Chapter 7

Use of Computers in Emergency Preparedness and Emergency Handling:

7.1 Introduction:

Every industry is designed to provide safe and satisfactory working environment. In nuclear industry from design to operation stage utmost care is taken to see that all operations are safe. But, despite the best efforts and optimum design accidents can take place. Accidents normally take place due to failure of components or human errors. Thus an industry has to be geared to meet an accident or emergency situation. In meeting this type of situation there is a difference between the conventional industry and the nuclear industry. In case of conventional industry normally the effects of accident are localised, though there are glaring exceptions like Bhopal tragedy in India (1984) whose off-site consequences were disastrous. In case of nuclear industry where the end result of an accident may be release of radioactivity in the environment, chances of off-site consequences are significant. Thus as a part of emergency preparedness one has to always think of both on-site and off-site radiological and environmental consequences.

The possibility of accidents is minimised by system of safety devices that gives 'defence in depth' and so restrict the damage due to an accident that may occur. The three well-known accidents which have taken place in nuclear industry are at (i) Windscale, U. K., (1957), (ii) Three Mile Island (TMI),
U.S.A. (1979) and (iii) Chernobyl, U.S.S.R. (1986). Of these accidents the one at Chernobyl was of a very severe nature because of its off-site radiological consequences. Except these 3 major accidents and few minor accidents nuclear industry has excellent record of safety during its history spanning over nearly 5 decades. Accidents may occur in other areas also where radioactive sources are handled. The Goiania accident at Brazil (1987) is a classic case of this type. Briefly described below are the 3 major nuclear accidents, their causes and the after effects.

7.2 Windscale Fire:

The Windscale (Sellafield) reactor was a simple type of reactor, whose main aim was the production of the weapon grade material. It was using natural uranium canned in aluminium as fuel and graphite was used as moderator. Cooling was achieved by passing air over the fuel on a once through basis. The accident occurred during the routine controlled release of stored Wigner energy from the graphite of one of the piles. At the time of accident aluminium cladding in many of the fuel cartridges had given way and fission products were released into the cooling channels. Though large amount of radioactivity was retained on the filters still there was a release of activity in environment through the stack. The most important radiologically significant elements released were $^{131}\text{I}$ and $^{137}\text{Cs}$. Iodine (half life 8 days) chiefly irradiates the thyroid and cesium (life 30 years) causes prolonged contamination of country side and buildings. $^{137}\text{Cs}$ irradiates the whole body when ingested or inhaled, and via
external radiation [Tyror-1989].

It is important to note that there was no rapid catastrophic failures associated with this incident since it developed over a period of days. It did not give rise to any seriously high doses or any deterministic effects. Also there was no public exposure of serious nature.

7.3 *Three Mile Island*:

The pressurised water reactor of 900 MW(e) situated at TMI, Pennsylvania U.S.A. suffered a serious accident on 28th March 1979. The accident at TMI can be considered as a combined effect of equipment malfunction, some design defects and operator error. The initial accident sequence which occurred in a period of minutes is as follows:

A feed water pump trip led to an absence of effective heat sink which led to rise in the primary system pressure. After about 15 minutes a pressure release valve opened (correctly but failed to close properly when the coolant pressure dropped). This failure was not noticed by the operators for nearly 2 hours as a result of which large quantity of activity was discharged into the containment sump. Since the sump pumps were running at this time, some of the water was transferred to the auxiliary building outside the containment building. Faulty decision made during the water loss resulted in about half the fuel lacking the coolant. This gave rise to substantial fuel damage and release of fission products into the containment building. The gratifying fact was that despite a considerable release of radioactivity from the damaged fuel no significant exposure was
suffered by the members of public. There was however, considerable anxiety regarding whether containment would hold. However, it proved to be effective. In spite of the fact that there was swift and catastrophic failure of the core, it did not give rise to any casualty at the site. Radiation doses received by the workers did not give rise to any deterministic effects. It can be stated that although the TMI accident was very serious from the viewpoint of damage to the reactor, the health consequences which arose due to it were relatively trivial.

7.4 Chernobyl :-

On 26th April 1986 at 0123 hours, what should perhaps be the worst accident in the history of commercial Nuclear power programme occurred at Chernobyl, Soviet Russia. The plant involved was a 1000 MW(e) reactor of the RBMK type which is peculiar to the U.S.S.R. The brief details of the accident are as follows:

The accident occurred during a test being carried out on a turbo generator at the time of a normal scheduled shutdown of the reactor. It was intended to ascertain the ability of the turbo generator to supply electrical energy during station blackout i.e. the short period of time until stand by diesel generator could supply emergency power. Written test procedures that were unsatisfactory and serious violation of basic operating rules placed the reactor at low power in cooling conditions, which could not be stabilised by manual control. Subsequent events led to the generation of steam voids which introduced positive reactivity and resulted in an increasingly rapid rise of power.
Attempts were made to stop the chain reaction but a rapid shutdown was not possible because the operators, deliberately and in violation of rules, withdrew most control rods from the core and switched off some important safety systems [IAEA-1986, IAEA-1988]. Reactor power went up to 480 times the rated power resulting in two explosions in quick successions. The rapid energy release ruptured the fuel, causing an explosion of sufficient energy to disrupt the 1000 tonne reactor cover plate. This was followed by the second explosion after 2-3 seconds which resulted in hot pieces of the reactor core and the fuel being ejected from the building causing fire in the surrounding areas. The damage to the reactor permitted the influx of air, which then caused graphite to burn. This fire raged unabated for five days before being quenched. Large amounts of radioactive materials released were carried in the form of gases and dust particles by air currents contaminating the land around the station and were widely dispersed over the territory of Soviet union, over many other (mostly European) countries and in traces over the entire Northern hemisphere. The total activity released was estimated to be approximately 70 MCI (megacuries) excluding noble gases. Radioactive releases from the plant continued for several days and were not stopped until 10th May 1986. Due to release of activity in the surrounding areas of power station, approximately 1,35,000 people were evacuated and shifted to farther areas from the accident place.

203 persons were found to have acute radiation syndrome. These cases were confined to firemen and plant workers and there
was none amongst the general public. Two deaths were reported to have occurred immediately following the accident. A further 29 fatalities were subsequently reported from the persons who had suffered from acute radiation syndrome [Tyror-1989].

The material cost of control, resettlement and decontamination have been enormous [UNSCEAR-1988]. Some of the people who dealt with emergency lost their lives. The accident brought forth the deficiencies in RBMK reactor design and operation procedures. The accident would also provide valuable information for medical and other emergency services. Experience in the treatment of acute radiation syndrome and of beta radiation skin burns has been greatly increased. On a wider scale Chernobyl also introduced the world to the actual nuclear trans-frontier pollution.

7.5 **Nuclear Event Scale to Estimate the Magnitude of an Accident**

The effect of a nuclear accident will greatly depend upon its magnitude. It can be a minor accident in which there is a release of activity in the surrounding area in the plant to a very major one which may have very serious off site and on site environmental and health effects. As mentioned above all nuclear installations follow a defence in depth approach. Violation of certain plant conditions may cause loss of defence in depth provision, which may lead to a serious accident. On site impact of an accident normally may result in very high exposures of the plant staff, severe damage of plant equipment and in some cases severe core damage. While off site impact of it may be the release of activity in the environment which may cause exposure
of members of public. Offsite impact also includes contamination of a large area in the vicinity of the plant whose effect on the population will be felt for long time. After studying a large number of accidents from those which were not of very serious nature to few major accidents which have taken place, IAEA has proposed the international nuclear event scale for promptly communicating to the public in consistent terms the safety significance of events reported at nuclear power plants [IAEA-1990]. By putting events into proper perspective, the Scale can facilitate a common understanding between the nuclear community, the media, and the public. These events are classified as i) Accidents, ii) Incidents and iii) Events of no safety significance and illustrated in Tables 7.1 and 7.2. Tables also include all the major nuclear accidents of the past which are classified as per their magnitude.

7.6 Objectives of Environmental Monitoring System

The three important accidents and the nuclear event scale are described above to give an idea about the consequences of a nuclear accident. To prevent an accident and to control its after effects if it has already taken place, great amount of planning, preparation and implementation efforts in the form of training, instruments (mostly automated) and decision making are required. Continuation of favourable nuclear safety records depend upon strict adherence to standards and regulations. This goal can be achieved by combining both human efforts and better quality of instrumentation support. For making the planning for purpose of emergency management nuclear sites are faced with a number of
<table>
<thead>
<tr>
<th>LEVEL</th>
<th>DESCRIPTOR</th>
<th>CRITERIA</th>
<th>EXAMPLES</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ACCIDENTS</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td><strong>MAJOR ACCIDENT</strong></td>
<td>* External release of a large fraction of the reactor core inventory typically involving a mixture of short and long-lived radioactive fission products (in quantities radiologically equivalent to more than tens of thousands terabecquerel of iodine-131). Possibility of acute health effects. Delayed health effects over a wide area, possibly involving more than one country. Long-term environmental consequences.</td>
<td>Chornobyl, USSR 1986</td>
</tr>
<tr>
<td>6</td>
<td><strong>SERIOUS ACCIDENT</strong></td>
<td>* External release of fission products (in quantities radiologically equivalent to the order of thousands to tens of thousands of terabecquerel of iodine-131). Full implementation of local emergency plans most likely needed to limit serious health effects.</td>
<td>Windscale, UK 1957; Three Mile Island, USA, 1979</td>
</tr>
<tr>
<td>5</td>
<td><strong>ACCIDENT WITH OFF-SITE RISKS</strong></td>
<td>* External release of fission products (in quantities radiologically equivalent to the order of hundreds to thousands of terabecquerel of iodine-131). Partial implementation of emergency plans (e.g., local sheltering and/or evacuation) required in some cases to lessen the likelihood of health effects. * Severe damage to large fraction of the core due to mechanical effects and/or melting.</td>
<td>Three Mile Island, USA, 1979; Windscale, UK 1957</td>
</tr>
<tr>
<td>4</td>
<td><strong>ACCIDENT MAINLY IN INSTALLATION</strong></td>
<td>* External release of radioactivity resulting in a dose to the most exposed individual off-site of the order of a few millisieverts. * Need for off-site protective actions generally unlikely except possibly for local food control. * Some damage to reactor core due to mechanical effects and/or melting. * Worker doses that can lead to acute health effects (of the order of 1 Sievert).**</td>
<td>Saint-Laurent, France, 1980; Three Mile Island, USA, 1979; Windscale, UK 1957</td>
</tr>
<tr>
<td><strong>INCIDENTS</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td><strong>SERIOUS INCIDENT</strong></td>
<td>* External release of radioactivity above authorized limits, resulting in a dose to the most exposed individual off-site of the order of tenths of a millisievert. * Off-site protective measures not needed. * High radiation levels and/or contamination on-site due to equipment failures or operational incidents. Overexposure of workers (individual doses exceeding 50 milleister).**</td>
<td>Vendellos, Spain 1989; Saint-Laurent, France, 1980</td>
</tr>
<tr>
<td>2</td>
<td><strong>INCIDENT</strong></td>
<td>* Technical incidents or anomalies which, although not directly or immediately affecting plant safety, are liable to lead to subsequent re-evaluation of safety provisions.</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td><strong>ANOMALY</strong></td>
<td>* Functional or operational anomalies which do not pose a risk but which indicate a lack of safety provisions. This may be due to equipment failure, human error or procedural inadequacies (such anomalies should be distinguished from situations where operational limits and condition are not exceeded and which are properly managed in accordance with adequate procedures. These are typically “below scale”.)</td>
<td></td>
</tr>
</tbody>
</table>

**The doses are expressed in terms of effective dose equivalent (whole body dose). Those criteria where appropriate also can be expressed in terms of corresponding annual effluent discharge limits authorized by National authorities.**

**These doses are also expressed, for simplicity, in terms of effective dose equivalents (sieverts), although the dose in the range involving acute health effects should be expressed in terms of absorbed dose (grays).**

**Table 7.1 The International Nuclear Event Scale for prompt communication of safety significance**
<table>
<thead>
<tr>
<th>LEVEL/DESCRIPTOR</th>
<th>OFF-SITE IMPACT</th>
<th>ON-SITE IMPACT</th>
<th>DEFENCE-IN-DEPTH DEGRADATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>7 MAJOR ACCIDENT</td>
<td>MAJOR RELEASE: WIDESPREAD HEALTH AND ENVIRONMENTAL EFFECTS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6 SERIOUS ACCIDENT</td>
<td>SIGNIFICANT RELEASE: FULL IMPLEMENTATION OF LOCAL EMERGENCY PLANS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5 ACCIDENT WITH OFF-SITE RISKS</td>
<td>LIMITED RELEASE: PARTIAL IMPLEMENTATION OF LOCAL EMERGENCY PLANS</td>
<td></td>
<td>SEVERE CORE DAMAGE</td>
</tr>
<tr>
<td>4 ACCIDENT MAINLY IN INSTALLATION</td>
<td>MINOR RELEASE: PUBLIC EXPOSURE OF THE ORDER OF PREScribed LIMITS</td>
<td>PARTIAL CORE DAMAGE</td>
<td>ACUTE HEALTH EFFECTS TO WORKERS</td>
</tr>
<tr>
<td>3 SERIOUS INCIDENT</td>
<td>VERY SMALL RELEASE: PUBLIC EXPOSURE AT A FRACTION OF PREScribed LIMITS</td>
<td>MAJOR CONTAMINATION</td>
<td>NEAR ACCIDENT - LOSS OF DEFENCE-IN-DEPTH PROVISIONS</td>
</tr>
<tr>
<td>2 INCIDENT</td>
<td></td>
<td>INCIDENTS WITH POTENTIAL SAFETY CONSEQUENCES</td>
<td></td>
</tr>
<tr>
<td>1 ANOMALY</td>
<td></td>
<td>DEVIATIONS FROM AUTHORIZED FUNCTIONAL DOMAINS</td>
<td></td>
</tr>
<tr>
<td>0 BELOW SCALE</td>
<td></td>
<td></td>
<td>NO SAFETY SIGNIFICANCE</td>
</tr>
</tbody>
</table>

Table 7.2

Underlying logic of the scale
(Criteria given in matrix are broad indicators only)
questions such as [Dickerson et al-1976]:

(i) To access the health hazards to the operating staff and public at large in case of an accident.

(ii) How fast and to what extent will a release of hazardous materials diffuse under a particular set of circumstances and weather conditions?

(iii) What predictive information can be derived to permit adequate decisions in an emergency?

(iv) How can routine releases of toxic emissions be planned so as to minimize potential impact on the surrounding environment?

Atmospheric Release Advisory Capabilities (ARAC) is a concept developed in U.S.A. [Dickerson et al-1976, Dickerson et al-1980] to meet the above objectives. The prime objective of any such concept is to provide information and early warning in real time to the site officials about normal or emergency releases from the plant. For this the current requirements and techniques for monitoring and sampling of radioactivity in the environment of a nuclear facility are discussed in the subsequent Sections.

A computer based environmental monitoring system around a nuclear power plant is described by Abani et al [1988] which is able to monitor releases from the plant both in normal and accident conditions. This concept is based on having a central computer unit and large number of satellite units located around the plant which can interact with the main unit in real time.
mode. Block diagram of such a system is given in Fig. 7.1. Computer modelling techniques can help considerably in visualising the emergency scenario and also provide good guidelines for corrective action. Various types of systems and computer codes used for this purpose are discussed later on.

7.7 Environmental Monitoring System and Telemetering of Data:

**Ring Monitoring System and its use in Normal and Emergency Periods:**

In every country where a nuclear facility exists, its regulatory body will specify the guidelines for monitoring of radioactive releases from the nuclear plants. These recommendations broadly envisage a ring of remote monitoring stations within a radius of 10 km distance circle area, which can monitor the dose rate in the environment on continuous basis [Maushart-1986, Deme et al-1987]. This arrangement is normally called 'ring monitors' because the monitors surround the plant like a ring. Their actual locations shall depend upon main wind direction and population density. They are installed in such a way that if there is release from the plant, it is going to cross at least one of these monitors. It is highly desirable that gamma dose rates at these stations are measured and communicated to the central computers in real time, in order to enable the authorities to recognise automatically and instantly any significant release from a plant. Such high demand can only be met by the extensive use of advanced microcomputers and big computer systems. Nuclear systems are particularly acceptable to the microprocessor technology since these systems tend to remain
FIG. 7: BLOCK DIAGRAM OF A COMPUTER AIDED EMERGENCY RESPONSE SYSTEM (Ring monitors). Sub systems No. 1 to 8 are environmental monitoring systems.
isolated or stand alone for purpose of reliability and redundancy. Microprocessors offer the capability of automatic data acquisition and digital processing of data at reasonable cost while maintaining a modular and distributed approach [Einolf et al-1979].

The proposed emergency management system should achieve following objectives viz.,

(i) monitoring of radioactive releases from the plant,
(ii) early warning of an accident and
(iii) management of emergency if it has actually occurred.

The ring monitoring stations are of great use even in normal plant operation as they will continue to indicate that the releases are within the controlled limits. To get an early warning about the abnormal release from the plant, ring monitors will be of great help. It is important to note that in case an accident occurs, there is no stack emission but the radioactive materials are released into the atmosphere due to leakage of the hermetically sealed system. Since release is not from the normal routes of the plant, it may be missed by the monitors installed at various vantage points in the plant. In such a case, to start with, the amount of radionuclides emitted to the environment are unknown. If the release follows the direction of any of the remote monitors installed, it will be detected and central emergency system will be immediately alerted, which can start the follow-up action. With the use of good colour graphic displays in
case of emergency, it can give a good assessment of the plant releases and dose levels in the region. One such system used at nuclear power plant at PAKS in Hungary is described by Deme et al [1986], Kanyar et al [1986] and Deme et al [1987]. In a low level release they can be very useful in determining the direction and order of magnitude of release. A good monitoring system would have saved a lot of grief at TMI [Cline-1983]. At the time of Chernobyl accident the monitors installed in Sweden first detected an unusually high radioactivity. After calculating the activity levels and the trajectory it first announced that a nuclear accident has taken place in Soviet Russia.

Each of the units in the ring monitoring system is expected to have its own radiation measuring unit and data acquisition system. Radiation monitoring unit may be based on ionisation chamber type detector, G.M. counter or a NaI(Tl) based system [Cline-1983]. Many commercial suppliers offer these types of detector systems. Each reports an energy response that is relatively flat from 80 keV to 2000 keV. This assures an accurate dose measurement. This measuring unit is provided with its own intelligence by connecting it on-line to a computer locally. The computer is basically used for handling of measurements, sequencing of events, converting count rates to dose rates, storing of the results and it also provides a real time link to the central computer. A standard IBM PC/XT, details of which have been given in chapter-1 can be easily used for this purpose. System should have battery back-up so that in case of mains failure it can retain the important data. Block diagram of a
A typical environmental monitoring unit (also called remote monitoring unit) is given in Fig. 7.2. This local computer system works as a remote terminal to the main computer whenever it has to communicate with the central computer. In case of failure of main computer or failure of communication link, it will continue to work as stand alone computer and does storage and processing of the data which is generated locally.

We are in the process of installing ring monitors around the Tarapur environment. These proposed ring monitors will have a simple G.M. counter to monitor the activity of the surrounding area and store the data on the PC attached to them. From PC, via a VHF telemetry link, it will transfer data to the main system. These remote monitors will be unmanned normally and work on round the clock basis. Main system where the emergency controller is present all the 24 hours will store and process these data. In case of activity levels above the preassigned values, computer will draw attention of the controller by visual as well as audible alarm.

For dose measurement purpose, standard averaging time is 1 hr. In case of background increasing above a certain level, averaging time can be reduced to 10 min. In normal operation, once in 24 hours, the data is downloaded on the main computer for permanent storage [Maushart-1986]. At any time, last 72 hours values are available in the memory. They can be called by the main computer whenever needed.

7.8 Meteorological Data Acquisition System:

Both in case of normal and accidental releases from a
FIG. 7.2. BLOCK DIAGRAM OF AN ENVIRONMENTAL MONITORING SYSTEM
nuclear plant, exposure to public and its effect on the environment will greatly depend upon the meteorological conditions of the site at the time of release. Thus meteorological data is the most vital information needed in such situations. In case of an accident this information greatly helps in tracking the plume which in turn helps in locating the areas and the population groups most likely to be affected. For this purpose meteorological data are continuously monitored and recorded. The sensors for measuring meteorological parameters are fixed on a meteorological tower at various heights. Typical measurement comprises [Lattanzi-1987]:

- temperature gradient,
- time averages of wind speed and direction (typically over 15 minutes),
- rainfall and the associated rate,
- atmospheric humidity and pressure,
- solar radiation.

Wind speed and solar radiation are the important parameters to automatically evaluate stability class [Pasquill's weather category] as an input to the isodose plotting program.

The data obtained from these sensors are being processed on line by the PC which gives output every 15 minutes. This data can be transferred by the PC directly to the main computer or any of the environmental monitoring sub-stations on request. The PC and the computer will hold codes for dose distribution calculations and using this data they can generate iso-dose curves. Such a system developed at Trombay is described in by Abani et al.
This facility of collecting meteorological data was already existing at Tarapur and is now connected on-line to our central computer.

7.9 Central Computer System for Emergency Management:

The concept that is being developed is to connect the various sub-systems described above to a central computer. In this scheme all the remote terminals which are part of the environmental monitoring units at the various plant sites are hooked to the main computer by the use of communication lines. The communication lines use line drivers or MODEMs so that signal can be transmitted to long distances. Communication is either by means of leased lines or a telephone network. The lines for shorter distances can be connected by the use of line drivers and for longer distances MODEMs can be used. Use of telephone cables is not a very reliable method, but it is easy to use. A VHF link also can be used for data communication. Microprocessor based systems using VHF (radio link) offer many advantages. One important advantage is that they can be easily shifted from one place to another. One such system is described by Sharma et al. [1987]. The plant radiological status data are fed to the main computer using these lines. Thus a concept of a central emergency monitoring station is evolved, which in real time is connected to the various plants on the site, meteorological laboratory, environmental survey laboratory and remote monitoring stations specially put for measurement of radioactivity released due to planned or accidental releases.
The emergency co-ordination centre system has the following tasks:

(i) To receive on-site radiological and meteorological data on regular intervals and do instant processing of this data to assess the environmental radiological status. [Lattanzi-1987].

(ii) To update the main database.

(iii) To evaluate the radiological impact on the environment due to data received in past 1 hour. It predicts the radiological situation and the expected impact on the population and environment due to radioactivity release by means of a simple transport and diffusion simulation code. It also plots iso-dose curves periodically based on the immediately available release data from any plant or environmental monitoring unit.

(iv) To continuously monitor whether any remote environmental monitoring stations has failed to send data due to malfunctioning.

(v) To take corrective action if any abnormal conditions are observed. It is programmed to decide about the various types of emergency situations. In case of an accident a decision maker has to consider [Govaerts-1987]:

(a) A set of information which is nearly invariable (e.g. plant characteristics, inventory of toxic products, site characteristics etc.). These data will normally be available in an accessible data base.
(b) A set of data which varies by time or by happenings of an unusual occurrence or an accident (e.g. meteorological data, releases from the plant, environmental dose data etc.).

Second set of information is updated at each moment. Based on these data emergency director will take a decision. He may even ask for more information from the plants before taking a decision.

At this stage the emergency Director himself becomes a functional element of the system. His task is not limited to inputting the data, but he is called to ask the right questions to the system which assists him by providing the right answers and the required up-to-date information.

This system also serves as a parallel communication medium between the units in case of failure of normal communication channels. The computer is also planned to have codes for organisational aspect of emergency management to help in quick decision making.

Additionally it will be receiving various types of data from a nuclear plant, like stack discharged activity and air flow, reactor operational data, meteorological parameters and effluent discharge data from the plant.

The central computer will normally be located away from the nuclear power plant site but at an easily accessible place. In our case, central computer is located at the Health Physics Laboratory, which is nearly 1.5 Kms away from the Tarapur Atomic Power Station. In normal times it will maintain telemetry link
with the remote systems and receives environmental dose data from them, and stores them after processing. Using various computer codes it will calculate the activity or dose distribution in the various areas surrounding the plant. High resolution colour graphic displays can show the momentary radiological situation. In case of an abnormal release from the plant the dose received from environmental monitors and wind direction data will help considerably in estimating the source term which in turn will help in assessing the on-site and off-site emergency situation and the relief measures to be taken.

Application programs and simulation codes for the emergency management need fairly large memory as they shall be managed at various priority levels. Also it has to manage a personnel dose data base of few thousand workers. It will also have a very big data base related to emergency data. Thus the system chosen should have a large core memory to store bulk data and should be able to do very fast calculations. It should have bulk memory like Winchester disk which is fast and have high capacity to store the large volume of data. It should have large number of I/O channels to be connected to various remote terminals, on-line monitors, area monitors and ring monitors. VAX 11/730, NORSK DATA-500 or PDP 11/23 series of computers are suitable for such operations.

7.11 Details of the Computer System Installed at the Site:

As a part of emergency management the candidate has designed and installed a computer based emergency management system around Tarapur Atomic Power Station, Tarapur, India. This system is
built around a PDP-11/23 computer system. The specifications of this computer system are as follows:

- Sixteen bit CPU,
- 256 Kbyte Memory,
- 186 Mbyte capacity Winchester disc drive,
- Dual floppy drive (8" size),
- An industry standard 9 track IBM Magnetic tape,
- 300 LPM Printer.

System uses 'RSX-11M plus', a multi-user operating system. It supports use of 16 terminals. It has got various language compilers and a MACRO assembler.

With this main system, there are a large number of remote terminals attached. As explained earlier, IBM PC/XTs are used as remote terminals to the system. Fig 7.2 explains schematically how PC/XT is attached to the environmental monitoring system. The advantage of using stand alone IBM PC/XT computers as remote terminals is manifold. By using terminal emulation software this computer can be used as a terminal to the main system. This way it can send data to the computer and also receive from it. Since these systems have 5½" floppy disc drives, the data stored on this disk can be transferred to the main system in file form. Similarly data files can be received from the main computer.

In case of an accident, the meteorological station will be transferring the wind speed and wind direction data using which the plume can be followed. Movement of plume will indicate in which direction activity is spreading. For a particular isotope and source term, the isodose curves can be plotted on the screen.
Since PC/XT monitor has graphic capability these curves can be easily plotted at the plant site itself. Software for plotting of the isodose curves have been developed already at our centre [Hukkoo et al-1985]. Candidate has installed this software package on the main system. Since we are following an approach of distributed processing, these types of packages are installed on the remote units also. A typical isodose curve plotted on the screen is shown in Fig. 7.3. Another important point to be borne in mind is that since occurrence of emergency is a rare phenomena, the remote monitors chosen should have capability of using them as stand alone computers, so that they can be put to optimum use. IBM PC/XT meets this criteria.

7.11.1 Details of MODEM :-

MODEM (MOdulator-DEModulator) interface allows serial communication between systems using telephone lines. The modulator on the transmitting end converts the serial data into distinct tones which are demodulated on the receiver end back into serial data. MODEMs are also used to connect a user's CRT terminal to a master computer system at a remote installation. Most computers connect to a MODEM via a RS232 port. Communication rates for MODEMs are usually limited to about 1200 bits per second and are therefore much slower than directly connected CRT terminals [Rafiquzzaman-1990]. Specifications of the MODEMs used by us are given below:

CCITT V22 bis 1200 bps, asynchronous mode.

Data format : 1 start bit, 8 data bits, none parity, 1 or 2 stop bits.
Fig. 7.3 A typical graphic display showing isodose curves for a hypothetical release at Tarapur Atomic Power Station.
Compatible with VTERM and CROSSTALK software packages.

Facility for voice/data switching.

Data encoding: Full duplex using frequency division multiplexing.

One terminal is put at the Tarapur Atomic Power Station, the nerve centre of all important activities around Tarapur, which is 1½ Kms away from the emergency centre. This terminal is connected to the main computer by use of telephone lines and MODEM at both the ends. Second terminal is installed at Fuel Reprocessing Plant which is also connected to the main system by use of telephone lines.

7.11.2 Details of the LASER Unit:

Third terminal is installed at Micro-Met laboratories. Since the topology of the site does not permit the connection with the help of cables, we have used a LASER link. In this case, the communication is in the line of sight. Specifications of the LASER unit use are as follows:

The GaAs LASER data communicator consists of two transreceiver units which can transmit 10 K bits/sec of digital data up to a range of 1 Km. Each transmitter emits IR pulses of 200 nsec duration with a peak power of 4 W. At the receiver end, the light pulses are focussed on a photodiode with the help of suitable optics, which converts them into electrical pulses. Thus the data is exchanged without laying any cable. The system is compatible with RS232 serial interface; thus serial data transmission is easy. Wavelength used for the LASER is 9040°A (invisible)
7.12 **Usefulness of the Computer** :-

As a part of emergency management with the help of computer, a great emphasis is given to the following points:

1) Data reduction and information presentation
2) Emergency plant status display
3) Simulators
4) Expert systems.

From the environmental monitoring units, meteorological stations and the plant site, large amount of data is received by the computer. This data is processed continuously and only that part of the data which is of use in future will be stored. Some of this data in visual form is presented on VDU screen for inspection. Old information is replaced with new one as soon as it is made available to the computer.

Since this computer is connected all the time to the plant control room, some important parameters related to the plant status can be obtained any time. In case of emergency it displays the status of the plant on real time basis.

Occurrence of an emergency is a rare phenomena. Problem then arises, how to train the plant personnel and the emergency management staff to combat the emergency. In such situations computers are of great help. Simulators are developed on the computers which are programmed to display conditions similar to emergency. Operators are trained about how to face, respond and act in emergency, with the help of these programs.
The necessity for specialised simulator training course, which is many respects is more profitable than training on the plant itself. The simulates enables the trainee to cope with disturbed situations which he would encounter only rarely in actual operation [Vignon-1988]. With the simulation of emergency situation, periodic drills in the plant can be conducted, which will bring out various shortcoming of the emergency planning and preparedness program.

Using the techniques of artificial intelligence, various types of expert systems are developed on computer. These systems help and guide the staff in case of emergency about the types of actions to be taken.

7.13 Numerical Modelling and Environmental Impact Assessment :-

Calculation for long term doses due to release from the nuclear plant can be carried out by using the sector-average method, if the release is only through the monitored channels. The period for which doses are calculated can be typically 1 month or 1 year. For these calculations a constant rate of emission is assumed and meteorological conditions measured for a long period are taken into account. The chronic releases to atmosphere give rise to a dose commitment to the population residing within a radius of few kilometers of the plant. Using these programs isodose curves can be drawn and taking diffusion climatology of the site into account, dose commitment to this group of population can be calculated. A computer program available for this purpose is given by Hukkoo et al [1985].
In case of accidental release to environment, sector average method will not give accurate results. It is desirable that for calculation of dose in this case current data from the telemetric stations should be taken into account. Govaerts et al [1987] describe one such method, in which, in case of accidental release, sector average method is substituted by a model which uses meteorological data belonging to the same 10 min interval as the recorded emission data. Thus the expected radiation level at further points of the environment can be estimated on the basis of measured data and the meteorological parameters.

In an accident situation, accuracy of this method will depend upon how far plume passes the individual telemetry station, on one hand and on the correctness of the assumption for the temporal variation of the emission rate on the other hand.

For detailed regional assessment, three dimensional numerical transport and diffusion models that can be used to estimate regional air concentration and ground deposition from continuous or instantaneous point source or sources, are to be implemented on the central computer. MATHEW/ADPIC [Dickerson et al-1976] codes are the one used for this purpose. In case of emergency, telemetry station will also be able to receive and display MATHEW/ADPIC calculation from the main computer.

7.14 Conclusions :-

Computer aided emergency response systems is of great help both in case of normal release through the stack and in case of accidents when release may be from an unexpected place in the plant. Application of models in conjunction with meteorological
data and data received from telemetry station can help in tracking of the plume direction and subsequently to estimate the doses to the population. An early warning about a release may save a disaster and will greatly help in deciding on interventions and corrective action in time. The system is very useful in emergency and even in normal times it can be useful for training of personnel.

For dose projection or protective action assessment, however use of these systems of environmental monitors gives some difficulty [Cline-1983]. Firstly, to get an accurate information, large number of stations are required, which needs a very high budget. Secondly due to uncertainties in the plume location and size, plume gamma energy composition and local meteorological phenomena, dose projection for the system may be inaccurate. Effluent monitoring, TLD grids and survey teams are the other methods of assessing dose from noble gas releases in a nuclear accident. Emergency action plan usually calls for mobile teams to track the release plume and attempt to monitor the iodine activities in the plume.