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REPORT

Fire Fighting Capability Assessment Program Darlington NGS

by

Fire Cross Consultants

Prepared for
the Atomic Energy Control Board
under its Regulatory Research
and Support Program
Ottawa, Canada

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**FIRE FIGHTING CAPABILITY
ASSESSMENT PROGRAM - DARLINGTON NGS**

A report prepared by Fire Cross Consultants Incorporated, under contract to the Atomic Energy Control Board.

ABSTRACT

This is a report on the completion of work relating to the assessment of the capability of Darlington NGS to cope with a large fire incident. This included an evaluation of an exercise scenario that would simulate a large fire incident and of their fire plans and procedures which became the subject of interim reports as part of the process of preparing for the fire fighting and rescue exercise. Finally the execution of fire plans by Darlington Nuclear Generating Station (NGS), as demonstrated by their application of human and material resources during a simulated large fire, was observed.

RÉSUMÉ

Le présent document constitue un compte rendu de la dernière étape des travaux destinés à évaluer la capacité de la centrale de Darlington à faire face à un incendie majeur. Ces travaux ont comporté l'évaluation d'un exercice simulant un grand incendie et des plans et procédures établis par la centrale pour faire face à un tel sinistre. Ces plans sont devenus l'objet de rapports provisoires dans le cadre du processus de préparation au travail de sauvetage et de lutte contre l'incendie. Enfin, on a évalué la mise en application des plans de protection-incendie de la centrale nucléaire de Darlington, par l'observation de l'utilisation faite des ressources humaines et matérielles au cours de l'exercice de simulation.

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FIRE FIGHTING CAPABILITY ASSESSMENT PROGRAM - DARLINGTON NGS

EXECUTIVE SUMMARY

The evaluation exercise was held at Darlington NGS on January 19, 1994. It was a bitterly cold day with a temperature of -21° C. Driven by a 50 km/h wind out of the west/north-west, the wind chill was extreme. It got underway at 0914 hours, when smoke generators were started by Ontario Hydro exercise controllers under the direction of Mr. Peter Kimball. It was observed that at least two of the three main rooms of involvement, rooms S -138 and S-150, quickly filled with smoke to the degree where visibility was reduced to approximately one metre by 0922 hours. Overall, the exercise was a reasonable simulation of an incident involving a "large fire" as such is defined at Appendix B and was the most comprehensive and best managed of any yet observed at a Nuclear Generating Station. Although it was apparent that knowledge of the specifics of the scenario did not extend beyond the controllers and evaluators, widespread advance knowledge of the timing of the exercise created abnormal circumstances which detracted from its authenticity.

The weather conditions made it very difficult for the Construction Fire Department and the Clarington Fire Department in particular. While it is conjecture on our part, it may well have mitigated against effective ventilation which would have required opening a door to the exterior to allow smoke and gases to escape and the frigid air to enter. Failure to ventilate delayed rescue and fire fighting operations to a critical degree. By way of example it required approximately twenty-four minutes after the alarm of fire for the responders to locate a casualty with painful injuries in room S-152. The same holds true for water on the fire by Emergency Response Team (ERT). Taken singularly, ventilation was the most significant shortcoming. Communications difficulties, both technical and procedural, was also an area that had a detrimental effect on the overall operation. Communications however did not directly effect the initiation of fire fighting and rescue operations.

Plans were generally good although there remains some areas that need attention as indicated in Appendix C. The attitude of the responders was also a recognizable strength in that all appeared to be trying to do the best job possible. Fire fighting equipment and personal protection equipment was suitable, of good quality and in good condition.

During the preparation and review of this report what is normal and what is abnormal staffing generated divergent views and associated commentary amongst all concerned. This, despite the fact that the number of responders who participated had only minimal effect, positive or negative, on fire fighting and rescue operations. By becoming a focal point it blurred the more important issue of what are normal circumstances and what are abnormal circumstances.

To look at circumstances first, it can be stated with confidence that unwanted fire(s) invariably occur without warning at times and dates dictated by the dynamics of the situation. If the foregoing logic is accepted, it follows that in normal circumstances fire crews have no advance notice of the occurrence of fire. In turn, it follows that for fire crews to have advance notice of the occurrence of fire would constitute abnormal circumstances. The more this principle is violated the more realism is sacrificed.

Staffing, insofar as the evaluation exercise was concerned, is of lesser relative importance. Even so, it is of interest to view the subject from the perspective of what is normal and what is not. As part of this process, subsequent to the exercise *Fire Cross* was advised that ERT minimum/maximum duty strength was eight/fourteen. It was also established that thirty-five ERT members were on duty at the time of the exercise and that this would be the case more than fifty percent of the time during normal daytime working hours. Based on this, these latter conditions would prevail for approximately twenty-four hours out of every one hundred and sixty-eight hours in a week. It would therefore be normal for approximately fifteen percent of the time and abnormal for approximately eighty-five percent of the time.

To address the results of the evaluation in broader terms, it was evident that further improvements are required in order for the goal of having an effective fire fighting and rescue service to be realized. In this regard, the time taken to locate a casualty that could be readily seen and to apply water on the fire cannot be considered an acceptable standard. Clearly the casualty that suffered painful but not life threatening injuries in room S-152 would have succumbed to the heat, smoke and gases produced by the fire during the almost one half hour time period between the explosion/fire and his discovery by responders. The first water on the fire by the ERT occurred at the same time and although more difficult to accurately project the results of this delay, it may be anticipated that the fire could have developed, perhaps dramatically, during this period of time and caused a great deal of avoidable damage.

Finally, it was evident that the framework for the provision of efficient fire fighting and rescue services was in place. This constitutes a significant improvement over what has been observed at an earlier evaluation at Bruce NGS. Since the last evaluation of plans, procedures and fire fighting and rescue operations at another NGS by *Fire Cross*, we have observed that there has been remarkable improvement in the first two areas and encouraging improvements in the latter area. Where this report is concerned, the intent was to structure it in a manner that would permit it to serve as a vehicle or catalyst for further improvements. Particular attention was focused on this aim in the preparation of recommendations or suggestions.

FIRE FIGHTING CAPABILITY ASSESSMENT PROGRAM - DARLINGTON

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LIST OF ACRONYMS

AECB	-	Atomic Energy Control Board
DNGS	-	Darlington Nuclear Generating Station
ECI LP	-	Emergency Cooling Injection - Low Pressure
EOC	-	Emergency Operations Centre
ERT	-	Emergency Response Team
FAX	-	Facsimile
MCC	-	Mortal Control Centre
mm	-	Millimetre
NGS	-	Nuclear Generating Station
PA	-	Public Address (System)
PASS	-	Personal Alert Safety System
SCBA	-	Self Contained Breathing Apparatus
SERC	-	Shift Emergency Response Coordinator
S/M	-	Servicing/Maintenance
SOG	-	Standard Operating Guideline

1. INTRODUCTION

The assessment of the fire plans of Darlington NGS and the observation of an exercise involving a simulated large fire to gauge their probable effectiveness in dealing with a genuine emergency of such magnitude was conducted under the provisions of AECB Project No. 2.128.5.

The results of the work have been compiled and presented in such a way as to provide an executive summary and individual sections on six main subject areas followed by a section on conclusions and recommendations. As well, additional information is included as attachments.

2. METHODOLOGY

The methodology was to develop a definition of what would constitute a large fire in a nuclear power generating station and subsequently to assess the exercise scenario and fire plans relative to this definition. Based on this work, suggestions for making improvements and recommendations for correcting deficiencies were compiled and presented.

After the passage of a period of time to provide an opportunity for the results of the foregoing phase to be applied, the capacity of Darlington NGS to deal with fire related emergencies was evaluated by observing an exercise based on a simulated large fire. Following this *Fire Cross* attended a debriefing session conducted by the exercise controllers for all responders and the exercise was discussed on broad terms with AECB personnel.

3. SCENARIO

The Ontario Hydro scenario for the exercise is reproduced in Appendix A. The scope of the scenario was sufficient to simulate the occurrence of a "large fire" as that term has been defined for nuclear generating stations. In this regard it required the involvement of in-plant emergency services and management and the assemblage of off-site emergency services. The basics of the scenario was that a forklift collided with a trailer, of a highway type tractor/trailer rig that was parked at a loading dock in the services building. The accident caused the propane fuel tank on the forklift to explode, causing a fire in rooms S-138, S-147 and S-150 and some other damages in these and adjoining rooms. As well there were two casualties, one requiring medical attention and the other a fatality.

The methods used to impart a descriptive image of the incident to responders was based on the use of visual simulation supported by actual alarms from fire detection and fire suppression systems and by voice inputs by Ontario Hydro exercise controllers. The simulation was generally good. Smoke generators, flashing lights, fans, an exploded propane tank and casualty simulation were the key components, all of which worked quite well.

The integrity of the exercise was protected due to the exercise controllers being careful not to include a suggested or recommended course of action as they, from time to time, provided voice inputs. This approach nevertheless resulted in *Fire Cross* not knowing what or when information regarding the incident was released. In turn, this made it more difficult to anticipate what, when

and where some specific action should or should not be taken.

One actual alarm, which was to have been transmitted by the wet pipe sprinkler system protecting "low level" waste storage in room S-147, did not occur.

A requirement, fundamental to the validity of the evaluation, was that the exercise retain an element of surprise not significantly unlike an actual incident. This was not achieved. There was apparent widespread knowledge of the event amongst Darlington Nuclear Generating Station (DNFS) personnel regarding timings and the like, with only specific details retaining an appropriate degree of confidentiality. Basically the situation was quite similar with at least Clarington. It was not established whether or not the same held true for the Construction Fire Department.

A final point that could apply to both the development and administration of an exercise scenario, is the need to be more cognizant of the passage of time after the exercise is initiated. In this regard, a means of causing the situation to worsen unless certain things have been achieved is in order.

4. PLANS

The Fire Safety Plan and that component of the Conventional Emergency Manual dealing with Emergency Response Teams (ERT) Standard Operating Guidelines (SOG) were reviewed and reported upon in August 1993. This was done as part of the preparatory phase leading to a scheduled evaluation of DNFS's capacity for dealing with a "large fire" as defined at Appendix B. Both documents were found to be generally quite well considered. However, there were a number of areas that required restructuring.

A deficiency of particular concern was the manner in which fire fighting resources, external to the plant, are alerted and assembled. Specifically, the policy that was in place that required the first fire fighting organization involved in fighting a fire to do so on its own until such time as it was determined that control and extinguishment could not be established before calling for back-up resources, was held to be ill considered. Even at this point, support was to be called out on an incremental basis; first the Construction Fire Department or the ERT depending upon the location of the fire and, if this combined force was not successful, the Clarington Fire Department would then be called. Comments in more detail are included in Appendix C.

An item that became more evident during the tracking of the exercise was that the titles Incident Commander and Shift Emergency Response Coordinator (SERC) appeared to be used interchangeably which was found to be somewhat confusing. This is addressed more specifically in the section on Operations.

5. EQUIPMENT

During and immediately after the exercise, spot checks were conducted on the fire fighting equipment available for use at the fire scene. Fire carts were readily available from several locations and were well equipped with a good variety of tools, nozzles, hose, etc. in excellent condition. Accessibility to hose cabinets and portable extinguishers was good and the condition of both was also excellent.

Fire fighters protective clothing, including such items as helmets, bunker gear, boots, and gloves, were all found to be of good quality and in good condition. Self contained breathing apparatus (SCBA), with 4.5 cu ft/127.5L cylinders, were suitable and well maintained. Personal alert safety system (PASS) personal alarms, which sound an audible alarm if a fire fighter is motionless for approximately thirty seconds or when deliberately activated by the wearer, were attached to SCBA harness.

Although the equipment and protective clothing of the additional resources that attended from Construction and Clarington Fire Departments was not examined in detail both appeared to be satisfactory. Although the resources of Clarington, which included specialized equipment, were not used or required during the exercise, their potential value was nevertheless significant.

6. PERSONNEL

The human resources available at this simulated fire incident exceeded requirements. In fact the number of emergency personnel who actually responded to the incident undoubtedly was greater than would be available in the event of an emergency during all time frames with the exception of a portion of normal daytime working hours Monday through Friday. Based on information contained in Ontario Hydro's feedback dated March 4, 1994 concerning the draft final report, the ERT staffing level that was in place during the exercise could be held to be abnormal over approximately eighty-five percent of the time. Although it is recognized that there are a number of advantages to having as many interested, emergency trained personnel as possible involved with a simulated incident of this scope in order to absorb valuable experience, it imposed some complications in the area of command and control.

In assessing staffing levels it is of primary importance to determine and evaluate what might be expected to be the case in normal circumstances. In support of this *Fire Cross* collected the following information. Respecting DNGS policy, there is a requirement to have a minimum duty strength of 1 SERC and 7 ERT personnel, two of which must be qualified as Field Captains. The maximum number of ERT personnel that would be on a shift was stated to be 14. In addition a crew of 4 persons including a Captain could respond from the Construction Fire Department as could crews made up of regular and/or volunteer fire fighters from Clarington's Fire Stations #1 and #4. All three organizations can augment their on-duty strength with the call-back of off-duty personnel.

Looking ahead, it was reported that due to policy decisions made by Ontario Hydro and the Municipality of Clarington, there will be some changes to the size and configuration of fire fighting resources available to DNGS beginning in 1995. Based on the information that was available it may be anticipated that the key changes will be those related to the closing of Clarington's current #1 Fire Station now located approximately 8.5 km from DNGS and the opening of a new #1 Fire Station approximately 7 km from DNGS and to the disbandment of Ontario Hydro's Construction Fire Department. In addition, Clarington advised that the new fire station will be staffed on a 24 hour basis, with augmentation by volunteers. Past practice had been to staff this station between 0600 hours and 1800 hours and to depend exclusively on volunteers during other time periods. Regarding these matters Ontario Hydro advised, that on disbandment of the Construction Fire Department, the number of ERT personnel per shift would be increased to 18 and the minimum duty strength increased to 12. They further advised that all ERT members would be trained to a "green" radiological hazards qualification.

By way of quantifying the human resources situation that prevailed during the exercise, details regarding the contingent of personnel that were involved are shown in Table I.

Table - I

Position/Function	Number of Personnel
Incident Commander (SERC)	1
Assistant	1
SERC- (Administration Building)	1
BASE - Base Duties	1
- Scribe	1
- Resource Persons (1 SERC)	2
Fire Team # 1	4
Fire Team # 2	4
Fire Team # 3	4
Construction Fire Crew	5
Clarington Fire Department	15
Sub-total	39
Additional personnel assigned to other functions: ie First Aid/"Green Men"/Logistics	40
Total	79

7. COMMUNICATIONS

It was noted that recommendations made following earlier evaluation exercises and reviews of plans at other NGS had been included in DNGS plans and procedures which improved radio procedures immeasurably. For DNGS, Section 5.1 of the standard operational guidelines (SOG) on ERT Radio Procedure is a comprehensive and suitable procedure. This notwithstanding, good radio procedures and discipline broke down under the stress of the incident. Specifically, the exercise revealed a number of communications related matters that were less than satisfactory. These are addressed in the following paragraphs.

Some of the incident participants experienced technical difficulties with transmissions over the VHF radio system and resorted to the telephone system which eased the situation to some degree.

It was observed that the radio systems used by the ERT members and the Clarington Fire Department were on different frequencies and that this required that the Clarington Senior Officer carry and monitor two radios. This arrangement was inefficient and could not provide the level of communications that is a fundamental requirement for the coordination and direction of fire fighting operations. This situation becomes more critical when more than one fire fighting organization is involved.

In general, there was excessive radio chatter and transmissions that were distracting and unnecessary. It was noted that personal names and, in some cases, new call signs were being used by the persons operating the radios. Moreover, the use of the radio system to transmit non-emergency messages was evident in circumstances where the telephone system would have been more suitable.

8. OPERATIONS

8.1 Overview

The incident scene involved the Central Service Area building, level elevation 100.0 meters, specifically rooms S-138, S-147, S-150, S-152 and the cable spreading room directly above room S-138.

At 0914 hours mechanically generated smoke, flashing lights and other visual stimuli were introduced into the exercise area. At 0918 hours a fire alarm signal was sounded on the PA system followed by an announcement giving the location and informing that it was an exercise. It was apparent that both the Construction Fire Department and the Clarington Fire Department were called at more or less this time and that all fire fighting organizations initiated their response upon receipt of the alarm.

Some timings of interest, including those given above, are as follows:

- a. 0914 hours - Mechanically generated smoke, flashing lights, fans and other visual stimuli were introduced into the exercise area;
- b. 0916 hours - Unit Zero operator was advised that there was smoke visible at the incident scene;
- c. 0918 hours - A fire alarm signal was sounded on the PA system;
- d. 0924 hours - ERT Fire Captain 3 did a first (very limited) size-up of the incident;
- e. 0927 hours - Construction Fire Department arrived at a side door to room S-150;
- f. 0930 hours - Fire Cart # 6 arrived at room R-103;
- g. 0937 hours - Clarington Fire Department arrived;

- h. 0938 hours - First water on the fires (Construction Fire Department);
- i. 0942 hours - ERT have water on the fire;
 - Casualty requiring medical attention found in office; and
- j. 0947 hours - Recognition by ERT of the fatally injured casualty in room S-138.

As is evident there are matters that require attention in this area.

8.2 E.R.T. "Base"

As provided for in the ERT Standard Operating Guidelines, the ERT Base position is filled by a qualified ERT member. At 0919 hours, approximately one minute after the announcement of the alarm, an ERT member logged in as "Base" in ERT room T2-308. The position of SERC was filled simultaneously.

The "Base" member immediately took charge of Base operations and throughout the exercise demonstrated the skills and knowledge necessary to assume this role and responsibility. Notwithstanding the difficulties experienced with communications throughout the exercise, this key ERT control and logistics centre operated efficiently and met all demands that could be expected during an incident of this nature.

Although the manning of "Base", in the Fire Response Protocol, does not require that an additional position be assigned for the purpose of recording incident details on the white marker board and generally assisting "Base", it was apparent that the person who was assigned this role was a necessary part of the "Base" team. During an incident of this scope, the member filling the role of "Base" is not able to leave the desk area and a second person is required. The role of a Scribe in these circumstances is one of importance.

ERT room T2-308 served as the assembly point for all ERT members (trained responders) to serve as a manpower pool for designated assignments. The qualifications and sequence of arrival determined the task to be performed and the person was logged in prior to assignment. Inasmuch as SERC appeared to exercise command from this location for a considerable period of time, there was additional activity in the room which did not impair "Base" functions but did cause some stress. It was also evident that the presence of controllers and evaluators added to this stress as might be expected.

To evaluate the effectiveness of "Base" the flowchart contained in the ERT Standard Operating Guidelines provided a basis for measuring performance with expectations. The evaluation included some of the following functions:

- a. use of plans, manuals, and check lists;
- b. maintaining the log and assignment record of ERT members and other responders;

- c. the flow of information to various levels of command;
 - d. records keeping of all actions;
 - e. the tracking and accounting of various teams;
 - f. monitoring and informing crews of SCBA usage time;
 - g. radiation protection checks;
 - h. ensuring that backup resources were contacted;
 - i. arranging and confirming security response;
 - j. checking that "Green Men" assignments were completed and recorded;
 - k. utilization of radio and telephone communications; and
 - l. keeping casualty information records including first aid/ambulance and /hospital activities.
- The "Base" operation was conducted in such a manner that ensured that this function of the exercise was a success and that personnel assigned to this position performed at an outstanding level. The most difficult problem to cope with at this location was the inconsistency of radio communications; however, this concern is dealt with in another portion of this report.

8.3 Incident Command

Having had the opportunity to observe similar exercises requiring incident management systems at other NGS it was evident that the plans for this function reflected a marked improvement.

The on-duty SERC, in the building that the exercise originated within, elected to establish the Incident Command Post in the emergency response base room (ERT-T2-308). The location chosen for the command post was two stories above and some distance north of the incident site. This reduced the influence of the Incident Commander on the fire fighting crews and was not the most convenient and accessible to outside support services.

The SERC on duty in the Administrative building responded to "Base" and was directed by the Incident Commander to respond to the fire scene. In addition, a supernumerary SERC was in training with ten ERT members and responded to the ERT room and assisted the Incident Commander. It was observed that the Incident Commander was not recognizable during his time in the Command Post since he wore no markings or distinctive headgear. It was also noted that the supernumerary SERC in attendance wore a white helmet.

It was noted that the Incident Commander provided the guidance and direction necessary to initiate the actions to deal with the incident. However, as the exercise progressed, it became evident that the Incident Commander was not receiving sufficient information or adequate communications

to maintain control of the fire incident.

The SERC from the Administration building established himself in charge of the fire scene and undertook the duties and responsibilities of the Incident Commander related to the control of the fire and rescue crews, the Clarington Fire Department, and the Construction Fire crew. He introduced a new radio call sign of "Fire Sector Officer" and used that title and terminology throughout the exercise.

The Incident Commander attended the fire scene on two occasions. The first visit was thirty-five to forty minutes after the start of the exercise and the second visit was some one hour and fifty minutes after the start of the incident. It is of interest to note that the appropriate SOG indicated that the commander should have a "walk-by" and "size-up" during the initial stages of the incident. It may well be that the delay in the Incident Commander attending the scene could be attributed to the fact that the "Fire Sector Officer", to a considerable degree, performed this function.

It was noted that communication difficulties were being experienced by the Incident Commander over the radio system and often communications were conducted by telephone. Particular difficulty was experienced in contacting the Fire Sector Officer and the ERT Fire Captains.

8.4 Fire Fighting and Rescue

At 0924 hours ERT Fire Captain 3 arrived and made a visual size-up by looking into room S-150 through a pane of glass in the outside door. Visibility through the window was virtually nil due to dense smoke. At the same time, an ERT cart was taken from its room and brought to an area of the east-west corridor at the door to room S-150. At this point Fire Captain 3 could not establish radio communication with "Base" and utilized a telephone to report. Fire Captain 3 and crew, all in protective clothing, SCBA etc., were assembled and ready.

At 0925 hours the Construction Fire Department arrived and requested instructions. At 0927 hours they were at the door to the stair on the west side of room S-150 near room S-152. From this point, at 0938 hours, they delivered the first water used on the fire. Visibility continued to be very limited due to smoke conditions. In any case they were unable to advance into the fire area due to lack of qualifications on radiation hazards. This crew made their attack into room S-150 from a room on the west side by passing through the base of a stairway. The crew and hose remained in this location throughout the exercise which kept doors leading to the stair open and which allowed smoke and gases to migrate both vertically and horizontally.

At 0931 hours the "Fire Sector Officer" was at the Staging Area. At 0941 hours he instructed #3 Crew to enter room 103. The crew proceeded to a hose cabinet located at an area marked "R2-114", took a charged 38mm (1½") hose line, entered Room S-150 and commenced fighting the fire. The first water on the fire by the ERT organization was at 0942 hours. It was noted that the donning of protective clothing and equipment appeared to be slow and very deliberate. It was also noted that there were three command position personnel who did not use full protective clothing. One, in fact, did not use any protective clothing.

The presence of dense smoke, which in normal circumstances might be expected to be toxic, continued to seriously restrict visibility largely due to lack of ventilation. It is of interest to note that ventilation of a fire scene refers to the systematic removal of heated air, smoke and gases from a structure and the replacement of these materials with cooler air. The cooler air facilitates entry by fire fighters for rescue and other fire fighting duties. In the conditions created for the exercise, if there was concern regarding the mechanical ventilation system, the fire crew could have requested that it be temporarily shut down until such time as the immediate demands for ventilation of the fire scene were satisfied. Although *Fire Cross* was not aware of it at the time, subsequent to the exercise it was learned that the Exercise Controller had instructed that the air exchange system be turned off for greater realism. This would indicate that the system can safely be shut down on a temporary basis.

Despite the conditions described above, at 0942 hours Fire Captain 2 and Fire Crew 3 located the casualty in room S-152. Shortly thereafter, at 0946 hours, Fire Captain 1 and crew extended a 38mm hose (1½") line to room S-138 and commenced fire fighting operations. Following this, at 0950 hours, Fire Captain 3 and crew began fire fighting operations on the trailer. At this point the Incident Commander (one of three SERC's that became involved) made his first on-scene assessment of the incident, some thirty-two minutes after the alarm of fire signal on the PA system. He sought and received a briefing from the "Fire Sector Officer"(the SERC for the Administration Building) who, after apparently inventing the call sign, had established control on-scene. In this regard, while the new call sign may have caused some confusion initially, the manner in which he exercised command and control was commendable.

At 0951 hours, Fire Captain 2, with crew, initiated a primary search. In doing this, they extended a 38mm (1½") hose line into room S-150 through the two-leaf door from the east/west corridor. The hose line held the doors partially open and allowed the products of combustion (in this case, mechanically generated smoke) to extend into the corridor.

At 1002 hours an "all clear" was declared on-scene and a "Fire Watch" established. Some time later, at 1020 hours, the fire was declared out. Why this time difference occurred was not determined although difficulty with communications appeared to be the most probable reason.

At 1007 hours a search of room S-138 was undertaken and an open hatch cover leading to the room above was found at 1010 hours.

At 1035 hours the Clarington Fire Department implemented overhaul operations that included extensive exploration for fire extension. At 1056 hours the Clarington Fire Captain and the "Fire Sector Officer" began a detailed examination of the scene with the aim of determining cause. This activity was pursued in a very professional manner.

At 1133 hours a representative of the Ontario Fire Marshal's Office, who had been called in as a result of the fatality, arrived on the scene.

9. CONCLUSIONS and RECOMMENDATIONS

9.1 General

The conclusions are essentially the identification and description of matters requiring the attention of the licensee. The recommendations outline the direction that this attention should take. In all cases care was taken to ensure that any recommended course of action offered a practical solution that is achievable.

9.2 Exercise Inputs

9.2.1 Conclusion

It was concluded that the use of voice inputs at, in the main, unscheduled points as the scenario unfolded rather than explicit written cue cards or the like, caused the evaluation to be somewhat less precise in some situations than would otherwise be the case.

9.2.2 Recommendation

It is recommended that the use of voice inputs be restricted to urgent matters relating to such things as safety and that routine exercise inputs be in the form of explicit and descriptive written cue cards or the like.

9.3 The Element of Surprise

9.3.1 Conclusion

It was concluded that the lack of an element of surprise caused the evaluation to take place in abnormal circumstances and that it would be highly unlikely that such circumstances would prevail during the routine operation of the plant.

9.3.2 Recommendation

It is recommended that an exercise and evaluation protocol be developed for the specific purpose of alleviating this situation with special attention to reaching agreements with senior local management at NGS with the aim of developing procedures that will restrict advance information to senior management regarding the planning and conducting of fire fighting and rescue exercises.

9.4 Plans and Procedures

9.4.1 Conclusion

It was concluded that, although generally in good order, there were a number of subjects within the plans and procedures that warranted review and adjustment. As well, there was also a number of matters that had been overlooked. This is addressed in more detail in Appendix C.

9.4.2 Recommendation

It is recommended that the comments at Appendix C be reviewed and that adjustments and additions be made wherever possible.

9.5 Personal Protective Clothing and Equipment

9.5.1 Conclusion

It was concluded that the personal protective equipment available to fire fighting personnel, in terms of completeness, quality and condition was satisfactory to meet health and safety standards.

9.5.2 Recommendation

It is recommended that Management continue to review the type of personal protective equipment required in order to keep pace with technological advances and health and safety regulations.

9.6 Changes to Fire Fighting Resources

9.6.1 Conclusion

It was concluded that the planned changes to fire fighting resources will have both advantages and disadvantages for DNGS. The advantages may be anticipated to include the benefits of having a Clarington fire station 7 km rather than 8.5 km from DNGS and the fact that it will be staffed full time rather than part time. Conversely the disbandment of the Construction Fire Department, located as it was immediately adjacent to DNGS, will require that ERT operate on a stand alone basis for a longer period of time before resources external to the plant can become involved.

9.6.2 Recommendation

It is recommended that in light of the planned changes DNGS officials responsible for the ERT work closely with officials of the Clarington Fire Department in order to ensure the transition into the new configuration is done in an orderly manner.

9.7 Radio Procedures and Discipline

9.7.1 Conclusion

It was concluded that the failure to practice good radio procedures and discipline detracted from the effectiveness of the total operation.

9.7.2 Recommendation

It is recommended that proper radio procedures and disciplines be strictly adhered to in order to make transmissions more precise and easily understood and to sharply reduce unnecessary radio traffic. When lengthy reporting or conversations are necessary, the telephone should be utilized whenever possible.

9.8 Incompatible Radio Frequencies

9.8.1 Conclusion

It was concluded that the lack of a common radio frequency for use by all responding fire fighting forces prevented acceptable levels of communications and mitigated against efficient interface between all the fire crews.

9.8.2 Recommendation

It is recommended that a review of the radio frequencies be made to establish a common frequency for use by both in-plant and off-site emergency response teams that might be expected to respond to fire related emergency situations at the Darlington NGS. The provision of the fire protection mutual aid channel on DNGS radios seems a practical solution.

9.9 Unofficial Radio Call Signs

9.9.1 Conclusion

It was concluded that the action taken by the SERC from the Administration Building to establish a new radio call sign and title for the responsibilities he undertook and performed admirably, altered the flowchart guidelines in the Operating Manual and created some confusion as to who was executing the Incident Commander's duties and responsibilities.

9.9.2 Recommendation

It is recommended that only those radio call signs specifically listed in fire related plans and guidelines be used and that additions to this list be made only after thorough review and analysis. This process could be used to determine whether or not the addition of "Fire Sector Officer" to the list of radio call signs would enhance fire fighting and rescue operations.

9.10 "Base" Recorder

9.10.1 Conclusion

It was concluded that the use of a Scribe as a component of "Base" worked very well and that the lack of such position would detract from its ability to function effectively during an emergency associated with a working fire.

9.10.2 Recommendation

It is recommended that plans and/or procedures be amended so as to require that, when it has been established that there is a working fire, a person be assigned to record events on the white marker board or by using other recording methods and assist in handling message traffic on telephones.

9.11 Incident Commander Clarification

9.11.1 Conclusion

It was concluded that the fact that three qualified SERCs responded to the incident appeared to cause some confusion with respect to who was to discharge the duties and responsibilities of the Incident Commander.

9.11.2 Recommendation

It is recommended that to reduce the risk of confusion when more than one SERC responds to an incident, the procedures and flowcharts in the ERT Standard Operating Guidelines should be reviewed to ensure the terminology of Incident Commander is dominant, and that the Incident Commander must wear appropriate identification.

9.12 Incident Command

9.12.1 Conclusion

It was concluded that the attendance of the Incident Commander at the fire scene is recognized by all command systems as being an important element of information gathering necessary for the orientation of the Incident Commander. Where this evaluation exercise was concerned, the Incident Commander did not visit the scene in the early stages and therefore was forced to operate without valuable information.

9.12.2 Recommendation

It is recommended that the Incident Commander determine the extent of the fire by carrying out an orientation and size-up ("walk-by") as early in the incident as is reasonably possible.

9.13 Location of Command Post

9.13.1 Conclusion

It was concluded that the location of the Command Post, which was somewhat remote from the fire scene and inconvenient for off-site fire crew commanders to gain access to, was not conducive to effective incident command.

9.13.2 Recommendation

It is recommended that consideration be given by the Incident Commander to locate the command post in reasonable proximity to the incident to ensure visibility and accessibility to the ERT Captains and supporting agencies. It is further recommended that a suitable Mobile Command Post, that would include the appropriate equipment and materials, be provided for easy relocation to a suitable position adjacent to the incident. (See Appendix E for additional information)

9.14 Radiation Hazard Qualifications - Fire Crews

9.14.1 Conclusion

It was concluded that, while the Construction Fire Crew was the first to apply water to the simulated fire, they could not advance into the fire area due to the lack of "Orange Badge" or like qualifications on radiation hazards. It was further concluded that this detracted from their potential effectiveness.

9.14.2 Recommendation

It is recommended that both the members of the Clarington Fire Department who might be expected to be first responders to DNGS and the members of the Construction Fire Department be provided with training on radiation hazards sufficient so that each would attain and maintain an "Orange Badge" qualification level. If this cannot be achieved, increased integration of "green" qualified personnel into response procedures, at least until such time as the qualification of all ERT members to the "green" level has been completed, would be a reasonable alternative. It is further recommended that when all ERT members are qualified to "green" level the feasibility of fully integrating ERT and Clarington fire crews be explored with Clarington's Fire Chief.

9.15 Ventilation of the Fire Area

9.15.1 Conclusion

It was concluded that the failure to use the fire fighting operations procedure of ventilation to release products of combustion seriously restricted and delayed rescue and fire suppression activities. It was further concluded that responders at the fire scene did not recognize that the air exchange system was not operating and that this quite likely influenced their decision on ventilation.

9.15.2 Recommendation

It is recommended that, if the subject of ventilation practices is not included in the training program for ERT members, the program be expanded to include the advantages, considerations and methods for the ventilation of a structure with an interior fire.

9.16 Use of Personal Protective Clothing

9.16.1 Conclusion

It was concluded that the amount of time taken to don personal protective clothing and equipment was excessive and was of concern as was the failure of some crew members to do so. On the one hand this delayed the undertaking of rescue and fire suppression activities and on the other hand, unnecessarily exposed personnel to the adverse effects of a hostile environment.

9.16.2 Recommendation

It is recommended that response procedures be carefully assessed with the aim of identifying any steps in the process that are consuming more time than necessary and that, if this identifies areas with potential for improvement, such be implemented.

9.17 Hose Lines - Quantity, Capacity and Timeliness

9.17.1 Conclusion

It was concluded that four 38mm (1½") hose lines provided sufficient flexibility and flow rate to suppress fire in the fuels involved but that the time taken to put the lines in operation was excessive.

9.17.2 Recommendation

It is recommended that ERT practice hose laying evolutions to attain a level of efficiency that provides for hose lines to be put into service expeditiously but without requiring unwanted and unwarranted rushing about by crew members.

9.18 Spread of Contamination

9.18.1 Conclusion

It was concluded that the extending of hose lines through doors leading to a stair and doors leading to the east/west corridor prevented these doors from closing and allowed smoke and gases to spread and that this constituted avoidable contamination. It was further concluded that this was exacerbated by the failure to ventilate.

9.18.2 Recommendation

It is recommended that the need to prevent contaminants produced by fire from migrating to areas of a structure not involved in the fire be emphasized in fire crew training.

9.19 Exercise Scheduling

9.19.1 Conclusion

It was concluded that, based on the policies and practices that were in place regarding ERT staffing levels, the number on duty during daytime hours Monday through Friday was substantially greater than the number on duty during all other time periods. It was further concluded that it would be appropriate and of special interest to conduct a fire fighting and rescue evaluation exercise during a time period when ERT staffing would be at the lower level to assess what, if any, impact this would have on the effectiveness of the fire crews.

9.19.2 Recommendation

It is recommended that a future fire fighting exercise be scheduled for a time period when the lower staffing level would be in effect.

Appendix A

Ontario Hydro Scenario for 1993/1994 Fire Exercise at Darlington NGS

INITIAL NOTE:

This scenario requires several barriers to be impaired to meet the exercise objectives and to ensure an adequate challenge to the responders. The walls to the switchroom are approximately 14 inches of poured concrete with a large concrete pillar in front of the doors. It would be improbable that the forklift would accidentally through the doors to the switchroom. Also, the ceiling of the switchroom is sealed with firestops and the hatchways to the cable spreading room are substantial and normally closed and latched in position. This would significantly increase the available time to for mitigation of the fire.

The Stage:

A tractor trailer is backed up to the loading dock in S-150 (refer to attached drawing). Piles of bagged waste are in the 2 visible active waste sorting rooms (S-145 & S-147). M³ containers are stacked along the west wall of S-150. The S/M supervisor is in room S-152. Another person is on a forklift and is preparing to load the tractor trailer with containers of active waste.

Initiating Event:

The S/M person back the forklift under the edge of the tractor trailer catching the propane cylinder and ripping it open. The gas rapidly vapourizes and explodes initiating a major fireball and shockfront.

The driver of the forklift is killed and driven forward by the blast. His foot jams the accelerator and the forklift ricochets from the walls and into the switchroom doors to room S-138. The door partition is hit with sufficient force to drive it like a spear through Buss 121 causing an immediate ground fault.

The explosion bursts the windows and doors to the small office seriously injuring the S/M supervisor. Also, every combustible item in the immediate area is ignited. The explosion also takes out all wiring for the electrically operated overhead door.

The forklift comes to rest in the switchroom, S-138, and is burning (tires, upholstery, etc) filling the switchroom with heavy, acrid smoke and heat. This will burn for 20-30 minutes. If left unattended, other missiles will be produced (exploding shocks, etc.). The smoke detector in S-138 is activated.

Workers who had previously been working in the switchroom, left the ceiling hatches to the cable spreading room open. This allows heat and smoke from the burning forklift to rise into the cable spreading room and commence degradation of the cables. Smoke detectors in the spreading room activate.

The combustible material in S-150, S-145 and S-147 is burning. S-145 & S-147 sprinklers will activate within 10 minutes and control the fires in these rooms quickly. The major item burning in S-150 is the tractor trailer.

Control Room Scenario:

Control room staff feel the vibration of the explosion, receive annunciation for the trip of Bus 121 and within minutes, will receive annunciation from the smoke detection system.

Immediate consequence of the trip is the loss of ECI LP Pumps creating a Level 3 impairment of the safety system.

Within a few minutes, the smoke detector in the cable spreading room will activate. This will indicate potential risk for the balance of the ECI system which could lead to a Level 1 impairment of a safety system.

The control room will get an indication of the sprinkler system activating within approximately 10 minutes.

Contam. Casualty Scenario:

The S/M supervisor is seriously injured, but he is lying on the floor (minimizing impact of smoke inhalation and heat). His injuries are such that he can survive for about 1- 1 1/2 hours before succumbing to his injuries if not rescued.

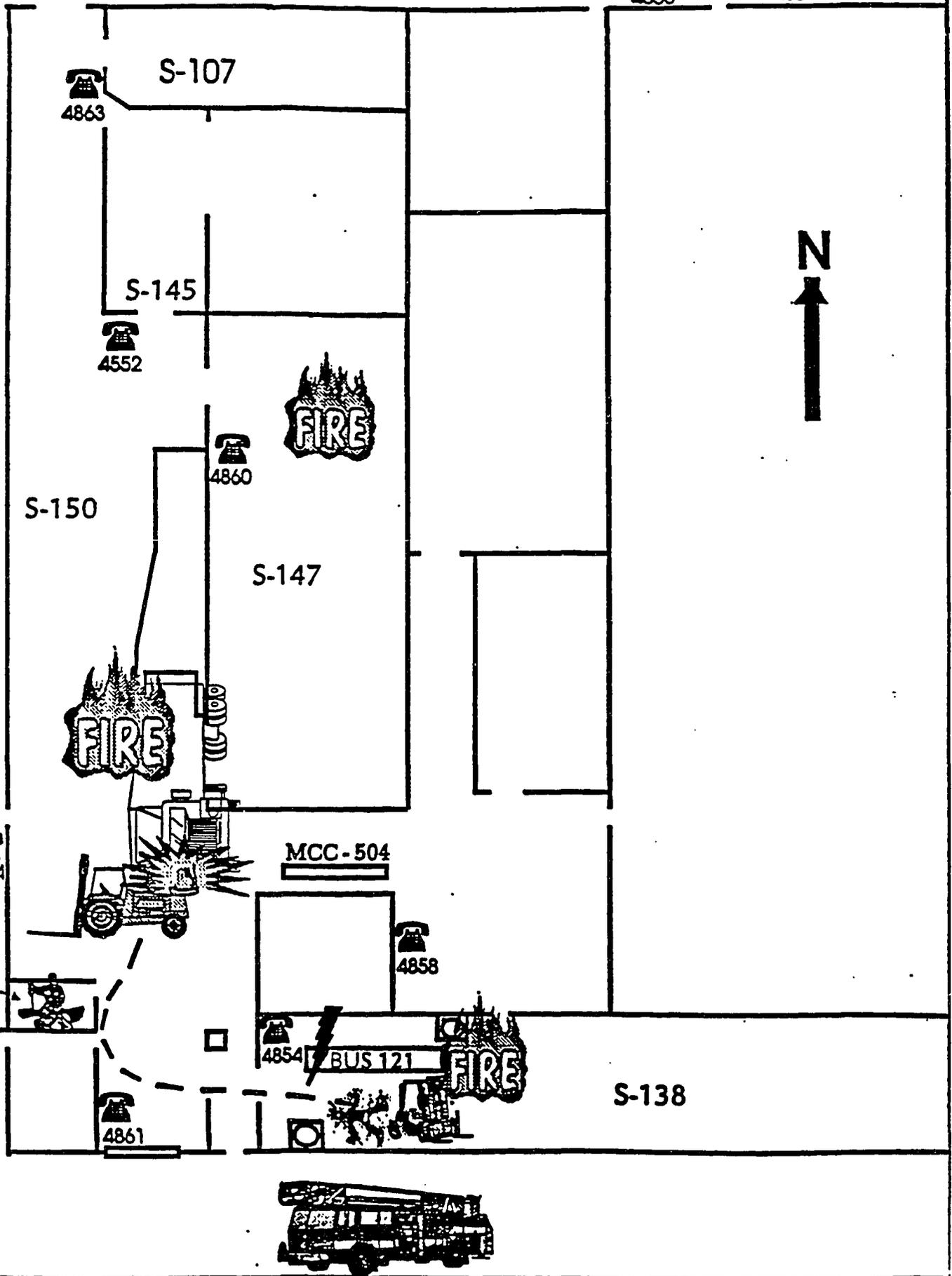
The forklift driver is dead. This will require implementing fatality procedures.

Scope:

The exercise will commence with the initiation of the scenario and continue through to the mitigation of the fire, the subsequent investigation and follow-up meeting. The medical portions of the scenario will be evaluated up to the ambulance leaving the site. The hospital portion of the exercise will be role played.

1993 Darlington Fire Exercise

100 Elevation - Unit 0



Appendix B

Definition of a Large Fire and Basic Requirements for the Exercise

Definition of a "Large Fire"

For the purposes of exercises and evaluations at NGS a "Large Fire" may be described as a fire involving sufficient combustible and/or flammable material so as to over-tax the initial response force. It should have the potential to extend to fuel not involved initially, pose a threat to personnel, cause casualties and be of sufficient severity to require the assistance of off-site fire fighting resources including, where appropriate, alerting members of any mutual aid plan that is in place in the area. In addition, it should require the notification of key persons in the Ontario Hydro and AECEB organizations and such others as may have similar need to know and to act.

Scenario for a "Large Fire" Exercise - Basic Requirements

Fundamentally the exercise scenario must reflect the provisions contained in the definition of a large fire. As well, there are a number of items that may not be obvious but that should be included to ensure the broadest possible evaluation of as many functions as possible. For example:

- a. first notification of fire should, at least from time to time, be through activation of a fire suppression system, fire detection system or a manual pull station; (Actions by persons in key positions in the early stages of a fire incident may be substantially different when an alarm is received on the fire alarm system than would be the case if there was voice communications via telephone.)
- b. something falling from above or say the explosion of a compressed gas cylinder can often be used to cause casualties;
- c. input cards or the like should be fully descriptive of the situation but should not in any way contain or imply a solution; and
- d. a special reception desk, staffed by an evaluator, should be set up to facilitate the completion of telephone calls, communications by FAX and the like to persons or agencies outside the confines of the NGS .

Appendix C

A Review of Darlington NGS Fire Safety Plan and ERT Standard Operating Guidelines

Part One - Overview

Introduction

This review was conducted to evaluate the scope and clarity of fire fighting plans and the suitability of fire fighting strategy prepared by Ontario Hydro for the Darlington Nuclear Generating Station. As a follow on to this, if any changes were found to be required and useful, a further aim was to develop appropriate recommendations to the AECB. What follows is therefore based on these precepts. The comments are arranged in three parts. Part one is an overview of the subject, part two is exclusive to the Fire Safety Plan while part three addresses the portion of the Conventional Emergency Manual that deals with ERT Standard Operating Guidelines.

General

Both documents were found to contain plans that were generally quite well considered. There was however one weakness of a fundamental nature that was cause for special concern. This was the policy of having the first responding fire fighting organization fight a fire until such time as it is established that control and extinguishment cannot be achieved, before calling back-up resources. Even at this point support was to be called out on an incremental basis. First the Construction Fire Department or the ERT depending upon the location of the fire and if this combined force was not successful, the Clarington Fire Department would then be called out. The delays inherent in this approach to assembling fire fighting resources could well result in very extensive fire losses that are potentially avoidable.

A matter that we found to be surprising, was that it appears that the Emergency Operations Centre (EOC) is not activated during a major fire. We had anticipated that it would and that the ERT Room would serve as the assembly, outfitting and dispatch centre for emergency responders but would not be involved with providing other operations support. At this point we are of the view that the most effective operations support and control would be that which could be provided by the EOC. Further, it might be expected that if a fire situation were to deteriorate to a certain undetermined point, the circumstances would force its activation. This would impose a change during an emergency operation that could cause some confusion. Activating the EOC as a matter of routine when an alarm of fire is raised, initially staffed by as little as one person, would set up a standard pattern for communications and for obtaining support of any nature that would apply in all circumstances.

There was also a number of areas in the plans that would benefit from adjustment. As well, there were some subjects that appeared to have been overlooked. Where the latter is concerned the following warrant attention. Specifically:

- a. special provisions for disabled persons;
- b. minimum acceptable duty strength for the ERT;
- c. notifying and obtaining advice from the Coroner in the event of a fatality; and
- d. notifying the Police as soon as it is established that there is a working fire.

(See proposed definition of "Working Fire" at part three)

Item a., at the very least, and perhaps item b. should be considered as mandatory requirements for the Fire Safety Plan. It would also be useful to have policy on items c. and d. included even though they may well be addressed in other documents. In assessing these matters, it does not seem unreasonable to take the view that fire fighting plans should have a stand alone capacity on matters relating to fire fighting.

Regarding item d. above, a policy statement on this subject could be combined with notification of back-up fire fighting resources in the Fire Safety Plan along the lines outlined below. Specifically:

Mandatory Notifications - Working Fire

When it is established that there is a "Working Fire" the Station Operator shall contact:

- a. the Construction Fire Department if the fire is in the operations areas and request assistance;
- b. the ERT if the fire is in the construction areas and request assistance;
- c. the Clarington Fire Department and request assistance; and
- d. the Police for information purposes.

Part Two - Fire Safety Plan

In this part we include comments on various items of the Fire Safety Plan. The reference numbers used refer to the item number being commented.

Reference 3.1.1-5 and 3.2

There appeared to be conflict between these two references in that the former directed persons to go to their designated assembly area while the latter directed persons to respond as the PA system instructs. This needs to be addressed.

Reference 3.1.2-1

When an alarm of fire is received automatically the Unit Zero operator is directed to acknowledge the alarm. It was not understood what actions would need to be taken to satisfy the instruction. This should be clarified.

Reference 3.1.2-1 and 3.1.2.2

The second sub-paragraph in both references required the Unit 0 Operator to - "Sound the fire tone and by PA Announcement warn personnel in the vicinity to keep clear of the area." This would seem to be an adequate means of alerting the ERT Crew and causing its members to respond. It also seems logical to assume that the ERT Crew, once on the scene, would as a matter of routine, provide situation reports as information of substance becomes known.

The third sub-paragraph in both references required the Unit 0 operator to - "Send the ERT Crew to investigate and report back". If, as this indicated, the ERT Crew does not respond until specifically directed to do so, it constitutes a delay that should be avoided. The fire tone and initial PA announcement should trigger a response by the ERT.

Reference 3.3.1-3

It is somewhat difficult to state in explicit terms what the concerns are with this reference. It tends to give the impression that fire responses are unnecessarily encumbered by bureaucratic procedures. Whether or not this is so in practice is another matter. In any case it would seem logical that fire fighting resources would be dispatched to the incident as soon as they become available. This, without any requirement for communication with the Shift Supervisor or feed-back from an advance party. A reassessment is therefore recommended.

Reference 3.3.1-7

The last sentence was out of context with the sentence that preceded it. As well, as written, it directed rather than requested the Senior Town Fire Officer to do a certain thing which may not be appropriate. Perhaps the sentence should be a stand alone item as 3.3.1.9 and be worded along the following lines - "When it appears that the fire suppression operations have been successfully concluded, the SERC shall request the Senior Town Fire Officer to confirm that the fire has been extinguished."

Note: If the above is adopted it could also be applied to the last item in reference 3.3.2 and fourth last item in reference 3.4.

Reference 3.3.2

Although the reference indicated that the ERT will assist the Construction Fire Crew when necessary, it did not indicate how the alerting was to be done or the form the response would take. A precise statement on this matter would seem in order.

Reference 4.0

This article required that regular fire drills be held to ensure staff are competent in this field and to check the viability of the Fire Safety Plan. In light of the fact that "regular drills" is somewhat vague in its meaning it might be more appropriate to state that - "drills will be held at intervals not exceeding".

Reference 4.3

The fourth item in this reference indicated that fire drills were to be conducted every three months in all buildings to which the provisions of sub-section 3.2.6. of the Building Code applies. This is quite in order, however for the convenience of those responsible for applying the Fire Safety Plan, a listing of the buildings to which this applies could be helpful.

Reference - Appendices D and E

Paragraph 4.0 of Appendix D indicated that the control room coordinates search and rescue activities. In Appendix E, paragraph 2.0-(a) designated the First Operator as being the Person/Group responsible for search and rescue activities. Paragraph 2.0-(b) stated that the ERT Person/Group shall locate and rescue missing persons. This would appear to be an overlap that could cause confusion during an emergency.

Generally speaking, search and rescue has not had benefit of a common approach in these plans. In addition to Appendices D and E, it was dealt with in the Fire Safety Plan in references 2.3.2 and 3.3.1 which applied chiefly, or perhaps exclusively, to the ERT. On the other hand, where the Construction Fire Crew is concerned neither references 2.3.3 nor 3.3.2, which dealt with matters quite similar to those addressed in references 2.3.2. and 3.3.1, provided any direction.

A comprehensive re-evaluation of the function should be undertaken.

Part Three - Conventional Emergency Manual (ERT Standard Operating Guidelines)

In this part we include comments on various items of the Conventional Emergency Manual. The reference numbers used refer to the item numbers being commented. The format of this part is intended to reflect the format of the above manual.

Reference 5.2

The acronym, or perhaps more properly the initials, ISC was used in this reference. The fire emergency response organization, as was given in the Fire Safety Plan, did not assign any role to ISC. For the purposes of these comments it was assumed that ISC was intended to identify the In-Station Coordinator, radio call sign ISAAC. In principle the same held true for the Off-Site Coordinator, radio call sign OSCAR. In light of the fact that both had been assigned dedicated radio call signs, it would be logical to describe the responsibilities of each in the Fire Safety Plan.

Reference 5.8.2, 5.8.5 and 5.9

In reference 5.8.2 and in reference 5.9 under definitions, the term "Loss Stopped" was defined as meaning - Fire is out. Later in reference 5.9, in the second box in the flow chart at page 5.59, it was stated that - when the fire is confirmed out by the SERC, the standard report term "FIRE OUT" is used. In reference 5.8.5-5. it was stated that - When the fire is extinguished the radio call "FIRE OUT" shall be made.

Since some damage can occur after combustion ceases from water, the elements and the like, it is suggested that "Fire Out" is the more accurate term. In any case, whatever term is chosen should be used consistently.

Reference 5.8.2 and 5.9

Fire related definitions were listed in both of these references. Neither were listed as definitions in the table of contents and both were well removed from the beginning of this document. There were no definitions in the Fire Safety Plan. To achieve the benefits that definitions can yield they need to be located at, or at least near, the beginning of a document. Where fire related definitions are concerned it is suggested that the most suitable location would be immediately after "Introduction" in the Fire Safety Plan and at the beginning of the Standard Operating Guidelines in this document. To avoid imposing a need to renumber subsequent portions of either document, numbering of this area could use zero as the first digit. (i.e. 0.1 INTRODUCTION, 0.2 DEFINITIONS)

The definitions that were given for the incipient fire phase and the smoldering fire phase omitted useful information. The steady state phase and a number of other important definitions were not included. As well, the definition that was listed for a working fire was incorrect. In this regard, it may well be that the definition was intended to describe the steady state phase. It needs to be recognized that the term "Working Fire" is not suitable for identifying a phase of fire but rather describes a situation that requires that certain actions be taken. It would be appropriate to use the term in the same context as LOCA is used. Accordingly, to provide more useful information to those with responsibility in this field, it is suggested that the definitions given in subsequent paragraphs be inserted in the manner outlined in the preceding paragraph. This, with the proviso that terms that have been defined and are not by this listing readdressed, be retained and relocated as outlined above.

0.2 DEFINITIONS

0.2.1 INCIPIENT PHASE

The incipient phase is the earliest phase of a fire beginning with the actual ignition. The fire is limited to the original materials of ignition. In the incipient phase, the oxygen content of the air has not been significantly reduced, and the fire is producing water vapour (H_2O), carbon dioxide (CO_2), perhaps a small quantity of sulphur dioxide (SO_2), carbon monoxide (CO), and other gases. Some heat is being generated, and the amount will increase as the fire progresses. The fire may be producing a flame temperature well above $537^\circ C$ ($1000^\circ F$), yet the temperature in the room at this stage may only be slightly increased.

0.2.2 STEADY-STATE BURNING PHASE

For the purposes of simplicity, the steady-state burning phase (sometimes referred to as the free-burning phase) can generally be considered the phase of the fire where sufficient oxygen and fuel are available for fire growth and open burning to a point where total involvement is possible. During the early portions of this phase, oxygen-rich air is drawn into the flame, as convection (the rise of heated gases) carries the heat to the uppermost regions of the confined area. The heated gases spread out laterally from the top downward, forcing the cooler air to seek lower levels, and eventually igniting all combustible materials in the upper levels of the room. This early portion of the steady-state burning phase is often called the flame spread phase. The presence of heated air is one of the reasons fire fighters are taught to keep low and to wear protective breathing equipment. At this point, the temperature in the upper regions can exceed $700^\circ C$ ($1300^\circ F$). One breath of this superheated air can sear the lungs.

Thermal columns will normally occur with rapid air movements upward from the base of the fire. As the fire progresses (in a confined space) through the latter portions of the steady-state burning phase, the fire continues to consume oxygen until it reaches the point where there is insufficient oxygen to react with the fuel. The fire is then reduced to the smoldering phase, but this fire needs only a fresh supply of oxygen to burn rapidly.

0.2.3 HOT-SMOLDERING PHASE

After the steady-state burning phase, flames may cease to exist if the area of confinement is sufficiently airtight. In this instance, burning is reduced to glowing embers. As the flames die down, the room becomes completely filled with dense smoke and gases. Air pressure from gases being given off may build to the extent that smoke and gases are forced through small cracks. Room temperatures in excess of $537^\circ C$ ($1000^\circ F$) are possible. The intense heat will have liberated the lighter fuel fractions, such as methane, from the combustible material in the room. These fuel gases will be added to those produced by the fire and will further increase the hazard to the firefighter and create the possibility of a backdraft if air is improperly introduced into the room. If air is not introduced into the room, the fire will eventually burn out, leaving totally incinerated contents.

0.2.4 BACKDRAFT

In the hot-smoldering phase of a fire, burning is incomplete because of insufficient oxygen to sustain the fire. However, the heat from the steady-state burning phase remains, and the unburned carbon particles and other flammable products of combustion are available for instantaneous combustion when more oxygen is supplied. Improper ventilation, such as opening a door or breaking a window, supplies the dangerous missing link, oxygen. As soon as the needed oxygen rushes in, the stalled combustion resumes; it can be devastating in its speed, truly qualifying as an explosion. Backdraft can be the most hazardous condition a firefighter will ever face.

The following characteristics may indicate the potential for a backdraft to occur:

- Pressurized smoke exiting small openings
- Black smoke becoming dense grey yellow
- Little or no visible flame
- Smoke leaving the building in puffs or at intervals
- Smoke-stained windows
- Muffled sounds
- Sudden rapid movement of air inward when opening is made

This situation can be made less dangerous by proper ventilation. If the room or building is opened at the highest point involved, the heated smoke and gases will be released, reducing the possibility of an explosion.

0.2.5 ROLLOVER

Rollover, sometimes referred to as flameover, takes place when unburned gases released during the incipient phase or early steady-state phase accumulate at the ceiling level. These superheated gases are pushed, under pressure, away from the fire area and into uninvolved areas where they mix with oxygen. When their flammable range is reached, they ignite and a fire front develops, expanding very rapidly and rolling over the ceiling. Rollover differs from flashover in that only the gases are burning and not the contents of the room. The rollover will cease when the main body of the fire is extinguished or reduced in intensity to the point where it does not produce sufficient flammable gases to feed the rollover.

0.2.6 FLASHOVER

Flashover occurs when flames flash over the entire surface of a room or area. The actual cause of flashover is attributed to the build-up of heat from the fire itself. As the fire continues to burn, all the contents of the fire area are gradually heated to their ignition temperatures. When they reach their ignition point, simultaneous ignition occurs, and the area becomes fully involved in fire. The actual ignition is almost instantaneous and can be quite dramatic. A flashover can usually be avoided by directing water toward the ceiling level and the room contents to cool the materials below their ignition temperatures.

0.2.7 WORKING FIRE

A working fire is any fire that cannot be extinguished by the occupants using portable fire extinguishers and therefore requires intervention by a fire department or other organized fire fighting force.

0.2.8 PRIMARY SEARCH

Note: Text to be developed by Ontario Hydro.

0.2.9 SECONDARY SEARCH

Note: Text to be developed by Ontario Hydro.

Reference 5.8.4

In the interests of clarity it is suggested that the next to last sentence be adjusted to read as follows: "When the search is complete and no victims are found the message - All Clear - shall be transmitted via radio by to.....".

Reference 5.8.5

It is suggested that paragraph 5 be expanded to indicate who is responsible for transmitting the "Fire Out" message and to whom it is to be directed.

The assumption made in the first box of the flow chart that presented the view that the Construction Fire Department and the Newcastle/Clarington Fire Department would have been called at this point (before fire fighting operations start) is of doubtful validity. This is so since the policy given in the Fire Safety Plan at reference 3.3 indicates that the ERT would first attempt to extinguish the fire if it were in the operations areas and if assistance was found to be needed would call the Construction Fire Department. (The reverse would apply for fires in the construction areas). If this combined force was also unsuccessful the Newcastle/Clarington Fire Department would then be called.

Appendix D

Clarington Fire Department

The Municipality of Clarington provides fire protection services to the Darlington Nuclear Generating Station. In addition to response to the site for emergencies, there is an ongoing relationship through the provisions of the Ontario Fire Code. There exists a Fire Safety Plan, revised on May 28, 1993, and jointly approved by Darlington NGS and the Clarington Fire Department.

The Clarington Fire Department consisted of 23 full time personnel. The department was managed by a Chief and a Deputy Chief and there were 16 fire fighters, 4 dispatchers, and 1 fire prevention officer. In addition, there were approximately 120 volunteer fire fighters.

The Department was responsible for servicing an area of 236 square miles, with a population of 51,000. Fire Stations 2, 3, and 5 were serviced solely by volunteer fire fighters, as were Fire Stations 1 and 4 during the evening hours. There was a Fire Captain and 3 fire fighters on duty at both stations 1 and 4 between the hours of 0600 and 1800, seven days a week.

In October, 1994 a new Fire Station #1 and Fire Headquarters, located at #2 Highway and Waverly Road (#57 Highway), should be operational and will replace the existing one. The manning of this station with a Captain and 3 fire fighters on a 24 hour basis will be accomplished with the employment of 8 additional paid fire fighters. #4 Fire Station would be manned at the same level as currently exists.

Location of Stations

The fire stations designated "first responders" to Darlington NGS were located as follows:

- a. Station #4 was located on Trulls Road (Courtice Road area) some 8.7 kilometres from DNGS; and
- b. Station #1 was located near Liberty Street and #2 Highway some 8.5 kilometres from DNGS. Station #1 will be relocated to #2 Highway and Waverly Road in October, 1994, some 7 kilometres from DNGS.

Response Times

Response time to Darlington NGS via Holt Road Access was calculated to be as follows:

- a. Station #4 was calculated to be 9.7 minutes during the hours of 0600 and 1800 and an additional 5 minutes during evening times; and
- b. Station #1 was calculated to be 9.5 minutes during the hours of 0600 and 1800 and an additional 5 minutes during evening times. New Station #1, scheduled for opening in October 1994, was calculated to be 8.0 minutes on a 24 hour basis.

Mutual Aid

Clarington Fire Department was a member of the Durham Region mutual fire aid system which had been organized and which was operating on a reciprocal, no charge basis, among the eight participating Fire Departments. Formal agreements are in place between the participating municipalities authorizing the Fire Departments to provide aid when required. The method of alerting and activating the plan was via telephone or radio to the Oshawa Fire Department communications centre. It was noted that there were two radio frequencies to which the departments have common access: a Durham Regional frequency and an Ontario Fire Marshal frequency. The closest mutual aid partner of Clarington, in the event that assistance was required at Darlington NGS, would be the Oshawa Fire Department. In summary, the importance of an efficient and adequate mutual aid system must be considered to be an essential part of the overall protection services of the Clarington Fire Department.

Communications

The communications methods that were being used to report and process fire alarms and in the conduct of fire fighting operations included:

- a. two way radio with the base station located at #1 Fire Station;
- b. the 911 Emergency Telephone Reporting System and other telephones; and
- c. pagers and telephones to alert volunteer fire fighters.

The main operational frequency of the Clarington Fire Department was 153.125 MHZ. In addition, a Regional and a Ontario Fire Marshal frequency was available at the base station radio, vehicle mounted radios and hand-held portable radios. It is worthy of note that there was no compatibility of radio frequencies between the Clarington Fire Department and Darlington NGS radio systems.

The area was serviced by the 911 Emergency Telephone Reporting System and there were two telephone lines from 911 to the base station in #1 Fire Station. There were also three regular emergency reporting telephone lines retained from the old system.

Training

Regular training programs are conducted at each fire station location because there was no special facility provided and because of the size and diversity of the area to be serviced. Individual members attend and qualify at various levels at the Ontario Fire College at Gravenhurst, Ontario. Regional fire training schools are held, from time to time, on specialized programs such as hazardous materials, auto extrication, etc.. Training facilities of their mutual aid partners are utilized when available, and some cross training with Ontario Hydro had been conducted.

Appendix E

Mobile Command Post : Concepts & Components

Concepts

There are a number of concepts that may be considered when planning the Command Post function in support of fire fighting and rescue operations. For the purposes of this paper it is proposed that there are three concepts that could have useful application for an NGS. Concept I is to have a single primary location, such as the ERT Base Room, that would be used on all occasions except when specifically precluded by circumstances. This could be augmented by having one alternate location. Concept II is based on having a mobile Command Post with its location to be chosen spontaneously to satisfy the demands of any given emergency situation. Concept III is to some degree a combination of the other two. Specifically, it requires the pre-selection of a number of locations that would be suitable to serve as Command Post depending upon the location of the incident. The resources for the support of this concept could be assembled and maintained as if for Concept II.

Concept III may well offer the most advantages in that it could provide adequate flexibility as well as an opportunity for the matter to be studied in advance of an incident and to be included in fire plans. As well, it would offer a unique opportunity to interact with the Clarington Fire Department by arranging for their participation in the selection process. If this concept is pursued each location could be given a phonetic designation that would of course be known to all concerned, most particularly ERT and Clarington Fire Department. For example the selected locations, at least one of which should be external to the plant, could be designated as Alpha, Bravo, Charlie, Delta, Echo and so on. Information on the location of the Command Post could then be passed to Clarington during their response by a concise radio message. Again for example, the radio message could be - "Command Post location is Delta".

Group A Components

Without attempting to be all inclusive, typical components for a mobile Command Post includes:

- a. stationery;
- b. fire related plans and procedures;
- c. communications equipment;
- d. nominal roll and phone/pager numbers of ERT members;
- e. a listing of important telephone/pager numbers;
- f. pertinent information on systems within the complex;
- g. check list (s) for Incident Commander and others as appropriate; and
- h. other items that experience may show are needed.

Group B Components

In order to give the package a greater capacity to function with reduced reliance on in place resources, group A components could be augmented by the following:

- a. wheeled cart;
- b. stowage for group A components;
- c. folding table(s);
- d. folding chairs;
- e. folding marker board; and
- f. other items that experience may show are needed.