF PICKERING NGS-A & NGS-B COMMON SYSTEMS

The installation of a secondary or external rubber seal on the expansion joints in the pressure relief duct is on schedule. Upon completion of the modification by mid-1995, all the 23 expansion joint seal assemblies will have double seals and become testable. This will provide better assurance that the containment system will meet our availability requirement.

In 1990, Ontario Hydro staff found that the controllers that operate the three instrumented pressure relief valves would not operate as assumed in the safety analysis. With our approval, they made temporary changes to the controllers. In 1994, they replaced the controllers to make their operation comparable with the safety analysis.

STATION MANAGEMENT

Ontario Hydro management completed its first year of operation within its new organization. As shown in Events Reported to the Atomic Energy Control Board, there were still a significant number of human performance-related events. This may be a result of worker's lack of ownership, low morale, limited job commitment or poor procedural compliance. We expect to see continuing focus by management in these areas.

Management successfully introduced a process that encouraged employees to report events that are considered near misses as a means to identify the problems.

In 1992, management conducted post trip reviews after every reactor trip regardless of cause. Causes were determined and corrected before any trip was reset. In 1994, a reactor safety outage review process was applied to each maintenance outage during the planning and execution phases of the outage. All these processes served to improve the safe operation of the stations.

Last year, we reported that Ontario Hydro Pickering Nuclear Division lost many experienced nuclear safety staff to early retirement and that there was a significant influx of redeployed staff to nuclear safety positions. Although this division's share of the loss is disproportionately lower than at other stations, we noted that Ontario Hydro continued to deliver urgently needed training to their analysis and assessment staff. Also, we noted that the relocation of Ontario Hydro nuclear safety staff from its downtown Toronto offices to the station did improve the timeliness of their support to station operating staff on nuclear safety issues.

❑ Business Improvement Program

At the start of 1994, Ontario Hydro Nuclear replaced its four-year old *Quality Improvement Program* with a *Business Improvement Program*. This change integrated the different pre-existing quality improvement programs of the various work groups that became part of Pickering Nuclear Division. Also, Ontario Hydro added more business-based indicators to the older technical and management programs. We will continue to track these indicators.

❑ Action Items and Commitments Management

Ontario Hydro uses a database system to manage the *action items* and monitor the progress on the resolution of licensing activities. Action items are formal requests to Ontario Hydro made by the Atomic Energy Control Board staff. Ontario Hydro staff also keeps track of progress on their commitments to us. If a commitment is deemed important to reactor safety, we will treat it as an action item.

This year we opened 25 action items and were able to close 26. At the end of the year there were 174 open action items. Figure 7 shows a comparison of action items open and closed, outstanding action items and commitments from 1992 to 1994. To resolve the backlog of action items, Ontario Hydro Nuclear Safety Department has undertaken a program with the Atomic Energy Control Board staff to reduce the number of outstanding issues. This resulted in a temporary increase in the total number of open items but will improve the commitment/action item closure process and will result in an anticipated reduction by the end of 1995.

Due to the variation in complexity of each action item, we do not measure station performance on the completion of the number of action items. However, it is important to keep the number of outstanding action items low to ensure as few safety-related issues remain unresolved as possible.

❑ Significant Event Reports

According to the licence conditions, Ontario Hydro issues significant event reports on station events that require reporting. It documents the circumstances of the event and shows initial actions taken and actions planned. There were 183 SERs issued in 1994 compared to 206 and 144 in 1993 and 1992, respectively. Generally, more than one action is generated as a result of a SER.

Figure 8 shows that there were fewer actions completed in 1994 than in 1993. At the end of 1994, there remained a total of

Figure 7: ***ACTION ITEM OPEN, CLOSED, STILL OPEN AND OPEN COMMITMENTS (Number vs Year)***

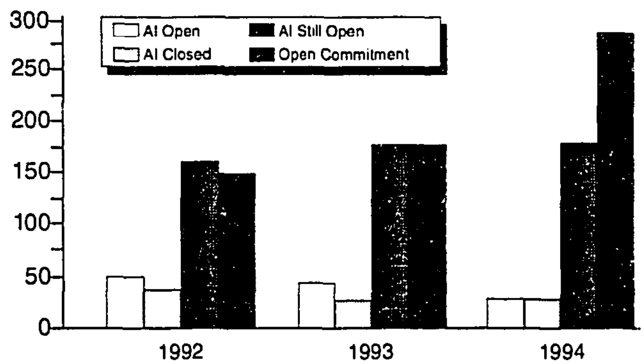
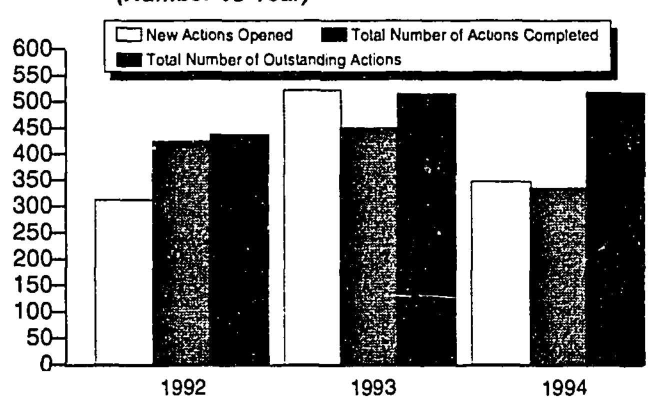


Figure 8: ***ACTIONS RESULTING FROM SERs (Number vs Year)***



521 outstanding actions. Ontario Hydro staff should improve on the completion of their outstanding actions.

TRAINING

Late in 1993, we audited Operator Field Training effectiveness. We noted several deficiencies in the way Ontario Hydro Pickering Nuclear Division conducted operator on-the-job training and the way operators performed some field tasks. We clearly identified these deficiencies to both station and training staff.

In response to our findings and to provide a better focus on field tasks, the Training Unit rewrote existing on-the-job training tests and formally identified those field tasks that should receive periodic refresher training. To establish a more uniform standard on the conduct and evaluation of field tasks, the Training Unit also gave seminars to each of the responsible operating staff.

The recent operator family restructuring required a revision to the technical and field training packages. Many operators have not received or completed all the new requirements. Loss of experienced instructors due to downsizing and early retirement has delayed training delivery. Also, even though Ontario Hydro Pickering Nuclear Division operates the stations with more than the minimum required number of operators, the shift schedule restricts the rate at which operators can be released for upgrade training. As a result, not all the operators will be trained to this new standard before 1998.

We will continue to monitor the quality and quantity of operator training.

The licence requirement for the number of Atomic Energy Control Board authorized staff was met during 1994.

❑ Power Workers Union Potential Strike

In anticipation of a possible strike by the Power Workers Union in April, Ontario Hydro trained non-union staff to maintain the stations when the reactors are shut down. Ontario Hydro required our approval to use its plan of operation and we closely monitored the progress made. To get our approval, Ontario Hydro had to satisfy us that it had enough well-trained staff and a plan to deal with both expected and unexpected conditions. The plan was never carried out, as Ontario Hydro and the union reached an agreement without a withdrawal of the workers.

EMERGENCY EXERCISES AND DRILLS

❑ Station Radiation Emergency Preparedness and Drills

All crews did their required four radiation emergency drills in 1994.

In the past, we witnessed and evaluated one full-scale drill that the station staff carried out during the year. This year, however, our contractor completed a report on criteria to use when evaluating on-site nuclear power plant emergency plans. As a result, instead of witnessing a full-scale drill, we used the criteria in the report to evaluate the emergency response capability of the Pickering station. We expect to have our results published in early 1995.

Last year, we reported finding areas in the stations' emergency response that needed improvement. Ontario Hydro has now either corrected the issues to our satisfaction or is working on them. We also recommended that provincial and municipal emergency organizations actively take part in future large-scale drills. An exercise with the participation of the provincial and municipal emergency organizations is planned for early 1995.

In 1990, an Ontario Hydro report recommended a schedule for doing 10 formally evaluated drills and 10 crew-initiated drills each year. This meant increasing the number of formally evaluated drills from one to 10. Ontario Hydro has been struggling with both the cost and resources required to meet this goal. Ontario Hydro holds 20 drills per year, but only formally evaluates two. We will pursue this issue further with Ontario Hydro.

❑ Station Fire Emergency Exercises

There were no joint Ontario Hydro-Pickering Fire Department fire drills in 1994. All crews did complete their required four fire and rescue drills and most crews did more. As reported last year, Ontario Hydro completed putting into place a new fire fighting program. They evaluated the program at the Bruce and the Darlington sites and will do an evaluation with a joint drill at Pickering in 1995. This year, Ontario Hydro made good progress in addressing some of our more immediate fire protection concerns.

SAFETY ANALYSIS FOR PICKERING NGS-A

❑ Large Loss Of Coolant Accident - Containment Underpressure Transient

On July 5, 1994, Ontario Hydro reported that when the temperature inside the pressure relief duct is below 0°C, steam condensation inside the duct would reduce the containment repressurizing time from 46 hours to about 20 hours, following a large loss of coolant accident. This resulted in a reduction in the accident response time. Ontario Hydro staff have determined the options to correct the situation and a design change has been approved.

❑ Failure of Boiler Divider Plates

Ontario Hydro staff did a preliminary assessment of the effect of large loss of coolant accidents on the divider plates in the boiler. Divider plates are in the bottom portion of the boilers and keep the heat transport system *heavy water* inlet and outlet sides separate. Ontario Hydro's assessment shows that if the pipe break is at the outlet of the boilers all three divider plates in the affected quadrant could get damaged.

However, if the pipe break is at the inlet side of the boilers, there would be no divider plate damage.

Ontario Hydro staff believes that the divider plate damage would not affect the conclusions of the safety analysis. Following a loss of coolant accident, flow is not required through the boilers and fuel cooling does not require operation of the heat transport pumps or boilers. The emergency core cooling system alone can maintain fuel cooling.

This preliminary conclusion needs to be verified by more detailed analysis. Ontario Hydro staff will do this analysis for both large and small loss of coolant accidents on Pickering stations and will update us regularly on the status of the work under way. An inter-utility task force has been established to deal with the failure of the divider plates in a generic manner.

❑ Boiler Divider Plate Leakage

During boiler cleaning, Ontario Hydro staff found that small leaks can occur between the plate dividing the inlet and outlet sides of the boiler. The analysis shows that under regular operating conditions, with the reactor at power, these leaks do not affect reactor safety. However, the leaks could affect fuel cooling, if thermosyphoning is used to remove heat via the boilers when the reactor is shut down and depressurized.

Ontario Hydro staff revised the operating procedure to prevent this operating condition. They will also check the state of the divider plates when each unit is shut down for planned maintenance.

Currently, we are reviewing Ontario Hydro's staff assessments to confirm their conclusions.

❑ Discrepancies between Measured and Calculated Adjuster Rod Worth

The design of the stainless steel adjuster rods in PNGS-A is different from other reactors. This has led to the discrepancies between the measured and the calculated *adjuster rod reactivity worth*. However, the root cause of these discrepancies is not fully understood and is still being investigated.

To account for these discrepancies, we imposed temporary restrictions on allowable reactor power and certain trip setpoints to ensure safe reactor operation. These restrictions are applicable for operation when one or more adjuster rods are withdrawn from the reactor *core*.

Since we reported these discrepancies last year, Ontario Hydro has provided and discussed with us their preliminary investigation findings. We are assessing these findings with the aim of identifying the cause of the discrepancies.

We are also reviewing the method that Ontario Hydro used to calculate the adjuster rod worth and other documents submitted to us to support the request for the removal of the imposed restrictions.

SAFETY ANALYSIS FOR PICKERING NGS-B

❑ Trip Parameter Effectiveness Criteria

In licensing, we judge the effectiveness of reactor *trip parameters* to prevent fuel *dryout* for some accident events, like loss of electrical power and loss of service water. Recently, Ontario Hydro used a fuel temperature limit as a criterion in the safety analysis. They submitted a study report to support their application.

Last year, we wrote that we were reviewing Ontario Hydro's report and started a research project to examine the experimental results of this report. Our review and the research project are now complete. We are currently drafting an Atomic Energy Control Board staff position paper on this issue.

❑ Flux Detector Replacement

Pickering NGS-B in-core *neutron flux* detectors, due to aging, have experienced significant degradation in insulator resistance. If not replaced, failed detectors could impair the two safety shutdown systems and the *reactor regulating system* necessitating reactor power derating or shutdown. As they are costly to repair, Ontario Hydro proposed to install new detectors similar to those used in other CANDU reactors.

We reviewed and approved in principle the proposed changes. However, we requested Ontario Hydro to submit more information for final approval.

QUALITY ASSURANCE

The station *Quality Assurance* Section reached full staff complement in 1994. As a result, the section did more *audits*, assessments and surveillance of station activities during the year. Although performance in the mandatory topic areas was about the same as the previous year, more project-specific quality assurance programs and procedures were either prepared, revised or reviewed. We viewed these as indications of increased management and staff support and awareness of quality assurance.

However, Ontario Hydro management did not meet its commitments to issue its new divisional Quality Assurance Program Manual for the station in March, 1994. We expect Ontario Hydro to issue the new manual, required following reorganization, in early 1995.

❑ Health Physics Assessments/Appraisals

Assessments/Appraisals of the Role of Operating Instructions at Ontario Hydro

In 1994, we did Phases 1 and 2 of our assessment of the role of operating instructions at Ontario Hydro. We will be ready to present the results of these two phases in the next annual report.

Our assessment includes five phases that are designed to assess the preparation, validation and use of operating instructions at Ontario Hydro. It also includes an assessment of the process to incorporate the operating experience at the stations, and from other stations, into these operating instructions. In the future, we will also look into the adequacy of the training programs for the users of these operating instructions.

Assessment/Appraisal of Radioactive Work Management at Ontario Hydro

In 1993, we reported that there were three significant radiation exposure incidents at Ontario Hydro. As a result, in 1994 we did an appraisal on how Ontario Hydro plans and does radioactive work. The appraisal team found that:

- Management had already taken some corrective actions.
- Line Management and the field radiation control unit periodically assess the Pickering radiation protection program.
- Radiation protection specialists and management are identifying and eliminating the causes of the problems.
- Many workers and supervisors are not very concerned with contamination control. They do not consider radioactive contamination a serious problem.
- Some experienced workers at PNGS-B are complacent about tritium hazards. This has the potential of causing significant whole body doses to workers when tritium levels increase suddenly in their immediate work area.
- Although detailed radiation protection programs and procedures are in place at Ontario Hydro, workers do not always follow these procedures while doing the actual work. Ontario Hydro Health Physics has problems allocating resources to do the necessary periodic assessments.

To correct these problems, Ontario Hydro management is actively rewriting these radiation protection policies and procedures to make them easier to use.

❑ AECB Site Staff Inspections

Our routine inspections program revealed no serious deficiency that could affect reactor or public safety. However, Ontario Hydro needs to monitor outage activities more closely, particularly inside the reactor buildings, to maintain control of *housekeeping* and provide a safer work environment.

We noted the good practice of identifying and posting, in the main control room, the primary and secondary heat sink requirements for cooling the reactor during a unit outage. This is a positive step to increase operator awareness of the fuel cooling requirements even when the reactor is shut down. Ontario Hydro staff also closely monitored the guaranteed shutdown state conditions and unit start-up activities.

We observed that the master work plan for the outage unit was not always kept up to date. During control room inspections, we noted that there were regular alarm indications that needed attention. They are the result of outstanding field deficiencies that require long term solutions.

During 1994, general stations' housekeeping did not show improvement despite station management initiatives to address similar findings in 1993. We continued to find contaminated waste bags in uncontrolled areas. Clean-up during and after a unit outage often resulted in contaminated material being placed in areas without proper contamination control.

To improve the stations' housekeeping, Ontario Hydro assigned responsible managers for most areas of the stations. However, management still has to assign responsibility for the unzoned areas. Our inspections revealed that housekeeping in these areas tends to get out of control at times.

While we reported that additional radiation detection instruments had been placed throughout the stations last year, we noted that regular servicing of these instruments was not always done. We also found defective portable instruments without deficiency report tags to show that requests had been filed for their repair.

To address the improper practice of smoking in radiation areas, a station team formulated a smoking policy. The policy, which took effect late in the year, banned smoking anywhere in the stations except in designated areas. We will check if this new policy stops workers from smoking in radiological areas.

SAFEGUARDS

During 1994, Ontario Hydro provided to us all the required reports. All their planning and work related to *safeguards* was done on time. Also, we received very good cooperation at all levels from Ontario Hydro.

The *International Atomic Energy Agency* verified the inventory in the PNGS-A *irradiated fuel bay*. The verification showed that Ontario Hydro made additional improvements in record keeping for older material in the bay.

Canada is a signatory of the *Treaty on the Non-Proliferation of Nuclear Weapons*. Pursuant to the Treaty, Canada has entered a Safeguards Agreement with the International Atomic Energy Agency. This Agreement provides the International Atomic Energy Agency with the right and the responsibility to verify that Canada is fulfilling its Non-Proliferation Treaty commitment not to use its peaceful nuclear program to make nuclear weapons or nuclear explosive devices.

We include a requirement for the application of International Atomic Energy Agency safeguards in the Operating Licences. To comply, Ontario Hydro must provide access and assistance to International Atomic Energy Agency inspectors for verification purposes, and for the installation and maintenance of International Atomic Energy Agency equipment at the station. The station must also provide timely reports on the movement and location of all nuclear materials within the station.

CONCLUSIONS

Ontario Hydro operated both PNGS-A and PNGS-B safely in 1994. We believe that the risk to the workers and the public was acceptably low.

We saw fully satisfactory or improved performance in:

- Compliance with Atomic Energy Control Regulations;
- Special safety systems availability;
- Commitments regarding capital projects to improve plant safety;
- Radiation releases from the station and public radiation safety;
- Chemistry control;
- Quality assurance;
- International Atomic Energy Agency safeguards support.

Areas that need improvements are:

- Compliance with operating licence conditions;
- Radiation contamination awareness and radiation doses received by workers;
- Human performance-related errors and procedural compliance;
- Control of key replacement parts;
- Number of unnecessary shutdown system actuations during an outage;
- Fire hazard awareness;
- Preventive maintenance performance;
- Completion of outstanding significant event follow-up actions;
- Formal evaluation of station radiation emergency preparedness and drills;
- Training of field operators;
- Housekeeping and outage work control;
- Servicing of radiation detection instruments;
- Outstanding field deficiencies causing regular alarm indications.

We expect Ontario Hydro to focus more attention on improving these areas in 1995.

GLOSSARY

Action Item	A formal request by an AECB project office to a licensee for specific actions to be carried out. We consider such actions necessary for safe reactor operation.
Adjuster Rod Worth	The amount of reactivity that solid rods of a neutron absorbing material (cobalt or stainless steel) introduces in a reactor core.
Annulus Gas System (AGS)	A continuously circulating system of carbon dioxide gas in the spaces between the *pressure tubes* and *calandria tubes.* It thermally insulates the tubes from each other and permits early detection of tube leaks.
As Low As Reasonably Achievable	An underlying safety principle requiring licensees to always minimize radiation doses to workers and to the public, taking social and economic factors into account. This requirement supplements the need to meet legal limits.
Atomic Energy Control Act	The federal act that established the AECB and allows it to regulate the nuclear industry in Canada.
Atomic Energy Control Regulations	Regulations made pursuant to the *Atomic Energy Control Act* by the AECB.
Atomic Radiation Worker	A worker who is authorized to perform duties that may result in a dose greater than the limit for members of the public.
Audit	Verification and evaluation of a document, process or work related to station operation.
Availability	The percentage of time a piece of equipment can perform its designated function.

Becquerel (Bq)
The SI unit for the radioactivity of a source. It is equivalent to one disintegration per second.

Bleed Condenser
Equipment that reduces pressure and temperature of *heavy water* before passing it through the ion exchange system to storage.

Boiler
Also known as a *steam generator.* A *heat exchanger* that transfers heat from the *heavy water* coolant to light water to produce steam in its upper portion. Piping from the *boiler* carries the steam to the *turbine.*

Boiler Tubes
Also known as *steam generator tubes.* The inverted U shaped tubes that contain the *heavy water* coolant, separating it from the natural water outside the tubes which boils to produce steam. Boilers typically contain several thousand tubes.

Business Improvement Program
See *Quality Improvement Program.*

Calandria
A cylindrical unpressurized stainless steel vessel which holds the *moderator. Pressure tubes* span the calandria.

Call-up
Also known as scheduled *preventive maintenance.* A routine maintenance item or performance check completed at regular intervals.

Canada, Deuterium, Uranium (CANDU)
A Canadian designed reactor moderated and cooled by *heavy water* and fuelled with natural uranium. "CANDU" comes from **Can**ada, **D**euterium, **U**ranium.

Carbon-14
A radioactive isotopes of carbon produced in some reactor systems.

Containment
The building surrounding the reactor. It isolates the reactor from the environment and prevents radiation, which might be released in an accident, from escaping. It also contains the *filtered air discharge system.*

Contamination — The undesirable deposition of radioactive material anywhere, particularly in places where its presence may be harmful.

Control Equipment Room — This room contains the control equipment for those systems being controlled from the *Main Control Room*. The room contains instrument racks, interlock and logic equipment racks, control computers, control distribution frames and general distribution frame protection and control circuits.

Core — The heart of a nuclear reactor containing the *fuel bundles*, *moderator (heavy water)*, as well as various detectors and control devices. Heavy water coolant passes through the *channels* containing the *fuel bundles*.

Critical Group — A well-defined group of people who receive more radiation from a given source (e.g., a particular waste discharge) than any other defined group.

Derived Emission Limit (DEL) — A calculated amount of radioactive material that, if released from the station, would result in a radiation exposure of 5 mSv to a member of the public in the worst possible case. Five mSv is the maximum annual radiation exposure allowed for members of the public by the *Atomic Energy Control Regulations*. The calculation is done by examining the effect of the radioactivity on a theoretical person who lives full time at the station boundary, eats only food harvested local to the station, and drinks only water from the station's discharges. This theoretical individual is known as the 'critical individual'.

Dose — Generally, the quantity of radiation energy absorbed by a body.

Dousing Spray — A collection of nozzles in the upper portion of the *reactor building* or *vacuum building*, at single or multi-unit stations respectively. They spray ordinary water inside the building to reduce pressure should it exceed a predefined limit.

Dryout

Term used to describe the formation of a stable film of vapour on a heating surface. It is dangerous to establish this condition because the heating surface temperature must be very high.

Electrosleeving

Electrosleeving is a multi-step electro-chemical process by which an ultra-fine grained microstructure nickel sleeve is electroformed, in-situ onto the inner surface of a boiler tube. This process strengthens the boiler tubes that have pitting corrosion on the outside diameter and leave them fit for service.

Emergency Coolant Injection System (ECIS)

Also known as the *emergency core cooling system*, or ECCS. A supply of cold water that can quickly be injected into the *fuel channels* of the reactor if the normal source of cooling water is lost. It also provides long-term cooling for the fuel by recovering water from the *reactor building* floor.

Emergency Core Cooling System (ECCS)

See *emergency coolant injection system* (ECIS).

Emergency Service Water System (ESW)

A system that primarily supplies cooling water to essential *safety-related systems* if normal service water supplies are unavailable.

Equivalent Calendar Year

A time used for recording radiation doses received by *atomic radiation workers* that is usually not less than 50 consecutive weeks (dosimetry year). If averaged over any period of five consecutive dosimetry years, the period shall be not less than 52 weeks.

Expansion Joint Seal

A flexible material that seals the joints between different sections of the *pressure relief duct* as they expand and contract with changing temperature. Each joint forms part of the *containment* boundary.

Filtered Air Discharge System (FADS)	A filtered ventilation system that operates in the long term following a *loss of coolant accident* (LOCA). It functions to maintain the reactor *containment* structure sub-atmospheric. It also allows a controlled and monitored release of radioactive products to the environment.
Fuel Bundle	A collection of thirty-seven pencil shaped elements containing natural or depleted uranium. End plates hold it together as a cylinder.
Fuel Channel	See *pressure tube.*
Fuel Handling	The system that is responsible for fuel changing and storage of new and irradiated fuel.
Generator	Equipment that converts the mechanical power delivered by the *turbine* into electricity. There is one generator for each reactor.
Gray (Nano)	The SI unit of absorbed radiation dose, one joule per kilogram. One Gray is the same as 100 rads. One nanoGray (nGy) is one billionth of a Gray.
Grid	Also known as bulk electrical system. The provincial electrical distribution system.
Gross Beta/Gamma	A measurement of the total beta and gamma radioactivity in a sample.
Guaranteed Shutdown State (GSS)	A method for ensuring that the reactor stays shut down. It includes injecting *poison* into the *moderator* or draining the *moderator* from the reactor.
Heat Exchanger (HX)	Equipment that transfers heat between systems.
Heat Transport System	See *primary heat transport system.*

Heavy Water (D_20)
Also known as deuterium oxide. Heavy water is a clear, colourless liquid that looks and tastes like ordinary water. It occurs naturally in water in very small amounts. Unlike ordinary water, which has hydrogen and oxygen (the well known H_2O formula), heavy water has deuterium and oxygen (D_2O).

Deuterium is hydrogen with an extra neutron in its nucleus. This extra neutron makes heavy water about 10% heavier than ordinary water.

CANDU reactors use heavy water as a *moderator* and coolant. Heavy water is a *prescribed substance*. We regulate its production.

Housekeeping
The act of keeping a station neat and tidy, with equipment and components stored properly.

International Atomic Energy Agency (IAEA)
The IAEA is a United Nations agency. It provides a system of *safeguards* to make sure that states do not divert nuclear materials to non-peaceful activities. It also provides an international forum for nuclear safety.

Iodine 131 (I-131)
A radioactive isotope of iodine produced in *fuel bundles* while the reactor is operating.

Irradiated Fuel Bay (IF)
A large pool of ordinary water that cools and shields *fuel bundles* discharged from the reactor.

Jumper
A temporary modification to a component in the station or to an item of the station's documentation (e.g., drawings, procedures).

Loss of Coolant Accident (LOCA)
An accident in which a failure in the *primary heat transport system* causes the *heavy water* coolant to be lost faster than the normal heat transport coolant supply can replace it. The *emergency coolant injection system* provides fuel cooling if this happens.

Main Control Room (MCR)	A centrally located room that contains a control panel and console for each unit, the *fuel handling* control panels, the common services control panel and the unit and common electrical control panels.
Moderator	The *heavy water* in the *calandria* that slows the neutrons released by fission to energies at which they are likely to produce additional fissions. Because the moderator surrounds the *fuel channels*, it also provides cooling and protection if a major accident caused a complete loss of cooling to the *fuel channels*.
Net Capacity Factor (NCF)	The ratio of the actual net electrical power produced to the design 100% net electrical power, over a specified period.
Neutron Flux	The product of the density of neutrons at a particular point in the reactor and their average speed. It is directly proportional to total heat generated through fission and, therefore, to thermal power.
Noble Gases	Gases produced in the *fuel bundles* during operation. They are radioactive and decay to produce particulates, some of which are also radioactive.
Nuclear Generating Station (NGS)	A facility comprised of a single or multi (usually four) reactor units. Each unit converts the fission energy released in the reactor to electrical energy.
Operating Policies and Principles (OP&P)	An Ontario Hydro document, which we approve, that outlines the safe operating boundaries for a station. It also defines when staff may make decisions and when they must get approval from a higher authority.
Outage (Forced, Planned)	The time during which a reactor is not delivering power to the *grid*. Outages may be forced, by equipment malfunction for example, or planned to carry out routine maintenance.
Particulate	Any radioactive material that is in particle (e.g., dust) form.

Physical Security Regulations	Regulations we issue stating the physical security standards at nuclear facilities.
Poison	Any material in the core that readily absorbs neutrons unproductively, and therefore removes them from the fission chain reaction.
Prescribed Substance	Any substance that can release atomic energy or is necessary for the production or use of atomic energy. We regulate prescribe substances.
Pressure Relief Duct (PRD)	A common duct that connects all *reactor buildings* of a multi-unit station to the *vacuum building*. The duct is made of reinforced concrete sections joined by expansion joint seals.
Pressure Tubes (PT)	Also known loosely as *fuel channels*. Tubes that pass through the *calandria* and contain twelve or thirteen *fuel bundles*. Pressurized *heavy water* flows through the tubes, cooling the fuel. They form part of the pressure boundary for the *primary heat transport system*.
Preventive Maintenance	Maintenance carried out to avoid breakdowns.
Primary Heat Transport System (PHT)	A closed cooling circuit that carries heat produced in the *fuel bundles* to the *boilers*. It does this by circulating *heavy water* at high pressure through the *fuel channels* and the *boiler tubes*.
Process Failure	Failure of a *process system*.
Process System	Any of the reactor's systems that assists in the process of turning fission energy into electricity. This distinguishes them from safety systems, which function only to protect the reactor.
Quality Assurance (QA)	A formal program of standards, procedures and checks that control the quality of work carried out on the station.

Quality Improvement Program (QIP)	A program Ontario Hydro started to improve the quality of reactor operation.
Radiation Protection Regulations	Regulations the licensee issues that state the radiation protection standards to be met at a station. These regulations require our approval.
Radionuclide	Another term for a radioactive element.
Reactor Building (RB)	A reinforced-concrete building that serves as a support and an enclosure for the reactor and some of its associated equipment.
Reactor Regulating System (RRS)	The system that controls reactor power. It monitors *neutron flux* shape and important operating parameters so that power may be reduced if any parameter is outside specific limits.
Reportable Event	An event which affected, or which under slightly different circumstances could have affected, public or worker safety, health, security or the environment.
Rubber Area	A specially prepared area of the floor in the station where it is foreseen that there will be loose radioactive *contamination*. Its purpose is to contain the contamination and not let it spread. Persons entering put on rubber overshoes before stepping into the area, and remove them when leaving.
Safeguards	An international program of monitoring and inspection carried out by staff of the *International Atomic Energy Agency.* Safeguards ensure that nuclear materials in the station are not diverted for non peaceful use.
Safety-Related System	A system required for the successful operation of safety systems. Such systems include the various classes of electrical power, plus instrument air and service water supplies.
Safety Report	A licensee document that describes the design of the station. It also describes the safety analysis completed to show that the risk of operating the station is acceptably low.

Safety Support System	Systems and features of a station used solely for safety functions. Examples include the *emergency service water system* and the emergency power supply system.
Shutdown Cooling System	A collection of equipment that cools the fuel bundles to remove decay heat after a normal reactor shut down.
Shutdown System (SDS)	A method of quickly shutting down a nuclear reactor with the rapid introduction of neutron absorbers that stop a chain reaction. Most *CANDU* reactors have two independent shutdown systems. Each can shut down the reactor safely. It *trips* when the *trip parameter* reaches the setpoints.
Shutdown System No. 1 (SDS1)	The primary method of quickly shutting down the reactor when certain parameters enter an unacceptable range. It involves the release of spring assisted gravity-drop neutron absorber elements known as *shutoff rods.*
Shutdown System No. 2 (SDS2)	An alternate method of shutting down the reactor by rapidly injecting a neutron poison (gadolinium nitrate) into the *moderator.*
Shutoff Rods (SR)	Neutron absorbing rods that can be dropped into the reactor under abnormal conditions to shut it down quickly and safely.
Sievert (milli, micro) (Sv, mSv, μSv)	A measurement of radiation exposure. One Sievert (Sv) is the same as 100 rem. One millisievert (mSv) is one thousandth of a Sievert (0.001 Sv). One microsievert (μSv) is one millionth of a Sievert.
Special Safety Systems	There are four *special safety systems*: *shutdown system no. 1*, *shutdown system no. 2*, *emergency core cooling system* and *containment*. They are each functionally independent systems that can shut down the reactor, provide cooling and contain any radioactivity if a problem occurs with the *process systems.*
Treaty on the Non-Proliferation of Nuclear Weapons (NPT)	An international treaty that came into force in 1970, and to which Canada is a party. Its primary aim is preventing the spread of nuclear weapons.

Trip — A rapid shutdown of the reactor in response to the detection of certain abnormal and potentially dangerous conditions.

Trip Coverage — The measure of how well the trips protect the reactor against specific potential accidents.

Trip Parameter — A property (e.g., temperature, pressure) of a system that is continuously measured and compared with a limiting value (trip setpoint). If it reaches the trip setpoint, it activates a *shutdown system.*

Tritium — A radioactive isotope of hydrogen produced in the reactor's *heavy water* during operation.

Turbine — Equipment comprised of several bladed wheels that rotate when steam from the *boilers* flows through them. The kinetic energy of the steam converts into mechanical energy that turns the rotor of an electrical *generator*, producing energy.

Unavailability — The fraction of time that a system or component is not available to fully perform its function if it would be called upon to do so.

Vacuum Building (VB) — A cylindrical concrete structure with an emergency water storage tank and a *dousing spray* system. Vacuum pumps keep it at a very low sub-atmospheric pressure. A *pressure relief* duct connects it to the *reactor buildings* of a multi-unit station. This ensures that the pressure within the containment will be brought below atmospheric pressure shortly after a pressure rise in a *reactor building.*

Whole Body Dose — The radiation exposure that affects all of the body tissue. Radiation that penetrates the body completely, or radioactive materials absorbed by the body, cause it.