Disaster Management, Electrical Safety Procedures and accident prevention.

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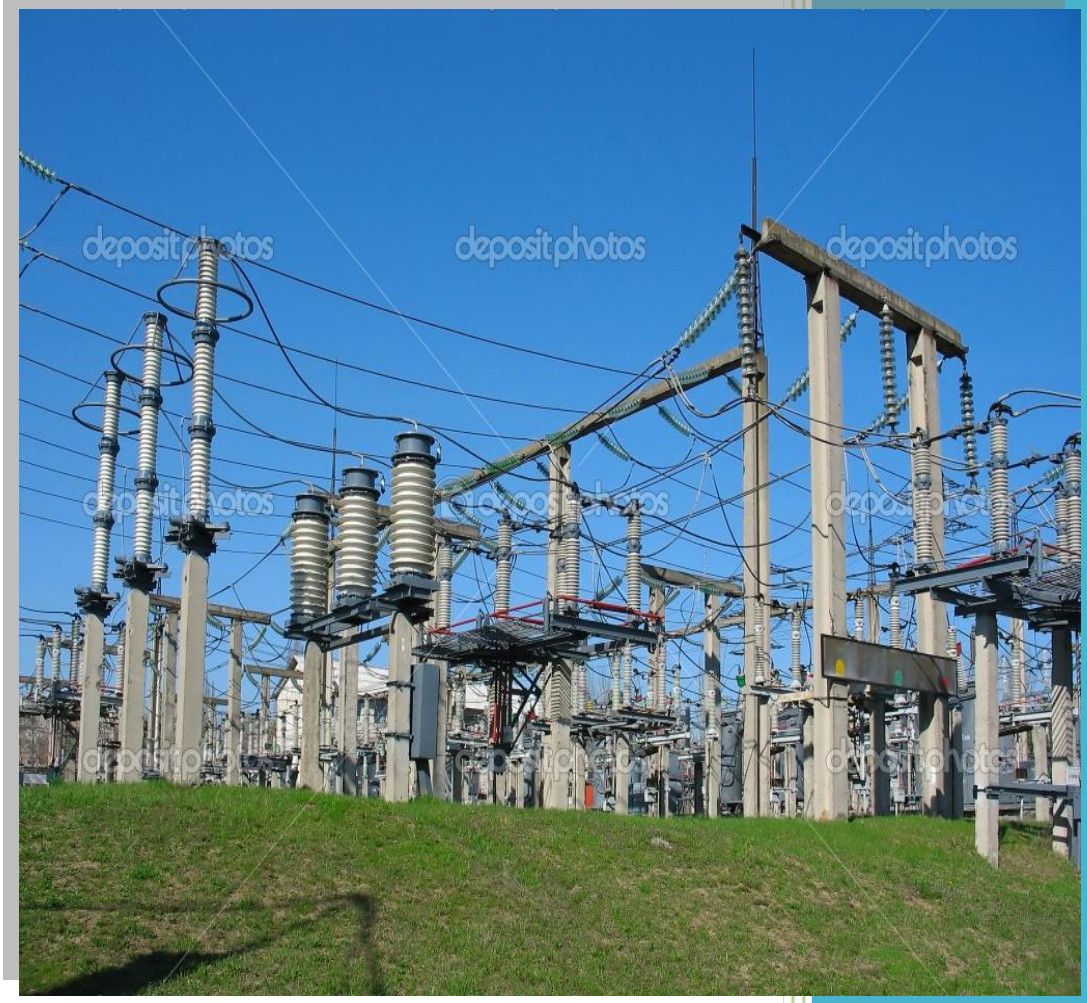


Chapter 1.

Disasters and Impacts warning systems and Response management and mitigation.

1. Disasters and Impacts warning systems and Response management and mitigation

1.1 *Disasters:*

At regular but unpredictable intervals, people around the world are affected by natural hazards. These may be caused by climate (e.g. drought, flood, cyclone) geology (e.g. earthquake, volcano, tidal wave, landslide) the environment (e.g. pollution, deforestation, desertification, pest infestation) or combinations of these. Hazards become disasters when people's homes and livelihoods are destroyed. Poverty, population pressures and environmental degradation mean that increasing numbers of people are vulnerable to natural hazards. Increasing population and urbanization is increasing the world's exposure to natural hazards, especially in coastal areas (with greater exposure to floods, cyclones and tidal waves). Although worldwide disaster occurrence seems to follow an upward trend, some of their

impacts on societies (victims and economic damages) have not increased as preparedness has improved.

The second Wednesday in October is International Day for Natural Disaster Reduction which focuses on the urgent need for prevention activities to reduce loss of life, damage to property, infrastructure and environment, and the social and economic disruption caused by natural disasters.

World Scenario:

In 2008 there were 354 natural disasters in which 236,000 people died and 211,628,186 were affected. This compares to the average for 2000-2007 of 397 natural disasters, with 66,812 deaths and a total of 231,588,104 people affected.

Asia was the region worst affected in 2008 with 141 events including, Cyclone Nargis in Burma which left nearly 140,000 people dead (or missing, presumed dead) and an earthquake in Sichuan, China killing 87,476 which made up 93% of the global disaster toll.

2008 was the deadliest year since 2004, the year of the Indian Ocean tsunami.

Indian sub-continent has experienced a number of natural disaster & calamities like earth quake, cyclone, flood, drought, famine, fire etc. causing loss of life, damage to property & disruption of essential services interruption in electricity & water supply, disruption of transportation, loss in agriculture fields etc.

Electricity Supply System as "Critical" infrastructures:

Critical systems are those, if disrupted, would significantly impact public health and safety, the economy, and/or national security. **Electric**

supply network assets can be termed as Critical Infrastructure. The maintenance of essential services such as Electricity supply is required for overall disaster management including search and rescue. Electricity supply services may be termed as the life-line of all such operations. One of the primary challenges in power supply related emergency preparedness is to meet the needs and concerns of all affected parties. Any prolonged interruption of the supply of Electricity would do considerable harm to the national economy and the people.

As disaster may occur suddenly with or without warning, disaster prevention is better than disaster response because it will be difficult even for the best measures to replace disaster preparedness, and even the highest level of preparedness will never cover all aspects of disaster response. Disasters are inevitable but mostly unpredictable, and they vary in type and magnitude. The best strategy is to have some kind of disaster recovery plan in place, to return to normal after the disaster has struck. For an enterprise, a disaster means abrupt disruption of all or part of its business operations, which may directly result in revenue loss. To minimize disaster losses, it is very important to have a good disaster recovery plan for every business subsystem and operation within an enterprise.

1.2 *What is Disaster?*

Disaster is a sudden, calamitous event bringing great damage, loss, and destruction and devastation to life and property. The damage caused by disasters is immeasurable and varies with the geographical location, climate and the type of the earth surface/degree of vulnerability. This influences the mental, socio-economic, political and

cultural state of the affected area. Generally, disaster has the following effects in the concerned areas,

1. It completely disrupts the normal day to day life
2. It negatively influences the emergency systems
3. Normal needs and processes like food, shelter, health, etc. are affected and deteriorate depending on the intensity and severity of disaster.

It may also be termed as "a serious disruption of the functioning of society, causing widespread human, material or environmental losses which exceed the ability of the affected society to cope using its own resources."

Thus, in simple terms we can define disaster as a hazard causing heavy loss to life, property and livelihood.

1.3 *Types of disaster:*

Generally, disasters are of two types – **Natural** and **Manmade**.

Based on the devastation, these are further classified into major/minor natural disaster and major/minor manmade disasters. Some of the disasters are listed below,

Major natural disasters:

Flood

Cyclone

Drought

Earthquake

Minor natural disasters:

Cold wave

Thunderstorms

Heat waves

Storm

Major manmade disaster:

Setting of fires

Epidemic

Chemical pollution

Deforestation

Wars

Minor manmade disaster:

Road / train accidents, riots

Food poisoning

Industrial disaster/ crisis

Environmental pollution

Different types of disaster strike at different part of country with varying intensity. Whereas water, wind and environmental related disaster are fairly predictable in advance, geological related disaster (viz. earthquake, tsunami etc.) and manmade disasters never come up with advance information. All such disaster disrupts the infrastructure and as a result, the power supply services may be affected and in extreme cases, even may remain interrupted for a long time.

1.4 *Disaster Management Cycle:*

Disaster management is a complex series of activities that include risk assessment, prevention measures, and preparedness to cope with future disasters, emergency response to a disaster, recovery and reconstruction.

Disaster management aims to reduce, or avoid, the potential losses from hazards, assure prompt and appropriate assistance to victims of disaster, and achieve rapid and effective recovery. The Disaster management cycle illustrates the ongoing process by which governments, businesses, and civil society plan for and reduce the impact of disasters, react during and immediately following a disaster, and take steps to recover after a disaster has occurred. Appropriate actions at all points in the cycle lead to greater preparedness, better warnings, reduced vulnerability or the prevention of disasters during the next iteration of the cycle. The complete disaster management cycle includes the shaping of public policies and plans that either modify the causes of disasters or mitigate their effects on people, property, and infrastructure. The mitigation and preparedness phases occur as disaster management improvements are made in anticipation of a disaster event. Developmental considerations play a key role in contributing to the mitigation and preparation of a community to effectively confront a disaster. As a disaster occurs, disaster management actors, in particular humanitarian organizations become involved in the immediate response and long-term recovery phases.

The four disaster management phases illustrated here do not always, or even generally, occur in isolation or in this precise order. Often phases of the cycle overlap and the length of each phase greatly depends on the severity of the disaster.

1.4.1 Mitigation: Minimizing the effects of disaster.

Examples: building codes and zoning; vulnerability analyses; public education.

Mitigation activities actually eliminate or reduce the probability of disaster occurrence, or reduce the effects of unavoidable disasters. Mitigation measures include building codes; vulnerability analyses updates; zoning and land use management; building use regulations and safety codes; preventive health care; and public education.

Mitigation will depend on the incorporation of appropriate measures in national and regional development planning. Its effectiveness will also depend on the availability of information on hazards, emergency risks, and the countermeasures to be taken. The mitigation phase, and indeed the whole disaster management cycle, includes the shaping of public policies and plans that either modify the causes of disasters or mitigate their effects on people, property, and infrastructure.

1.4.2 Preparedness: Planning how to respond.

Examples: preparedness plans; emergency exercises/training; warning systems.

The goal of emergency preparedness programs is to achieve a satisfactory level of readiness to respond to any emergency situation through programs that strengthen the technical and managerial capacity of governments, organizations, and communities. These measures can be described as logistical readiness to deal with disasters and can be enhanced by having response mechanisms and procedures, rehearsals, developing long-term and short-term strategies, public education and building early warning systems. Preparedness can also take the form of ensuring that strategic reserves of food,

equipment, water, medicines and other essentials are maintained in cases of national or local catastrophes.

During the preparedness phase, governments, organizations, and individuals develop plans to save lives, minimize disaster damage, and enhance disaster response operations. Preparedness measures include preparedness plans; emergency exercises/training; warning systems; emergency communications systems; evacuations plans and training; resource inventories; emergency personnel/contact lists; mutual aid agreements; and public information/education. As with mitigations efforts, preparedness actions depend on the incorporation of appropriate measures in national and regional development plans. In addition, their effectiveness depends on the availability of information on hazards, emergency risks and the countermeasures to be taken, and on the degree to which government agencies, non-governmental organizations and the general public are able to make use of this information.

1.4.3 Response: Efforts to minimize the hazards created by a disaster.

Examples: search and rescue; emergency relief.

The aim of emergency response is to provide immediate assistance to maintain life, improve health and support the morale of the affected population. Such assistance may range from providing specific but limited aid, such as assisting refugees with transport, temporary shelter, and food, to establishing semi-permanent settlement in camps and other locations. It also may involve initial repairs to damaged infrastructure. The focus in the response phase is on meeting the basic needs of the people until more permanent and sustainable solutions can be found. Humanitarian organizations are often strongly present in this phase of the disaster management cycle.

1.4.4 Recovery: Returning the community to normal.

Examples: temporary housing; grants; medical care.

As the emergency is brought under control, the affected population is capable of undertaking a growing number of activities aimed at restoring their lives and the infrastructure that supports them. There is no distinct point at which immediate relief changes into recovery and then into long-term sustainable development. There will be many opportunities during the recovery period to enhance prevention and increase preparedness, thus reducing vulnerability. Ideally, there should be a smooth transition from recovery to on-going development.

Recovery activities continue until all systems return to normal or better. Recovery measures, both short and long term, include returning vital life-support systems to minimum operating standards; temporary housing; public information; health and safety education; reconstruction; counselling programs; and economic impact studies. Information resources and services include data collection related to rebuilding, and documentation of lessons learned.

Good development and community preparedness can reduce the impact of a disaster especially for the most vulnerable people, such as those living in hazard-prone areas with few financial resources to help them recover if they lose their means of livelihood.

1.5 *Present status of Disaster Management Efforts in India*

India covers an area of 32, 87,263 sq.km extending from snow covered Himalayan heights in the North to the tropical rain forests of the South. In the North, the territory is bounded by the Great Himalayas and stretches southwards tapering off into the Indian ocean between the Bay of Bengal and the Arabian Sea. The main land extends between latitudes 8º4’ and 37º6’ North and longitudes 68º7’ and 97º25’ east,

measuring about 3200 km from North to South and West to East. This vast land frontier of 15,200 km and coastline of 7,500 km also has groups of islands located both in the Bay of Bengal and the Arabian Sea. Hardly any other country has such a large land mass with such a diverse range of geo-agro-climatic zones. The main land of India comprises of four regions, namely, the Great Mountain Zone, Plains of the Indus, Ganges and the Brahmaputra; the Desert Region, and the Southern Peninsula. The Himalayan range comprises three almost parallel ranges interspersed with large plateaus and valleys. The mountain wall extends over a distance of 2,400 km with a varying width of 240 to 320 km. The plains about 2,400 km long, are formed by basins of three distinct river systems, viz., the Indus, the Ganges and the Brahmaputra. The desert region is clearly delineated in two parts - the Great Desert running beyond Rann of Kutch to Rajasthan - Sindh Frontier while the little desert extends between Jaisalmer and Jodhpur up to Punjab. The desert region is inhabited by local communities which have developed their own coping and recovery mechanisms. Between the two deserts is a zone of absolutely sterile region, consisting of rocky land cut up by limestone ridges.

1.5.1 National Disaster Management Authority of India

National Disaster Management Authority (NDMA) has been constituted by Government of India under the Disaster Management Act' 2005 to coordinate its efforts towards Disaster Management, The DM Act, 2005 enjoins on NDMA the responsibility to lay down policies and guidelines for disaster management and to enable timely and effective response to Disasters. This involves prevention, mitigation, capacity building, preparedness and response natural and manmade disasters.

1.5.2 Roles and Responsibilities of NDMA

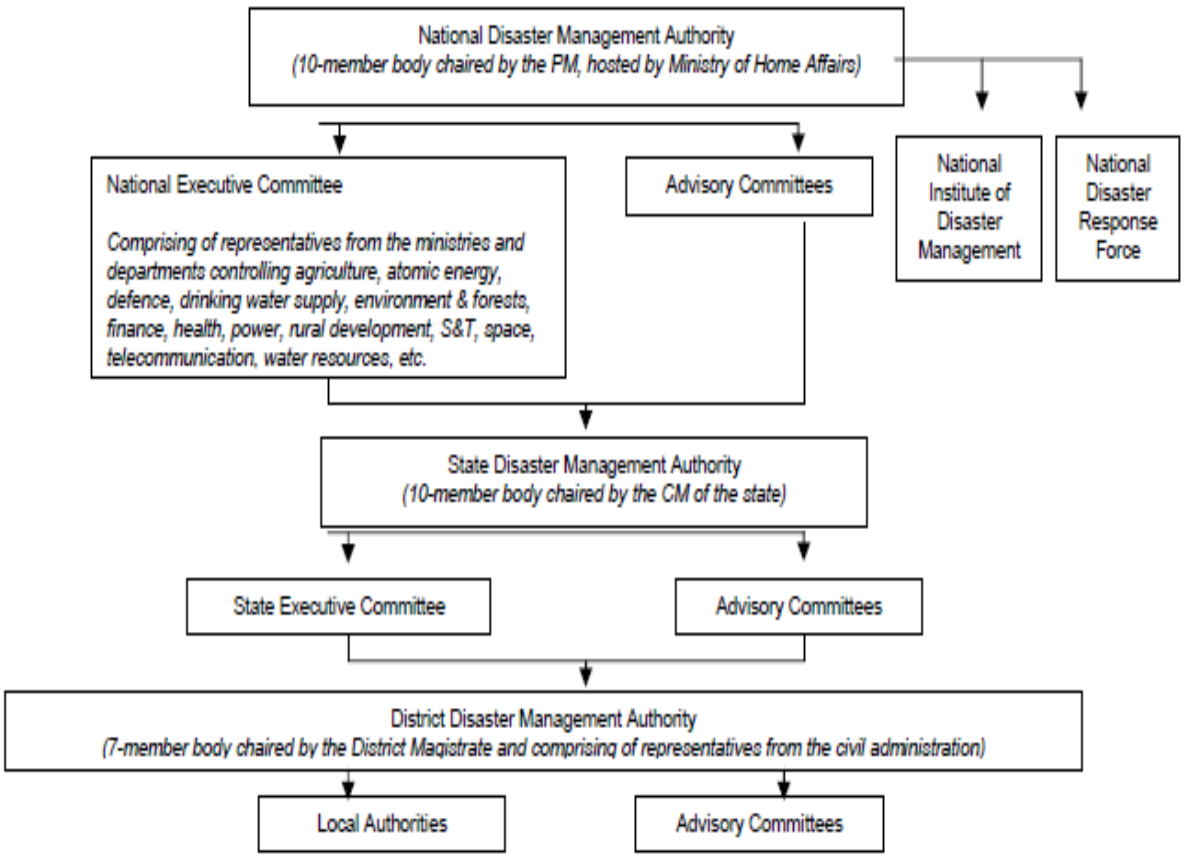
NDMA as the apex body is mandated to lay down the policies, plans and guidelines for Disaster Management to ensure timely and effective response to disasters. Towards this, it has the following responsibilities:-

- Lay down policies on disaster management;
- Approve the National Plan;
- Approve plans prepared by the Ministries or Departments of the Government of India in accordance with the National Plan;
- Lay down guidelines to be followed by the State Authorities in drawing up the State Plan;
- Lay down guidelines to be followed by the different Ministries or Departments of the Government of India for the Purpose of integrating the measures for prevention of disaster or the mitigation of its effects in their development plans and projects;
- Coordinate the enforcement and implementation of the policy and plan for disaster management;
- Recommend provision of funds for the purpose of mitigation;
- Provide such support to other countries affected by major disasters as may be determined by the Central Government;
- Take such other measures for the prevention of disaster, or the mitigation, or preparedness and capacity building for dealing with the threatening disaster situation or disaster as it may consider necessary;
- Lay down broad policies and guidelines for the functioning of the National Institute of Disaster Management.

1.5.3 National Disaster Response Force (NDRF)

The Disaster Management Act, 2005 has mandated constitution of National Disaster Response Force (NDRF), a Specialist Response Force, for the purpose of specialized response to natural and man-made disasters. This Force will function under the National Disaster Management Authority which has been vested with its control, direction and general superintendence. This will be a multi-disciplinary, multi-skilled, high-tech force for all types of disasters capable of insertion by air, sea and land. All the eight battalions of National Disaster Response Force (NDRF) are equipped and trained for all natural disasters including four battalions in combating nuclear, biological and chemical disasters.

1.6 *Disaster Management Structure in India*



1.6.1 Preparedness and Rehabilitation measures in India:

An ideal Disaster Management System needs to support the activities related to preparedness, prediction, damage assessment and rehabilitation. In recent years, the focus of disaster management community is increasingly moving on to more effective utilization of emerging technologies such as

Remote sensing,

Geographic Information System, and

Satellite Communication, enabling to prepare for and mitigate potential impacts.

Several critical inputs are required in order to take preventive measures through vulnerability analysis, hazard zonation and prior risk assessment at regional and local levels and timely and reliable weather forecasts and advance warnings of severe weather to minimize loss of life and damage and facilitate timely and effective rescue, relief and rehabilitation of the affected population.

Under the existing framework in the country, the responsibility of undertaking rescue, relief and rehabilitation measures rests with the concerned State Government. The Central Government provides financial and logistic support in the event of major disasters. A Crisis Management Committee in the State with senior representatives from the Government departments and Central agencies located in the State oversees the disaster management actions. At the district level, District Plans are prepared in advance for implementation during a crisis with adequate powers for decision-making. A Calamity Relief Fund at the national level provides additional funds required for various actions.

The Central Relief Commissioner in the Ministry of Home Affairs is the focal point at national level and coordinates appropriate dissemination of warnings received from India Meteorological Department, Central Water Commissioner etc. and adequate financial support. Based on critical assessment of the current system and technological advances, several new initiatives have been taken up and a paradigm shift in disaster management, emphasizing mitigation, prevention and preparedness has occurred. A roadmap has been drawn up drawing upon the strength of technology inputs and resilience building in

communities. Institutionally, separate Disaster Management Authority is being set up in the States.

1.6.2 Disaster Mitigation efforts in India:

Several actions have been initiated towards disaster mitigation. .

A national Communication Plan has been drawn up harnessing the modern systems of communication for information flow, dissemination of warnings etc. A web-based inventory of specialist resources required for disaster management support has been operationalised.

The National Institute for Disaster Management is entrusted with developing training capsules, disaster management codes, human resource development, and awareness creation programs and education. The overall stress is to make the disaster management program in the country more effective with appropriate technology inputs and grass-root level participation.

1.6.3 Emergencies involving the electric power system:

These place special burdens on both the electric utility and the state to implement appropriate and effective control measures. The electric power system is subject to numerous technical constraints restricting what can or cannot be done to prevent power outages. The system also contains many automatic control devices that respond almost instantaneously to perturbations in supply, demand, and other system conditions. Hence, some measures taken to prevent outages can actually increase risk and, in some cases, create cascading effects that can collapse the entire system in a matter of minutes.

With power sector reforms underway, in India most of the Utilities have been unbundled and major Utilities in Generation, Transmission and Distribution are under State sector.

Natural disasters can disrupt utility operations, with repercussions that last for years requiring considerable electric infrastructure to be rebuilt. These disasters will have economic impacts, in the form of cost recovery through tariff revisions on utilities and their customers for years to come. All such events present significant operational, public communications, and project management challenges for utilities. Success or failure in handling such natural events is typically driven by both a utility's service restoration performance and its ability to inform the public. Fast or slow restoration, responses to customers' inquiries and interactions with the media all have a major impact on a company's reputation.

1.7 *Disaster Management Plan (On site and Off Site):*

Successful restoration performance must be based on well-conceived planning and effective execution against the plans.

1.7.1 Application of IT in Disaster Management:

Though it is not possible to completely avoid the natural disasters, but the sufferings can be minimized by creating proper awareness of the likely disasters and its impact by developing a suitable warning system, disaster preparedness and management of disasters through application of information technology tools. The changing trends have opened up a large number of scientific and technological resources and skills. It may be observed that advancement in Information Technology in the form of Internet, GIS, Remote Sensing, Satellite communication, etc. can help a great deal in planning and implementation of hazards reduction. For maximum benefit, new technologies for public

communication should be made use and natural disaster mitigation messages should be conveyed through these measures.

1.7.2 Disaster warning:

It is important to note that disaster warning is indeed a system, not a singular technology, constituting the identification, detection and risk assessment of the hazard, the accurate identification of the vulnerability of a population at risk, and finally, the communication of information about the threat to the vulnerable population in sufficient time and clarity so that they can take action to avert negative consequences. This final component underscores the importance of education and creating awareness in the population so that they may respond with the appropriate actions.

1.7.3 Key Players in Disaster Warning

The United Nations International Strategy for Disaster Reduction (UN/ISDR) identifies several key parties that play major roles in the disaster management process.

Communities, particularly those most vulnerable, are vital to people-centered early warning systems. Their input into system design and their ability to respond ultimately determine the extent of risk associated with natural hazards. Communities should be aware of hazards and potential negative impacts to which they are exposed and be able to take specific actions to minimize the threat of loss or damage.

Local governments should have considerable knowledge of the hazards to which their communities are exposed. They must be actively involved in the design and maintenance of early warning systems, and understand information received to be able to advise, instruct or engage

the local population in a manner that increases their safety and reduces the potential loss of resources on which the community depends.

National governments are responsible for policies and frameworks that facilitate early warning, in addition to the technical systems necessary for the preparation and issuance of timely and effective hazard warnings for their respective countries.

Regional institutions and organizations should provide specialized knowledge and advice in support of national efforts to develop or sustain the operational capabilities of countries that share a common geographical environment.

International bodies should provide support for national early warning activities and foster the exchange of data and knowledge between individual countries. Support may include the provision of advisory information, technical assistance, and policy and organizational support necessary to ensure the development and operational capabilities of national authorities or agencies responsible for early warning practice.

Non-governmental organizations (NGOs) play a critical role in raising awareness among individuals and organizations involved in early warning and in the implementation of early warning systems, particularly at the community level.

The private sector has a diverse role to play in early warning, including developing early warning capabilities in their own organizations. The private sector has a large untapped potential to help provide skilled services in the form of technical manpower, know-how, or donations of goods or services (in-kind and cash), especially for the communication, dissemination and response elements of early warning.

The media plays an important role in improving the disaster consciousness of the general population and in disseminating early warnings. The media can be the critical link between the agency providing the warning and the general public.

The scientific community has a critical role in providing specialized scientific and technical input to assist governments and communities in developing early warning systems.

1.7.4 Different Communication Channels Used in Disaster Warning

Channel	Benefits	Challenges
Radio and Television	Widespread	Takes time to get the warnings Limited use at night
Telephone (fixed and mobile)	Messages delivered quickly	Problems of authenticity Does not reach non-users Congestion
SMS	Quick Messages can be sent to groups	Congestion Does not reach non-users Local language problems
Cell broadcasting	No congestion Can address a group simultaneously	Does not reach non-users Local language problems
Satellite radio	High reachability	Cannot be used to educate masses Only good for specific points
Internet/Email	Interactive Multiple sources can be checked for accuracy of information	Not widespread
Amateur/Community radio	Excellent for rural, poor and remote communities	Not widespread People lose interest if used only in case of disaster
Sirens	Can be used even at night Good in rural areas	Maintenance of the system Cannot disseminate a detailed message

1.8 *Improving the restoration process*

To prepare for future crises and develop ways to reduce the impact of disaster, there are two areas in which efforts can be focused.

Raising the company's ability to plan and prepare for the response

Restore service, and repair the damage

1.8.1 Hardening the infrastructure

Reducing the impact of future disasters by assessing the infrastructure to identify ways to make it more resilient

A table below indicates details of efforts on part of a power Distribution Utility in improving the Restoration process by hardening the infrastructure.

Improving the restoration process	Hardening the infrastructure
Service restoration – Timeliness – Effectiveness _ Communications and expectation-setting – Selecting, prioritizing, and restoring "essential" customers such as hospitals, police, fire, shelters, nursing homes – Coordinating with emergency management agencies, government – Setting expectations and communicating with customers on estimated restoration times	_ **Disaster-resistant system** – Maintenance program changes such as vegetation management – Asset replacement strategies – System design changes incorporating equipment and material strength, underground versus overhead lines, etc. _ **Business continuity** – Resilience of non-electric infrastructure, such as call centers, corporate offices – Adequacy of redundant or back-up systems for communications and IT

Improving the restoration process	Hardening the infrastructure
–As a group through the media –Individually through call centers _ Planning and working with partners – Other utilities and crews – Tree-trimming and line contractors – Suppliers of poles, cables, transformers, etc. – Hotels, caterers, other logistics partners to stage and support the work force – Police, state, and municipal workers _ Flexibility – Establishing and renewing restoration strategies and plans – Adapting plans to the nuances of individual events	– Employee availability, including ability to support employees who have sustained losses **_ Business justification and feasibility** – Understanding of vulnerabilities – Potential benefits of hardening the system (SAIFI, SAIDI) – Life-cycle costs – Initial capital – Ongoing O&M

Addressing these elements can help to improve restoration performance, maintain a positive public image, and support strong relationships with regulators and governmental leaders.

It is seen that following framework would be useful in preparing for and managing disaster responses, as well as for improving restoration performance

1.9 *Improving the Restoration process- Preparation*

The disaster restoration process can be improved by resorting to following actions.

1.9.1 Request Selected Customers to Reduce Load:

Working with State regulators to develop demand response programs that can be used in emergency situations can help. Such programs can be active load management with direct control of equipment or voluntary response where the customer selects equipment to be controlled based upon current operations. Some of these programs can provide emergency response in as little as thirty minutes to help maintain the reliability of the bulk power system during a capacity deficiency.

1.9.2 Request All Customers to Voluntarily Reduce Load

Communication through public systems and Utility's own information channels can be made to give relief.

1.9.3 Reduce Voltage:

Reduce operational voltage, usually by less than 5-6%, in order to mitigate system contingencies. At this level, most customers will not notice a change, however public notification should accompany such action as certain electrical equipment may be adversely affected by this action.

1.9.4 Implement Rotational load shedding:

Rotational load shedding program can be adhered to.

Assure system reliability

Emergency Communications Protocols with State Regulatory Agencies

Join in mutual aid agreements

Cooperate with state emergency and homeland security authorities

Inform the public

1.10 *Disaster Management in Power Utilities:*

Approach and Deployment

Under several different types of circumstances, electric power ***systems*** could be damaged well beyond the level of normal design criteria for maintaining reliability. Earthquake, Flood and Hurricane type of natural disaster could damage many electric power system components, causing widespread outages over a long period of restoration and recovery. Even more ominously, terrorists could emulate acts of sabotage and destroy critical components.

Electric utilities normally plan for the possibility of one, or occasionally two, independent failures of major equipment without their customers suffering any significant outage. If the system can be better protected, or made sufficiently resilient to withstand greater levels of damage, then the risk of a major, long-term blackout will be reduced. However, any such measures will cost money. Utilities are taking some steps, but apparently, generally consider the risk to be too low to warrant large expenditures, which would ultimately be borne by their consumers or by stockholders if the State Regulatory commission did not approve inclusion of these costs in the rate base.

A variety of events, both natural and manmade, can cause power outages. Widespread outages or power shortages lasting several months or more are unlikely unless significant components of the bulk power system—generation and transmission-are damaged. The most probable causes of such damage are sabotage of multi-circuit transmission facilities, and very strong earthquakes or hurricanes.

All the electricity network components are directly connected to each other (Generation, Transmission, Distribution and Utilization). As such Disaster management cannot be considered in isolation by individual Utility. Co-ordinate efforts are desired by all.

1.10.1 Overview of costs of blackouts:

Blackouts have impacts that are both direct (the interruption of an activity, function, or service that requires electricity) and indirect (due to the interrupted activities or services). **Direct impacts** include food spoilage, damage to electronic data, and the inoperability of life-support systems in hospitals and homes. Direct impacts can be avoided if the end-user has backup systems, but these have often proved unreliable.

Indirect impacts include property losses resulting from arson and looting, overtime payments to police and fire personnel, and potential increases in insurance rates. Indirect impacts may be partially mitigated through contingency planning, improved communications, customer education, social programs, and other planning approaches.

To estimate costs, utilities and Regulatory Commissions (SERC & CERC) rely on either hypothetical cost analysis or reconstruct the level of economic activity that might have occurred had there been no blackout. Both of these methods have inherent uncertainties, and theoretical models have their own shortcomings. Also, indirect and social costs often cannot be quantified but only enumerated.

1.11 *Sectoral impacts*

1.11.1 Industrial:

Many industrial processes are highly sensitive to power disruptions. An interruption of less than 1 second can shut equipment down for several hours. Outages can spoil raw materials, work-in- progress, and finished goods. Spoilage is a significant problem in chemical processes, steel manufacture, food products, and other industries.15 Blackouts also pose opportunity costs from idle factors of production. Human health and safety effects are another major concern in industrial outages. Not only are the workers exposed to possible injury or health hazard from the power interruption, the neighboring population also could be exposed to risk from hazardous spills or releases due to the loss of environmental or safety equipment.l6

1.11.2 Commercial:

For many commercial customers, any outage of **duration** of more than 1 or 2 seconds has a significant cost due to computer problems, equipment jamming, or ruined product. For these firms a l-hour outage is not substantially more costly than a 10-second outage.

With the increasing pervasiveness of computers and communications systems in all economic activity- commercial sales, offices, industrial process control, finance, communications, public works control, government-their performance in a blackout affects all impact sectors. The major consequences include costs associated with the inability of the computer to perform critical functions, loss of data, and possible damage to the computer and peripheral equipment. Degradation of storage media is a major concern if the room temperature strays too far from the norm.18 Critical systems usually have backup power sources, although most are not designed for an extended blackout, when the operating environment becomes more of a concern.

An entirely new industry has grown up around the need for backup systems and recovery services for heavily computer-dependent activities. Computer security companies take over computer functions, such as payroll, inventory, and records maintenance, when disasters temporarily or permanently disable corporate computers.

Some utilities define the commercial sector as what is left over after accounting for residential and large industrial customers. Commercial establishments can be categorized as that sell products and those that provide services. The potential for product damage and the ability to make up lost production are critical here. Food stores and warehouses, for example, can have significant spoilage costs. Similarly, fast-food outlets not only can have high spoilage costs, but also service immediate demand and usually cannot make up lost business.

1.11.3 Agriculture:

Pumping of water from wells gets affected. Longer durations may hamper the standing crops, sowing and harvesting operations. There can be significant hazards to livestock (animals and plants) and produce during a blackout. Sensitive processes include incubation, milking, pumping, heating, air-conditioning, and refrigeration.

1.11.4 Residential:

People become more aware of their dependence on electricity and the machines during a blackout. Without electricity, air-conditioning is off, and many people do not have heat or hot water. In high-rise buildings, people must use stairwells. Senior citizens and the disabled are at an extreme disadvantage in outages. Consumers do not have lights, refrigerators and freezers, stoves and microwave ovens, toasters, dishwashers, intercoms, televisions, clocks, home computers, elevators and escalators, doorbells, hair dryers, heated blankets, can openers, food processors, carving knives, toothbrushes, razors, and garage door openers. With the advent of high-tech electronics, most people have Inverters or battery-operated radios or TVs, but few keep enough batteries on hand **to** last more than a few hours.

1.11.5 Transportation:

A blackout affects virtually every mode of transportation. Subways, elevators, and escalators stop running, and corridor and stairwell **lights** usually are out. Street traffic becomes snarled without traffic lights. Gasoline pumps do not work, and the availability of taxis and buses declines over time. Parking lot gates and toll booths will not operate. Pedestrians are perhaps the least affected, although their danger increases without traffic signals and after dark with the loss of street

lighting. Trains running on diesel can still function, but doing so can prove hazardous without signal lights.

1.11.6 Telecommunications:

There is a growing reliance on telecommunications networks in all sectors of economy. Businesses and government depend on reliable communications to perform routine tasks.

Also, businesses are using their communications systems and the information stored in them to achieve a competitive advantage and to restructure their organizations on a regional or global basis. Thus, the failure of a communications system can lead not only to market losses but also to the failure of the business itself. The functioning of all crucial municipal public services, such as police, fire, etc., will also depend on telecommunications. Extended power outages can affect telecommunications networks and lead to economic disruption. The extent of the disruption will depend on whether telecommunications networks, both public and private, have emergency backup power systems and how reliable the backup systems are. Today, many networks have their own dedicated emergency backup system which can support only for few hours.

1.11.7 Emergency Services:

Emergency services include police and fire and their communications and transport, as well as hospitals. Power outages can also affect these services. All hospitals have emergency power systems to support the most critical activities, such as operating rooms, intensive-care units, emergency services, etc.

Depending on the facility, auxiliary power systems may not be able to support some other activities, including x-ray, air-conditioning, refrigeration, elevators, etc. Fire-fighting and police communications could be severely disrupted by the loss of power. Fire alarm systems may be inoperable and fire-fighting maybe hampered in those areas where some power is required for pumping water.

1.11.8 Public Utilities and Services:

Public utilities include electric, water, gas, sewage, garbage, and related services (e.g., public health inspection). Water supply systems generally rely on gravity to move water from reservoirs through the mains and to maintain pressure throughout the system. Some power may be required at pumping stations and reservoirs. Electricity is needed in treatment and pumping of sewage. An outage at a treatment plant causes raw sewage to bypass the treatment process and flow into the waterways. Lack of pumping station power prevents sewage flow and ultimately causes a backup at the lowest points of input (usually basements in low-lying areas).

1.12 *System Impact of the Loss of Major Components:*

One factor leading to reliability and resilience is the highly interconnected network common to modern power systems (Regional and National level grids). Because of the vast size of most power systems, no individual power plant or transmission component is critical to the operation of any power system. An electric system typically has many power plants. An individual power plant, even a large multi-unit one, supplies only a small fraction of the total demand of most control areas.

Distribution systems are not designed to have such a high level of reliability as the bulk system. In fact, the great majority of outages that customers experience result from distribution system problems, not from the bulk system (around 80 percent by one estimate).However, unlike bulk system failures, distribution-caused outages are localized, and utilities have considerable experience in responding to them.

1.12.1 Short-term bulk power system impacts:

The Importance of Any One Component: Preparing for Normal Failure

Most bulk power systems are designed and operated to continue operation following the failure of any one device without interrupting customer service or overloading other equipment. This is commonly referred to as the “n-1 operating criterion. Some utilities prepare for two such contingencies (called the n-2 operating criterion). Few systems make some exceptions to the n-1 criterion for certain major facilities. In such systems, some customers may be briefly interrupted following certain outages, but with no overloading of other equipment leading to uncontrolled or cascading outages.

Impacts of Multiple Failures: Islands and Cascading Outages

When abnormal, multiple failures occur, a power system typically undergoes ‘‘system separation” in which portions of the system disconnect from each other. Some of these isolated portions, called “electrical islands,” may have an imbalance of supply and loads. Those islands have either more generation than load or more load than generation, causing the system frequency to deviate from its normal value of 50 Hz and transmission voltages to exceed design limits. In

turn, protective relays would cause several generators and transmission circuits to disconnect from the island, resulting in a blackout. Other islands may have a balance of supply and demand, allowing continued operation even though disconnected from the rest of the system.

“Cascading outages” occur when the failure of one or more components causes the overloading and failure of other equipment and breakup of the system into islands in an uncontrolled fashion. It is not possible to accurately predict the way a system will break up after a major disturbance-there are too many variable factors. Utilities do analyze their systems and implement plans to help anticipate and control the likely pattern of islands. Their analyses show that the pattern of islands will vary depending on the location of loads, which units are operating, how much each unit is generating, the configuration of the transmission network, and the specific second- by-second sequence of events causing the disturbance. However, one can predict that cascading failures will extend over large areas, in some cases over a multistate region.

Preparing for Extreme Contingencies

Because uncontrolled, cascading outages can be so widespread and difficult to recover from, Utilities have made special provisions to avoid them even though the circumstances leading to them are viewed as highly unlikely. In addition to planning for ‘normal’ contingencies, Utilities also plan for ‘extreme’ contingencies. The reliability criteria of the system is specified by the ‘Grid code’ It specifies the way in which the bulk power systems shall be planned and operated in a manner to avoid uncontrolled, area wide interruptions under certain extreme contingencies. Under extreme contingencies, substantial outages may occur, but should not extend across an entire system.

1.12.2 Long-term Bulk System Impacts

The Importance of Any Few Components: Large Reserves and Peak Capacity

There may be a daily cycle of shortages or rotating outages during hours of peak demand. The large surplus of generating capacity over demand results from two factors: Installing sufficient capacity to meet peak loads; and planned reserve margins in excess of peak demand. Power systems are designed to meet widely fluctuating loads which reach their peak for only a few hours in any year. Most utilities plan to install generation reserve margins of 15 to 20 percent. Utilities install reserve capacity in order to accommodate both planned and unplanned needs such as scheduled maintenance, unexpectedly high load growth and equipment outages.

Transmission systems are planned to accommodate both the geographical distribution of power plants as well as the changing patterns of loads. Thus, the reserves of generation are necessarily accompanied by similar reserves of transmission. Transmission networks also link the many utilities in the Nation's regional interconnections. Some transmission systems are heavily loaded by economy energy transfers both within and among regions. However, at certain times such as extreme peak periods or when scheduled maintenance or unplanned outages have reduced actual reserve margins, failure of only a few key generation or transmission components units could significantly disrupt service.

1.12.3 System Impact When No Outages Occur:

Higher Costs and Lower Reliability

Any loss of generation and transmission capacity reduces the reliability of a system somewhat. The destruction of one or more major generating or transmission components reduces a system's reserves, leading to fewer options and less resilience for any further component outages. The degree to which reliability is reduced depends on the level of installed reserve margins.

Bulk system recovery from outages

Restoring service involves starting generation or reclosing circuit breakers and adding load in small increments, slowly piecing the system back together. For customers in small islands adjacent to an area that remains interconnected, power may be restored in a few minutes. Isolated islands will take longer, especially those that were completely blacked out.

A power system is restored by successively restarting generators, connecting transmission lines, and connecting load until significant islands of operating load and capacity are available. Then the separate portions of the system are connected to each other. In this way, the portions of the system that are operable can be completely restored and returned to as near normal operation as feasible. Restoration of an outage should begin within minutes of an outage. The length of time to restore full service depends on the design of the system, the severity of the blackout, and the components damaged.

1.12.4 Efforts to Reduce Energy Systems Vulnerability:

Efforts of various institutions, including the utility industry, Government agencies, States, Regulatory commissions and electrical equipment manufacturing industry would enable reducing the vulnerability.

Utilities

Physical protection of electric power facilities does not appear to be a high-priority item for utility management. Historically, deliberate attacks on electric power facilities have not resulted in power or financial losses significant enough to justify a major investment in physical security. However, it is important to note that the utility industry is concerned about vulnerability and has been working quietly on security issues for some time. Utilities recognize that communication is an important part of any security plan.

Under emergency conditions, including sabotage, the ability to communicate is even more critical. Thus, utilities place a high priority on the restoration of communication networks during emergencies. Utilities also recognize the need for improved communication with law enforcement officials and other utilities. Virtually all utilities with key facilities have established contact with the local Government offices. They can assist utilities in evaluating threats, inspecting facilities, and planning emergency responses. In addition, utilities have encouraged additional information exchanges between operating personnel and security managers to ensure adequate emergency preparedness.

Public, PPP and Privately owned Utilities (Generation and Transmission):

Public Utilities like NTPC, NHPC, NPC and CTU (Central Transmission Utility) PGCIL at central level and STUs (State Transmission Utilities)

for different states can work out and implement plans to reduce the power system vulnerability.

As privately owned merchant power plants and Transmission Licenses getting connected to the grid, a need to work out jointly a strategy to address the issue has arisen.

1.13 *Vulnerability Program:*

A Vulnerability Program with its purpose is to reduce the risks of energy system interruption can be developed. A typical program may consist of four phases:

Phase I to include case studies to determine the nature of vulnerabilities in the electric power industry which require considerable input from industry, central government, State, and local governments.

Phase II may establish an industry outreach program which can provide information and solicits industry/ government joint cooperation.

Phase III of the program can include additional case study exercises and other industry outreach efforts.

Phase IV will identify national security vulnerabilities which cannot be addressed by the power industry alone. This phase may include Union Government funded programs to remedy power system vulnerability concerns.

Regulatory Commissions:

Regulatory commissions (CERC and SERCs) normally allow utilities to recover security costs. For example, security fences and guards, and monitoring and surveillance equipment are included in the overall cost of operating a power facility. Also, spare components are typically held as an essential part of the operation and are included in the ARR (Annual Revenue Requirement) exercise. Utilities have expressed reluctance to employ additional security measures. Among the arguments they have raised is a concern that Regulatory commissions would disallow any related expenditures. This concern is as yet untested. It is possible that commissions may find that no need exists for additional security against very low-probability events (e.g., concerted aggression against utility systems). If so, they would be unlikely to allow utilities to charge for such expenditures. However, if utility activities are in response to National emergency preparedness policy or guidelines, approval of expenditures is more likely.

1.14 *Options to reduce impacts of disaster:*

Various measures can be taken to reduce vulnerability disruption if damage does occur. Given the unpredictability of these types of disruptions and the uncertainty of their costs, it is not possible for a cost/benefit analysis to determine how much protection is worthwhile. The desirability of further measures is a matter of judgment more than analysis, as is the potential role of the government in stimulating greater protection.

The measures that could be useful in reducing the risk can be

- preventing or minimizing damage to the system;

- Harden key substations-protect critical equipment within walls or below grade, separate key pieces of equipment such as transformers, toughen the equipment itself to resist damage, etc.
- Surveillance (remote monitoring) around key facilities (coupled with rapid-response forces).
- Maintain guards at key substations.
- Improve coordination with law enforcement agencies to provide threat information and coordinate responses.
- Minimizing the consequences of any damage that does occur; and Improve emergency planning and procedures for handling power flow instability after major disasters and ensure that operators are trained to implement these contingency plans.
- Modify the physical system-improve control centers and protective devices, greater redundancy of key equipment, increased reserve margin, etc.
- Increase spinning reserves.
- Assuring that recovery can be accomplished as rapidly as possible.
- Identification of potential spares and resolution of legal uncertainties.
- Clarify Legal/institutional framework for sharing reserve equipment.
- Stockpile critical equipment (transformers) or any specialized material (e.g., various types of copper wire) needed to manufacture this equipment.
- Assure availability of adequate transportation for a stockpile of very heavy equipment by maintaining database or rail/barge equipment and adapting Schnabel cars to fit all transformers if necessary.
- Monitor domestic manufacturing capability to assure adequate repair and manufacture of key equipment in times of emergency.

In addition, the evolution of the electric power system can be guided toward inherently less vulnerable technologies and patterns.

General reduction of vulnerability -

1. Emphasize inherently less vulnerable technologies and designs where practical, including pole-type transmission lines, underground transmission cables, and standardized equipment.

2. Move toward an inherently less vulnerable bulk power system (e.g., smaller generators near loads) as new facilities are planned and constructed.

Limiting Consequences:

If damage cannot be prevented, the next best thing is to ensure that impacts on customers are as low as possible. Utilities have already installed protective devices on the transmission networks such that it is unlikely that blackouts would cascade beyond the directly affected region. Other steps can be taken that would further reduce the extent of the impacts.

- Improve Emergency Planning and Procedures
  Considerable contingency planning under a variety of conditions is necessary to ensure that the best responses are identified
- Modify the physical system
- Increase spinning reserve

Speeding recovery:

Once the system has been stabilized, operators try to restore power as quickly as possible. Even after severe damage, power to parts of the system usually can be restored within a few hours by isolating the damage and resetting circuit breakers. Restoration to full service and

reliability depends on at least temporary repair of the damage. The measures here are intended to eliminate constraints to both short term and long-term recovery.

The main focus areas could be

- Contingency planning
- Clarification of Legal and institutional framework for sharing of equipments and manpower between different Utilities
- Maintaining stock of critical equipments

Chapter 2.

Electrical safety procedure and manuals.

2. Electrical safety procedures and manuals.

2. 1 Safety:

Safety is necessary in every business activity from following aspects:

- To save lives of personnel engaged in work including self, colleagues, general public & animals.
- To protect the departmental and public property
- To reduce loss of revenue
- To reduce the loss of service due to non availability of men, machines and services.
- To reduce loss due to reduction in productivity due to loss of man hours & equipment failure etc.
- To discharge social commitment of responsible industry.

Operating conditions of an electricity distribution & supply undertaking pose a larger scope for accidents. Electricity is a loyal servant but never

excuses. If used carelessly, electricity can burn, shock or even kill. Electricity must be treated with respect. Safety precautions are necessary when working with or near electricity so as to significantly reduce the risk of electrical injury to self and others. Looking into the risks and dangers arising from dealing with installation, maintenance or use of electricity, various safety related provisions are enacted & regulations are made. Statutory safety related provisions in the Electricity Act' 2003 & CEA Regulations- 2010 are as under.

2. 2 Electricity Act' 2003: (Sections related to safety)

53. (1) The Authority may in consultation with the State Government, specify suitable measures for –

(a) protecting the public (including the persons engaged in the generation, transmission or distribution or trading) from dangers arising from the generation, transmission or distribution or trading of electricity, or use of electricity supplied or installation, maintenance or use of any electric line or electrical plant;

(b) Eliminating or reducing the risks of personal injury to any person, or damage to property of any person or interference with use of such property;

(c) Prohibiting the supply or transmission of electricity except by means of a system which conforms to the specification as may be specified;

(d) Giving notice in the specified form to the Appropriate Commission and the Electrical Inspector, of accidents and failures of supplies or transmissions of electricity;

(e) Keeping by a generating company or licensee the maps plans and sections relating to supply or transmission of electricity;

(f) Inspection of maps, plans and sections by any person authorized by it or by Electrical Inspector or by any person on payment of specified fee;

(g) specifying action to be taken in relation to any electric line or electrical plant, or any electrical appliance under the control of a consumer for the purpose of eliminating or reducing a risk of personal injury or damage to property or interference with its use;

67 (2) The Appropriate Government may, by rules made by it in this behalf, specify, -

(j) the procedure for fencing, guarding, lighting and other safety measures relating to works on streets, railways, tramways, sewers, drains or tunnels and immediate reinstatement thereof;

73. The Authority shall perform such functions and duties as the Central Government may prescribe or direct, and in particular to –

(c) Specify the safety requirements for construction, operation and maintenance of electrical plants and electric lines;

161. (1) If any accident occurs in connection with the generation, transmission, distribution, supply or use of electricity in or in connection with, any part of the electric lines or electrical plant of any person and the accident results or is likely to have resulted in loss of human or animal life or in any injury to a human being or an animal, such person shall give notice of the occurrence and of any such loss or injury actually caused by the accident, in such form and within such time as may be prescribed, to the Electrical Inspector or such other person as

aforesaid and to such other authorities as the Appropriate Government may by general or special order, direct.

(2) The Appropriate Government may, if it thinks fit, require any Electrical Inspector, or any other person appointed by it in this behalf, to inquire and report-

(a) as to the cause of any accident affecting the safety of the public, which may have been occasioned by or in connection with, the generation, transmission, distribution, supply or use of electricity, or (b) as to the manner in, and extent to, which the provisions of this Act or rules and regulations made there under or of any license, so far as those provisions affect the safety of any person, have been complied with.

(3) Every Electrical Inspector or other person holding an inquiry under sub-section (2) shall have all the powers of a civil court under the Code of Civil Procedure, 1908 for the purpose of enforcing the attendance of witnesses and compelling the production of documents and material objects, and every person required by an Electrical Inspector be legally bound to do so within the meaning of section 176 of the Indian Penal Code.

2.2. 1 CEA (Grid Standards) Regulations, 2010:

Safety related regulations in Grid Standards are:

Regulation 19 – Safety:

(a) CEA (Supply and Safety) Regulations, 2006 shall be complied with.

(b) Contingency procedures shall be prepared and kept handy for use of operators at each sub-station and switchyard.

(c) All staff members shall be trained in safety procedures at regular intervals. The entities shall require their personnel to follow the safety rules during operation and maintenance.

(d) Safety Rules shall be displayed prominently.

(e) The firefighting equipment shall be made available at all substations, switchyards and converter stations and shall be checked periodically for its upkeep. Mock exercises in fire fighting shall be carried out periodically.

20. Maintenance of Tools and Equipment.- The maintenance staff of the transmission licensee must be made aware of the list of tools, devices and equipment for various maintenance and rectification works on transmission lines, sub-stations and converter stations. The tools must be readily available and certified for usage.

2.2. 2 CEA (Measures relating to Safety & Electricity Supply) Regulations, 2010:

As per section 53 (1) of Indian Electricity Act' 2003, CEA has the authority to specify suitable measures for provisions relating to safety and electricity supply.

As per section 185 (c) of the Indian Electricity Act' 2003, Indian Electricity Rules, 1956 made under section 37 of the Indian Electricity Act, 1910 as it stood before such repeal shall continue to be in force till the regulations under section 53 of this Act are made.

CEA has powers to make regulations regarding suitable measures relating to safety and electric supply under section 53 as per power delegated vide section 177 (1) (g) IE Act' 2003. Accordingly CEA has made these regulations viz. "CEA (Measures relating to safety & Electricity Supply) Regulations, 2010" under section 177 of IE Act' 2003**.**

Therefore, the Indian Electricity Rules, 1956 stand repealed with the making of these regulations.

Relevant safety related provisions in this regulation are:

Regulation 3 - Designated person(s) to operate and carry out the work on electrical lines and apparatus.

Regulation 12 - General safety requirements pertaining to construction, Installation. Protection, operation and maintenance of electric supply lines and apparatus.

Regulation 13 - Service lines and apparatus on consumer's premises.

Regulation 14 - Switchgear on consumer's premises.

Regulation 15 - Identification of earthed and earthed neutral conductors and position- of switches and switchgear therein.

Regulation 17 - Accessibility of bare conductors.

Regulation 18 - Danger Notices.

Regulation 19 - Handling of electric supply lines and apparatus.

Regulation 20 - Supply to vehicles and cranes.

Regulation 21 - Cables for portable or transportable apparatus.

Regulation 22 - Cables-protected by bituminous materials.

Regulation 23 - Street boxes.

Regulation 24 - Distinction of different circuits.

Regulation 25 - Distinction of the Installations having more than one feed.

Regulation 26 - Accidental charging.

Regulation 27 - Provisions applicable to protective equipment.

Regulation 28 - Display of instructions for resuscitation of persons suffering from electric shock.

Regulation 29 - Precautions to be adopted by consumers, owners, - occupiers, - electrical contractors, electrical workmen and suppliers

Regulation 30 - Periodical inspection aid testing of installations.

Regulation 31 - Testing of consumer's installation:

Regulation 32 - Installation and testing of generating units.

Regulation 39 (2)- The supplier shall take all reasonable precautions to avoid any accidental interruptions of supply, and also to avoid danger to the public or to, any employee or designated person when engaged on any operation during and in connection with the installation, extension, replacement, repair and maintenance of any works.

IS and other standards to be followed:

Beside above regulations, the following code of practice as per IS & Standards shall be referred for construction, operation & maintenance of lines / sub-stations.

1) Code of practice for Earthing (IS3043 – 1966)

2) Code of practice for installation & maintenance of transformer (IS1886 – 1961)

3) Code of practice for selection, installation and maintenance of transformers (IS10028 part-III – 1981)

4) Specification of insulating oil for transformers and switchgear (IS335 – 1963)

5) Code of practice for maintenance of insulating oil (IS1866 – 1961)

6) Guide for safety procedure and practices in electrical work (IS 5216 – 1969)

7) R.E.C. safety manual 3/1974

8) R.E.C. specifications and construction standards 1/1971 & 1981

9) R.E.C. manual 6/1976 installation & maintenance manual for 33/11 KV sub-station.

10) R.E.C. manual 7/1975 maintenance manual for 33 KV, 11 KV lines, medium & low voltage lines.

11) R.E.C. manual 10/1976 manual for design of 33/11 KV sub-stations for rural electrification system.

2.2. 3 Do's and Don'ts (Ref IS: 5216 (Part II) – 1982

General safety precautions:

Sr No	Do's	Don'ts
1	Preach and practice safety at all times. Good work can be spoiled by an accident	Do not wear loose clothing, metal watch straps, bangles or finger rings while working on electrical appliances. Do not hang clothes and other such

Sr No	Do's	Don'ts
		things on electrical fittings
2	Work carefully. Haste causes many accidents. Be sure of what you are doing	Do not use a ladder without a lashing rope, otherwise the ladder should be held firmly by another person.
3	Examine before use of safety devices such as mats, rubber gloves, ladders, insulated pliers for their soundness	Do not work on a pole or other elevated positions if there is a live part on it without a safety belt and rubber gloves unless a competent person stands on the ground nearby to direct operations and give warning.
4	Always add acid or soda to water and not vice versa	Do not go carelessly near running belts and machines
5	Always report immediately to the person in charge any dangerous condition or practice observed	Do not remove danger notice plates or other signs or interfere with safety barriers or go beyond them
6	Always be cautious while lifting or removing a heavy apparatus or material	Do not bring a naked light near a battery. Smoking in a battery room is prohibited.
7	Warn others when they seem to be in danger near a live conductor or	Do not allow visitors and unauthorized persons to touch or handle electrical apparatus or come within the danger

Sr No	Do's	Don'ts
	apparatus	zone of high voltage apparatus
8	Always be careful and take no chance against any possible accident	Do not enter excavations which give obnoxious smell or work in badly lit, ventilated or congested areas
9	Attend at once to all injuries however slight they may be	Do not touch a circuit with bare fingers or hand or other makeshift devices to determine whether or not it is alive.

2. 3 CEA (Safety Requirements for Construction, Operation & Maintenance of Electric Plants & Electric Lines) Regulations, 2011:

Salient features of this regulation are:

1) Regulation 4 - Safety provisions related to the owner:
   i. Safety to be made an integral part of the work process to ensure safety for employees including employees of contractor, sub-contractor as well as public
   ii. ISO-18001 certification to be obtained for all existing & under construction electrical plants & lines
   iii. To set up sound & scientific safety management system
2) Regulation 5 - "Safety Manual" complying with the statutory requirements & manufacturers recommendations is to be prepared by the owner. Minimum contents of the Safety Manual are also provided
3) Regulation 6 - Safety Officer & Safety Committee is to be appointed by the owner
4) Regulation 7- Safety provisions related to contractor

5) Regulation 8 - Reporting of accidents
6) Regulation 9 - Emergency Management Planning
7) Regulation 10 - Medical facilities to be provided
8) Regulation11 -Safety & training awareness

2. 4 Accident prevention Methods:

General observations on accidents:

1) Accidents are caused they do not happen.
2) If proper attention is given to the safety aspects and the laid down procedure, majority accidents and consequential damages to the personnel and property can be avoided.
3) Safety is studied at the start of training and forgotten subsequently.
4) Safe work practices have not been accepted to be a force habit.
5) Laxity on the part of personnel actually engaged in the work.
6) Not following safety instructions.
7) Complacent approach of supervisory personnel.
8) Non availability and improper maintenance of safety gadgets.

Causes of accidents:

1) Snapping of Conductors.
2) Accidental contact with live electric wire / equipment.
3) Violation / neglect of safety measures / lack of supervisions.
4) Defective appliances / apparatus / tools.
5) Inadequate / lack of maintenance.
6) Unauthorized work / Sub-standard construction.
7) Others reasons (inadequate knowledge / training of the work force, leakage of current etc.)

1) Snapping of Conductors can be attributed to:

- Ageing of conductors / insulators.
- Improper sag.
- Non-standard spans.
- Inadequate supervision during construction and monitoring thereafter.
- Inadequate maintenance.
- Non-availability of skilled manpower and tools to carry out repair works etc.

Remedial measures to avoid snapping of conductor:

a) Proper inspection during construction and before energisation followed by regular monitoring.
b) History of the line is to be built up as a data base to assess the ageing of conductors / insulators.
c) Replacement of aged conductors / insulators wherever warranted.
d) Maintaining the standard spans and proper stringing

2) Reasons for accidental contact with live electric wire / equipment:

a) This is one of the most common reasons for accident with the employees / operating staff of the utilities.
b) Operating staff not properly skilled / trained.
c) Similarly, the work is not being supervised by qualified personnel
d) Inadequate ground clearance / operational clearance of the live parts.
e) Ignorance about the discharging line / equipment before starting of maintenance work / repair works.

f) Error in isolation of supply.
g) Non-availability of safety tools & devices (as per IE Rule 36)
h) Absence of clear instructions and supervision i.e. standard codified maintenance manuals should be prepared which will guide the maintenance personnel to follow the standard instruction including line clearance / return procedure.

3) Remedial measures to avoid violation / neglect of safety measures / lack of supervisions:

- Formulation of safety policy
- Training to the workforce
- Enforcement of safety practices
- Adequate supervision
- Fast acting protection relays / releases may be considered for distribution lines.

4) Remedial measures to avoid unauthorized work / Sub-standard construction/ defective appliance/apparatus/tools:

- Around 6 to 7% of the reported cases of accidents / fatalities (in Orissa state) are due to the reason of un-authorised work / defective appliances / apparatus etc
- Unauthorized work should be checked in accordance with the various available legal / mandatory provisions.
- Scrupulous follow up of various quality control orders of Govt. may help in reducing the large number of accidents caused by sub-standard appliances / equipment.
- The owners of the installation should provide approved type of safety tools and protective equipment to operating staff / workmen and ensure use of safety devices.

General precautions to be taken:

1) Consider safety aspects during planning of work
2) Explain the area which is safe to work & ensure that entire team has understood the same
3) Restrict entry of unauthorized persons
4) Nominate one among the team exclusively for close watch during the work
5) Only authorized work men should be allowed to climb the pole, structure, work on line
6) Work on live line should be done with due permission from the competent authority and under the supervision of a qualified officer.
7) Before switching on any equipment, check that equipment is in perfect working order and t is properly earthed.
8) Use rubber hand gloves, rubber boots, aprons, safety helmets etc while operating circuit breaker, GOD etc
9) Do not bring food or snacks into the working area like control room, switch yard etc.
10) Use proper pulley block & rope slings for lifting and removing heavy loads since incorrect and careless handling can cause accidents.
11) Position in correct and stable posture while working
12) Live wire should never be exposed
13) Use correct size and quality of fuse wire
14) Do not use sub-standard material
15) Always ensure that all blades of GOD are operated
16) In case of Ht UG cable, before starting the work ensure that the cable is discharged
17) In case of cable loop system, the cable shall be identified with source and destination
18) Ensure that fire extinguishers are in good condition
19) Fire extinguishers shall have marking for the specific class of fires

20) Do not avoid using PTW system

2. 5 Safety Practices:

Treatment of Electricity

Shock:

1) Act at once - delay is Fatal.
2) Death from electric shock is rarely instantaneous.
3) Heart Fibrillations (Heart Muscle Tremors) persist as long as 30 minutes af Shock. Therefore life can be saved by Immediate Artificial Respiration.
4) Send for but never wait for a Doctor.
5) Continue Artificial Respiration for four hours after apparent death.
   Release from contact :

6) Switch off current immediately or send someone to do so. Do not attemp person from contact with high voltage unless suitable articles insulated f voltage are used for this purpose. When attempting to force a person from co or medium voltage, use rubber gloves, boots, mat or insulated stick, but if available, use a loop of rope, cap or coat to drag the person free. Whatever i be dry and non conducting.
   After release :

7) Lay the victim on a dry firm surface and remove any foreign material from th the breathing. If there is no sign of breathing or restlessness start artific immediately. Do not lose any time, and if possible send for the Doctor an Check that the jaws are lifted and head tilted back so that the mouth and th Check the pulse and continue respiration till the pulse is felt. Keep the pat allow him to get the fresh air.

Permit to Work (PTW):

Permit to Work (PTW) is the most important safety system followed to minimize the risk of injury or damage when working on live electrical installation. This electrical safety procedure safeguards employees from accidently energizing any equipment or line, without them knowing that the particular system is under maintenance and that people are currently working on it. Any electrical equipment or line which are under maintenance or where some work is going on become extremely hazardous when they are turned on. People can get electrocuted causing accident should these equipment or line suddenly acquire power. Core of this safety procedure is making sure that source of power is cut off. Equipment or circuits that are de energized must be rendered inoperative and must have tags attached at all points where the equipment or circuits could be energized. Tags are provided to alert the people not to turn on the power source of these equipments for the same are currently in service.

Taking “Work Permit” from the terminal substation at each end of transmission line is an essential procedure to be completed before taking up any work on electric supply lines and apparatus. As per Regulation 5 of the CEA (Safety Requirements for Construction, Operation & Maintenance of Electric Plants & Electric Lines) Regulations, 2011, “Safety Manual” shall contain the procedure for obtaining permission to work for carrying out work on electrical installation.

On receipt of request for issue of PTW, standard procedure for isolation of plant & equipment to protect people from injury & damage to equipment is followed by the person who issues the permit. PTW specifies the nature & extent of work & conditions eg. Isolation that must be observed, places where personnel are working for a specified time. A PTW must be seen as as only one safeguard and other safeguards should be employed as appropriate.

Essential components of the Work Permit System are:

- Work Planning,
- Work Execution,
- Permit issuer's responsibilities,
- Permit taker's responsibilities.

Works Planning involves the following:

- Defining of Works scope
- Review drawings / system
- Inspection of worksite
- Identify safety precautions
- Ensure compliance with regulations
- Develop work procedure
- Assign responsibilities
- Communication procedures
- Work execution

Work Execution :

- Preparatory work
- Issue work permits
- Supervision monitoring
- Testing
- Re-Instate equipment

- Return work permit
- Handback plant / equipment

Permit issuer's responsibilities

- Inspection/Review work area
- Identifying hazards
- Defining safety precautions
- Observing principles of safe working practices
- Creating work permit conditions
- Reviewing work with permit acceptor
- Issuing work permit
- Implementing handback procedure

Permit acceptor's responsibilities

- Understanding of work procedures
- Understanding potential hazards and safety precautions
- Accepting the safe work permit
- Observing permit conditions
- Complying with handback procedure

Many accidents have occurred due to lack of Work Permit or non observance of its consigned safety measures. Sample work permit format is attached.

2. 6 Sample format of PTW:

……
……

Original/ Duplicate Permit No. ……/……

---------- Distribution Company, ----------

Permit to Work on Electrical Equipment or Line

Issued to ----------.

I hereby declare that the following electrical equipment/line is dead and isolated from all live conductors:

Caution notices have been affixed to all the controlling switches.

Details of points at which the electrical equipment is connected to earth:

Details of electrical equipment/ line which is safe to work:

All other equipment/ line are live.

Any other specific limits or instructions:

----------Date: ------/-------/-------

Time of issue: --------- Issued by

Time limit: ---------- (signature)

(Name & Designation)

(When permit is issued over phone, name/designation of the authorized person at the other end & sr. no. of permit (s) must be noted)

Serial number of permit Sending end ---------- / Receiving end ----------

---

---------- I hereby declare that all men, earthing(s) and materials under my charge have cleared the said equipment / line and the men have been warned that it is no longer safe to work on the electrical equipment specified in this permit.

Date: ------/-------/------- Returned by

Time: --------- (signature)

(Name & Designation)

I hereby declare this permit as cancelled.

Date: ------/-------/-------

Cancelled by

Note: 1) This permit after being issued by a competent person for the work to proceed is to be handed over to the authorized person in-charge of the work and retained by that person until the work is completed or stopped by the authorized person.

2) The electrical equipment mentioned herein must not be again made alive until this card has been signed and returned by the person in-charge of the work to the issuer of the permit.

2. 7 System Gadgets and PPEs (Personal Protective Equipments)

2.7. 1 Inspection and testing:

Inspection, testing and maintenance of Tools, instruments and equipment is required to be carried as a drill at regular intervals as well as before start of any work. Inadequate maintenance may lead to serious electrical accident risks. Where any doubt exists that the insulation of tools and equipment might not be adequate they should

not be used. Insulated tools and equipment must be suitable for the work and be maintained in good working order, including by regular maintenance and testing. Maintenance and inspection should be carried out according to manufacturer's instructions.

The tools that are poorly maintained, inappropriately used or not fit for purpose can cause injuries, for example:

- Electric shock and explosion if an energised cable is cut, regardless of whether by cable cutters or a hacksaw
- stripping cable can cause injuries ranging from electric shock to burns and cuts, and
- Tightening connections can cause short circuits and explosions, for example a spanner can slip and bridge two phases, resulting in burns.
- Insulating medium might conceal a mechanical defect that could cause an open circuit in a testing device.

We will now discuss the maintenance, inspection and testing carried on various safety gadgets / tools, PPEs that are used while working on electrical installations.

2.7. 2 Fire Extinguisher

Fire extinguishers are divided into four categories, based on different types of fires. Each fire extinguisher also has a numerical rating that serves as a guide for the amount of fire the extinguisher can handle. The higher is the number, the more fire-fighting power.

- **Class A** extinguishers are for ordinary combustible materials such as paper, wood, cardboard, and most plastics. The numerical rating on these types of extinguishers indicates the amount of water it holds and the amount of fire it can extinguish. Geometric symbol (green triangle)
- **Class B** fires involve flammable or combustible liquids such as gasoline, kerosene, grease and oil. The numerical rating for

class B extinguishers indicates the approximate number of square feet of fire it can extinguish. Geometric symbol (red square)

- **Class C** fires involve electrical equipment, such as appliances, wiring, circuit breakers and outlets. Never use water to extinguish class C fires - the risk of electrical shock is far too great! Class C extinguishers do not have a numerical rating. The C classification means the extinguishing agent is non-conductive. Geometric symbol (blue circle)
- **Class D** fire extinguishers are commonly found in a chemical laboratory. They are for fires that involve combustible metals, such as magnesium, titanium, potassium and sodium. These types of extinguishers also have no numerical rating, nor are they given a multi-purpose rating - they are designed for class D fires only. Geometric symbol (Yellow Decagon)

2.7. 3 Ladders, scaffolds and similar equipment

Electrocution, electrical burns and shocks and falls from ladders because of contact with electricity are the kinds of injuries and accidents that can occur when working with ladders on or around sources of electricity. Specific controls and actions are prescribed to prevent injuries and deaths while working with metal ladders.

Certain ladders, scaffolds and similar equipment may pose electrical accident risks including metallic or wire reinforced ladders and scaffolds are conductive and may create an electric shock path, for example:

- A ladder slipping while work is being carried out on it causes the worker on the ladder to touch exposed energised parts, for example grabbing a mains box
- a gust of wind blowing an extension ladder into nearby overhead power lines

- in switch rooms and switchyards—conductive devices such as aluminium ladders and scaffolds creating electric shock paths and current paths to earth, for example a metal wire reinforced ladder causing a fault to ground if the ladder touches a live 33 kV bus bar
- when using ladders, scaffolds and similar equipment, workers are more likely to touch open wiring such as overhead lines
- in cases where lines are carrying large currents conductive scaffolds may become subject to induction, and
- Portable scaffolds may damaging insulation when moved if the scaffold strikes conductors or leads.

This means that metallic, wire reinforced or otherwise conductive ladders should not be used in close proximity to equipment where they may contact electrical conductors or where an electrical accident may result from their use. These types of ladders should be avoided for any kind of electrical work.

Other effective risk control measures may include:

- Identifying if there are exposed energised parts nearby. In this situation, risk control measures such as de-energising, fitting covers, using a safety observer, or a combination of these, should be considered
- Employing safe work practices including:
    - two or more people carrying long devices in switchyards and switch rooms in a position below shoulder height
    - two people handling extension ladders in windy conditions, and
    - restraining ladders using head ropes or footropes, or both
- If conductive scaffolding is used within high voltage enclosures or in situations where there is induction, bonding the structure to the earthing system. Depending on the construction of the scaffold, a number of sections may need to be bonded to ensure an equipotential state.

2.7. 4 Insulating barriers and insulating mats:

Insulated barriers should be of suitable material to effectively isolate electrical workers from adjacent energised equipment. Insulated covers and mats should be visually inspected for possible defects before and after each use.

2.7. 1 Test instruments and training of workers for utilization:

The tools, testing equipment and PPE for testing and fault finding must be suitable for the work, properly tested and maintained in good working order.

Workers must be appropriately trained and competent in test procedures and in the use of testing instruments and equipment including:

- Being able to use the device safely and in the manner for which it was intended
- Being able to determine, by inspection, that the device is safe for use, for example the device is not damaged and is fit for purpose
- Being aware of the electrical safety implications for others when the device is being used, for example whether the device causes the electric potential of the earthing system to rise to a electrical accident level, and
- Knowing what to do to ensure electrical safety when an inconclusive or incorrect result is obtained.

Test probes and other equipment should be designed and selected so that they cannot inadvertently short circuit between live conductors or live conductors and earth. The terminals of test equipment should be shrouded and all other test sockets on measuring instruments should be designed as to prevent inadvertent contact with any live test socket

or conductor when equipment is in use. Where appropriate, test leads and testing devices need to be provided with suitable fuse protection. Testing equipment, where used in electrical accident prone flammable areas, should be designed and clearly marked as being suitable for use in these conditions.

Testing equipment used for detecting an energised source should be trialled first to prove that it is functioning correctly immediately before and after the test has taken place.

2. 8 Personal protective equipment (PPE):

PPE for electrical work including testing and fault finding must be suitable for the work, properly tested and maintained in good working order.

Training must be provided in how to select and fit the correct type of equipment, as well as training on the use and care of the equipment so that it works effectively.

Depending on the type of work and the risks involved, the following PPE should be considered:

- Eye Protection—metal spectacle frames should not be worn.
- Hand Gloves—use gloves insulated to the highest potential voltage expected for the work being undertaken. Leather work gloves may be considered for de-energised electrical work.
- Clothing—Cotton clothing is recommended. Use non-synthetic, of non-fusible material and flame resistant clothing. Clothing made from conductive material or containing metal threads should not be worn.
- Footwear—use non-conductive footwear for example steel toe capped boots or shoes manufactured to a suitable standard.

- Safety Belt/Harness—safety belts and harnesses should be checked and inspected each time before use with particular attention being paid to buckles, rings, hooks, clips and webbing.
- No metallic rings in the fingers or chain in the neck or such other metallic ornament be wore by the worker while working with electric lines

Tool safety tips:

- Use gloves and appropriate footwear
- Store in dry place when not using
- Don't use in wet/damp conditions
- Keep working areas well lit
- Ensure not a tripping hazard
- Don't carry a tool by the cord
- Don't yank the cord to disconnect it
- Keep cords away from heat, oil, & sharp edges
- Disconnect when not in use and when changing accessories such as blades & bits
- Remove damaged tools from use
- Proper foot protection (not tennis shoes)
- Rubber insulating gloves, hoods, sleeves, matting, and blankets
- Hard hat (insulated - nonconductive)

We may conclude by exhibiting a typical "Safety code instructions to employers and supervisors of "Electrical work".

Safety means prevention of loss of life & property, avoiding accidents & free from danger. In order to improve the safety to avoid accidents, all of us should follow the following points.

1. Attitude to achieve safety.
2. Proper use of safety devices.
3. Proper training for all
4. Proper up keeping of safety tools
5. Constant improvement upon the safe working practice
6. Analyze the cause of accidents & prevent reoccurrence

Employers Responsibility to improve Safety:-

The establishment & maintenance of the possible conditions of work is the responsibility of the management.

1. To allocate sufficient resources to provide & maintain safe & healthy working environment conditions of work.

2. To ensure that all adequate safety instructions are given to all employees.

3. To educate employees about materials equipment or processes used in their work.

4. To provide appropriate facilities for First aid.

5. To ensure regular safety & inspection by an authorized competent person.

6. To coordinate the activities of the company & of its contractors working under the Company premises for implementations & maintenance of safe systems of work at all times.

Responsibility of the Executives in Preventing Accidents:-

1. To ensure clear instructions to staffs regarding observations of safety rules

2. Ensure proper use of safety rules.

3. Ensure deployment of suitable staff to carry out work (Construction or maintenance).

4. Ensure availability of required safety devices to workers/staffs.

5. Do not allow workmen to work under Alcoholic influence.

6. Issue a proper PTW & prevent the possibility of back feed by proper isolation & earthing when to work on electrical lines & Sub stations.

2. 9 Procedures To Be Followed Before Working On Electrical Line Or Equipment:-

All electrical circuits are to be treated active & no work is to be carried out on any part of Electrical apparatus or circuits unless such parts are:-

1. Proper identification of real equipment /line where work is to be carried out

2. Switch off.

3. Isolated & all practicable steps taken to lock off from the live conductors.

4. Proved dead by means of approved apparatus (i.e voltage testers.)

5. Danger notice barriers, screens shall be fixed or removed under the supervision of an authorized person.

6. Released for work by issue of a permit to work (PTW).

7. Checked for de-energisation.

On completion of work for return of the PTW, the procedures for energizing the line or equipment should be the vice versa of the above statement of PTW issue.

Chapter 3

Accident prevention techniques and reporting procedures.

3. Accident Prevention Techniques and Reporting procedures

3. 1 Accident recording and reporting system

From a health and safety perspective the *primary* purpose of an accident investigation is to identify the causes of an accident in order to suggest remedial action which will prevent a recurrence. This will often involve looking beyond the immediate, or direct, cause to the underlying, or root, causes. Only when all of these have been identified and tackled, can we claim to have taken effective action.

Agreements can be entered into which contain requirements relating to accident investigation and reporting. This is often the case between clients and contractors and between clients and suppliers.

The term "accident" is defined as: "any undesired circumstances which give rise to ill health or injury; damage to property, plant, products or the environment; production losses, or increased liabilities".

The related term "incident" includes undesired circumstances and near misses with the potential to cause accidents. The key term here being "potential", it is particularly important to investigate incidents which had the potential to cause severe harm even if the actual harm caused was trivial.

An injury-accident involves personal injury and may also involve property damage.

A non-injury accident involves property damage but no personal injury.

3. 2 Proactive and reactive strategies:

Proactive (sometimes termed Active) monitoring provides feedback on safety performance within an organization *before* an accident, case of ill-health or an incident. It involves measuring compliance with the performance standards that have been set and achievement of the specific objectives laid down.

The primary purpose of Proactive monitoring is to measure success and to reinforce positive achievements in order to nurture a positive safety culture. It is not intended as a means of identifying and punishing failure. Proactive strategies are built upon Proactive monitoring techniques.

Reactive monitoring measures accidents, cases of ill-health and incidents. The idea being to identify the causes of these failures and to take remedial action which will prevent them occurring again. Whereas information is easier to obtain from serious accidents, it is less easy to

obtain from incidents (near misses or "near hits" which could have led to an accident but, fortunately, did not in this particular case).

Employees are often under pressure of work and do not realise the importance of filling in yet another form. If the safety culture is negative, staff become defensive and adopts the attitude of not reporting anything which may reflect badly upon them. Particularly if safety performance is part of the objectives upon which they are appraised. Only in a positive safety culture, which does not seek out people to blame for organizational failures, where staff members appreciate the importance of incident reports, will adequate information be gained.

It is worth remembering that utilising "near miss" information, in order to take action to prevent a serious accident occurring, is still part of a Reactive strategy. Even though an accident has not occurred, an incident has and you are reacting towards it. Such incidents are often referred to as “preventative opportunities”. This ratio between near misses and accidents often becomes obvious during accident investigations. While interviewing witnesses to an accident, it becomes apparent that similar events have frequently happened before. Only, in the past, fortune has smiled upon the participant and prevented a serious injury from occurring. Reactive strategies incorporate various monitoring techniques for accidents, cases of ill-health and near misses.

Organizations need to combine Proactive and Reactive techniques into an integrated system for investigating, monitoring and responding to changing situations. The following approach is suggested.

Proactive monitoring aims to ensure that:

- Inspections and reports are of adequate quality;
- Common problems / weaknesses are identified;
- Training needs are met;
- Deficiencies previously reported are rectified;
- Resource implications are recognised;
- Risk assessments remain valid

Whereas, Reactive monitoring deals with:

- Details of any injured people, including their names, age, sex, job title etc;
- Descriptions of the circumstances, including date, place, time and conditions;
- Details of events, including the direct causes of any injury, ill health or other loss and any underlying causes, for example failures in management control;
- Details of the outcomes, ie nature of injury, damage to property and other losses;
- Details of remedial actions, both immediate and longer term.

What makes a technique Proactive or Reactive is the purpose to which it is put.

That is: either to investigate dangerous situations, with a view to putting them right before an accident occurs; or to investigate accidents that have already occurred with a view to determining their causes and preventing a recurrence. However, some of the following techniques tend to be naturally Proactive or Reactive.

- Safety Survey / tour: Site or workplace visit to make general observations
- Safety Inspection: These are undertaken against set objectives to ensure that hazards are controlled within acceptable risk levels by maintaining established safety standards
- Safety audits: Serves to inform the Organisation as to how well it is performing with regard to safety plan / procedure set
- Check lists: A questionnaire with focused attention on possible risks and how they should be identified and controlled
- Safety sampling: Gives snapshot of safety in a particular area. All hazards spotted are jotted down for actions. This activity may generate safety survey / tour.
- More detailed methods

3. 3 Cause of Accident :

Accidents don't happen they are caused. If accidents were, in fact, uncaused, then the whole purpose of accident prevention would be defeated. However accidents are caused and often have far more than one cause.

A useful technique in analyzing the causes of accidents in order that suggestions can be made to deal with both the direct causes and the underlying, or root, causes, is the multi-causal analysis, or tree-diagram. Careful use of this technique can lead to identification of direct causes, indirect causes and underlying factors which contribute to the accident. A good approach to identifying these underlying factors is to use the technique known as ***MEEP***. This involves identifying underlying factors relating to:

- **M**aterials involved;
- **E**quipment being used;
- **E**nvironment being worked in; and
- **P**eople involved.

The multi-causal approach has the advantages of being open-ended so that a wide range of action can be recommended. Remember, if you only make recommendations to deal with the immediate, or direct, causes, it is unlikely that you will prevent a similar accident happening again. All you have done is to take “firefighting” action in order to gain the time to carry out a thorough investigation.

3.3. 1 Accident Statistics:

Accident statistics are an important way of determining trends within an organization and of benchmarking the safety performance of an organization in relation to the national average for a comparative industrial sector. Trends are more important indicators of health and safety performance then individual accident.

3. 4 Accident reporting:

Employers are placed under certain specific duties with regard to the reporting of accidents. In order to fulfill these obligations, managers and supervisors may be allocated certain roles and functions. Accident records should contain the following information:

- The date and time of the incident.
- The full name and address of the person(s) affected.
- The person completing the entry if different from above.

- The occupation of the person(s) affected.
- The nature of the injury or condition.
- The place where the accident or incident occurred.
- A brief but clear description of the circumstances.

The date and method of reporting events to the enforcing authority, e.g. by telephone, must also be kept. The accident book must be retained for at least three years from the last date of entry.

The following steps should take place following an accident or incident:

- Obtain treatment for any injury.
- Make the area safe following the incident, except where the accident results in a major injury, in which case the scene should be left undisturbed until advised otherwise by the enforcing authority.
- Enter details in the accident book.
- Inform the injured person's manager, or other responsible person.
- Keep informed of any after-effects of the incident, including periods of total or partial incapacity for work.
- Carry out an accident investigation with the primary purpose of identifying the causes in order to suggest remedial action in order to prevent a recurrence.
- Review existing workplace risk assessments and safe systems of work bearing in mind the accident investigation results.

Along with meeting legal requirements, the information gained can be used as the focus for accident investigation, as a benchmark to measure improvements against and as a monitor of the effectiveness of existing control measures. Employers need also to consider the

adequacy of existing emergency procedures when investigating accidents and incidents.

3.4. 1 Accident Reporting Procedure: (Statutory provisions):

As per Section 161 of the Electricity Act, 2003, detailed provision for "Notice of accidents and enquiries" are as follows.

(1) If any accident occurs in connection with the generation, transmission, distribution, supply or use of electricity in or in connection with, any part of the electric lines or electrical plant of any person and the accident results or is likely to have resulted in loss of human or animal life or in any injury to a human being or an animal, such person shall give notice of the occurrence and of any such loss or injury actually caused by the accident, in such form and within such time as may be prescribed, to the Electrical Inspector or such other person as aforesaid and to such other authorities as the Appropriate Government may by general or special order, direct.

(2) The Appropriate Government may, if it thinks fit, require any Electrical Inspector, or any other person appointed by it in this behalf, to inquire and report-

(a) as to the cause of any accident affecting the safety of the public, which may have been occasioned by or in connection with, the generation, transmission, distribution, supply or use of electricity, or

(b) as to the manner in, and extent to, which the provisions of this Act or rules and regulations made there under or of any licence, so far as those provisions affect the safety of any person, have been complied with.

(3) Every Electrical Inspector or other person holding an inquiry under sub-section (2) shall have all the powers of a civil court under the Code

of Civil Procedure, 1908 for the purpose of enforcing the attendance of witnesses and compelling the production of documents and material objects, and every person required by an Electrical Inspector be legally bound to do so within the meaning of section 176 of the Indian Penal Code.

Further details of intimation of Accidents are specified in “The Intimation of Accidents (Form and Time of Service of Notice) Rules, 2005. As per these Rules, intimation by authorized person of generating company or licensee, not below the rank of Junior Engineer or equivalent shall send to the Inspector a telegraphic report within 24 hrs of the knowledge of occurrence of the fatal accident and a report in writing in form “A” within 48 hrs of the knowledge of occurrence of fatal and all other accidents. Where possible a telephonic message should also be given to the Inspector immediately, if the accident comes to the knowledge of the authorized officer of the generating company / licensee or other person concerned.

Some State governments have also made Electricity (intimation of accidents) Rules. Provisions of these Rules shall also be followed by the licensees.

Format of Form “A” is reproduced below.

FORM A

FORM FOR REPORTING ELECTRICAL ACCIDENTS

1. Date and time to accident.

2. Place of accident. (Village /Town, Tehsil/Thana, District and State).

3. System and voltage of supply [Whether Extra High Voltage (EHV)/High Voltage (HV)/Low Voltage (LV) Line, sub-station/generation station/ consumer's installations/service lines/other installations].

4. Designation of the officer-in-charge of the generating company/licensee in whose jurisdiction the accident occurred.

5. Name of owner/user of energy in whose premises the accident occurred.

6. Details of victim(s):

(a) Human

Sl.	Name	Father's Name	Sex of Victim	Full postal address	Approximate age	Fatal/non-fatal
1	2	3	4	5	6	7

(b) Animal

Sl.No.	Description of animal (s)	Number(s)	Name(s) of owner(s)	Address(es) of owner(s)	Fatal/Non-fatal
1	2	3	4	5	6

7. in case the victim(s) is /are employee(s) of supplier:

(a) Designation of such person(s);

(b) Brief description of the job undertaken, if any:

(c) Whether such person/persons was/were allowed to work on the job.

8. In case the victim(s) is/are employees(s) of a licensed contractor,-

(a) did the victim(s) possess any electric workmen's permit(s), supervisor's certificate of competency?

If yes, give number and date of issue and the name of issuing authority;

(b) Name and designation of the person who assigned the duties of the victim(s).

9. In case of accident in the system of the generating company/licensee, was the permit to work (PTW) taken?

10.(a) Describe fully the nature and extent of injuries, e.g., fatal/disablement (permanent or Temporary) of any portion of the body or burns or other injuries.

(b) In case of fatal accident, was the post mortem performed?

11. Detailed causes leading to the accident.

(To be given in a separate sheet annexed to this form).

12. Action taken regarding first aid, medical attendance etc. immediately after the occurrence of the accident (Give details).

13. Whether the District Magistrate and Police Station concerned have

been informed of the accident (If so, give details).

14. Steps taken to preserve the evidence in connection with the accident to extent possible.

15. Name and designation(s) of the person(s) assisting, supervising the person(s) killed or injured.

16. What safety equipments were given to or used by the person(s) who met with this accident (e.g., rubber gloves, rubber mats, safety belts and ladders etc.)?

17. Whether isolating switches and other sectionalizing devices were employed to deaden the sections for working on the same. Whether working section was earthed at the site of work.

18. Whether the work on the live lines was undertaken by authorised person(s)? If so, the name and the designation of such person(s) may be given.

19. Whether artificial resuscitation treatment was given to the person(s) who met with the electric accident. If yes, how long was it continued before its abandonment?

20. Names and designation of persons present at, and witnessed, the accident.

21. Any other information / remarks.

Place...	Signature...
Time...	Name...
Date..	Designation...
	Address of the person reporting...

3.4. 2 Investigation procedures:

The first step in any accident investigation involves the gathering of factual information. This may involve plans of the workplace, drawings of equipment and witness testimony. An investigation often adopts the following structure:

- Establishing the essential facts: what happened, how and where, in the correct time sequence.
- Uncovering the underlying causes in order to complete a multi-causation analysis, bearing in mind factors related to Materials, Equipment, Environment and People (MEEP).

Finding out the facts is not always easy. For example, a key witness may be unavailable or some interviewees may not provide accurate information. Often the person involved in the incident has a memory blank caused by the trauma preventing their short-term memory being recorded in their long-term memory. This can cause them to remember vividly up to the incident and after the incident, but the incident itself is completely forgotten. In other cases there may be obvious reasons why the incident is claimed to be forgotten! Each statement obtained needs to be charted in a clear, chronological sequence to allow comparison between statements of locations, names, times, actions, consequences and other events. Through comparison, it is often possible to identify any statements which are distorted.

The questions of "how?" and "why?" in relation to causation of an accident or incident are far more subjective issues than the essential facts. Obtaining accurate answers to why certain things happened can be much more difficult than establishing the fact that they did happen. But these answers are essential to identifying the root causes. .

The level of detail required from an investigation should be sufficient to provide a report which can be used to make significant improvements in

health and safety management to prevent recurrence of similar or related accidents or incidents.

Obviously the more severe the actual or potential consequences of the accident or incident, the more resources need to be devoted to its investigation and analysis.

3.4. 3 Effectiveness of reports:

In order to be effective, and to allow standardisation and comparison with previous reports, the following classification of the data included in the report should be adopted:

- Immediate causes.
- Contributory causes.
- Hazards.
- Risk factors.
- Nature of injury or damage.
- Part of body injured.
- Type of property damaged.
- Age group and sex of victim.
- Occupation of victim.
- Work location.
- Substances involved.
- Type of equipment involved.
- Other matters for classification.

Lessons for risk management may be learned through examining the data relating to a number of accidents and incidents. But, this can only be carried out systematically where the data in each report is classified in a similar way. Additionally, lessons from trends may be learned by comparing accident data between two or more equivalent time periods. This can assist in the measurement of safety performance and ensure that resources are directed effectively to priority areas.

Employers have five main duties to consider in connection with accidents. These are in relation to the following:

- Emergency procedures.
- Statutory recording and reporting.
- Safety representative entitlements.
- Safety monitoring and identifying the occurrence of accidents and incidents.
- Safety review and learning from accidents and incidents.

A large number of accidents are caused by unsafe acts or unsafe conditions, or by a combination of both.

Unsafe acts often relate to human factors such as competence, motivation, attitude and perception. They need to be addressed by controls such as culture, training, awareness raising, involvement, empowerment and ownership of safety problems.

Unsafe conditions often relate to physical problems such as lack of machine guarding or high levels of airborne contamination. They need to be addressed through engineering and physical controls.

Only when a safe person works in safe conditions will the potential for accidents be greatly reduced. Therefore, accident investigation needs to concentrate on both unsafe acts and unsafe conditions.

3. 5 Accident Prevention:

Accident prevention can be defined as “an integrated program, a series of co-ordinated activities, directed to the control of unsafe mechanical

conditions, and based on certain knowledge, attitudes and abilities". It aims at the removal of mechanical hazards from the environment, and unsafe acts from people, before an accident occurs. The aim being the minimisation of risk (where its elimination is not possible) and the control of any residual risk. This takes the form of an immediate approach, through direct control of employees, machines and the environment.

Although a longer term approach, aimed at changing attitude and behaviour through education and training, needs also to be considered. Accident prevention programs need to counter the following basic dangers:

- Physical hazards.
- Chemical hazards.
- Biological hazards.
- Psychological hazards.
- Ergonomic hazards.

Accident prevention tries to curb accidental behaviour which could result in a near miss, an injury or a damage accident.

In many ways, accident prevention is the other side of the coin of accident investigation. Prevention aims to prevent accidents occurring, while investigation aims to find the causes of an accident to prevent it happening again. Both approaches require a logical and systematic analysis. Primary safety measures are introduced as remedial measures designed to prevent accidental behaviour occurring, whereas secondary safety measures are remedial actions designed to prevent, or reduce, the seriousness of outcomes from an accident that does occur.

3. 6 Accident Costs:

As accident and ill-health costs often come out of a variety of budgets (recruitment, training, materials, etc.), many organisations lack a mechanism to identify the costs and to examine them systematically. Valuable resources can be drained from an organisation in this way through the operation of what is known as the “secret siphon”.

Successful managers now treat safety management as an investment rather than as an overhead. For an investment in resources over a short time period, safety standards can be raised. The cost of maintaining this standard then reduces. However; the new standard helps reduce accidents, and their associated costs, over the long term. In this way investing in health and safety management can more than pay for itself. Grasping this essential fact requires a change in perception and attitude at senior management level.

Before placing a trainee with an employer it is essential to check that they have effective accident and incident reporting and investigation systems in place. Also It is expected that they appreciate the costs of accidents to their organisation and have a positive safety management system in place.

3. 7 Electrical Accidents Summary:

From 2003 to 2007, Electrical Safety Foundation International, USA (ESFI) found that 28,401 workers died on the job. The most common accident types were transportation accidents (10,363 cases), followed by assaults and violent acts (4,130) and falls (3,950).

In contrast, worker contact with electric current in some shape or form was responsible for 1,213 fatal workplace accidents during this period. Additionally, 13,150 workers who met with non-fatal accidents were so

severely injured from these electrical contacts that their injuries required time off from work.

Worker contact with overhead power lines was by far the leading cause of on-the-job electrical deaths. In fact, 43 percent of all occupational electrical fatalities during this 5-year period can be attributed to contact with overhead power lines. However, worker contact with overhead power lines was involved in only 2 percent of nonfatal electrical accidents. This finding emphasizes the need to train employees to be aware of power lines in their work vicinity as accidents involving power lines are far more likely to kill rather than injure the worker.

Worker contact with wiring, transformers or other electrical components was the second leading category of electrical fatality. This type of accident seems to occur more often to an employee whose job routinely involves working with electrical components, such as an electrician or contractor. This category accounted for 28 percent of electrical fatalities and 37 percent of nonfatal electrical accidents.

The third leading category of electrical fatalities involves **workers coming in contact with electric current from machines, tools, appliances or light fixtures**. This type of accident occurs more often to workers whose job duties included mechanical and electrical maintenance. For example, accidental electrocution due to contact with tools and apparatus whose grounding conductors were faulty or missing would be included in this category. This accident type accounted for 18 percent of all electrical fatalities and 35 percent of nonfatal workplace electrical accidents from 2003 to 2007.

One popular misconception involves the number of electrical fatalities caused by worker contact with underground power lines. Our examination of the data found only five such fatalities over the 5-year period of 2003-2007. In contrast, 45 workers were struck and killed by

lightning during that time. An additional 27 workers died in electrical accidents whose exact circumstances could not be identified.

Chapter 4

Standard safety earthing practices.

4 Standard Safety Earthing Practices

4. 1 Standard Earthing practices

By earthing, we generally mean an electrical connection to the general mass of earth, the latter being a volume of soil/rock etc., whose dimensions are very large in comparison to the electricity system being considered.

It is worth noting that in Europe and India we tend to use the term earthing, whilst in North America, the term “grounding” is more common. The IEEE definition of grounding is:

“Ground (ground system):

A conducting connection, whether intentional or accidental, by which an electric circuit or equipment is connected to the earth or some

conducting body of relatively large extent that serves in place of the earth."

Earthing of electrical installations is primarily concerned with ensuring safety. The earthing system is normally designed to provide two safety functions.

- **Safety of Personnel** To ensure that a person who is in the vicinity of earthed facilities during a fault is not exposed to the possibility of a fatal electric shock.
- **Prevent or minimize damage to equipment** due to heavy fault currents (to provide a low impedance path to earth for currents occurring under normal and fault conditions.
- Improve reliability of supply
- The earthing system is also used as a means of achieving safe working conditions during some types of maintenance or construction. Plant which was previously energised has to be switched off and its previously live components are connected to earth before any work can commence. This allows any stored energy to be discharged safely to ground and helps prevent dangerous voltages arising on the equipment being worked on.

Most often quoted reasons for having an earthed system are:

- To provide a sufficiently low impedance to facilitate satisfactory protection operation under fault conditions.
- To ensure that living beings in the vicinity of substations are not exposed to unsafe potentials under steady state or fault conditions.
- To retain system voltages within reasonable limits under fault conditions (such as lightning, switching surges or inadvertent contact with higher voltage systems), and ensure that insulation breakdown voltages are not exceeded.
- Graded insulation can be used in power transformers.

- To limit the voltage to earth on conductive materials which enclose electrical conductors or equipment.

Less often quoted reasons include:

- To stabilize the phase to earth voltages on electricity lines under steady state conditions, e.g. by dissipating electrostatic charges which have built up due to clouds, dust, sleet, etc.
- To eliminate persistent arcing ground faults.
- To provide an alternative path for induced current and thereby minimize the electrical “noise” in cables.
- Provide an equi-potential platform on which electronic equipment can operate.

Earthing is broadly divided as:

System Earthing (Neutral Earthing)

Equipment Earthing (Safety grounding) - Bodies of equipment, transformer tank, motor body, switchgear box, operating rods of AB Switch, etc)

4. 2 Earthed systems:

An earthed system has at least one conductor or point (usually the neutral or star point) intentionally connected to earth. For reasons of cost and practicality, this connection is normally made where the three individual transformer phase windings are joined, i.e. the star point or neutral. This method is adopted if there is a need to connect line to neutral loads to the system, to prevent the neutral to earth voltage fluctuating with load. The earth connection reduces the voltage fluctuation and unbalance which would otherwise occur. Another advantage is that residual relays can be used to detect faults before they become phase to phase faults. This can reduce the actual damage

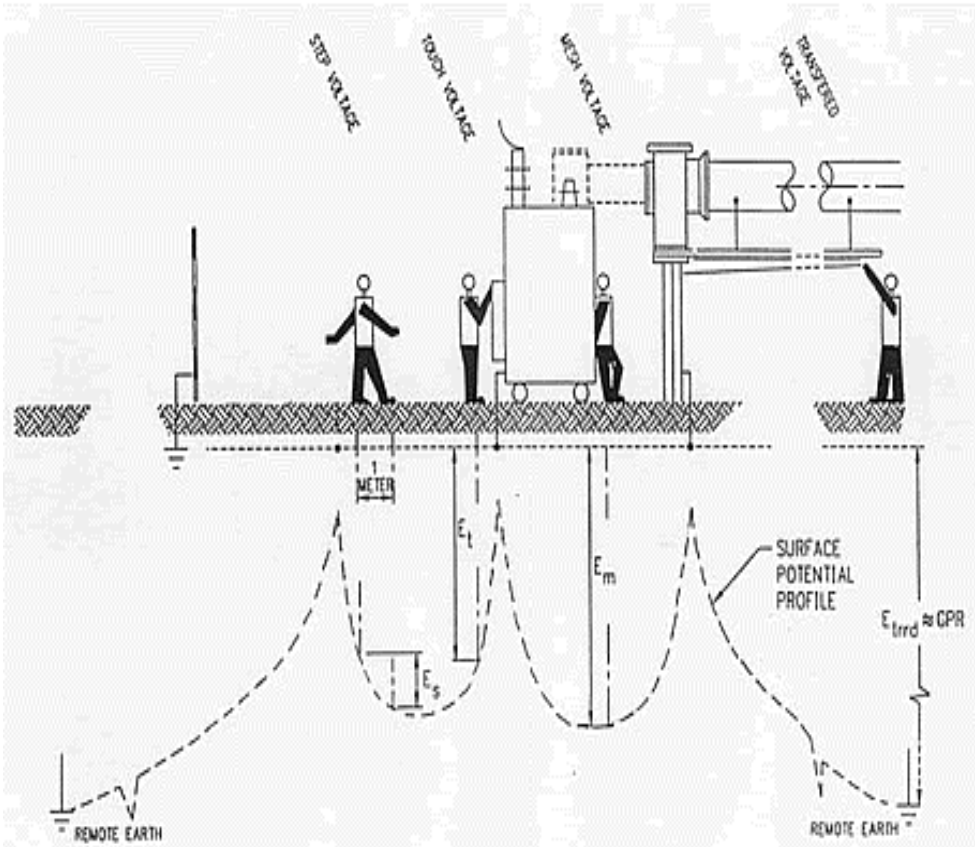
caused and the stresses imposed on other parts of the electrical network.

Guidelines have been issued under different Standards and Regulations for the Design, Installation, Testing and Maintenance of Main Earthing Systems in substations. The main items for consideration are-

4. 3 Ground potential rise (GPR):

The substation earth grid is used as an electrical connection to earth at zero potential reference. This connection, however, is not ideal due to the resistivity of the soil within which the earth grid is buried. During typical earth fault conditions, the flow of current via the grid to earth will therefore result in the grid rising in potential relative to remote earth to which other system neutrals are also connected. This produces potential gradients within and around the substation ground area as depicted in Figure below. This is defined as ground potential rise or GPR.

The GPR of a substation under earth fault conditions must be limited so that step and touch potential limits are not exceeded, and is controlled by keeping the earthing grid resistance as low as possible.



4.3. 1 Step voltage.

The difference in surface potential experienced by a person bridging a distance of one meter with the feet without contacting any other grounded object. Step voltage is caused by fault current through the earth (resistance)

4.3. 2 Touch voltage.

The difference in potential between a grounded structure or station and the surface potential at the point where a person is standing while at the same time having a hand in contact with the grounded structure or

object. Touch voltage is caused by a fault current in the earth establishing a potential difference between the feet on the earth contact point and the hand(s) in contact with substation equipment.

4.3. 3 Mesh Voltage

The mesh potential is defined as the potential difference between the centre of an earthing grid mesh and a structure earthed to the buried grid conductors. This is effectively a worst-case touch potential. For a grid consisting of equal size meshes, it is the meshes at the corner of the grid that will have the highest mesh potential.

4.3. 4 Transferred touch voltage.

It is a special case of touch voltage where a voltage is conducted toward or away from a grounded structure or station to a remote point. A transferred touch voltage (potential) can be contacted between the hands or hands and feet. Typically, the case of transferred voltage occurs when a person standing within the station area touches a conductor grounded at a remote point or a person standing at a remote point touches a conductor connected to the station grounding grid. In both cases during fault conditions, the resulting potential to ground may equal the full voltage rise of a grounding grid discharging the fault current, and not the fraction of this total voltage encountered in the "ordinary" touch contact situations.

4. 4 Maximum permitted step and touch potentials

The maximum permitted values of step and touch potentials vary widely between the different standards. The value of maximum permitted touch potential has a dominant role in determining the design of the earthing grid. As a general rule, if an earthing grid design satisfies the

requirements for safe touch potentials, it is very unlikely that the maximum permitted step potential will be exceeded.

4.4. 1 Standards and Regulations followed:

IS: 3043 – 1987 (Code of practice for Earthing)

IS: 5613 (part 1, 2, 3) Code of practice for design, installation & maintenance of O/H lines (Up to 11 KV, 11 to 220 KV & above)

IS: 2448: - 1981 (Protection of buildings and allied structures against lighting code of practice)

CEA (Measures relating to safety and electric supply) Regulations, 2010

IEEE STD 80-2000: IEEE Guide for Safety in AC Substation Grounding.

IEEE Standard 81 is the IEEE Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System.

BS 7354 - 1990: Code of practice for Design of high-voltage open-terminal stations.

4.4. 2 Design considerations:

- **The earthing conductors**, composing the grid and connections to all equipment and structures, must possess sufficient thermal capacity to pass the highest fault current for the required time. Also, the earthing conductors must have sufficient mechanical strength and corrosion resistance.
- **The earthing of metallic fences** around a substation is of vital importance because dangerous touch potentials can be involved and the fence is often accessible to the general public. Fence earthing can be accomplished in two different

ways: electrically connecting the fence to the earth grid, locating it within the grid area or alternatively just outside.

- Independently earthing the fence and locating it outside the grid area at a convenient place where the potential gradient from the grid edge is acceptably low.

4. 5 General Requirements of Earthing:

- Low value of Earth Resistance
- Acceptable surface potential gradients

Other types of earthing:

When the capabilities of certain equipment are limited, they may not withstand certain fault currents, and then the following types of earthing are resorted to limit the fault current. - -

- Resistance earthing
- Reactance earthing
- Peterson coil earthing.
- Earthing through grounding transformer.

Personal protective grounding

The primary purpose is to provide adequate protection against electrical shock causing death or injury to personnel while working on de-energized lines or equipment. This is accomplished by grounding and bonding lines and equipment to limit the body contact or exposure voltages at the worksite to a safe value if the lines or equipment are accidentally energized from any source of hazardous energy. The greatest source of hazardous energy in most cases is direct energization of lines or equipment from the power system.

Other sources of hazardous energy may include:

• stored energy (capacitors) • static build-up • faulted equipment

• Electromagnetic coupling •high-voltage testing • instrument transformer back-feed

Personal protective grounding is intended for temporary grounding during installation, maintenance, and repair or modification of lines and equipment. It is not intended to substitute for a prolonged or permanent plant or station equipment grounding connection which should be provided by permanent grounding and wiring methods.

In practice, all points in the protective grounded work area are maintained, as nearly as practical, at the same potential. This is accomplished by connecting (jumpering) all potential sources of electrical energy and conducting components with low resistance grounding jumpers to create a three-phase-to-ground short-circuit. Grounding jumpers must connected between the points of likely body contact, usually from the circuit phase conductors to grounded objects (ground grid), in a short and direct manner. The frame of the equipment is (and must be) permanently connected to the ground grid.

4. 6 Provisions under Central Electricity Authority (Measures relating to Safety and Electric Supply) Regulations, 2010.

"Earthed" or "connected with earth" means connected with the general mass of earth in such manner as to ensure at all times an immediate discharge of electricity without danger.

"Earthing system" means an electrical system in which all the conductors and appliances are earthed.

Regulation 16: Earthed terminal on consumer's premises

Regulation 41: Connection with the earth for systems at voltage normally exceeding 125 volts but not exceeding 650 volts

Regulation 42: Providing Earth leakage protected device

Regulation 48: Connection with the earth for apparatus exceeding 650 volts

Regulation 72: Earthing for overhead lines

Regulation 74: Protection against lightning

4.6. 1 Earthing arrangement for 33 KV substation as recommended by CEA:

Earthing shall be provided for:

a) Safety of personnel

b) Preventing and minimizing damage to the equipment as a result of flow of heavy fault currents.

c) Improving reliability of power supply.

Earthing shall be carried out in accordance with IS 3043 and safety regulations.

- The basic grounding system shall be in the form of an earth mat. Earth mat shall be provided within the substation area.

- MS flats shall be used for the earth mat. The earth mat shall be laid minimum 600 mm below the ground level. Risers of MS flats shall be provided near the equipment foundations for providing earth connections to equipment, steel structures etc.

- Size of the grounding conductor should be such that (i) it has thermal stability to flow the ground fault current (ii) it lasts at least for 50 years without causing break in the ground circuit due to corrosion and (iii) it is mechanically strong.

- Earth rods shall be uniformly distributed within the sub-station area and also located on the fence around the sub-station. The grounding rods shall be connected to the station earth mat.

- The earth rods shall be of mild steel of same diameter as earth conductor

- The maximum and minimum spacing requirements as per design shall be maintained.

The earthing must be designed so as to keep the earth resistance as low as possible and must not exceed the following limits:

33 kV Sub-stations	1.0Ω
Distribution Transformer Structure	5.0Ω
Tower footing resistance	10.0Ω

The resistance of the earth connection shall be maintained to such a value as to make the operation of the protective devices effective.

The step and touch potentials shall be within safe limits.

The ground potential rise shall be limited to tolerable values.

A surface layer of crushed stone shall be provided in the sub-station up to a depth of 75 cm.

Welding of ground connections may be done with extreme care.

- Neutral points of systems of different voltages, metallic enclosures, frameworks associated with current carrying equipment shall be connected to the single earthing system. All non current carrying parts shall be effectively earthed to the ground mat.

- Metallic pipes, cable tray sections, metallic stairs shall be bonded to ensure electrical continuity and connected to the earthing conductor at regular intervals.

4.6. 2 Earthing arrangement for 33/0.4 or 11/0.4 KV Distribution Transformer substation as recommended by CEA:

- Pipe earthling or rod earthing shall be provided for the distribution substation. 3 Nos. earth pits with three grounding electrodes shall be provided. Each electrode shall be GI pipe at least 2 inches in thickness and 8 feet long and buried vertically so as to leave about 4 inch pipe length above ground level. Earth connections shall be made as under :

- One direct connection from the 11kV lightning arrester and another direct and separate connection from LT lightning arrester if LT LA is provided.
  i) Transformer neutral earthing 2 Nos.
  ii) Transformer body earthing 1 no., one connection from the handle of the 11 kV Air Break switch, and channel earthing
  iii) One separate connection from the earthing terminal of pole.

- The transformer neutral earth pit shall be independent just opposite the LA earth pit. Adequate quantity of charcoal and salt shall be used to keep the earth sensitive.

- In rocky area black cotton soil shall be used to fill the earth pit.

- The value of combined earth resistance should not be more than 2 ohms.

4. 7 Soil Resistivity measurement:

An instrument termed as Earth megger (refer figure below) is used for this measurement.

Two methods are used for measurement.

Three Terminal: Two temporary electrodes spikes are driven in straight line one for current and the other for voltage at a distance of 150 feet and 75 feet from the earth electrode under test and ohmic values of earth electrode is read in the megger.

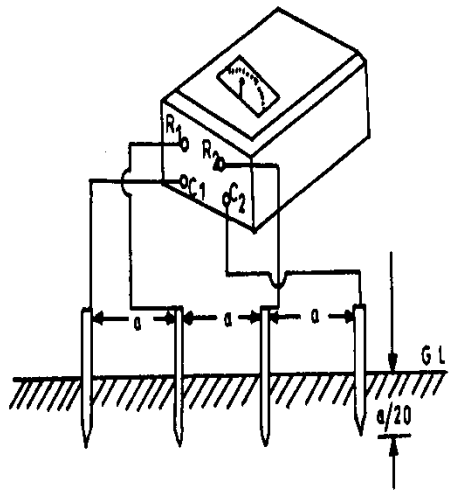
Four Terminals: Four spikes are driven in straight line into the ground at equal intervals. The two outer spikes are connected to current terminals of earth megger and the two inner spikes to potential terminals of the megger. Then the earth resistance is measured by rotating the megger till a steady value is obtained.

As per IEEE Standard 81

The four point method consists of driving four short ground rods into the soil, placed in a straight line, separated by a distance (a). The rods are only driven into the ground to a depth (b) = a /10. The test instrument induces a current (I) into the soil between the two outer rods and then measures the voltage (V) on the two inner rods. The resistance is equal to the voltage divided by the current (V/I). The instrument does the calculation. The instrument reading then has to be multiplied by 2pa to get the **average resistance.**

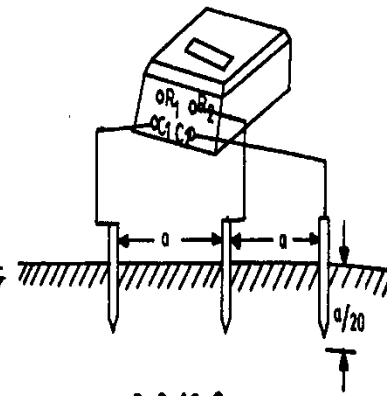
The resistance we measure with a rod separation of 2 or 4 meters is the average resistivity of the soil to the depth of 2 or 4 meters respectively.

If the 2-meter resistance and the 4-meter resistance are different, then the soil type, moisture content, and/or temperature of the top two meters of soil is different from the bottom two meters of soil.



6.6.13-3

Measurement of Earth Resistivity
(4 Point method)



6.6.13-2

Measurement of Earth Resistivity
(3 point method)

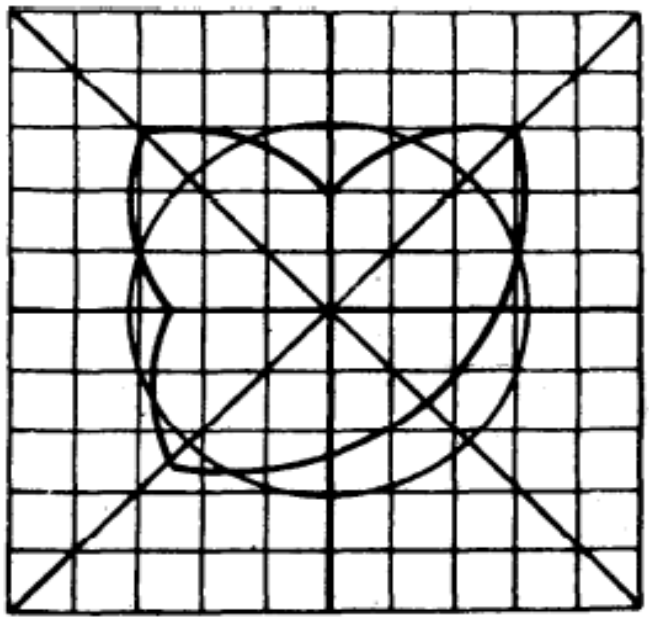
4. 8 Measurement of earth resistivity for EHV lines and substations (IS: 3043)

4.8. 1 For substations & generating stations:

Readings taken in 8 test directions from centre of station (may be more for large size areas) by gradually increasing the distance between electrodes till readings obtained are not changing appreciably

Readings are plotted to obtain polar curves area under which is measured

Circle of equivalent area is plotted; the value of radius of the circle gives average resistivity of soil which is considered for design of earthing grid



4.8. 2 For Transmission Lines

Along the direction of the line throughout the length approximately at every 4 Km distance, earth resistivity is measured with Wenner's 4 electrode method.

Typical values of soil resistivity are-

Black soil- 20 to 300 ohm-meter

Red loamy soil- 40 to 200 ohm-meter

Red sandy soil- 200 to 2000 ohm-meter

Coastal alluvium- 300 to 1300 ohm-meter

Laterite gravelly- 200 to 1000 ohm-meter

Important Definitions:

Earth Electrode is a rod, pipe, plate or an array of conductors, embedded in earth horizontally or vertically. In distribution system the earth electrode may consist of a rod of about 2 m long, driven vertically into ground. For sub-stations, an elaborate earthing system known as earth mat is used.

Earth current:_ The current dissipated by earth electrode into the ground.

Resistance of earth electrode:_ is the resistance offered by the earth electrode to the flow of current into the ground. This resistance is not the ohmic resistance of the electrode but represents the resistance of the mass of earth surrounding the earth electrode. Numerically, it is equal to the ratio of the potential of earth electrode with respect to a remote point, to the current dissipated by it.

Earthing Resistance of electrode is made up of –

- Resistance of the metal (Electrode)
- Contact resistance between electrode & soil
- Resistance of the soil from the electrode surface outwards in the geometry set up for the flow of current outward from the electrode to infinite earth
- The first two components are very small fraction of a Ohm & can be neglected

4.8. 3 Effect of Electrode Dimension and Soil Treatment on Soil Resistivity:

Pipe/ Rod/Strip has much lower resistance than plate of equal surface area

- Resistance is NOT inversely proportional to the surface area but making dimension large in one direction (say lengthwise) helps
- Change in Dia has minor effect on resistance
- Resistance rapidly diminishes in first 2 to 3 meters depth but less so beyond that (ref figure)

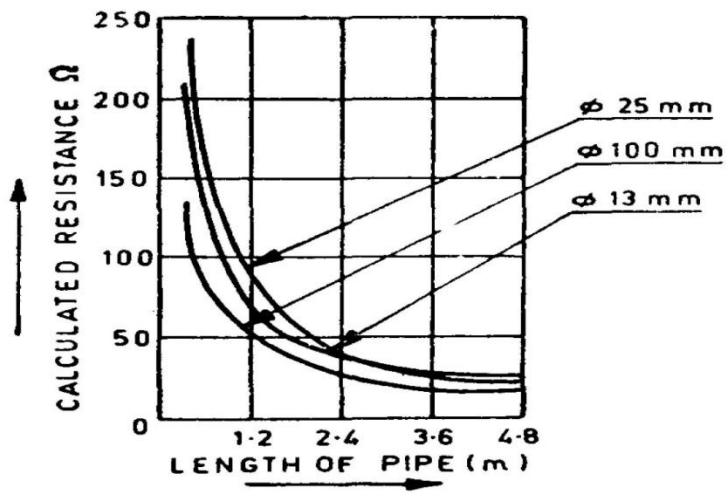


Fig. 11 Effect of Length of Pipe Electrode on Calculated Resistance for Soil Resistivity of 100 Ω m (Assumed Uniform)

- No of rods/ pipes in parallel help in reducing the effective resistance so long as the separating distance is outside resistance area of each pipe (Separating distance may be between equal to and twice the depth of burial since beyond this very little is gained
- Artificial treatment by adding salt, Na^2CO^3 & Charcoal surrounding the rod and filling since Soil resistivity is a property of soil to resists the flow of fault current from electrode to earth. It depends on moisture and salt content of the soil.

- Addition of salt and moisture to soil reduces the resistivity of soil. (Water & Salt content around 20% & 5% respectively, considered enough to get the desired soil resistivity beyond which there is no much effect. Charcoal increases water retention properties of soil.
- Electrodes packaged with 'BENTONITE' for driving in rocky soil help in increasing contact efficiency with general mass of ground

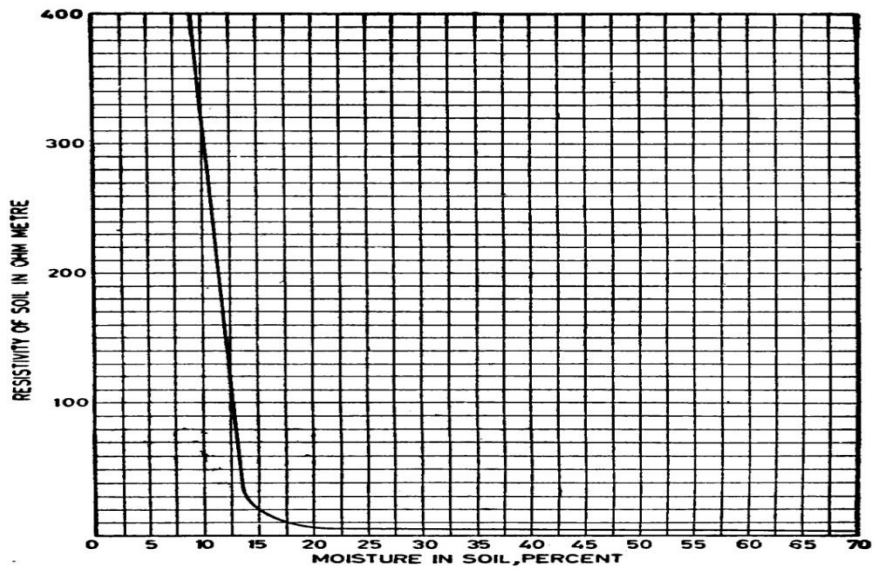


FIG. 9 VARIATION OF SOIL RESISTIVITY WITH MOISTURE CONTENT

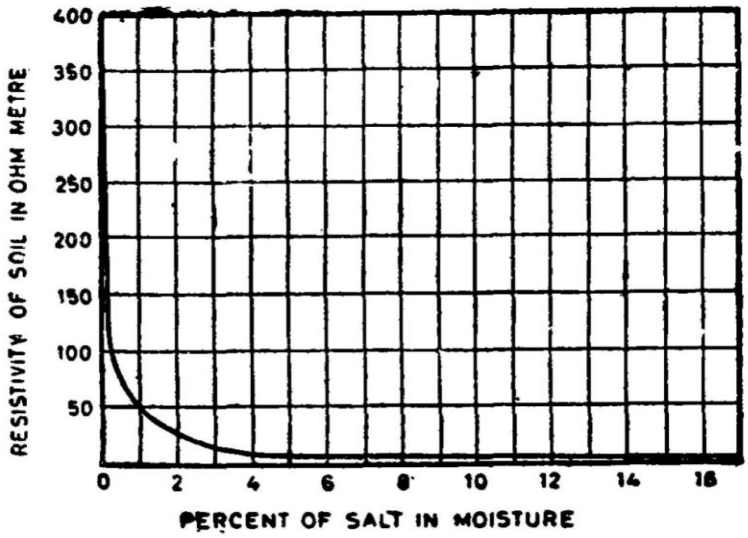


FIG. 10 VARIATION OF SOIL RESISTIVITY WITH SALT (Nacl) CONTENT, CLAY SOIL HAVING 3 PERCENT MOISTURE

Curves A1 & A2- show effect of depth of electrode on resistance in ohms.

Soil below 6 & 9 Mtrs consisted ballast, sand & gravel below which occurred London clay, so sudden fall in resistance after 9 Meters.

Curve C – is a case of a soil having Gradual reduction in resistance

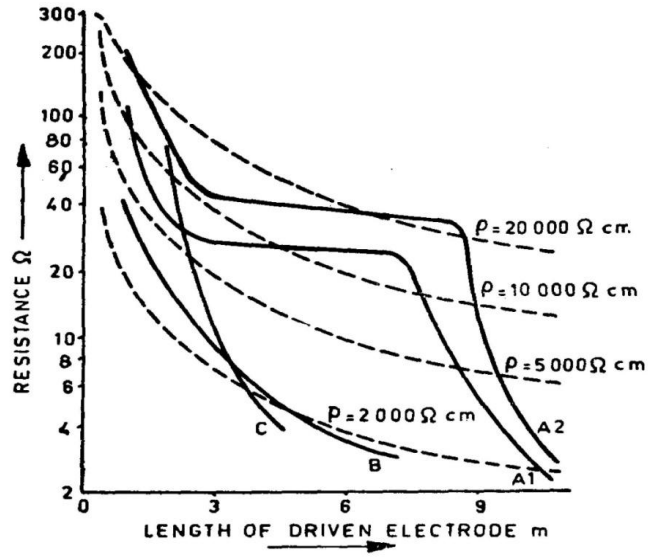


FIG. 12 CALCULATED AND EXPERIMENTAL CURVES OF RESISTANCE OF 13 mm DIA DRIVEN ELECTRODES

Recommended Earth Resistance values at different points are as below.

Power Stations	**0.5 ohms**
EHV Stations	**1 ohms**
33 KV Sub Stations	**2 ohms**
Distribution Transformer Sub Stations	**5 ohms**
Tower foot/pole resistance	**10 ohms**

Chapter 5

Power grid collapse

5. Power grid collapse.

Power system reliability is the overall objective in power system design and operation. It includes two main aspects: adequacy and security. Outages and large blackout occurred more and more frequently than before during the last 30 year which affected the normal consumption of consumers. This spotlighted our requirement to realize the complex phenomena related to power systems and the development of emergency controls and restoration In order to meet the need of the power system security, a self-healing grid is needed to monitor and response to the change within the whole network in time. Smart islanding is considered as an effective way to prevent small outages in the system from propagating into big blackout.

5. 1 Power system operation security :

With the increasing electric power demand, electric power system are operates closer to its stability limit. The operation of power system becomes more complicated and will become less secure. Power system Security can be defined as the ability of the electric systems to withstand sudden disturbances such as electric short-circuits or unanticipated loss of system element, without affecting delivering power to the customers. The objective of security analysis is to enhance the power system ability to run safely and operate economically. It relates to robustness of the system to imminent disturbances and, hence, depends on the system operating condition as well as the contingent probability of disturbances.

A power system is said to be operated in the normal state if the following conditions are met:

1. There is a perfect balance between power generation and load demand; consequently, the load flow equations are satisfied.
2. The frequency is constant throughout the system.
3. The bus voltage magnitude is within the prescribed limit.
4. No power system component is to be overloaded.

In the power system, the equipments are usually protected by automatic devices which can make the equipments quit the system immediately once it operates out of its limits. The event maybe followed by a series of further actions that cause other equipments disconnected from the system. This is called as cascading failures. If this process of cascading failures continues, then the system will suffer from blackout which means the whole network or most part of it may completely

collapse. Thus, it is not sufficient to merely maintain a system in the normal operating state. We need to specify a security for each system to withstand the disturbance under distinct conditions.

5. 2 Security criteria:

Even if we give a set of disturbances to a power system one at a time and it still can operate in the normal operating state, then the system is said to be secure. In practice, all power systems cannot avoid being affected by unpredictable faults and failures such as lightning strikes on transmission lines, mechanical failures in power plants, or fires in substations. In virtue that this nature phenomenon are unavoidable and happens relatively frequently, all power systems should be designated to withstand them without emergency. In order to avoid blackouts and wide scale consumer disconnections, the system should be operated with a sufficient margin which can be explained in terms of two elements: reserve generation and transmission capacity.
Reserve generation: Means Leaving enough reserve generation capacity in case of the loss of a generating unit.

Transmission capacity: Keeping enough transmission capacity to take up the flow that was flowing on the outage line.

We also need to know that the system is impossible to be 100% secure since a system which can be against all contingencies is obviously incredible. The fundamental principle only requires the system to defend against credible contingencies that are so called „N-1 contingency‟ as well as „N-2 contingency‟ . When the system is subjected to disturbance as losing any one of its N components and continues to operate normally, it is said to be „„N-1 secure‟ ‟ while the „„N-2 secure‟ ‟ means no consumer would be disconnected even if two components were suddenly disconnected. In engineering, the N-1

contingency secure are usually a metric for the operators to measure the security of the power system.

5. 3 System security function

Power system security may be divided into three modes.

- Steady state security which is created under the steady state condition of a power system.
- Transient security which copes with the transient state of a system when it is subjected to a disturbance.
- Dynamic security which concerns the system response of the order of few minutes

Usually security function concerns 3 major aspects

- System monitoring
- Contingency analysis
- Security constrained optimal flow.

The continuous updating information on the conditions of the power system is given to the operators through system monitoring. Based on this, some quantities such as, voltage, currents, power flows, and the status of electric equipments as circuit breakers, and switches in every substation in a power system transmission network can be measured and monitored. In addition, further information on frequency, generator unit outputs and transformer tap positions can be also gathered and transmitted back to the control center. By account of the complexity and arduousness of the task, the data will be processed by digital computers and then be arranged in a database which gives the chance for the operators to display the information on large display monitors. The computer can also identify the overload condition or voltage violations by comparing the incoming information with the given limits and remind the operators of reacting in time. In practice, supervisory control systems, a system which allow operators to control circuit

breakers and disconnect switches and transformer taps remotely, are always combined with such systems to create an new kind of systems. This is what we called SCADA (supervisory control and data acquisition) system. The SCADA system makes the real time monitoring and correction of overloads or out-of-limit voltages available. Commonly, a SCADA system is composed of three types of communication equipment: human–machine interface (HMI), master terminal unit (MTU), and the remote terminal unit (RTU). Supervisory Control and Data Acquisition System (SCADA) is a high tech computer system with associated communication network that enables supervision and control of power system network. Demand for power is increasing very fast due to continual improvement in quality of urban life style as well as expansion of industrial sector. To meet these challenges the need for a Real Time SCADA system in any modern power system utility is indispensable. The direct benefits of a modern SCADA system are:

•Constant access to Real Time picture of entire network showing power system voltage, frequency, MW, MVAR, etc.

• Supervision, monitoring and control of power in Real Time.

• Optimal operation of power system, i.e. generation and associated resources.

• Minimum of outage and faster restoration of the system in the event of Grid disturbances.

• Improvement in the quality of supply through better control of frequency, voltage and other parameters.

• Less dependence on basic telephone system.

The function of contingency analysis is aimed at dealing with the problems that happens within a short duration. Since it occurs so quickly that no operator could take action in time. This is often how the cascading failures come out. In order to refrain from this, we need to implement the contingency analysis programs into our operation computers to eliminate the troubles before they arise as much as possible.

On-line security analysis

The power system security analysis has three main goals.

1. Determination of the most probable time of contingency
2. Prediction of the impact on the whole system
3. Identification of proper control actions to reduce the risk of failures

In reality, the power system security analysis is usually performed according to N-1 contingency criteria.

5. 4 Power System Reliability:

The reliability of a power system is the ability of the system to pertain secure state when it is subjected to a set of contingencies. A more precise definition can be found in [35] , in which reliability of a power system refers to the probability of its satisfactory operation over the long run.

It denotes the ability to supply adequate electric service on a nearly continuous basis with few interruptions over an extended time period.

The reliability is composing of two aspects: security as well as adequacy.

On one hand, adequacy is the ability of systems to supply energy to their customers with satisfying the load demand. On the other hand,

security is the ability of the systems to withstand sudden disturbances such as short circuit or unanticipated loss of system elements. The two branches of reliability can be then given a new definition as security corresponds to dynamic security while adequacy concerns static security.

Comparisons of power system stability, security and reliability

Power system stability, security and reliability are three aspects that are widely used to describe the ability of systems to survive from the unexpected events which can destroy the equilibrium state of the operation. They are sometimes related to each other; however, there are still some differences among them.

Reliability is the overall objective in power system design and operation. To be reliable, the power system must be secure most of the time. To be secure, the system must be stable but must also be secure against other contingencies that would not be classified as stability problems, for instance, damage to equipment such as an explosive failure of a cable, fall of transmission towers due to ice loading or sabotage. As well, a system may be stable following a contingency, yet insecure due to post-fault system conditions resulting in equipment overloads or voltage violations.

System security may be further distinguished from stability in terms of the resulting consequences. For example, two systems may both be stable with equal stability margins, but one may be relatively more secure because the consequences of instability are less severe.

Security and stability are time-varying attributes which can be judged by studying the performance of the power system under a particular set of conditions. Reliability, on the other hand, is a function of the time-average performance of the power system; it can only be judged by

consideration of the system behavior over an appreciable period of time.

Security and reliability could be considered as the same issue sometimes, however, we can also distinguish them by adequacy. But we should not overlook such a fact that even the most reliable systems will not avoid to undertake periods of severe insecurity.

5. 5 Black start and restoration Procedure:

In an integrated power system, disturbances of major/minor nature can occur under various contingencies. Such disturbances can result in collapse of a part of the system or sometimes entire system, requiring restoration of the affected system in the minimum possible time. In order to achieve the same, it is therefore necessary to have a well laid down restoration procedure under various conditions of partial black out and /or total black out of the system.

In the event of a black out, the initial moments are extremely precious and it requires the right decision to be taken at first instance for speedy restoration of the system. Any lapse or delay in taking the right initial decision may prove to be very costly. Hence, it is of paramount importance that all the operating personnel of Load Dispatch Centers and the officials involved in grid operation should be thoroughly conversant with the restoration procedure so as to minimise the time taken in restoration of the system after partial /total black out. Further during the Restoration process the system operators, Power station and Substation personnel must act in consonance to normalize the grid.

Depending on the availability of transmission elements, generators and the type and the extent of blackout, restoration team on real time basis, should adopt the best procedure suited for the situation Based on Grid Code such restoration procedure is required to be formulated. All constituents of the grid are also advised to prepare station wise detailed

switching instructions in their control centers whenever required, so that the operators will have further clarity and restoration will be faster.

The black start procedure is required to be revised and updated, taking into consideration new generators and transmission elements included in the power system. It describes the procedures to be followed by all constituents for restoration of the grid in the shortest possible time causing no damage to plants and line and major equipments following a complete or partial collapse. The main thrust is on following items taking in to account available facilities / constraints.

- Secure generation
- Secure transmission
- Restore interconnection with neighbours
- Avoid utility plant damage
- Avoid consumer plant damage
- Restore demand
- Re parallel islands

5. 6 Black start facilities:

A list of generating stations with self start facilities is required to be prepared.

5.6. 1 Survival/Auxiliary power requirement:

Survival power can be defined as the minimum power required for avoiding the damage to the equipment in case of supply failure and keep the equipment fit for reuse immediately. Under black start failure the survival/auxiliary power would consist of the following:

- Turbine emergency oil pump
- Jacking oil pumps
- Barring gear of the turbine
- Lubricating oil pumps

- Compressors for breaker operation
- Emergency lighting
- Battery chargers communication & telemetry system.

As a general rule, the survival power requirement would be around 0.25-0.30% of the unit capacity.

Start up power requirement:

The startup power is the power required for the auxiliaries while the generating unit is restored. The requirement of startup power by various units is as follows:

Nuclear & Thermal: 7 to 8% of the unit capacity

Hydro: 0.5 to 1% of the unit capacity

Gas: 1.5 to 2%of the unit capacity

The startup power requirement for starting the thermal units is considerably high as the major auxiliaries like BFP, ID Fan, FD fan; CW pumps etc. are of bigger size and the starting torque is large. However, in case of hydro units, the requirement of start-up power is comparatively much lower because of relatively very few auxiliaries.

Synchronizing facilities at power stations/major sub-stations:

In order to build up the system, the synchronizing facilities play a very important role. The different generating stations and EHV substations having synchronizing facilities are to be identified. Generally all 400kV Stations in the region have Synchronizing facility.

Railway Traction Supply

During the time of System Restoration (Black Start) due importance is required to be given to the traction load and the supply to the grid points

feeding the Railway Traction Station is to be extended on priority. A List of Railway Traction Stations is to be kept ready.

System restoration approach:

While restoring the System the following specific points must be given due importance.

Systems with a fair dispersal of generating stations with Black Start facilities:

Those generating stations where black start facility are available should be started up and **stable islands** should be formed around these generating stations by connecting essential loads. These islands should be gradually interconnected at the earliest opportunity keeping into consideration the total load-generation balance. Care should be taken to add loads in steps keeping in view the load characteristics i.e. variation of load with respect to voltage & frequency.

Systems with limited and /or distant Black Start facility:

Providing start up power for systems which have few generating stations with black start facilities or the start up power to be imported from neighboring regions at one or two points is a challenging job. This is mainly due to the distance between the source of startup power and the generators and while extending the startup power care should be taken to control the voltages at various intermediate points. This can be achieved by providing loads and adjusting the taps of the transformers at the intermediate stations. Sufficient attention has to be given for MVAR management and line loadings to prevent secondary collapse during restoration which will extend the restoration time.

5. 7 Reactive Power Control:

During initial stages of restoration process, it is of utmost importance to keep the system voltages within the allowable limit. This can be accomplished by

- Charging the shorter line first
- Switching off capacitor bank
- Taking bus reactors into service
- Charging transformers and taking Bus reactors into service wherever available.
- Converting line reactors into Bus reactors wherever feasible.
- Operating generators at minimum voltage levels
- Changing transformer taps
- Energization of fewer high voltage lines.

Load & Generation Balance:

- Achieving load generation balance by restoring commensurate and essential loads only.
- Restoring load in small steps keeping in view the load characteristics.
- Paying special attention while restoring traction and other fluctuating loads.
- If considered essential, then by by-passing the U/F relays initially, until sufficient loads are connected & frequency stabilizes.
- Maintaining frequency close to 50 Hz.
- Keeping Generating units on FGMO

Priorities:

- Provide backup survival/start up power to nuclear units.

- Restore start up power supply to generating stations, critical sub-stations and load dispatch centers
- Formation of self sustaining Islands around the generating stations for which procedures should be laid down in advance.
- Avoid paralleling islands through weak ties.

Communication & Co-ordination:

- Ensuring reliable communication between LDC's, generating stations and major sub-stations.
- Agreed back up procedures & delegation of control in the event of failure of communication facilities.

Actions to be taken at Generating Stations and Substations:

- Each Substation/Generating Station should draw its own detailed procedure for the action to be taken in their stations during restoration
- To avoid delay in restoration ensure the proper functioning of bus couplers, synchronizing facility etc at regular intervals
- Ensure proper gas/air pressure in breakers and attend to minor leaks in time.
- Do not attempt charging the suspected element.
- Controlling high voltage during restoration to avoid damage to equipments
- In case of low battery condition during restoration (due to weak battery/long duration outage of power supply), to avoid excessive power drain, only the essential load/communication channels to be kept in service
- Detail procedure for such actions has to be prepared and kept handy by the concerned substation/generating station

Survival Power:

Ensuring availability of backup power supplies such as batteries, battery chargers, diesel sets to ensure supply to essential loads like air compressor for operation of circuit breakers, DC system for communication systems etc.

General Guidelines:

While each disturbance would be different and may require a different plan, nevertheless it would be useful to formulate general guidelines for the benefit of the load despatchers. These may be described as below:

- The operator at generating stations and sub-stations should have the knowledge of pre-identified synchronizing locations and pre laid down synchronizing procedures.
- Switching procedure should be clearly laid down and periodically reviewed.
- The transformer taps should be checked for desired setting to minimise voltage difference.
- The sub-stations operators and load despatchers should make a check of the capacitor banks and reactors in service & accordingly should carry out the switching operations for voltage control.
- Energising of high voltage lines and cables should be avoided until enough generating capacity is available.
- Provision of islanding schemes area-wise, power station wise, unit wise would enhance the ability to restore faster. These should be fully exploited.
- Start up power to nuclear plants should be extended fast as poisoning of the reactors would delay restoration of nuclear units.

- Guidelines for decision making should be clear and should be delegated to all the major sub-stations and generating stations under varied conditions.
- Imparting training & providing necessary documentation to the load despatchers

5. 8 Distributed Generation – Connection issues and new challenges

In the way the power grid is currently managed, it can be taken as given that the electric power flows from the higher voltage grid to the lower voltage grid. Increased share of distributed generation units may lead to inducing power flows from the low voltage into the medium-voltage grid. This bi-directional power flows asks for different protection schemes at both voltage levels.

Moreover, the added flexibility of DG asks for extra efforts on the grid operation side. As some customers might want to switch to the “island” mode during an outage, they should also meet the requirements for such operation mode. Next to guarantying no power supplied to the grid, they must be able to provide the ancillary services needed.

Moreover, once the distribution grid is back into operation, the DG unit must be able to be re-synchronized.

Major concern of utility grid operation in parallel with DGs is that the DGs do not operate under the direct control of utility grid. The most important operational requirement of the utility is avoiding accidental islanding of any DG site from the utility power source. According to utility, a power island thus formed may complicate the orderly reconnection of the power supply network and may present a potential hazard to the public and utility personnel. Besides, DG power supply can deviate from the required quality standards. Several guidelines have been introduced [18] in G59 to ensure that the presence of the

small DGs will not detract from the quality of supply to all customers connected to the system. Several of these guidelines include the need to provide islanding protection.

The principal objective for an islanding protection is to detect the power island condition to trip the inter-tie breaker between the power island and the utility. Thus the power island will not affect the orderly restoration of the utility supply to the rest of the network. Since the inter-tie breaker is used to connect two active systems, hence the power island can be reconnected to the utility after the network supply is established. The tripping time for the islanding protection should be critically decided such that the two systems are successfully separated first before any out-of synchronism reconnection attempt by automatic reclosure.

Currently the maximum separation time has been specified as 0.5 seconds however best target tripping time is 0.125 seconds. The fault level of DG Power Island is much less than that of conventional grid and short circuit back-up protection needs to be properly coordinated with this target tripping time. Islanding protection is quite complicated since the CB that causes the loss of connection could be any breaker or isolator connecting the main source of supply to the DG site. Besides, it is unlikely that the status of the CB is supervised or fitted with synchronism checking or live line/dead bus and live bus/dead line supervision.

Distributed generation complicates dispatching control of Electrical power system (EPS) and shifts its functions to distribution network. The problem here is highly uncertain operating conditions of the distributed generation because of uneven load of the units, lack of current information on their operation, etc. Some developments have appeared lately in which the attempts have been made to solve this problem by the distributed dispatching control system based on the Internet technologies. This gave birth to the notion of “virtual power plant” which

conditionally integrates distributed generations into one system by the distributed Internet-system of control.

Distributed generation complicates the relay protection and automatic control systems and emergency control of. With connection of distributed generation the distribution network acquires the features of the main grid, i.e. it faces the problems of stability and others. With the loss of power supply from the supply substation of the main grid it is possible to island a distributed generation unit for the load close in capacity thus providing power supply to important consumers.

5.8. 1 Impact of Blackout in day to day life:

The blackout demonstrates the central role that the electrical sector plays in any modernized, post-industrial society that relies on critical infrastructure elements and networks to underpin its social, cultural and economic fabric. When residents and consumers have to face blackouts, their ability to access banking and financial information in real time become compromised. Residents no longer can have access to media devices (including television, radio and Internet). Telecommunications companies experience difficulty receiving the requisite amount of fuel to power its backup generators, which are installed to provide electricity to the local area network cellular facilities. Without the emergency power, the coverage area of subscribers would have been severely compromised. Hospitals and emergency services have to struggle to maintain full operational capacity. Power to oil pipelines gets cut, reducing the flow to refineries and limiting the amount of available refined oil available for purchase at the limited number gas station pumps that were still operating. Commuters discover that traffic lights, railroad crossings and bridge toll booths are no longer functional. Similarly, commuters travelling by train or aircraft may be confronted with significant delays or, in many cases, cancelled transportation.

5.8. 2 Role of Utility staff:

Restoring service involves starting generation or reclosing circuit breakers and adding load in small increments, slowly piecing the system back together. For customers in small islands adjacent to an area that remains interconnected, power may be restored in a few minutes. Isolated islands will take longer, especially those that were completely blacked out.

A power system is restored by successively restarting generators, connecting transmission lines, and connecting load until significant islands of operating load and capacity are available. Then the separate portions of the system are connected to each other. In this way, the portions of the system that are operable can be completely restored and returned to as near normal operation as feasible. Restoration of an outage should begin within minutes of an outage. The length of time to restore full service depends on the design of the system, the severity of the blackout, and the components damaged.

5.8. 3 Speeding recovery:

Once the system has been stabilized, operators try to restore power as quickly as possible. Even after severe damage, power to parts of the system usually can be restored within a few hours by isolating the damage and resetting circuit breakers. Restoration to full service and reliability depends on at least temporary repair of the damage. The measures here are intended to eliminate constraints to both short term and long-term recovery.

The main focus areas could be

- Contingency planning
- Clarification of Legal and institutional framework for sharing of equipments and manpower between different Utilities

- Maintaining stock of critical equipments

5.8. 4 Information to all concerned:

Apart from actions taken to bring the power delivery system to normalcy it is necessary to inform from time to time during the blackout to all the consumers, other members of public, those in charge of emergency services (police, fire) and other Utilities (water, gas, telecommunication, etc)

A warning can be defined as the communication of information about a hazard or threat to a population at risk, in order for them to take appropriate actions to mitigate any potentially negative impacts on themselves, those in their care and their property.

The occurrence of a black out hazard does not necessarily result in a disaster while hazards cannot be avoided, their negative impacts can be mitigated. The goal of early public warning is to ensure to the greatest extent possible that the hazard does not become a disaster. Such warnings must be unambiguous, communicate the risks succinctly and provide necessary guidance.

The success of a warning can be measured by the actions that it causes people to take, such as evacuation or avoiding at-risk areas. In a disaster situation, there is no doubt that timely warnings allow people to take actions that saves lives, reduce damage to property and minimize human suffering. To facilitate an effective warning system, there is a major need for better coordination among the early warning providers as well as those handling logistics and raising awareness about disaster preparedness and management.

5.8. 5 Request for Conservation:

With the sudden loss of power and the fragility of the electrical grid foretelling the possibility of rolling blackouts, numerous requests are made to private citizens, industry and the government to curb energy consumption. The news media can consistently report that the grid system could experience another widespread blackout, rolling blackouts or brownouts if consumer demand exceeded generation capacity. The pleas for reduced consumption can largely be successful.

5.8. 6 Preparing for Extreme Contingencies

Because uncontrolled, cascading outages can be so widespread and difficult to recover from, Utilities have made special provisions to avoid them even though the circumstances leading to them are viewed as highly unlikely. In addition to planning for 'normal' contingencies, Utilities also plan for 'extreme' contingencies. The reliability criteria of the system is specified by the 'Grid code' It specifies the way in which the bulk power systems shall be planned and operated in a manner to avoid uncontrolled, area wide interruptions under certain extreme contingencies. Under extreme contingencies, substantial outages may occur, but should not extend across an entire system.

5. 9 Case Study: Present Status of Grid Operation and Management in India:

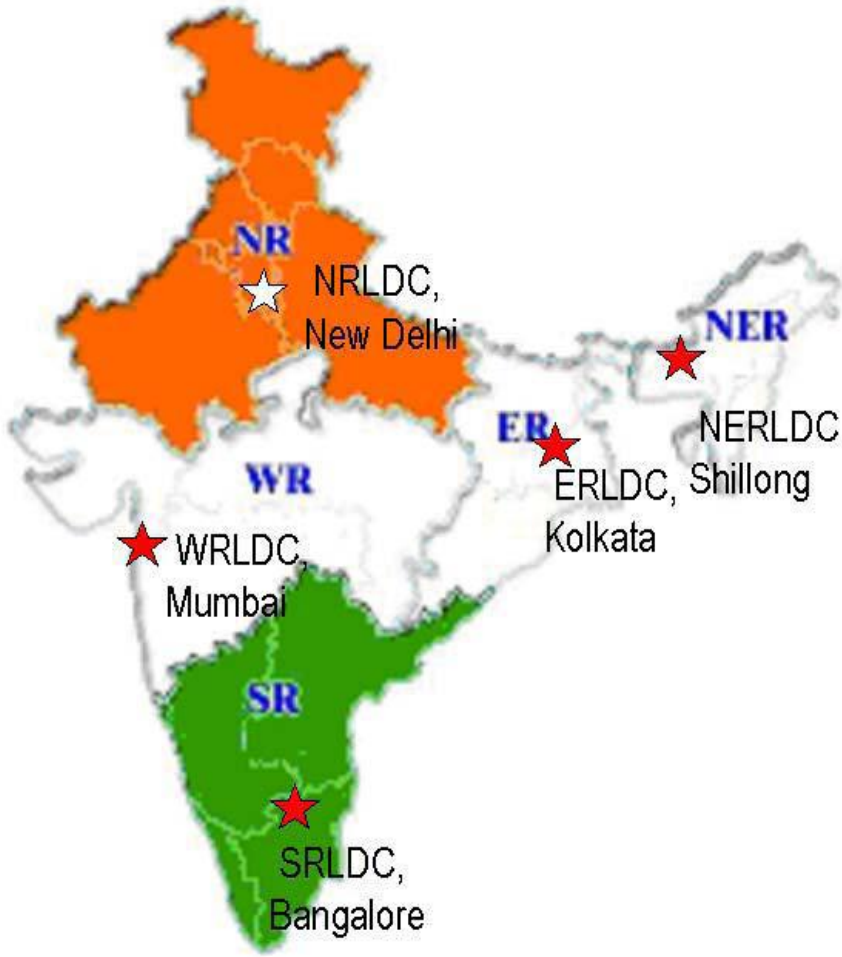
Ref: Report for Transmission & Distribution by POWERGRID

Introduction

The Indian Power sector, classically driven by technical considerations, is now subject to various market forces. This has resulted in power

systems being operated closer to the edge. Under these conditions operating and maintaining the grid within acceptable parameters is a challenge. Deficit conditions prevailing in the country are a well known fact. Stress on quality supply is increasing day by day. Here starts the role of Grid Management. Grid Management effectively means managing supply and demand to maintain frequency, voltage and stability of the network. It essentially requires taking care of the overall reliability, security, economy and efficiency of the power system.

Figure: The Five Electrical Grids in India.



In India Grid management on regional basis started in sixties. Over a period of time, State grids were inter-connected to form regional self sufficient grid. Whole of the India was demarcated into 5 regions namely Northern, Eastern, Western, North Eastern and Southern region. In order to harness the diversity in terms of time, availability of resources, seasonal crops, industrialization, the need of grid interconnection was felt.

At present out of 5 regional grids Northern, Eastern, Western and North Eastern grids are synchronously connected forming central grid operating at one frequency. The North Eastern and Eastern grids were connected in October 1991 followed by East and West grids in March 2003 and North and East grids in August 2006. Southern grid operates at different frequency and is asynchronously connected to central grid through HVDC link to facilitate the transfer of power from central grid to southern grid and vice-versa.

Load Despatch Centers

Operation of each of these regional grids is handled by the regional load dispatch centers, RLDC's. The state grids are managed and operated by state load dispatch centre (SLDC). National Load Despatch Centre (**NLDC**) is for scheduling and despatch of electricity across various regions and also coordinating cross border energy exchanges in real time. Power System Operation (PSO) in India is being coordinated through five regional and more than thirty state control centers. These control centers owned by different utilities collaborate with each other for executing their statutory responsibility of ensuring a secure, reliable, efficient and economic power system operation. Behavior of electricity deficit such a large interconnected power system gives rise to a dynamically varying system states. These states are normal, alert, emergency and restorative. The operator has to quickly asses the contingencies and maintains the system to normal state under all situations and at all time.

In order to accomplish the objectives of security and economy, Indian system operators have at their disposal a number of tools to manage the system in real time.

These tools range from Supervisory Control and Data Acquisition (SCADA) systems, sophisticated state estimators to safety schemes.

Safety Schemes

System security is achieved by making system operation tolerant of the outage of any component. Following safety net are available at present in Indian grid to achieve system security.

Under Frequency Relay (UFR) Load Shedding

Under frequency relay, rate of change of frequency load shedding and islanding schemes are strength of grid defense plans. With the increase in grid size the settings of under frequency relays and quantum of load shedding have been modified over a period of time.

Rate of change of frequency [df/dt]

With the interconnection of 4 grids the rate of change of frequency is not very steep as the inertia of grid has increased. 1st stage df/dt is at 0.1 Hz. /sec (freq. 49.9 Hz.). This has saved the integrated NEW grid at least on two occasions 1) Total loss of generation at Vidhyachal 2) Loss of generation at Korba complex (about 3000 MW).

1st stage of df/dt takes care of large contingencies even when network is integrated and plays an important protective role when the networks are islanded.

Islanding schemes

Various islanding schemes are also operational in different region for survival of smaller islands during contingencies. These islanding schemes are mostly for metro cities and sensitive nuclear generation.

Special protection schemes

Control strategies are very important for emergency control of the system. The SPS concept is designed to detect a particular system condition that is known to cause unusual stress to the power system and to take some type of predetermined action to counteract the observed condition in a controlled manner. It uses modern means of communication and automation system for reliable and quick operation.

These special control schemes have been provided at few places in Indian grid. This scheme is in place at Talcher-Kolar and Rihand-Dadri HVDC link to take care of the contingency of tripping of Single pole/Bi pole.

State-Of-The-Art SCADA/EMS System

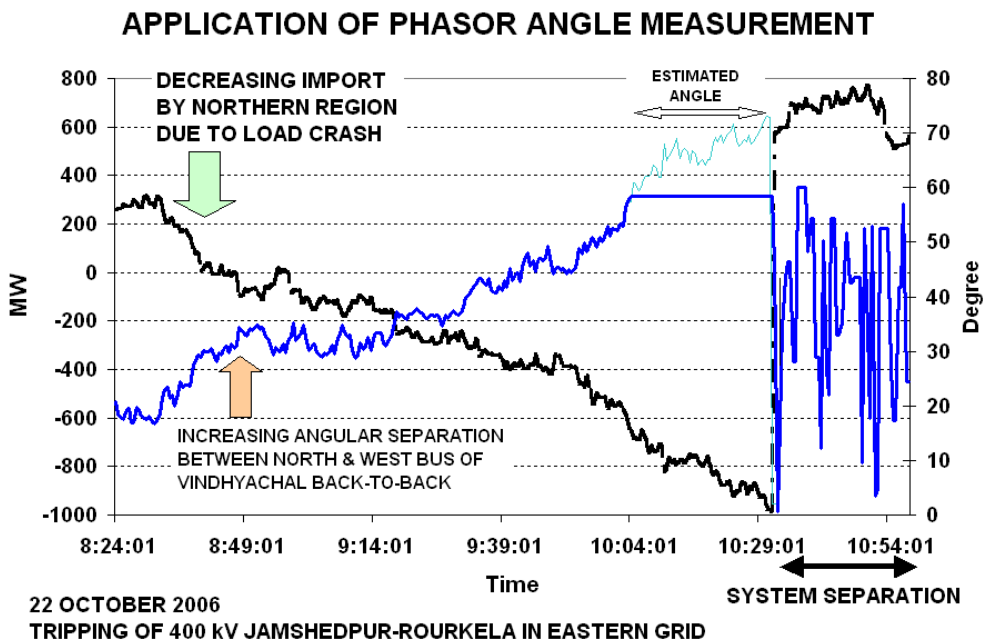
SCADA system which is the sensory organ of grid operator measures vital system variables through RTU (Remote terminal Unit) or SAS (Substation automation system) installed at all the important locations in the grid. The recorded data is transmitted through modern communication channels and displayed in the operator consoles in load despatch centers It provides real time control and monitoring of energy management facilities to optimize system reliability, load dispatch, voltage control, system restoration, switching operations, planned maintenance outage, data recording, load flow, analyses of existing & future system conditions and thereby optimize operation to each constituent in particular and the Region as a whole.

Effective visualization techniques and tools are used to empower the system operator in facilitating quick response under critical conditions. Techniques used by the Indian grid operators are Tabular presentation, Bus Diagrams, Flow gate Illustration, Control Area- Tie Line Representation, Geographical Displays, Contouring, Three Dimensional Representations and Animation.

Angle measurement

With the integration of regional grids there has been a paradigm shift in the operation of power system in India. Knowledge of neighboring system has become essential for real time security assessments of the integrated system. Phase angles are measured at strategic locations in the network. The assessment of system state using phase angle measurement not only gives system behavior at low frequency

oscillations but is also a good visualization tool to monitor the health of integrated power system.



On one of the incident of system separation due to the tripping of Jamshedpur - Rourkela line of eastern region it was observed that angular difference continued to increase between Vindhyachal North and West bus prior to tripping giving precise information about the system state.

Smart Grid

The complexity of Grid is increasing continuously due to Growing number of interconnections within and across the regions. The real time information available today through conventional SCADA/EMS system is limited to analog and status data from the remote terminal units. Information, such as indications of protective control actions, event/fault records, device settings are not available. System dynamics are not

taken in real time evaluations. Emergency controls such as load shedding do not consider system-wide conditions. Protective relay settings are static – no intelligence is embedded to allow adaptation to the changing system conditions.
To take care of above complexities and to ensure safe, secure and reliable operation of large interconnected Indian Grid, system operation in future would be equipped with an Intelligent/Smart Grid with placement of Phasor Measurement Unit, Wide Area Monitoring, Self Healing, and adaptive islanding features etc with an intent to quickly evaluate system vulnerability with respect to cascaded events involving faults, device malfunctions and provide remedial action.

Initiatives have been taken to implement Smart Grid pilot projects for grid security of Indian grid.

(a) Implementation of Pilot project for installation of PMUs (Phasor Measurement Units) in Northern Region

(b) Implementation of CSIR approved Project “Intelligent Monitoring & Control of the Interconnected Electric Power Grid using WAMS.

To keep track of new technology & development POWERGRID is also a member of International group VLPGO (Very Large Power Grid Operators) with other international utilities. VLPGO is a common platform where worldwide large Grid Operators come together for mutual benefit, sharing common problems and solution.

Chapter 6

Fire fighting techniques – Electrical and oil fires.

6. Fire fighting techniques – Electrical and oil fires:

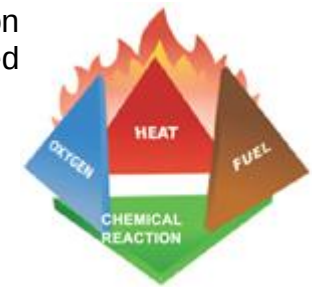
6. 1 Fire Fighting Techniques- Electrical and oil fires

What is 'fire'

For longer than recorded history, fire has been a source of comfort and catastrophe for the human race. Fire is rapid, self-sustaining oxidation process accompanied by the evolution of heat and light in varying intensities. Fire is believed to be based on three elements being present: fuel, heat and oxidizer. Fire disasters can occur above the ground (in tall buildings and on planes), on the ground, and below the ground (in mines). Sometimes they occur in circumstances that are unexpected or unpredictable. Firestorms can be natural or human generated.

6. 2 The Fire Tetrahedron

This is a model used by the fire fighting and protection industry to identify the four major components required to start a fire.



Heat: Fire cannot begin or continue without a sufficient amount of heat. It is necessary therefore, to reduce the amount of heat in case of a fire. This can be done with the application of extinguish ants like water and certain types of powder and gas.

Fuel: Without fuel, a fire will stop. When fire consumes all the burnable fuel, it will extinguish itself without external aid. Unfortunately it is neither safe, nor practical to rely on this in case of a potentially large fire. Fuel can be rendered harmless by using chemical means.

Oxidising agent (usually oxygen): Without oxygen, fire can neither begin nor sustain itself. A decrease in oxygen levels slows the combustion process.

Chemical reaction: A chemical reaction is essential to both start a fire and keep it burning. E.g.: combustion is the chemical reaction that feeds a fire more heat and allows it to continue.

From a spark to an inferno in 6 minutes flat:

What adds to the large-scale destructiveness of fire is the incredible speed at which it grows. A flame unchecked can amount to a furnace that even a fire brigade would find impossible to put out, in barely six minutes. So clearly, the sooner you act, the easier it is to put out a fire.

The stages of fire:

Stage 1: Ignition

This is the only stage at which a fire extinguisher can be used safely, when the flame is relatively small.

Stage 2: Critical

Fire begins to engulf large areas and a huge amount of extinguishing agent is required to put it out. Only sophisticated sprinkler systems will prove useful at this point.

Stage 3: Blaze

By now the fire is out of control. It can only be put out with thousands of liters of extinguishing agent. Only a fire brigade might be able to tackle it. Not so much to put out the fire, but to prevent it from spreading to neighbouring properties.

6. 3 Types of fire

All fire incidents can be divided in many ways depending on the cause of fire outbreak, but broadly there are two types of fires, one is natural and other is manmade.

Natural: Fires which are considered as natural are basically earthquake, volcanic eruption and lightning - generated fires. The most significant direct impact of power systems on fire following an earthquake is that electric power is a major fire ignition source. In addition to dropped distribution lines, power circuits in damaged houses are another major ignition source. There have been cases where as many as two-thirds of all ignitions after an earthquake has been attributable to power system.

Manmade: Fire caused by human/machine errors are considered as manmade fires, e.g. industrial or chemical fire disasters, fires at social gatherings due to Electrical short circuit fires, accidental fire and kitchen-fires. Rural and urban residential and non-residential structural fires are also largely manmade fires.

Electricity is good servant but bad master. It can prove to be very dangerous if circuits are not properly protected. The major fault that appears in electrical network or equipment is termed as short circuit. In short circuit, the supply phase and neutral or earth is short circuited accidentally due to foreign metallic substance coming in contact with phase & neutral or earth or due to overload thereby damaging the insulation resulting in short circuit i.e. directly connected resulting in heavy current flow called "short circuit current". This high current

heats up the terminations, switches, plugs & cable due to which temperature rises to such a high degree that it is sufficient to generate sparking which further leads to fire.

An electrical fire can be caused due to many reasons. Some of the major reasons are:

1. Short circuit in wiring/cables
2. Loose connections giving rise to sparking
3. Overloading of conductors/cables and equipments
4. Electrical source close to flammable materials
5. Use of inferior grade materials and equipments
6. Use of undersized fuses leading to sparking and breakdown
7. Generation of static electricity

A few simple steps can go long way in warding off any kind of an electrical fire. We can abide by the following measures and protect office/ equipment from any kind of fire:

1. Always use good quality (ISI) cables.
2. Please make sure that electrical outlets are designed to handle appliance loads.
3. If an electric appliance smokes or gives away an unusual smell, unplug it immediately, then do the proper servicing before using it again.
4. Please avoid joints in wiring (taping of wires). Instead, use extension box with fuse or else go for soldering and proper mechanical joints.
5. Always renew the wiring after ageing. Replace electrical cords that are cracked or frayed.
6. Please use adequate capacity fuses for protection. Do not increase the ratings without ascertaining reason of fuse

blowing. Don't tamper with fuse box. Install the Fuse board away from combustible materials like paper, oil, curtains etc.

7. Please keep flammable material (gasoline, oil etc.) safely in special containers.
8. Please disconnect electrical tools and appliances when not in use.
9. Please use correct rating Earth Leakage Circuit Breaker (ELCB). A leakage current even of 1 ampere can cause electrical fire. A correctly chosen ELCB can detect the leakage current and can cut-off circuit thus reducing the fire-risk.

6. 4 Mainly fires are categorized in following four classes. (According to ISI - 2190/1979)

The classification of fire is done according to the material by which the fire is caused.

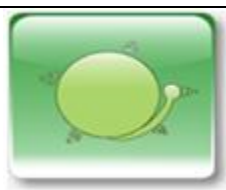
Class A fires involve solid materials of an organic nature such as wood, paper, cloth, rubber and plastics that do not melt.

Class B fires involves liquids. They include petrol, diesel, thinners, oils, paints, wax, cooking fat and plastics that melt.

Class C fires involve electricity.

Class D fires involve flammable metals such as magnesium, aluminium, titanium, sodium and potassium.

Four Essential Means to Prevent Electrical Fires

	ALARM Identify the location of the nearest fire alarm. Know what the fire alarm sounds like.
	FIRE EXTINGUISHER Install sufficient number of Fire Extinguishers at strategic locations. Know where to find them, know how and when to use them. Check them periodically.
	**SMOKE DETECTORS** 1. Make sure to install them in your premises. They alert you about the fire well before the situation becomes critical. 2. Maintain smoke detectors with new batteries every year. 3. Have a smoke detector in every room and on every floor. 4. Test it monthly. Replace it after every 8 to 10

	years.
	FIRE DRILLS Organize precautionary fire drills from time to time.

6. 5 Dealing With Electrical Fires:

Electricity fires can be caused due to someone else's negligence as well. The following tips will help you in safely getting out of the fire when you are caught in that situation:

SEAL THE ROOM: Use wet clothing or towels to stuff around cracks in doors and seal up vents. Close doors and protect yourself against smoke.

USE WATER: Keep a wet Cloth over your nose and mouth, breath through your nose only.

SIGNAL FOR HELP: Call building management for help. If you have no phone, signal at the window for help.

DO NOT BREAK WINDOWS: Flames and smoke can travel back to you from the outside. If you need air, open the window for an instant & close it.

CRAWL LOW UNDER SMOKE: During a fire, smoke and poisonous gas rise with the heat. The air is cleaner near the floor. Crawl on your

hands and knees to the nearest exit, keeping you head 12 to 24 inches (30 to 60 cm) above the floor.

STOP DROP AND ROLL: If your clothes catch fire, do not run. Stop where you are, drop to the ground, cover your face your hands, and roll over to smother the flames.

DON'T JUMP: If you are above the 2nd floor, wait to be rescued. By remaining calm, you increase chances of survival!

6. 6 Fire Extinguishers:

A **fire extinguisher** is an active fire protection device used to extinguish or control small fires, often in emergency situations. It is not intended for use on an out-of-control fire, such as one which has reached the ceiling, endangers the user (i.e., no escape route, smoke, explosion electrical accident, etc.), or otherwise requires the expertise of a fire department. Typically, a fire extinguisher consists of a hand-held cylindrical pressure vessel containing an agent which can be discharged to extinguish a fire.

At the top of the cylinder, there is a smaller cylinder filled with compressed gas. A release valve acts as a locking mechanism and prevents this gas from escaping. When you pull the safety pin and squeeze the lever, the lever pushes on an actuating rod which presses the valve down to open a passage to the nozzle. The compressed gas is released, applying a downward pressure on the fire-extinguishing material. This pushes the material out the nozzle with high amounts of pressure. Although the temptation is to aim the extinguisher at the flames, the proper way to use the extinguisher is to aim it directly at the fuel.

6.6. 1 Types of Fire Extinguisher:

Fire extinguishers are divided into four categories, based on different types of fires. Each fire extinguisher also has a numerical rating that serves as a guide for the amount of fire the extinguisher can handle. The higher is the number, the more fire-fighting power. The following is a quick guide to help choose the right type of extinguisher.

- **Class A** extinguishers are for ordinary combustible materials such as paper, wood, cardboard, and most plastics. The numerical rating on these types of extinguishers indicates the amount of water it holds and the amount of fire it can extinguish.

- **Class B** fires involve **flammable or combustible liquids** such as gasoline, kerosene, grease and oil. The numerical rating for class B extinguishers indicates the approximate number of square feet of fire it can extinguish.

- **Class C** fires involve **electrical equipment**, such as appliances, wiring, circuit breakers and outlets. Never use water to extinguish class C fires - the risk of electrical shock is far. Class C extinguishers do not have a numerical rating. The C classification means the extinguishing agent is non-conductive.

- **Class D** fire extinguishers are commonly found in a chemical laboratory. They are for fires that involve combustible metals, such as magnesium, titanium, potassium and sodium. These types of extinguishers also have no numerical rating, nor are they given a multi-purpose rating - they are designed for class D fires only.

Materials used in fire extinguishers are given in table below:

Extinguisher type	Used for ordinary fire?	Used for electrical fire?	Used for oil fire?	Used for chemical fire?
Soda-acid/ Water Carbon-dioxide*	Yes	No	No	No
Halon	No	Yes	Yes	Yes
Carbon dioxide	No	Yes	No	No
Dry chemical Powder	No	Yes	Yes	Yes
Foam	No	No	Yes	No

6.6. 2 Fire Fighting Tips

All fires can be very dangerous and life-threatening. Your safety should always be your primary concern when attempting to fight a fire.

Before deciding to fight a fire, be certain that:

- You have the proper fire extinguisher for what is burning.
- Assure the pressure is at the recommended level. On extinguishers equipped with a gauge, the needle should be in the green zone - not too high and not too low.

- You know how to use your fire extinguisher. There's not enough time to read instructions when a fire occurs.

How to Fight a Fire Safely

- Always stand with an exit at your back.
- Stand several feet away from the fire, moving closer once the fire starts to diminish.
- Use a sweeping motion and aim at the base of the fire.
- Be sure to watch the area for awhile to ensure it doesn't re-ignite.

Never Fight A Fire If

- The fire is spreading rapidly. Only use a fire extinguisher when the fire is in its early stages. If the fire is already spreading quickly, evacuate and call the fire department.
- You don't know what is burning. Unless you know what is burning, you won't know what type of fire extinguisher to use.
- You don't have the proper fire extinguisher. The wrong type of extinguisher can be dangerous or life-threatening.

There is too much smoke or you are at risk of inhaling smoke. Seven out of ten fire-related deaths occur from breathing poisonous gases produced by the fire.

6. 7 First Aid Treatment:

A first aid kit is an extremely important thing to have to avoid aggravating the effects of simple accidents like cuts, wounds and fainting. It is easy to have a first aid kit and the contents are very easily available. The very basic contents for first aid kits should

include items for minor injury treatment like cold compress, wounds, and minor sprains. The international standard for first aid kits is that they should be identified with the ISO graphical symbol for first aid (from ISO 7010) which is an equal white cross on a green background.

Aim of first aid:

- To assess the situation.
- To recognize the problem.
- To provide immediate care
- To preserve life.
- To prevent worsening of injury.
- To promote recovery.
- To arrange transfer to a hospital or for doctor advice.

Types of first aid kits

The types of first aid kits required in emergency differ as per the situation. You can have the first aid kits in different sizes and shapes. They can range from the handy carry kits to the large ones required to deal out with many people.

Whether the first aid kits are purchased from a drug store or self made, they must include all necessary items. First aid kits can be either bought from market or can be made at home.

First aid kit should have:

1. Cotton Pads/Balls - these could be the lightest component in a kit and most often the most necessary for minor and major injuries.
2. Bandages - for open wounds, bandages are very important to cover your broken skin and prevent infection.

3. Medical Tape - medical tapes are also a necessity for wounds as they will basically hold gauze bandages. They can also hold light splints especially the ones used for the fingers.
4. Alcohol wipes - You can either buy a bottle of alcohol or ready-made wipes or you can have both. In any accident that includes wounds and open skin, antiseptics are needed for cleaning and preventing infection.
5. Medical Scissors - You can buy 4 to 5 inches long medical scissors which are very helpful in cutting through bandages and tapes.
6. Pain Relievers - for immediate relief during injuries, it is always a good to keep an assortment of pain relievers in survival first aid kit.
7. Antibiotics/Antibiotic Ointment - to prevent internal or external infections, antibiotics are very helpful. Antibiotic is anti-bacteria so to prevent swelling of the wounds.
8. Instant Cold Pack - for sprains, joint and closed injuries cold packs are necessary. You can purchase these plastic packages in any pharmacy or drugstore. You can also use this to lower down very high fever.
9. Tweezers - for splinters or thorns, a good quality pair of tweezers is always helpful. You can choose to have a plastic or metal whatever suits your needs well.
10. Rubber Gloves - just to cover your hands and ensure you cannot infect the wounds you are treating on, these gloves are also important. For injuries during adventure trips or during the times there no enough water around to wash your hands after treatment, rubber gloves will make you feel comfortable.

Fig: First Aid Kit Fig: Scissors
Fig: Tweezers

Fig: Disposable gloves Fig: Adhesive tape
Fig: Cotton

The electric shock happens when the person comes in contact with the source of electrical energy. The electrical energy passes by the tissues of a part of the body causing shock. It can cause the person devastating damage and even death.

Injuries Due to Electric shock	What Causes Electric Shock	Symptoms of Electric Shock.
Skin burns	Defective electric appliances	Unconsciousness
Burns to internal tissues	Damaged or chafed cords or extension leads	Difficulty to breathe or having no breathing.
Electrical damage to heart that may cause the heart to stop or beat randomly.	Electrical appliances in contact with or immersed in water	Weak and inconsistent pulse or having no pulse
	Wrong or deteriorated household wiring	Burns or the entrance and exit burns, where the electricity entered and left the body
	Knocked down power lines	
	Striking lightning.	

Burns are generally the harshest effects that happen particularly at the contact areas with the electrical source. The hands, head and heels are the common areas of contact. More than the burns, there are other injuries possible if the person throws clear electrical source with

muscular contraction with force. There can also be a case of spine injury. The patient can also have some internal injury particularly when they experience shortness of breath, pain in chest and pain in abdomen. Pain in hand or foot or can also indicate a possible broken bone due to electric shock. The children can have typical electrical mouth burn because of biting the electric cord appearing as the burn on lip. This area gets a red or dark and charred appearance.

Exams and Tests

The basic concern is to make out if there is any evident hidden injury subsists. Injury can happen to muscles, heart, or brain or to bones or organs from being thrown from electric source. The doctor can ask to have different tests as per the case and physical examination.

The tests for electric check are ECG, Blood count, Urine test, X Rays to look for fractures or dislocations, CT scan.

6. 8 Electrical Fires in Residential / Commercial Premises:

6.8. 1 *Indian Standard 1641:* code of practice for fire safety of building (general):

Each year all over world, hundreds of people die and thousands are injured in accidents involving Crores of rupees worth property loss. Property damage and/or physical and emotional injuries due to electrical fires can be devastating. While some fires are caused by faulty products, many more are caused by the misuse and poor maintenance of electrical equipment, incorrectly installed wiring, overloaded circuits and misapplied extension cords.

Electrical fires can also lead to long-lasting emotional distress on children and adults. Fires are unpredictable and uncontrollable, and may provide only seconds to get fellow family members and pets

safely outside. During a fire, people often lose all family heirlooms, photo albums and other irreplaceable items.

Most of these incidents can be prevented by following simple electrical fire safety rules. Although some of these fires are caused by electrical system failures and appliance defects, **many are caused by the misuse and poor maintenance of electrical appliances, incorrectly installed wiring, and overloaded circuits and extension cords.**

In addition to significant consequences for the homeowner, electrical fires impact the lives of fire-fighters who risk injury and possibly death fighting blazes caused by electrical problems. A fire-fighter's job is dangerous, and each year, thousands are injured while on duty. While information specific to fire fighter injuries resulting from residential electrical fires is not available, a rough estimate indicates that 60 percent of all fire-fighter injuries occur because of residential fires.

In fact, combined losses from all natural disasters – hurricanes, storms, floods, and earthquakes – represent just a fraction of the losses from fires. This makes fire safety initiatives by both homeowners and homebuilders key to reducing overall death, injury and property loss.

The key step to decreasing the annual impact of electrical fires begins with the homebuilding process. It is vital that builders, electrical contractors, electrical inspectors and anyone with knowledge of the available solutions who are involved in residential construction recognize the devastating impact on human life and educate the home buyer on the potential life-saving tools that are available. Saving a human life or preventing injury or property loss is well worth the minimal cost of additional electrical fire protection in the home.

Electrical Wiring

Most electrical fires result from problems with "fixed wiring", such as faulty electrical outlets and old wiring. Many are caused by cords and plugs, such as extension and appliance cords. In urban areas, faulty wiring accounts for 33% of residential electrical fires. Misuse of electric cords, overloading circuits, poor maintenance of cords, and running cords under rags or in high traffic areas often lead to electrical fires that could have been avoided.

Home Appliances

Heating and Cooling appliances consume the most electricity and sometimes cause electrical fires. Those most often involved are electric geysers and ovens, dryers, central heating units, air-conditioners, televisions, radios and record players. Always follow the manufacturer's safety precautions when using an appliance. Many people overlook seemingly-harmless warning signs such as overheating, an unusual smell, short circuits, sparks and sputters. If any of these occur, the appliance should be immediately turned off and unplugged. Contact the manufacturer in order to determine what steps to take next. However, if the appliance functions well, you may have encountered an electrical wiring problem and should contact a certified electrician to check the wiring in your home.

Some Safety Precautions

- Routinely check your electrical appliances and your home wiring
- Replace all old, worn out, or damaged appliance cords
- Use electrical extension cords wisely
- Keep clothes, curtains and other potentially combustible items away from all heaters

- Never overload extension cords or wall sockets

The most important fire precaution is to have a functioning smoke alarm in your home and commercial establishments.

Safety Devices:

Circuit protection devices limit or stop the flow of current automatically in the event of a ground fault, overload, or short circuit in the wiring system. Well-known examples of these devices are fuses, circuit breakers, ground-fault circuit interrupters, and arc-fault circuit interrupters. Fuses and circuit breakers open or break the circuit automatically when too much current flows through them. When that happens, fuses melt and circuit breakers trip the circuit open. Fuses and circuit breakers are designed to protect conductors and equipment. They prevent wires and other components from overheating and open the circuit when there is a risk of a ground fault. Earth Leakage Circuit Breakers (ELCB), are used in wet locations, construction sites, and other high-risk areas. These devices detect the leakage current in the wiring installations and interrupt the flow of electricity within as little as 1/40 of a second to prevent electrocution. ELCBs compare the amount of current going into electric equipment with the amount of current returning from it along the circuit conductors. If the difference exceeds 5 milliamperes, the device automatically shuts off the electric power. Arc-fault devices provide protection from the effects of arc-faults by recognizing characteristics unique to arcing and by functioning to de-energize the circuit when an arc-fault is detected.

Fuses and Circuit Breakers

when a fuse blows or a circuit breaker is tripped, find out what caused it to overload before replacing or resetting it. Check the operation of

ELCB (Earth leakage Circuit Breakers) and do not bypass the safety devices. Correct the problem and if you cannot find the source or feel uneasy about the situation, do not hesitate to call an electrician.

Electrical switches and circuit breakers Enclosures
Have a professional electrician replace old or damaged enclosures with modern, three-wire, polarized receptacles. To minimize fire and shock hazards, proper grounding is essential. Also, make sure that appliance plugs match their receptacles. Never cut off or bend the ground pin of a three-pronged plug as this ground connection protects you from shock caused by a faulty cord or a malfunctioning appliance.

Warning Signs

Many electrical problems can be detected before they cause a fire or harm someone. To better ensure electrical fire safety, learn to be alert and pay attention to any irregular electrical function in your home. Some warning signs include:

- A recurring problem with blowing fuses or tripping circuit breakers
- Experiencing a tingle when you touch an electrical appliance
- Discoloration of wall outlets
- A burning smell or unusual odour coming from an appliance or wiring
- Flickering lights

If you notice any of the above warning signs or if an appliance functions oddly, take appropriate measures to prevent an accident. Unplug the malfunctioning appliance immediately. If necessary, cut off power to the problem circuit by disconnecting the fuse or tripping the circuit breaker manually and locate the problem. When in doubt, contact an electrician or call the power company to inspect the

electrical connections outside your home. Electrical fire safety is a serious matter and precaution is of utmost importance.

Fire Precautions in buildings:

The following are some of the precautions that have to be followed to prevent Fire hazard,

6.8. 2 Fires in Electricity substations and norms of fire fighting:

The risk of fire in substations has been comparatively historically low, but the possible impacts of a fire can be catastrophic. Fires in substations can severely impact the supply of power to customers and the utility company's revenue and assets.

These fires can also create a fire hazard to utility personnel, emergency personnel, and the general public. The recognition of the fire hazards, the risks involved, and the appropriate fire-protection mitigation measures are some of the key considerations for the design and operation of new or existing substations.

Particular Fire Risks to Substations:

Substations contain a number of features that represent particular fire risks:

• Automated substations are generally unattended.

• The equipment in substations operates at relatively high energy levels.

• Some substation equipment contains significant fuel loads. In particular oil cooled transformers and reactors, and large cable banks contain significant masses of flammable material.

• Cable ducts and conduits can act as paths for oil following a transformer failure.

• Unsealed ducts can convey burning oil into adjacent buildings.

Substation fires cannot be attributed to one single cause

Objectives of Fire Safety

The main objectives of fire safety are

• To minimise both the probability and the consequences of postulated fires.

• To detect and suppress fire with particular emphasis on passive and active fire protection system and adequate capacity for the systems necessary to achieve and maintain safe plant shut down with or without off-site power.

• To ensure that a failure, rupture or an inadvertent operation does not significantly impair the safety capability of the structures, systems and components.

• To address not only the direct effects of flame, radiant heat and explosion but also to the potential for the release of hazardous materials and hazardous combustion products in the event of fire and the potential for the release of water and other fire fighting media contaminated during fire fighting.

To meet these objectives, there are

Passive Fire Safety Systems (PFSS) - The Passive Fire Safety Systems are those systems, where no moving components are involved and which are provided to detect, prevent spread, or suppress fire. The examples are fire barriers, fire seals, fire detectors, fire retardant paint etc.

Active Fire Safety Systems (AFSS) - The Active Fire Safety Systems are those systems where moving components are involved and which are provided to protect against fire. The examples are fire pumps, fire hydrants, sprinklers, extinguishers, etc.

It is recommended that the designer refer to the **standard IEEE 979 [1] "Guide for Substation Fire Protection"**

6. 9 Substation Hazards

The physical objects or conditions that create latent (undeveloped) demands for fire protection are called hazards. Every fire hazard has the following attributes:

Types and Origins of Substation Fires as Reported by a Major Utility, 1971–1994

Types and Origins of Fires	**Percentages**
Oil-insulated circuit breakers	14.0
Current transformers	14.0
Power transformers	9.3
Hot work procedures (welding, cutting, and grinding)	9.3
Potential transformers	7.8
Engine-driven generators	7.0
Arson	6.3
Smoking	6.0
Lightning	4.7
Flammable liquid storage or handling	3.1

Terrorism	1.6
Miscellaneous fires	15.8

The “miscellaneous fires” category covers a wide range of fires from grass fires to a plastic wall clock failing and catching fire. It is impossible to predict all of the different types of fires that can occur.

One of the key steps in the design of new substations and the assessment of existing substations are to identify conditions that are fire hazards. Once the fire hazards of a planned or existing substation are identified, then fire protection measures can be incorporated to eliminate or lessen the fire hazard.

There are a wide range of types and causes of the fires that can occur in substations. The types of fires depend on the equipment and systems used in the stations.

Fires involving dc valves, outdoor or indoor oil-insulated equipment, oil-insulated cable, hydrogen-cooled synchronous condensers, or PCB-insulated equipment are usually well documented, and these types of equipment are easily recognized as a fire hazard. There are a number of other substation-specific types of fires that are not as well documented.

Energized electrical cables with combustible insulation and jacketing can be a major hazard because they are a combination of fuel supply and ignition source. A cable failure can result in sufficient heat to ignite the cable insulation, which could continue to burn and produce high heat and large quantities of toxic smoke. **Oil-insulated cables** are an even greater hazard, since the oil increases the fuel load and spill potential.

The hazard created by mineral-oil-insulated equipment such as transformers, reactors, and circuit breakers is that the oil is a significant fuel supply that can be ignited by an electrical failure within the equipment. Some of the causes of internal arcing within the mineral insulating oil that can result in fire are (This arcing can produce breakdown gases such as acetylene and hydrogen) **Infiltration of water, failure of core insulation, exterior fault currents, and tap-changer failures**. Depending on the type of failure and its severity, the gases can build up sufficient pressure to cause the external shell of the transformer tank or ceramic bushings to fail or rupture. Once the tank or bushing fails, there is a strong likelihood that a fire or explosion will occur. A possible explosion could cause blast damage. The resulting oil-spill fire could spread to form a large pool of fire, depending on the volume of oil, spill containment, slope of the surrounding area, and the type of the surrounding ground cover (i.e., gravel or soil). Thermal radiation and convective heating from the oil spill fire can also damage surrounding structures and structures above the fire area.

Substations are exposed to the common industrial fire hazards such as the use and storage of flammable compressed gases, hot work, and storage and handling of flammable liquid, refuse storage, presence of heating equipment, and storage of dangerous goods.

6. 10 Switchyard Hazards

Some of the specific components encountered in substation switchyards that are fire hazards are:

- Oil-insulated transformers and breakers
- Oil-insulated potheads
- Hydrogen-cooled synchronous condensers
- Gasoline storage or dispensing facilities

- Vegetation
- Combustible service building
- Storage of pesticides or dangerous goods
- Storage warehouses
- Standby diesel-generator buildings

The failure of some of the critical components such as transformers and breakers can directly result in losses of revenue or assets.

Other switchyard components could create a fire exposure hazard to critical operational components (i.e., combustible service buildings located close to bus support structures or transmission lines).

6.10. 1 Control and Relay-Building Hazards

A control or relay building can include the following potential hazards:

- Exposed combustible construction
- Combustible finishes
- Emergency generators, shops, offices, and other noncritical facilities in the control buildings
- Batteries and charger systems
- Switchyard cable openings that have not been fire-stopped
- Adjacent oil-insulated transformers and breakers
- High-voltage equipment
- Dry transformers
- Workshops

A fire in any of these components could damage or destroy critical control or protection equipment. Damages could result in a long outage to customers as well as significant revenue losses.

6.10. 2 Indoor Station Hazards

Fires in indoor stations are caused by some of the same substation-related hazards as switchyards and control rooms. The impacts of any fires involving oil-insulated equipment, oil-insulated cable, and HVDC (high-voltage dc) valves in an indoor station can result in major fires, with accompanying large asset losses and service disruptions.

The basic problems with major fires in indoor stations are that the building will contain the blast pressure, heat, and smoke, and which can result in:

- Blast damage to the building structure (structural failure)
- Thermal damage to the building structure (structural failure)
- Smoke damage to other equipment (corrosion damage)

Design Requirements for Fire Safety

- Design requirements to minimise the potential for fire shall be specified in the early stage of design.
- a) Limiting the inventory of combustibles to the minimum extent practicable.

- b) Separation of redundant safety related divisions such that a single fire cannot prevent the performance of a required substation safety function.
- c) Separation of critical areas from non-critical areas such that a single fire in any noncritical area cannot prevent the performance of safety functions for either of the divisions.
- d) Establishing administrative procedures to control hazardous operations and introduction of combustible material.

Electric Circuits & Equipment:

- In closed ventilated areas, where smoke/heat venting is not possible, for power cables and control cables, halogen-free, fire-retardant, low smoke (FRLS) materials shall be used for sheathing. Fire survival cables having
- Copper conductors with special insulating materials are capable of maintaining circuit integrity for extended periods under fire conditions and meet the special Fire Survival Test as per IEC 331. These cables can safely be used in essential circuits, which serve plant safety functions.
- Placement of power & control cables on the cable racks should be such that preferably high voltage cables are on the top rack and low voltage cables are on the bottom rack.
- Cable routing should be so chosen to avoid passing close to equipment such as steam pipe lines, oil pipe lines, resistor grids and process equipment which are capable of producing heat. Where cables are required to be routed for loads located close to such systems, protection shall be provided to these cables.
- The cables shall be protected against oil spillages.

Transformers:

- All transformers shall meet the requirements of relevant Act and CEA Regulations
- Transformers installed inside fire areas containing systems important to safety should be of the dry type or insulated and cooled with noncombustible liquid.
- Transformers filled with combustible fluid that are located indoors should be enclosed in a transformer vault.
- Outdoor oil-filled transformers should have oil spill confinement features or drainage away from the buildings and have a fire rating of at least 3 hours. The transformers shall be protected by automatic high velocity water spray system or by carbon dioxide fixed installation system or Nitrogen injection and drain method.

Cable Trenches:

- All cable outlet points in the trench shall be insulated / sealed with fire resistant materials / fiber wools or light PCC to prevent spreading of fire.
- Fire barriers shall be provided in cable trenches at periodical intervals.

Fire detection and alarm system:

- In designing fire detection and alarm systems, it is important to consider the reliability of the system and individual components, to always perform their required functions. For fire detection systems, this reliability may be affected by the reduction in sensitivity or of sensing devices leading to non-

detection or late detection of a fire, or the spurious operation of an alarm system when no smoke or fire hazard exists.

- The detection system shall annunciate by audible and visual alarms in the control room and in-house fire station.
- Fire alarms shall be distinctive and shall not be capable or being confused with any other plant alarm.
- Reliable & uninterrupted power supply shall be ensured for the fire detection and alarm system. To take care of failure of main supply, emergency power from diesel generating set and back-up supply from battery system shall be provided.

6. 11 Fire prevention & control

Fire prevention activities can be categorized as Engineering, Training & Enforcement functions.

- **Engineering** refers to the careful planning of the fire safe buildings & processes. It also includes the proper interpretation of relevant fire codes & control of process hazards through design & installation of fire detection & protection systems. Engineering plays an important role in fire prevention program. Without proper engineering, the best training & enforcement programs cannot prevent fires. It includes proper building design & construction, hazard identification & analysis and installation of suitable fire detection & prevention systems in the plant.

- **Training/education** plays an important role in prevention of fire. Proper training in regular intervals should be imparted on all employees to increase fire consciousness among employees and to eliminate fire hazards in workplace. The

training also includes basic as well as advanced fire fighting procedures.

- **Enforcement** is the third important element of the fire prevention program. It deals with the activities of inspecting plants to ensure compliance with the relevant fire protection standards. Carefully planned inspection by a well-trained & experienced inspection team can prevent many serious fires. Through inspection, many hazardous conditions are discovered and effective control measures are taken before a fire occurs. Inspections can be periodic, intermittent and continuous. Periodic inspections are general in nature and cover all facilities & equipment as per standard format. Regulatory bodies, insurance companies normally carry out intermittent inspections to check compliance as per codes. The substation management itself carries out continuous inspection to check the healthiness of the fire detection & protection system.

Training to Utility Staff:

All employees should be trained to be thoroughly familiar with the safety procedures for their particular jobs. Moreover, good judgment and common sense are integral to preventing electrical accidents. When working on electrical equipment, for example, some basic procedures to follow are to:

• De-energize the equipment,

• Use lockout and Line Clear permit procedures to ensure that the equipment remains de-energized,

• Use insulating protective equipment, and

• Maintain a safe distance from energized parts.

Fire Risks to substations and Risk Assessment "Best Practice"

Substations contain a number of features that represent particular fire risks:

- With the process of substation automation many substations in future would be generally unattended.
- The equipment in substations operates at relatively high energy levels.
- Some substation equipment contains significant fuel loads. In particular oil cooled transformers and reactors, and large cable banks contain significant masses of flammable material.
- Cable ducts and conduits can act as paths for oil following a transformer failure.
- Unsealed ducts can convey burning oil into adjacent buildings.

Substation fires cannot be attributed to one single cause.

Process: (Conducting a Fire Audit)

Not all possible fire protection measures are necessary for every substation. It can be on the selective basis. The fire risk rating for each substation can be determined as follows:

- In the case of existing substations the substation shall be surveyed

- In the case of a proposed substations the data collection shall be completed on the basis of the design documentation;

- Review results of the Fire Risk Evaluation to identify those components contributing the rating assigned;
- Asset management and design teams review results and identify most appropriate upgrade measures and or need for full fire audit of the substation.

Fire Risk ratings to substations:

On the basis of the audit report a risk rating is assigned. These ratings may be as follows;

EXTREME

Where an extreme rating is returned for a new design, features in the design that caused the extreme fire risk rating shall be investigated and addressed in the design.

For an existing substation rated as extreme, the assessor shall immediately notify the substation in-charge. A full audit of the substation is required. The risk level must be reduced within 3 months. Subsequent inspection must occur within 12 months.

Very HIGH

Where a very high rating is returned for a new design, features in the design that caused the very high fire risk rating shall be investigated and addressed in the design.

For an existing substation rated as very high, the assessor shall immediately notify the substation In-charge. A full audit of the substation is required.

The risk level must be reduced within 9 months. Subsequent inspection must occur within 12 months.

• **HIGH**

Where a high rating is returned for a new design, features in the design that caused the high fire risk rating shall be investigated and addressed in the design.

For an existing substation rated as high, the assessor shall investigate possible cost effective measures to reduce risk level and action within 12 months. Subsequent inspections shall be carried out at two-year intervals.

MODERATE

Where a moderate rating is returned for a new design, features in the design that caused the moderate risk rating shall be investigated and addressed in the design.

For an existing substation rated as moderate, the assessor shall investigate possible cost effective measures to reduce risk level and action within 24 months. Subsequent inspections shall be carried out at four-year intervals.

LOW

Where a low rating is returned for a new design, the design shall be considered acceptable.

Where a low rating is returned for an existing substation, risk level shall be managed. Subsequent inspections shall be carried out at four-year intervals.

After conducting a Risk rating as above, a corrective action plan is emerged. This plan needs to be implemented.

Standards:

- IS: 1641-1988 Indian Standard

  Code of practice for fire safety of building (general):

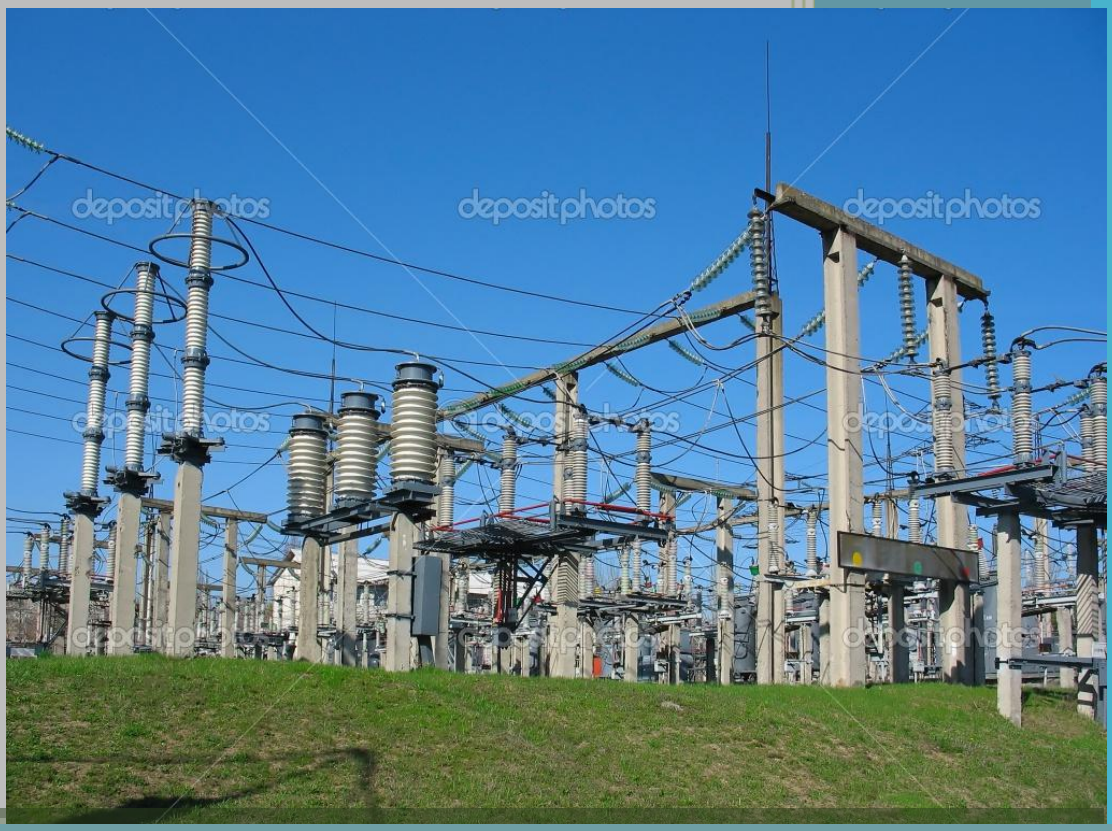
  General principles of fire grading and classification

6. 12 Annexure 1- White Paper: The real Impact of an Electrical Fire

As Enclosed.

6. 13 Annexure 2 ENA guide for Electrical Substation Fire safety and Risk Management;

As enclosed.



Chapter 7

First aid practice for different Emergencies: (St John Ambulance Staff)

7. First aid practice for different Emergencies (St John Ambulance Services)

7. 1 First Aid: (Emergency care for the injured)

First aid is the provision of initial care for an illness or injury. It is usually performed by non-expert, but trained personnel to a sick or injured person until definitive medical treatment can be accessed. Certain self-limiting illnesses or minor injuries may not require further medical care past the first aid intervention. It generally consists of a series of simple and in some cases, potentially life-saving techniques that an individual can be trained to perform with minimal equipment.

7.1. 1 First Aid Practice:

First Aid is the temporary help given to an injured or a sick person before professional medical treatment can be provided. This timely

assistance, comprising of simple medical techniques, is most critical to the victims and is, often, life saving. Any, layperson can be trained to administer first aid, which can be carried out using minimal equipments. Basic training in first aid skills should be taught in school, in work places and, in general, be learnt by all, as it is mandatory to our modern and stressful life.

Workplace injuries are costly to employees and employers alike. Every hour of every day millions of dollars are spent on medical expenses as a result of injuries.

Injuries are costly – costly to your employees, who pay the price in human suffering and inactivity; costly to you who as an employer faces both direct and indirect costs; and, costly to the nation – a nation struggling under the burden of increasing health care costs.

Since introducing safety-oriented first aid training St. John Ambulance is the best first aid training choice for your workplace.

Guiding principles

The key guiding principles and purpose of first aid is often given in the mnemonic "3 Ps".

These three points govern all the actions undertaken by a first aider.

• **P**revent further injury

• **P**reserve life

• **P**romote recovery

Limitations:

The nature of first aid means that most people will only have a limited knowledge, and in emergency situations, first-aiders are advised to FIRST seek professional help. This is done by calling, or assigning an able bystander to call, an emergency number. There is no worldwide common emergency number

In emergency situations, it is important that the responder seek help immediately, seeking professional help by other means, if telephone contact is unavailable. The risks of inadvertently doing further injury to a victim, and/or the responder sustaining injury themselves while applying aid, can often outweigh the benefits of applying immediate treatment.

7.1. 2 First Aid/ Protective Precautions

Awareness of Danger

The first thing that any first aider should be aware of when entering a situation is the potential for danger to them. This is especially important in first aid, as situations which are dangerous are the most likely to produce casualties who require first aid.

Danger can consist of:

• **Environmental danger** - A danger in the surroundings, such as falling masonry, broken glass, fast vehicles or chemicals.

• **Human danger** - Danger from people at the scene (including the victim) which can be intentional or accidental.

Barrier Devices

Keeping yourself protected is the first priority of any first aider. The key skill for this is awareness of your surroundings and the changing situation. Once you are aware of the hazards, you can then take steps to minimize the risk to one self. One of the key dangers to a first aider is bodily fluids, such as blood, vomit, urine and feces, which pose a risk of cross contamination. Body fluids can carry infections and diseases, including, but not limited to, HIV and hepatitis.

Gloves

The main tool of the first aider to avoid this risk is a pair of impermeable gloves. Gloves protect the key contact point with the victim (i.e. the hands) and allow you to work in increased safety. They protect not only from bodily fluids, but from any dermatological infections or parasites that the victim may have.

The first thing a first aider should do when approaching, or on their way to, a victim is to put on their gloves. Remember **GO** to the victim (Gloves On).

They are generally of three types:

• **Nitrile** - These gloves can come in any color (often purple or blue) and are completely impermeable to bodily fluids. These are the gloves most recommended for use during victim contact. This material is also rated for dealing with chemical spills. If you ever need to deal with chemical burns, these are the gloves to use (you can brush off dry chemicals with gloved hands if you use nitrile). Nitrile gloves, however, are also the most expensive.

• **Latex** - Usually white gloves often treated with powder to make them easier to get on or off. These are not used as widely as they once were due to a prevalence of allergies to latex. Latex allergies are

rarely life-threatening; if you must use latex gloves, ask the victim if they have a severe allergy to latex.

• **Vinyl** - Vinyl gloves are found in some kits, although they should not be used for contact with body fluids, though they are far better than nothing. They should primarily be used for touching victims who do not have external body fluids due to the glove's high break rate. For this reason, some organizations recommend they are not kept in first aid kits due to the risk of confusion.

CPR (cardiopulmonary resuscitation) **Adjunct (A CPR pocket mask, with carrying case)**

The other key piece of protective equipment that should be in every first aid kit is an adjunct for helping to perform safe mouth-to-mouth resuscitation.

With mouth-to-mouth resuscitation, there is a high probability of bodily fluid contact, especially with regurgitated stomach contents and mouth borne infections. A suitable mask will protect the rescuer from infections the victim may carry (and to some extent, protect the victim from the rescuer). It also makes the performance of CPR less onerous (not wishing to perform mouth to mouth is a key reason cited for bystanders not attempting CPR). CPR adjuncts come in a variety of forms, from small key rings with a nitrile plastic shield, up to a fitted rescue 'pocket mask'.

Other equipment

Larger first aid kits or those in high risk areas could contain additional equipment such as:

• **Safety glasses** - Prevents spurting or pooled fluid which could splay from coming in contact with the eyes.

• **Apron or gown** - Disposable aprons are common items in larger kits, and help protect the rescuers clothing from contamination.

• **Filter breathing mask** - Some large kits, especially in high risk areas such as chemical plants, may contain breathing masks which filter out harmful chemicals or pathogens.

These can be useful in normal first aid kits for dealing with victim who are suffering from communicable respiratory infections such as tuberculosis.

Often times, all of these will be included as a part of a larger kit. The kit should have a list of instructions on how to properly don/don off the equipment. Follow these instructions to prevent an accidental exposure.

7. 2 St. John's Ambulance Services:

St John Ambulance, is a common name used by a number of affiliated organizations in different countries dedicated to the teaching and practice of medical first aid and the provision of ambulance services, all of which derive their origins from the St John Ambulance Association founded in 1877 in the United Kingdom. Each national group falls within the charge of a Priory or National Council of the Venerable Order of Saint John in which each Priory ranks alongside the others.

In several priories St John Ambulance has commercial sections or subsidiaries operating to generate surplus for charitable activities;

these are structured much like other commercial bodies. The membership aspect of St John Ambulance is largely ranked, and members fall into a hierarchical structure of command. Ranks run from corporals, through sergeants and officers all the way up to high national ranks, but there is significant variation between priories and it is hard to generalize the structure too much from an international perspective.

Most members of St John Ambulance are not themselves members of the Order, and vice versa, so a major presence of the Order does not dictate a major presence of St John Ambulance. Most notably, the Order of St John is a Christian organization, whereas St John Ambulance is keen to ensure there is no allegiance to any particular religion or denomination, so as to remain available to all. St John Ambulance works on a more geographical nature than the Order, and has to contend with the differing national laws, medical practices and cultures of countries.

7.2. 1 First Aid Practice in Fractures:

Fracture can be defined as complete or incomplete break or a crack in a bone due to an excessive amount of force. A fracture may cause other internal injuries. In addition to the treatment below, if the fractured bone ruptures the skin, treat for an object in wound.

Recognition and treatment:

Step 1 of 3: Look for

- Swelling
- Unnatural range of movement

- Immobility
- Grating noise or feeling
- Deformity
- Loss of strength
- Shocks
- Twisting
- Shortening or bending of a limb

.

Step 2 of 3: Support and immobilise

- Support the injured limb
- Immobilise the affected part.

Step 3 of 3: Call for help

- Dial for an ambulance
- Treat for shock

7.2. 2 First Aid Practice in Wounds and bleeding:

Any break in the surface of the skin (wound), will not only allow blood and other fluids to be lost, but allow germs to enter the body. If the wound is minor, the aim of the first aider is to prevent infection. Severe wounds may be very daunting to deal with but the aim is to prevent further blood loss and minimise the shock that could result from the bleeding.

Some closed wounds such as bruising could indicate an underlying injury and first aiders need to be aware of the cause of injury as this may alert you to a more serious condition, such as internal bleeding.

Any open wound is at risk of becoming infected, it is important to maintain good hygiene procedures to guard against prevent cross infection between yourself and the casualty.

Minor cuts, scratches and grazes:

Treatment:

- Wash and dry your own hands.
- Cover any cuts on your own hands and put on disposable gloves.
- Clean the cut, if dirty, under running water. Pat dry with a sterile dressing or clean lint-free material. If possible, raise affected area above the heart.
- Cover the cut temporarily while you clean the surrounding skin with soap and water and pat the surrounding skin dry. Cover the cut completely with a sterile dressing or plaster.

Severe bleeding – Treatment:

- Put on disposable gloves.
- Apply direct pressure to the wound with a pad (e.g. a clean cloth) or fingers until a sterile dressing is available.

- Raise and support the injured limb. Take particular care if you suspect a bone has been broken.

Lay the casualty down to treat for shock.

- Bandage the pad or dressing firmly to control bleeding, but not so tightly that it stops the circulation to fingers or toes. If bleeding seeps through first bandage, cover with a second bandage. If bleeding continues to seep through bandage, remove it and reapply.

- Treat for shock.

- Dial for an ambulance.

Remember: protect yourself from infection by wearing disposable gloves and covering any wounds on your hands.

If blood comes through the dressing **do not** remove it – bandage another over the original.

If blood seeps through **both** dressings, remove them both and replace with a fresh dressing, applying pressure over the site of bleeding.

Objects in wounds

Where possible, swab or wash small objects out of the wound with clean water. If there is a large object embedded:

Treatment

- Leave it in place.
- Apply firm pressure on either side of the object.
- Raise and support the wounded limb or part.
- Lay the casualty down to treat for shock.
- Gently cover the wound and object with a sterile dressing.
- Build up padding around the object until the padding is higher than the object, then bandage over the object without pressing on it.
- Depending on the severity of the bleeding, dial 999 for an ambulance or take the casualty to hospital.

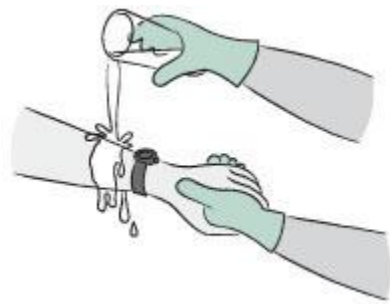
7.2. 3 First Aid Practice in Shocks:

Shock is a life threatening condition that occurs when the vital organs, such as the brain and heart, are deprived of oxygen due to a problem affecting the circulatory system.

The most common cause of shock is blood loss but it can also be caused by other fluid loss such as vomiting or severe burns. Shock can occur when the heart has been damaged by heart attack or angina and is unable to pump an adequate supply of oxygen to the body.

Recognition and treatment:

Step 1 of 3: Look for



- Pale face
- Cold, clammy skin
- Fast, shallow breathing
- Rapid, weak pulse
- Yawning
- Sighing
- In extreme cases, unconsciousness.

Step 2 of 3: Lay the casualty down with legs raised

- Treat any possible causes of shock
- Help them to lie down
- Raise and support their legs

- Loosen tight clothing
- Keep them warm.

Step 3 of 3: Call for help

- Call for emergency help.

7.2. 4 First Aid Practice in Burns and Scalds:

Start cooling the burn immediately under running water for at least 10 minutes

Make the casualty as comfortable as possible, lie them down.

- Continue to pour copious amounts of cold water over the burn for at least ten minutes or until the pain is relieved.

- Whilst wearing disposable gloves, remove jewellery, watch or clothing from the affected area - unless it is sticking to the skin.
- Cover the burn with clean, non-fluffy material to protect from infection. Cloth, a clean plastic bag or kitchen film all make good dressings.

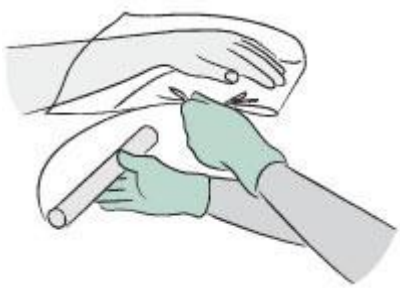
Treat for shock.

Minor burns

For minor burns, hold the affected area under cold water for at least 10 minutes or until the pain subsides. Remove jewellery etc. and cover the burn as detailed above.

If a minor burn is larger than a postage stamp it requires medical attention. All deep burns of any size require urgent hospital treatment.

Clothing on fire



- Stop the casualty panicking or running – any movement or breeze will fan the flames.
- Drop the casualty to the ground.
- If possible, wrap the casualty tightly in a coat, curtain or blanket (not the nylon or cellular type), rug or other heavy-duty fabric. The best fabric is wool.
- Roll the casualty along the ground until the flames have been smothered.

On all burns:

- **Do not** use lotions, ointments and creams.
- **Do not** use adhesive dressings.
- **Do not** break blisters.

7.2. 5 First Aid Practice in Sunburns:

Sunburn can be caused by overexposure to the sun or even a sun lamp. At high altitudes sunburn can occur even on an overcast summer day. Some medicines can trigger severe sensitivity to sunlight and rarely, it can be caused by exposure to radioactivity.

Most sunburn is superficial. In severe cases, the skin is a lobster red in colour and blistered - the casualty may also be suffering from heatstroke.

Recognition

Sunburn is often recognised by:

- Reddened skin.
- Pain in the area of the burn.
- Later there may be blistering to the affected skin.

Treatment

Your aims when dealing with somebody with sunburn is to move the casualty out of the sun or away from the source of the sunburn and to relieve any discomfort and pain.

Caution though, if there is extensive blistering or any other skin damage you need to seek medical advice.

- With minor sunburn cover the casualty's skin with light clothing or a towel.
- Move them into the shade or preferably indoors.
- Cool the skin by sponging it with cool water or by soaking the affected area in a cold bath or a cool shower for ten minutes.
- Encourage the casualty to have frequent sips of cold water.
- If the burns are mild calomine lotion or an after sun preparation may soothe them.
- For severe sunburn obtain medical aid.

7.2. 6 First Aid Practice in Heat stroke:

This condition is caused by a failure in the thermostat in the brain. This regulates the body temperature. The body then becomes dangerously overheated usually due to a high fever or prolonged exposure to heat.

Heatstroke can also result from the use of drugs such as ecstasy.

In some cases heatstroke follows heat exhaustion when sweating ceases and the body then cannot be cooled by the evaporation of sweat. Heatstroke can develop with very little warning, causing unconsciousness within minutes of the casualty feeling unwell.

Recognition

Recognition features may include:

- Headache.
- Dizziness and discomfort.
- Restlessness and confusion.
- Hot flushed and dry skin.
- A rapid deterioration in the level of response.

- A full bounding pulse.
- A body temperature above 40 degrees Celsius or 104 degrees Fahrenheit.

Treatment

Your aims are to lower the casualty's body temperature as quickly as possible and arrange urgent removal to hospital.

1. You need to quickly move the casualty to a cool place and remove as much of the outer clothing as possible.
2. Dial for an ambulance.
3. Wrap the casualty in a cold wet sheet and keep the sheet wet until the temperature falls to 38 degrees Celsius, or 100.4 degrees Fahrenheit, under the tongue or under the armpit.
4. If no sheet is available, fan the casualty or sponge them down with cold water. Once the casualty's temperature appears to have returned to normal replace the wet sheet with a dry one.
5. Always monitor and record the vital signs, the level of response, pulse and breathing rate until help arrives.
6. If the temperature starts to rise again repeat the cooling process.
7. Caution though, if the casualty becomes unconscious open the airway and check breathing and be prepared to give rescue breaths and chest compressions if necessary, or if the casualty is unconscious but breathing normally place them into the recovery position, please refer to the relevant tips.

7.2. 7 First Aid Practice in Head Injuries:

All head injuries are potentially serious and require proper assessment because they can result in impaired consciousness.

Injuries may be associated with damage to the brain tissue or to blood vessels inside the skull, or with a skull fracture.

A head injury may produce concussion, which is a brief period of unconsciousness followed by complete recovery. Some head injuries may produce compression of the brain (cerebral compression), which is life-threatening. It is therefore important to be able to recognise possible signs of cerebral compression - in particular, a deteriorating level of response.

A head wound should alert you to the risk of deeper, underlying damage, such as a skull fracture, which may be serious. Bleeding inside the skull may also occur and lead to compression. Clear fluid or watery blood leaking from the ear or nose are signs of serious injury.

Any casualty with an injury to the head should be assumed to have a neck (spinal) injury as well and be treated accordingly.

7.2. 8 First Aid Practice in Unconscious but breathing:

If a person does not respond to the sound of your voice or to gentle pressure applied to their body, it is likely they are unconscious.

Recognition and treatment

Step 1 of 7: Look for

- To confirm if someone is unconscious but breathing complete the steps of the **primary survey** - Danger, Response, Airway, Breathing (DRAB)
- If an AED is available refer to the steps for using an AED.
- Skip primary survey steps

Step 2 of 7: Check for danger

- Are you or they in any danger?
- If you have not already done so make the area safe and then assess them
- If a person is drowning, only enter the water to rescue them if it is safe to do so, you have been trainer to so and they are unconscious. Dial 999/112 for emegency help immediately for drowning victims.

Step 3 of 7: Check for a response

- Shout a command at them:
- *'Can you hear me?'*
- *'Open your eyes'*
- Gently shake their shoulders
- If they respond, check for severe bleeding and other injuiries
- Shout for help.

Step 4 of 7: Open the airway

- Help them to breath by opening their airway
- To do this, place one hand on the forehead and using two fingers lift the chin.

Step 5 of 7: Check breathing

- Position your cheek close to their mouth
- Look, listen and feel for no more than 10 seconds:
- look to see if the chest is rising and falling
- listen for breathing
- feel the breath against your chee
- If they are not breathing refer to the treatment for someone unconscious and not breathing - adults, children orinfants.
- If they are not breathing commence cardiopulmonary resuscitation (CPR).

Step 6 of 7: Put them in the recovery position

- Turn them onto their side
- Lift chin forward in open airway position and adjust hand under the cheek as necessary
- Check they cannot roll forwards

or backwards
- Monitor breathing continuously
- If injuries allow, turn them to the other side after 30 minutes.

Step 7 of 7: Call for help

- Call for emergency help.

7.2. 9 First Aid Practice in Unconscious and not breathing:

Recognition and treatment

Step 1 of 9: Look for

- To confirm if someone is unconscious and not breathing complete the steps of the primary survey - Danger, Response, Airway, Breathing (DRAB)
- If an AED is available refer to the steps for using an AED.
- Skip primary survey steps
-

Step 2 of 9: Check for danger

- Are you or they in any danger?

- If you have not already done so make the area safe and then assess them
- If a person is drowning, only enter the water to rescue them if it is safe to do so, you have been trained to do so, and they are unconscious. If you are not alonedial 999/112 for emegency help immediately for drowning victims.

Step 3 of 9: Check for a response

- Shout a command at them:
- *'Can you hear me?'*
- *'Open your eyes'*

- Gently shake their shoulders
- If they respond, refer to the treatment for someone
- Shout for help.

Step 4 of 9: Open the airway

- Help them to breath by opening their airway
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Step 5 of 9: Check breathing

- Position your cheek close to their mouth
- Look, listen and feel for no more than 10 seconds:
- look to see if the chest is rising and falling
- listen for breathing
- feel the breath against your cheek
- If they are not breathing commence cardiopulmonary resuscitation (CPR).

Step 6 of 9: Call for help

- If you have someone with you, **send them to dial** for an ambulance **immediately**
- If you are on your own, perform five initial breaths and one minute of CPR before leaving to dial 999 (or 112) and then return to continue with CPR
- If unconsciousness is due to drowning, you should give five initial rescue breaths and perform CPR for one minute before making the call.

Step 7 of 9: Give 30 compressions

- Place heel of your hand in the centre of the chest
- Place other hand on top and interlock fingers

- Keeping your arms straight and your fingers off the chest, press down by five to six centimetres and release the pressure, keeping your hands in place

- Repeat the compressions 30 times, at a rate of 100-120 per minute (about the speed of the song 'Nelly the Elephant').

Step 8 of 9: Give 2 rescue breaths

- Ensure the airway is open
- Pinch nose firmly closed
- Take a deep breath and seal your lips around their mouth
- Blow into the mouth until the chest rises
- Remove your mouth and allow the chest to fall
- Repeat once more.

Step 9 of 9: Continue CPR

- Continue resuscitation, 30 compressions to 2 rescue breaths
- Do not stop unless:
- Emergency help arrives and takes over
- They show signs of recovery such as coughing, opening eyes, speaking or moving purposefully and breathing normally
- You become so exhausted that you cannot carry on.

7.2. 10 First Aid Practice in Insect stings / snake bite:

Usually a sting from a bee, wasp, and hornet are not serious and are more painful than dangerous. But with any insect bite or sting it is important to look for signs of an allergic reaction.

Aims:

- Relieve any **swelling** and **pain.**
- Arrange any **medical treatment**, if necessary.

Treatment:

- You need to reassure and calm the casualty down.
- There will be pain and possibly some redness and swelling around the site of the sting.
- If the sting is visible, brush or scrape it off. You could use the blunt edge of a knife or a credit card for instance. Please don't use tweezers are you risk squeezing more poison into the wound.
- Apply an ice pack or cold compress for at least 10 minutes, and if possible raise the effected part.
- If swelling and pain persist advise the casualty to see their doctor.
- Stings to the mouth and throat can be dangerous. There is a risk of the tissues in the mouth and throat swelling which could cause the airway to become blocked.
- Sucking on an ice cube, or an ice cream or lolly for instance for children, or sipping cold water will prevent any swelling.
- However, if the swelling starts to develop and breathing becomes difficult then arrange for medical help immediately.
- Some people suffer <u>severe allergic reactions</u> to insect bites and stings, if the casualty shows any sign of impaired

breathing or swelling to the face, neck, tongue, mouth or lips or shows a wide spread rash then dial 999 or 112 for an ambulance.

Mechanical (Non electrical) Accidents:

An accident or mishap is an unforeseen and unplanned event or circumstance, often with lack of intention or necessity. It implies a generally negative outcome which may have been avoided or prevented had circumstances leading up to the accident been recognized, and acted upon, prior to its occurrence.

A mechanical accident is an event in which any type of mishap occurred due to failure / improper use of mechanical devise. This may be due to failure of a mechanical part inside vehicle causing an accident, failure of loaded crane during transit, **breaking of electrical conductor during stringing or breaking of electrical pole during erection etc.**

However during such type of accidents factures, cuts, wounds, head injuries and seizures etc, may occur. Some of the first aid practice in common types of problem is already discussed. However for Seizures first aid practice is described below;

7.2. 11 First Aid practice in Seizures:

A seizure - also called a convulsion or fit - consists of **involuntary contractions of many muscles in the body**.

The condition is due to a disturbance in the electrical activity of the brain. Seizures usually result in loss or impairment of consciousness.

The most common cause is epilepsy. Other causes include:

- Head injury
- Some brain damaging diseases
- Shortage of oxygen or glucose in the brain
- The intake of certain poisons including alcohol.

Epileptic seizures are due to recurrent, major disturbances of brain activity. These seizures can be sudden and dramatic. Just before a seizure, a casualty may have a brief warning period (aura) with, for example, a strange feeling or a special smell or taste.

No matter what the cause of the seizure, care must always include maintaining an open, clear airway and monitoring the casualty's vital signs - level of response, pulse and breathing. You will also need to protect the casualty from further harm during a seizure and arrange appropriate aftercare once they have recovered.

Recognition features

General recognition features are:

- Sudden unconsciousness
- Rigidity and arching of the back
- Convulsive movements.

In epilepsy the following sequence is common:

- The casualty suddenly falls unconscious, often letting out a cry.
- They become rigid, arching his back.
- Breathing may cease. The lips may show a grey-blue tinge (cyanosis) and the face and neck may become red and puffy.
- Convulsive movements begin. The jaw may be clenched and breathing may be noisy. Saliva may appear at the mouth and may be blood-stained if the lips or tongue have been bitten. There may be loss of bladder or bowel control.
- Muscles relax and breathing becomes normal; the casualty recovers consciousness, usually within a few minutes. They may feel dazed or act strangely. They may be unaware of their actions.
- After a seizure, the casualty may feel tired and fall into a deep sleep.

Your aims

- To protect the casualty from injury
- To give care when consciousness is regained
- To arrange removal of the casualty to hospital if necessary.

Treatment

- If you see the casualty falling, try to ease the fall
- Make space around them; ask bystanders to move away.
- Remove potentially dangerous items, such as hot drinks and sharp objects
- Note the time when the seizure started
- If possible, protect the casualty's head by placing soft padding underneath it
- Loosen clothing around the neck.

When the seizure has ceased

- Open the airway and check breathing
- Be prepared to give rescue breaths and chest compressions.
- Place them into the recovery position if the casualty is unconscious but breathing normally
- Monitor and record vital signs - level of response, pulse and breathing
- **Note the duration** of the seizure.

Caution

- **Do not** move the casualty unless they are in immediate danger.
- **Do not** put anything in their mouth or use force to restrain them.

Warning

If any of the following apply, dial for an ambulance.

- The casualty is **unconscious for more than 10 minutes**.
- The **seizure continues for more than 5 minutes**.
- The casualty is having **repeated seizures** or having their first seizure.
- The casualty is **not aware of any reason for the seizure**.

7.2. 12 First aid practice for severe allergic reaction:

A severe allergic reaction will affect the whole body, in susceptible individuals it may develop within seconds or minutes of contact with the trigger factor and is potentially fatal.

Possible triggers can include skin or airborne contact with particular materials, the injection of a specific drug, the sting of a certain insect or the ingestion of a food such as peanuts.

Recognition features

- Impaired breathing: this may range from a tight chest to severe difficulty
- There may be a wheeze or gasping for air.
- Signs of shock.
- Widespread blotchy skin eruption.
- Swelling of the tongue and throat.
- Puffiness around the eyes.
- Anxiety.

Treatment

Your aim is to arrange immediate removal of the casualty to hospital.

- Dial for an ambulance.
- Give any information you have on the cause of the casualty's condition.
- Check whether the casualty is carrying any necessary medication. If they are, help them to use it.

If the casualty is conscious:

- Help them to sit up in a position that most relieves any breathing difficulty; this is usually sitting up and leaning forward slightly.

If the casualty becomes unconscious:

- Open the airway and check breathing.
- Be prepared to give rescue breaths and chest compressions.
- Place them into the recovery position if the casualty is unconscious but breathing normally.

7.2. 13 First Aid practice in Low blood sugar:

When the blood-sugar level falls below normal (hypoglycaemia) brain function is affected. This problem is sometimes recognised by a rapidly deteriorating level of response.

Hypoglycaemia can occur in people with diabetes mellitus and, more rarely, appear with an epileptic seizure or after an episode of binge drinking. It can also complicate heat exhaustion or hypothermia.

Recognition features

There may be:

- A history of diabetes; the casualty may recognise the onset of a "hypo" attack.
- Weakness, faintness, or hunger.
- Palpitations and muscle tremors.
- Strange actions or behaviour; the casualty may seem confused or belligerent.
- Sweating and cold, clammy skin.
- Pulse may be rapid and strong.

- Deteriorating level of response.
- Diabetic's warning card, glucose gel, tablets, or an insulin syringe in casualty's possessions.

Treatment

Your aim is to raise the sugar content of the blood as quickly as possible and to obtain medical help if necessary.

- Help the casualty to sit or lie down.
- Give them a sugary drink, sugar lumps, chocolate or any other sweet food. Don't give them diet drinks; they don't have the sugar in them that they need.
- Alternatively if the patient has their own glucose gel helps them to take it.

If the casualty responds quickly:

- Give them more food and drink and let them rest until they feel better.
- Advise them to see their doctor even if they feel fully recovered.

Warning! If their consciousness is impaired don't give them anything to eat or drink as they may not be able to swallow or drink it properly.

If the condition does not improve:

- Monitor the level of response and look for any other possible causes.

If the casualty is unconscious:

- Open the airway and check breathing. (primary survey)
- Give chest compressions and rescue breaths if necessary.
- If the patient loses consciousness but is still breathing normally place them in the recovery position.
- Dial for an ambulance.
- Always monitor and record the vital signs, levels of response, pulse and breathing for instance and give this information to the emergency services when they arrive.

7.2. 14 First Aid practice in High blood sugar:

High blood sugar levels (hyperglycaemia) over a long period can result in unconsciousness. Usually the casualty will drift into this state over a few days. Hyperglycaemia requires urgent treatment in hospital.

Recognition features

- Warm, dry skin.
- Rapid pulse and breathing.
- Fruity/sweet breathe.
- Excessive thirst.
- If untreated, drowsiness, then unconsciousness.

Treatment

Your aim is to arrange urgent removal of the casualty to hospital.

- Dial 999 (or 112) for an ambulance.
- Monitor the level of response and look for any other possible causes.

If the casualty is unconscious:

- Open the airway and check breathing. (primary survey)
- Give chest compressions and rescue breaths if necessary.
- If the patient loses consciousness but is still breathing normally place them in the recovery position.
- Dial for an ambulance.
- Monitor and record the levels of response, pulse and breathing.

7. 3 Electrical Shock

Electric shock occurs when the body becomes part of an electrical circuit. Shocks can happen in three ways.

• A person may come in contact with both conductors in a circuit.

• A person may provide a path between an ungrounded conductor and the ground.

• A person may provide a path between the ground and a conducting material that is in contact with an ungrounded conductor. The terms high voltage and low voltage are relative terms. In transmission-line terminology, "low voltage" is much higher than the 600 volts. At home, you would not think of 600 volts as being low voltage. Even when applied to 120-volt circuits, the term low voltage is deceiving. To some people low voltage means low hazard. Actually, low voltage does not necessarily mean low hazard, because potential difference is only one factor making up the dangerous effects of electricity. For purposes of this Lesson, you can think of "low voltage" as being a potential difference of 24-600 volts. The extent of injury accompanying electric shock depends on three factors.

• The amount of current conducted through the body.

• The path of the current through the body.

• The length of time a person is subjected to the current.

The amount of the current depends on the potential difference and the resistance. The effects of low current on the human body range from a temporary mild tingling sensation to death. An electric shock can injure you in either or both of the following.

• A severe shock can stop the heart or the breathing muscles, or both.

• The heating effects of the current can cause severe burns, especially at points where the electricity enters and leaves the body. Other effects include severe bleeding, breathing difficulty, and ventricular fibrillation. In addition, you may strike something, or have some other accident as a result of your response to the shock. The effects of electric current are listed below.

7.3. 1 Current in milli-amperes Effects

1 or less No sensation; probably not noticed

1 to 3 Mild sensations not painful

3 to 10 Painful shock.

10 to 30 Muscular controls could be lost or muscle clamping

30 to 75 Respiratory paralyses

75mA to 4 **amps** Ventricular Fibrillation

Over 4 **amps** Tissue begins to burns. Heart muscles clamp and heart stops beating

Effects of Electrical Current on the Human Body

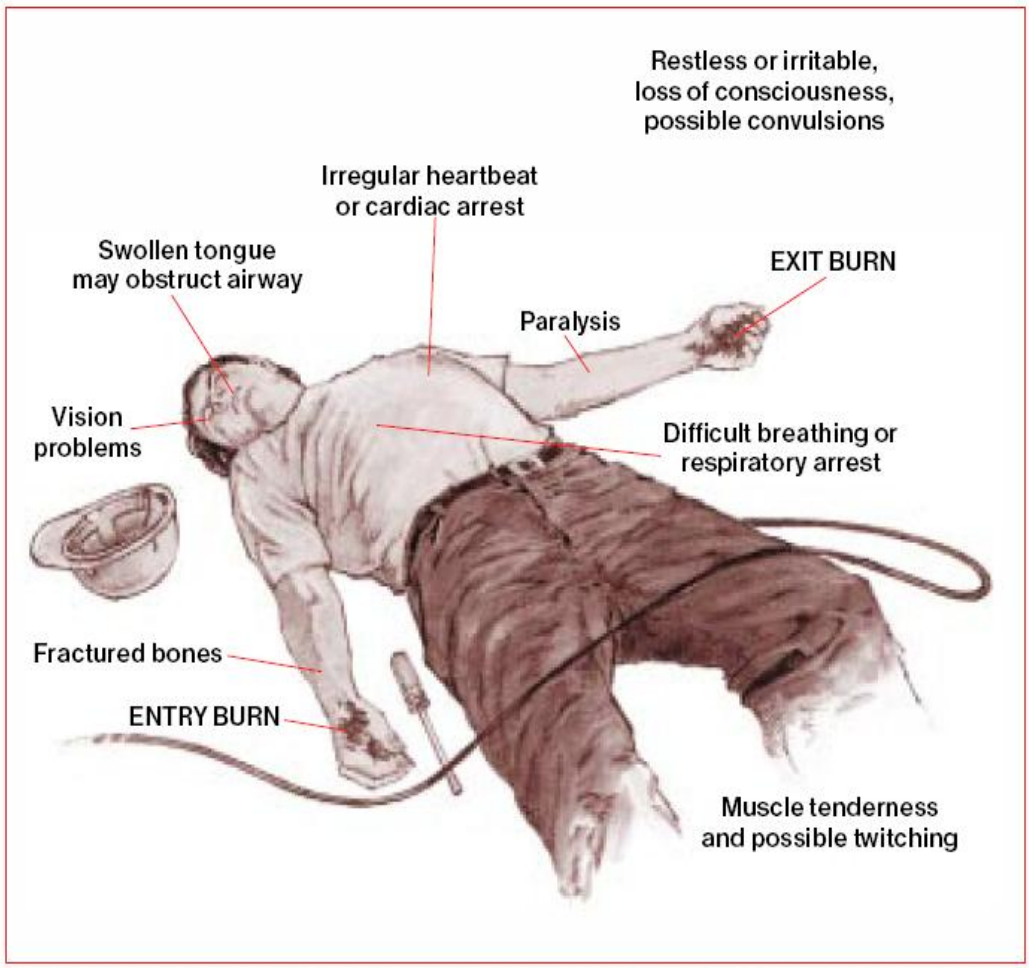
Current is the killing factor in electrical shock. Voltage is important only in that it determines how much current will flow through a given body resistance.

7.3. 2 Electrical Emergencies

Electrical accidents as shown in Figure cause countless injuries and cost the lives of hundreds of persons each year. Injury could be minimized and many lives saved if proper rescue techniques and treatment are used. Electrical accidents may occur at almost any time or place. Timely response and treatment of victims is a major concern. You must use your best judgment in an electrical emergency.

When an electrical accident occurs, due to the effect of muscle clamping, a victim is often incapable of moving or releasing the electrical conductor. Attempts to rescue an accident victim may pose as great a hazard for the rescuer as it does for the victim. Caution should be a primary consideration during any electrical accident or emergency. There should always be an emergency response plan for scheduled electrical maintenance or work.

Figure Worker with an Electrical Injury



A worker with an electrical injury may have any of a number of signs and symptoms.

7. 4 Electrical Accidents

Accidents happen when you least expect them, things to consider are:

They cost lives.

Rescue and treatment of shock is essential.

Lives will be saved if proper rescue techniques are used.

Rescue may pose as great a hazard for the rescuer as for the victim:

Victims may be unable to move.

Victims may be held to circuits by muscles that have contracted.

Victims must be rescued as soon as possible to survive.

Electrical Rescue Techniques

Approaching the accident:

Never rush into an accident situation.

Call the ‘Emergency number’ as soon as possible.

Get the aid of trained electrical personnel if possible.

Approach the accident scene cautiously.

Examining the scene:

Visually examine victims to determine if they are in contact with energized conductors.

Metal surfaces, objects near the victim or the earth itself may be energized.

You may become a victim if you touch an energized victim or conductive surface.

Do not touch the victim or conductive surfaces while they are energized.

De-energize electrical circuits if at all possible.

Methods to de-energize:

An extension or power cord probably powers portable electrical equipment.

Unplug portable electrical equipment to remove power.

Open a disconnecting device or circuit breaker to de-energize fixed electrical equipment.

Hazards and solutions:

Be alert for hazards such as stored energy, heated surfaces and fire.

If you can’t de-energize the power source use extreme care:

Ensure that your hands and feet are dry.

Wear protective equipment such as low voltage gloves and overshoes if available.

Stand on a clean dry surface.

Use nonconductive material to remove a victim from the conductor.

High voltage rescue:

Special training is required for rescues if high voltage is present.

Protective equipment such as high voltage gloves and overshoes must be worn.

Special insulated tools should be used

Insulated tools:

Insulated tools, with high voltage ratings, are a lifesaver!

Use devices such as hot sticks or shotgun sticks to remove a victim from energized conductors.

In some cases, nonconductive rope or cord may be used to remove a victim from a conductor.

Rescuing the victim:

Stand on a dry rubber blanket or other insulating material if possible.

Do not touch the victim or conductive material near the victim until the power is off.

Once power is off, examine the victim to determine if they should be moved.

Give “First Aid.”

7. 5 First Aid/ Electrocution

Electrocution is a related set of injuries caused by direct contact with live electrical connections. The effects can vary from minor to causing cardiac arrest.

Actions and Treatment

Caution

Before attempting to treat an electrocution victim, ensure they are not still in contact with live electricity. Turn off the power at the main or remove the victim from contact using a non-conducting material, such as a wooden pole.

• **Be aware of Danger** - The clear danger in this situation is the electrical supply.

• If the victim is still touching a live electrical source, either turn off the power to the source, or break the victim's contact with it. Find a non-conductive object (wooden broom handles are commonly used) and break the contact between the victim and the source. Should the victim be in contact with downed power lines, do not attempt a rescue. Instead, call and wait for professional rescuers to come and ensure the power lines are no longer live.

• **Call an ambulance immediately** - all victims of electrocution, whether conscious or unconscious require assessment in hospital.

• After ensuring the area is safe, begin a primary assessment - **check ABCs & begin CPR if required**.

• Conduct a secondary assessment looking specifically for 2 electrical burns.

• Electrical burns look like third-degree burns, but are not surrounded by first- and second-degree burns. They always come in pairs: an entry wound (smaller) and exit wound (larger). You should cover the wounds with nonstick, sterile dressings.

Remember that the most serious problem is rarely the burn, and cardiac arrest is very possible.

Electrocution causing unconsciousness

Serious electrocution may cause unconsciousness, at least for a brief period. If this is the case, conduct your primary assessment by checking ABCs. If they are not breathing, begin CPR. Airway swelling can occur from being electrocuted. Frequently check the victim's breathing.

If the victim received a serious electric shock, do not put the victim in the recovery position. Head/neck/back injuries along with multiple

fractures can occur from strong muscle contractions from being electrocuted. Begin a secondary assessment, looking specifically for 2 or more electrical burns - one entrance wound and one exit wound.

Continually evaluate the ABCs. Cardiac rhythm disturbances can quickly cause the victim to go into cardiac arrest.

Electrocution not causing unconsciousness

Those victims who are not rendered unconscious are likely to feel unwell after the experience, and may well complain of numbness or pins & needles in the area where through the electricity has passed. These victims must still be transported to a hospital for evaluation, as heart rhythm disturbances can lead to cardiac arrest.

7. 6 First Aid/ Airway Management

Airway Management

Airway management is the process of ensuring that:

1. There is an open pathway between a patient's lungs and the outside world, and

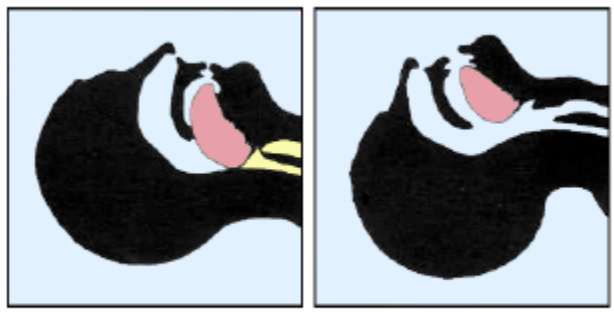
2. The lungs are safe from aspiration

Manual methods

Head tilt/ Chin lift

The head-tilt chin-lift is the most reliable method of opening the airway.

The simplest way of ensuring an open airway in an unconscious patient is to use a head tilt chin lift technique, thereby lifting the tongue from the back of the throat.



The head-tilt chin-lift is the most reliable method of opening the airway.

Jaw thrust

ILCOR no longer advocates use of the jaw thrust, even for spinal-injured victims. Instead, continue use of the head-tilt chin-lift. If there is no risk of spinal injury, it is preferable to use the head-tilt chin-lift procedure which is easier to perform and maintain

Artificial Respiration Methods to be adopted while treating persons met with electric shocks:

Intensive investigations during the past few years have indicated that the familiar Schafer prone pressure method of artificial respiration, which has been for many years taught and practiced, is less efficient than some other methods of resuscitation. Holger Nielsen, or back pressure-arm lift, method has awakened interest among all agencies concerned with life-saving techniques. These are designated as "push-pull" methods, as contrasted with others which consist of "pull"

alone or "push" alone; that is, they produce both inspiration and expiration. The Schafer method produces only expiration and relies on the resiliency of the chest for inspiration; by careful measurements it has been shown to be only half as efficacious as the "push and pull" types of treatment. The "push-pull" methods are described as follows:

The hip lift-back pressure method

This method supplements the old Schafer prone pressure method by adding the hip lift to produce inspiration. It alternates the lifting and lowering of the hips with pressure exerted on the lower part of the thorax. It is easy to learn and teach because it ises the same position for the operator as the Schafer method. The experimental studies showed that this method brought about the greatest pulmonary ventilation of any of those tested.

The arm lift-back pressure method (Holger Nielsen)

The victim is placed in the prone position with arms folded and hands placed one on the other. The face is then placed on the hands. The operator kneels at the victim's head and grasps the arms just above the elbows. The arms are drawn upward as the operator rocks backward until he meets firm resistance. The arms are replaced on the floor and the operator moves his hands to the midback (just below the scapulas) and rocks forward, exerting pressure to induce expiration. If the subject is large and the operator is small, this method may be substituted for the hip lift. Apparently it is recommended for general public use because of its simplicity for teaching and for performance, although it is slightly less efficient than the hip lift-back pressure.

The arm lift-chest pressure method (Silvester)

This method is satisfactory if the patient is on his back and for any reason must remain there. The arms are folded on the chest, and the operator kneels at the head. Grasping the arms just above the wrists, he draws them first upward, and then above the head until they touch the ground, inducing inspiration. The operator then places the arms again on the chest and presses downward to produce expiration.

RECOMMENDATIONS

Because of the varied situations in which artificial respiration may be employed, instruction in this life-saving measure should not be restricted to one method merely because it is easy for the operator to use.

All concerned staff should be familiar with the three push-pull methods outlined.

The method which provides the greatest possible respiratory exchange should be begun with the least possible delay. Neither ease of application nor fatigue of the operator should be considered during the crucial first five minutes. If the patient shows signs of life and cardiac function returns, a method requiring less effort may then be substituted if any further artificial respiration is needed.

Provisions of

Display of instructions for resuscitation of persons suffering from electric shock Instructions, in English or Hindi and the local

language of the District and where Hindi is the local language, in-English and Hindi for the resuscitation of persons suffering .from electric shock, shall' be affixed. by :the owner in a conspicuous place in every generating station, enclosed sub-station, enclosed switching station, mines and in every factory as defined: in, 'clause; (m).of section 2 of the Factory.Act,1948 (63 of 1948) in which electricity is used and in such other premises here electricity is used as the. Electrical Inspector may, by notice in writing served on the owner, direct.

(2) The owner of every generating station, enclosed sub=station, enclosed switching station and every factory or other premises to which these regulations “apply, shall ensure that all designated persons: employed by him- are acquainted with and are competent to apply the instructions referred to in sub-regulation (1).

(3)In every manned generating station; sub-station or-switching station of voltage exceeding 650 V. an artificial respirator shall be provided and kept in good working condition.

Chapter 8

Financial impacts of natural disaster and accidents.

8. Financial impact of Natural disaster and accident

8. 1 Financial Impact Analysis:

Natural disasters have a major impact on living conditions and economic development.

It is therefore essential to design and implement planning and prevention schemes and measures to help reduce such losses and to have the means of determining, after each disaster, the amount and type of damage sustained, as a basis for rehabilitation and reconstruction efforts.

Reported disaster frequency has doubled every ten years since 1960 with 96% of all deaths from natural disasters occurring in the global South (International Federation of the Red Cross and Red Crescent (IFRC/RC), 1999).

The annual average financial loss caused by natural disasters, accidents, technological accidents and urban fires, estimated between 1991 and 2000 in US$ millions at constant

2000 prices, was 234 in Africa; 21 293 in the Americas; 40 346 in Asia; 17 930 in Europe; and 1178 in Oceania (IFRC/RC, 2001).

All disaster loss estimates need to be viewed with caution. They are compiled from government reports and insurance statements with no common methodology and little transparency in their calculation. Moreover, they account only for loss of physical assets and indicate nothing of the full scale of personal loss and livelihood disruption, which is proportionately higher in less developed countries

Disasters of both natural and technological origin have a considerable impact on communities. The effects of disasters can be significantly reduced by well established counter disaster. These arrangements comprise comprehensive plans of prevention, preparedness, response and recovery and in more recent times, of mitigation. The recovery elements of these plans address the social, psychological and economic effects of disasters on communities.

The economic effects of disasters are mostly seen as physical damage to infrastructure.

The consequences of extended periods of trading or production down-time can result in bankruptcy, forced sale, business closure, loss of experienced workers, a depleted customer base and population shrinkage. These consequences are exacerbated by community losses resulting in a reduction in disposable income. The flow-on through the disaster affected community has been likened to the domino effect.

The term “economic” is generally used with respect to the costs to the community caused by the disaster while “financial” is used with respect to those schemes aimed at providing monetary sources to assist recovery.

The economic effects of disasters can be devastating and widespread. When disasters strike houses, businesses and community infrastructure

get damaged or destroyed and people's livelihoods are temporarily and sometimes permanently disrupted. **Physical damage is the most visible economic impact of disasters.**

However, the less visible impacts such as lost income through being unable to trade are just as significant and the consequences often last longer than the physical damage (for example, bankruptcy and business closures). The flow-on effects through a community can be pervasive.

Economic impacts are typically divided into two categories

- Tangible (those impacts we can assign a monetary value) and
- Intangible (impacts which are not easily expressed in monetary terms).

These impacts are then further subdivided into direct and indirect impacts.

- Direct impacts are those that result from the physical destruction or damage to buildings, infrastructure, vehicles and crops etc.
- Indirect impacts are due to the consequences of the damage or destruction.

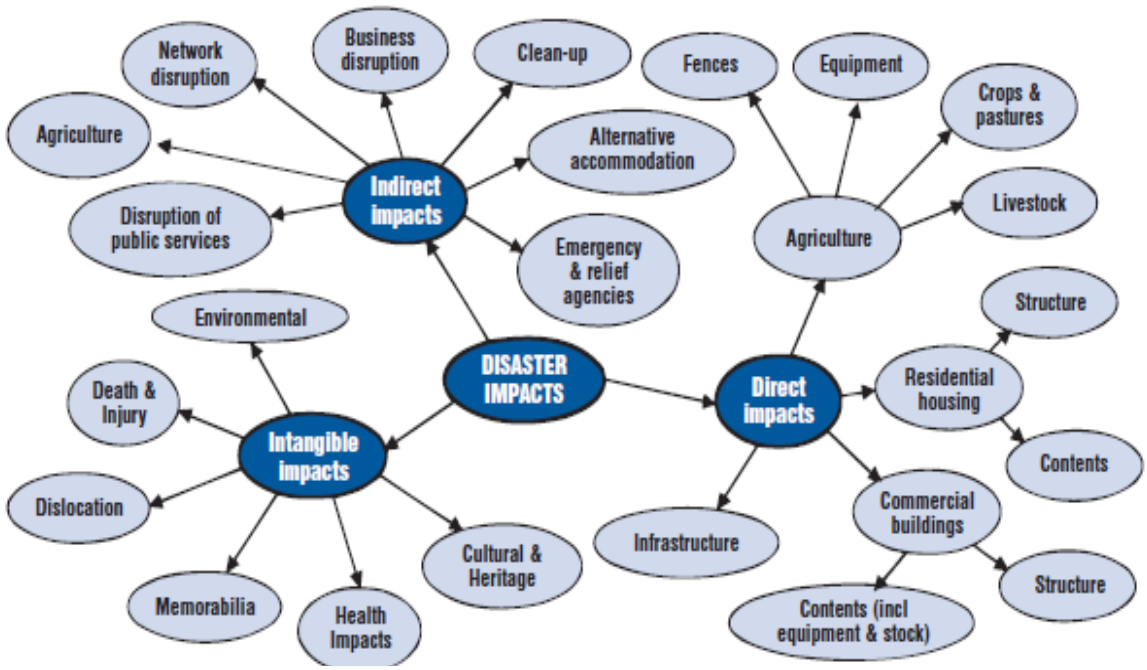
An alternative approach is to examine the impacts of disasters in terms of who or what is affected. Three groupings are common:

- Public infrastructure and community facilities;
- Business enterprises (commercial, industrial, retail, service, agricultural etc); and

- Residents and households.

FIGURE 1 THE ECONOMIC IMPACT OF A DISASTER

(Adapted from Bureau of Transport Economics 2001, Economic Costs of Natural Disasters in Australia, Report 103, Canberra).



8. 2 Direct Economic Impacts

8.2. 1 Public Infrastructure and Community Facilities

Lifelines (such as water and sanitation systems, electricity, gas, telecommunications and transport) are vulnerable to all types of disasters. Direct damage to lifeline infrastructure includes the immediate physical damage (e.g. roads cracked or washed away, destroyed electrical transformers and so on) and also the damage which may take some time before becoming visible (e.g. accelerated road deterioration due to the effect of water intrusion under road pavements).

Public buildings include schools, child care centers, kindergartens, hospitals, nursing homes, neighborhoods centers, churches, entertainment/ art/cultural centers, museums, clubs and so on.

Direct damage to public buildings can also be thought of using the break up into structural (e.g. roofs, walls etc), contents (e.g. furniture, floor coverings and specialist items like sound systems and paintings etc) and external (e.g. Playground equipment, swimming pools etc) damage.

8.2. 2 Business Enterprises

Business enterprises include commercial, industrial, retail, service and agricultural business types. The economic impact of disasters on agricultural enterprises is often treated separately from other business types. Essentially however the impact on businesses can be viewed as falling into 3 main areas.

1. Structural damage to buildings such as shops, factories, plants, sheds, barns, warehouses, hotels and so on. This includes

damage to foundations, walls, floors, roofs, doors, in-built furniture, windows etc.

2. Contents damage to fixtures and fittings (e.g. carpets), furniture, office equipment, farm equipment, records, product stock (finished manufactured products, works in progress and input materials), crops, pastures, livestock etc. and
3. External damage, for example, to motor vehicles and fences.

8.2. 3 Residents and Households

The residential sector includes houses, flats, unit, and townhouses and so on. The breakup of

1. Direct damage into structural (e.g. roofs, walls etc), contents (E.g. furniture, floor coverings etc) and
2. External (e.g. swimming pools, gardens etc) is equally useful for this category.

8. 3 Indirect Economic Impacts:

Indirect impacts are those that **are incurred as a consequence of the event**, but are not due to the direct impact. Many indirect impacts are common to the public/community sectors business, and household (for example, disruption and clean up).

8.3. 1 Disruption effects

The disruption to the community, businesses and households caused by disasters is pervasive. The economic impact of disruption and its consequences for community recovery is often overlooked, as economic recovery can tend to focus on the highly visible direct physical damage. The following categories list the common forms of disruption relevant to each area.

- Public services and network (Disruption examples)
  1. Transport (traffic delays, extra and networks operating costs etc)
  2. Loss of computer controlled systems
  3. Loss of other lifelines (e.g. electricity)
  4. Government services (e.g. education)

- Business (Disruption examples)

1. Lost or deferred production (e. g. manufacturing, agriculture, services etc)
2. Lost or deferred income/trade/ sales/value added (e.g. Tourism operators, retail traders etc)
3. Increased costs (e.g. freight, inputs)

Households (Disruption examples)

Additional costs (e.g. Alternative accommodation and transport, heating, drying out costs, medical costs etc)

Natural disasters can cause serious disruption to affected businesses which may not be able to operate during the event, and for some time afterwards, while the premises are being cleaned and equipment repaired. Business lost during this period can have devastating financial consequences and in some cases the business may not recover at all.

Loss of farm income due to a natural disaster can affect the economies of country towns.

Disasters that reduce farm expenditure can therefore have a major effect on the economies of small towns.

Clean up

Cleaning up after a disaster is another obvious area of indirect impact. The impact for public and community infrastructure, businesses and households is essentially the time it takes and the costs of cleaning materials.

Clean up activities typically include removal of mud and debris, disassembly and cleaning of machinery and equipment, removal of destroyed household and business contents items and so on.

Response costs

The time and effort of emergency services and volunteers in responding to disasters are another form of indirect impact. Costs typically include those associated with dealing the disaster agent, rescue, evacuation and other immediate response measures.

8. 4 Intangible Economic Impacts:

Intangible impacts are often described as a 'catch all' that includes all those **costs that are very difficult to estimate**, for which there is no agreed method of estimation and for which there is no market to provide a benchmark. Examples of intangible impacts are list below for each of the three main areas.

Public / Community (Disruption examples)

1. Health impacts (deferral of procedures, reduced quality of care etc)
2. Death and injury
3. Loss of items of cultural significance
4. Environmental impacts
5. Heritage losses
6. Lack of access to education, health, defence, art galleries and museums etc

- Business (Disruption examples)

1. Loss of personal memorabilia households
2. Inconvenience and disruption, especially to schooling and social life.
3. Stress induced ill-health and mortality
4. Pets
5. Quality of life
6. Dislocation

- Residents and Households (Disruption examples)

1. Loss of confidence
2. Loss of future contracts
3. Loss of experienced staff

Evidence suggests that the size of intangible costs is substantial and although most cannot be quantified, in many cases they do still have an economic impact that should not be ignored.

8. 5 Financial Recovery from Disasters:

The recovery of communities from the effects of disasters is assisted by a range of financial measures which provide a source of funds to business, government, householders and the community to effect recovery. These sources include Insurance, Natural Disaster Relief and Disaster Appeals.

8.5. 1 Disaster Insurance

Natural and manmade disasters impact upon businesses, homes and community infrastructure in any area, often without warning. Insurance

is a means of gaining financial compensation for the cost of restoration of the damage or loss caused by disasters.

The major types of insurance cover available to policyholders to recover from disasters are home and contents, property and business interruption policies. Home and contents policies usually provide replacement and reinstatement insurance which covers the cost of repairing and replacement of damaged property and contents

8.5. 2 Natural Disaster Relief Arrangements (NRDA)

The Natural Disaster Relief Arrangements are generally determined by the concerned Ministries of the Government. They provide Finance and Administration assistance to the affected territories to alleviate the financial burden associated with the provision of natural disaster relief and infrastructure restoration.

The objective of the NDRA is:

“To assist the recovery of communities whose social, financial and economic well-being has been severely affected by a natural disaster event”

8.5. 3 Public Disaster Appeals:

The local community generally comes to the aid of people affected by disaster through monetary donations to disaster appeal funds. The magnitude of disaster events, in terms of such things as the impact on individuals, geographical area and costs have primarily determined the source(s) from which a disaster appeal may be initiated. Generally, local authorities, non-government organisations or the media have

initiated disaster appeals when the disaster affects the people, businesses, etc. within that local authority's boundaries.

However, the various State governments and/or the political parties, Business communities at national / regional levels initiate disaster appeals which have national or special interest or widespread impact and that are considered to be beyond the capacity of one local authority to manage.

In the short term the post-disaster period can offer opportunities for acquiring foreign capital through reinsurance payments, remittances, international emergency relief and development aid. However, more usually this period of opportunity is short lived and insufficient to compensate for all losses, especially those systemic and secondary disaster impacts that may only be felt some time after the initial disaster shock.

8. 6 Case Study from Australia:

Gympie Floods 1999

Flooding commenced on the afternoon of 8 February 1999 and peaked at 22 meters at 4am 10 February, the highest level this century. Population is between 12,000 and 15,147 in Gympie and 31,862 in the Cooloola shire.

Economic Impacts

- Approximately **132 small businesses** in the CBD and other areas within Gympie town were inundated.
- **Cost of moving stock out, cleaning up, repairing damage, restocking of shelves and general loss of trade for 4–5 days.**

Some businesses lost up to two weeks' trade, a monetary value of up to $25,000.

- For example a jewellery business was impacted heavily as their Valentine's Day trading was lost.

- Maintain positive business attitude.
- Whilst most businesses affected by floods that pass through Gympie accept the associated risk or make provision for the "one in one hundred years", the height of the flood caught many unprepared. **Flood had more impact on the economy than any since European settlement.**
- **Nolan Meats** (140 employees) claim they had built their plant for the one hundred year flood but this one was 'a half inch higher' and have suffered $250,000 damages and lost $750,000 in turnover. This occurred immediately following $2.5m being spent on plant expansion and improvements, and at a time when the company was about to enter a second phase of development.
- **CSR and Laminex** (particle board and fiberboard plants) and the region's **sawmills** whilst in some cases not suffering flood damage, initially **lost 3 days production** and then again further production when the stocks of logs ran out. As a **flow on** the particle board plant will then not be able to produce through lack of mill waste. Logging roads in the region have suffered considerable damage and conditions will be too wet for logging operations for some time **(loss of business activity)**.

The Yabba Creek Bridge at Imbil was destroyed forcing Hyne and other millers to transport milled produce long distances, and will increase **transport costs** for mill waste for CSR. Bridge replacement cost is $1.2 million.

- Other direct flood costs were estimated at $2 million which included 55 houses inundated.

- The dairy industry in the region suffered **$8 million lost in fodder, fences, milk production and stock. Loss of power** prevented dairy cattle being milked for some time.
- A flow on effect has been a decline in trade from the rural community. Farmers have been affected through loss of crops, stock and damage to infrastructure, which has impacted on retail traders and service providers in the Gympie area.
- Another issue was that a number of businesses relocated to higher areas of the town to escape future flood impact which impacted on property owners as they found it difficult to find tenants for their premises.
- Road craft, listed as a 'firm in difficulty', was inundated by flood water. And
- An initial assessment of the short term effects based on the above impacts is $23 million.

Response

- The Immediate Response Plan was appropriate to help mitigate the impacts of this natural disaster.
- The Sunshine Coast State Development Centre made personal contact with 150 flood-affected businesses in the region.
- A senior business advisor established a shop front office in Gympie for approximately 8 weeks. The officer maintained a steady presence in the area in order to provide information (presentations to local organisations e. g. Chamber of Commerce and Cooloola Regional Development Bureau and one-on-one advice to businesses) on available DSD services and assistance to support the recovery of small business in the Cooloola region. Community suffers from flooding periodically so community system in place whereby local businesses work together to undertake "working bees" etc to get each other up

and running. Relationships and links between businesses were strengthened, leading to greater cohesiveness and cooperation with areas such as customer referrals from one business to another.

- CBD Committee established a flood action plan, particularly beneficial to business owners new to area that had not been through flood situation.
- Work with business people to discuss their plans for the future and how they can turn these into reality using marketing and planning tools.
- This officer was housed in DNR building, which provided corporate/ administration support via assistance with counter and telephone enquiries, IT and other administration assistance.
- Information has been provided to relevant organisations such as the CBD association on programs such as:
- Management—Skills Development Scheme (MSDS);
- Small Business workshops on marketing, strategic planning, “leading edge” and customer service to assist businesses adjust to the effects flooding has had on the Gympie/Cooloola regional economy;
- Firms in Crisis;
- Queensland Industry Development Scheme;
- Regional Business Development Scheme; and
- Business operators were assisted with information relating to the Queensland Rural Adjustment Authority.
- Coordinated whole of dept and whole of government assistance via existing programs.
- Specific assistance provided through the Queensland Meat Processing Industry Development Initiative to Nolan Meats.
- Officer maintained a client database to enable the Mary borough SDC to follow up at later date.

- Coverage of the wider business community, both flood affected and not, was achieved through press releases published in the Gympie Times and news bulletins on regional radio stations. And
- Total budget not including wages was $4010 over 12 week period.

Role of Regulators in the context of Disasters:

Governments and international organizations have always assigned importance to infrastructure development. The failure, in most parts of the developing world, of efforts to build up universally available and reliable telecom and energy infrastructures within a framework of government monopoly led to a focus on private participation in infrastructures in the last few decades. The primary purpose of the regulatory agency is to provide stability and certainty to the new private investors against arbitrary takings by the government (Levy & Spiller, 1994). However, all regulatory agencies are assigned multiple functions that fall under the broad headings of regulation for competition, regulation of oligopoly/monopoly and regulation to achieve social political objectives (Prosser, 1997). It has been observed that the responsiveness of government to disasters is an element in the general legitimacy of government. In the same way, a regulatory agency's responsiveness to a disaster can be critical in gaining much needed legitimacy. Thus disaster management is a prime area for regulatory intervention.

In one view, a disaster cannot be prepared for. It is a force majeure, an act outside human control. However, it is possible to mitigate the effects of disasters. For example, the accurate weather predictions and warnings that preceding a super cyclone can enable a major evacuation from the coastal areas and reduce the death toll.

In relation to infrastructure it is possible to take measures to reduce its vulnerability to damage, to minimize the damage and to build in redundancy so that services can be restored quickly. In a liberalized environment it may be argued that these decisions are managerial, and generally outside the scope of regulatory intervention.

However, the regulatory agency can have a powerful impact by providing incentives for actions that will achieve the desired socio-political objectives at reasonable cost, without infringing on the managerial autonomy of the operators.

If for example, the de jure or de facto practice is for the government, international agencies or the consumers to bear all the costs of disaster recovery there would be no incentive for the operator to design and operate the system in a way that would minimize damage in the face of disaster. If there is blanket exemption from penalty for system failure caused by disaster, there is no incentive to design systems and procedures for quick restoration of services.

Insurance is a good method of managing risk, but it is not a cure-all. If the insurance scheme is not properly designed, it can shift all the costs to consumers (many of whom may not even experience the disaster) without creating incentives for the company to set in place systems and procedures to minimize the vulnerability of the system to disaster.

Regulators will have to closely supervise the arrangements that operators make with insurers. The regulatory agency and policy makers should, however, be aware of the danger of too many escape clauses being inserted into the rules by experts from the operators,

Disaster recovery takes short-term and long-term forms. The short-term solutions lie in the making and implementation of effective contingency plans. A clearly demarcated “period of exception” would allow quick and flexible responses without having to abandon the normal procedural safeguards across the board.

The long-term solution to disaster recovery lies in the proper allocation of risk beforehand (preferably before new investors enter the market) so that the incentives are properly aligned. Obviously, the investor has to bear some part of the costs of recovery. Otherwise there would be no incentive to build and maintain robust systems. Because the investor in a regulated market does not have an easy option of exit, it is also reasonable for the consumers to bear part of the risk. Because government and the general population has an interest in prompt restoration of vital services it is also reasonable to allocate part of the risk to government. What is important is that these decisions must be taken before the disaster occurs and that they must be part of the knowledge base of the investor.

8. 7 Case of Indian Electricity Sector

(Abstract from TERI paper- Regulatory Design for Disaster Preparedness and Recovery by Infrastructure Providers: South Asian Experience)

Pre-reform disaster management

The electricity business in India still is almost completely controlled by the government, except for a few small distribution companies that were in private hands. Electricity in

India is a concurrent subject with the central government having the responsibility for overall planning and development through central public sector undertakings and the State Governments having the responsibility for state level planning, operations, tariff setting etc. With the government retaining the responsibility for policy formulation, regulation, ownership, disaster management etc. all the other stakeholders in the process had a minimal role to play. None of the infrastructure service providers really felt the need for disaster impact mitigation measures such as insurance cover. It was expected that any damage loss suffered would be made good by the government from its exchequer and this usually happened at the cost of social development programs. The role of the government as an owner came into conflict with its role as a regulator and these came into conflict with its role as an employment provider resulting in a totally skewed allocation of resources. The consumer in India, over the years, had become so accustomed to the very poor quality of service that he assumed a most fatalistic attitude to any disruptions caused by natural disasters.

As a result, very few State Electricity Boards (Electric Utilities) have any kind of a contingency plan and, in any case, are not subject to any legal or mandatory requirements to assume responsibility for disaster related events. In the ten-year period from 1989 to

1998, India suffered from over 10 disaster events on an average annually and over 4000 lives are lost every year with millions others affected.

Post-reform disaster management

The Indian electricity sector is in the process of reform. The first State to pass reform legislation, in 1995, was the State of Orissa on the east coast of India. The Electricity Regulatory Commissions (ERC) Act at the central level was passed only in 1998 although the reforms program was started in 1991 by way of invitation to the private sector to

participate in generation activities. The ERC Act mandated the establishment of the Central Electricity Regulatory Commission, while paving the way for reforms and the establishment of independent regulatory commissions at the state level.

As one of the first states to embrace basic reforms, Orissa had achieved a functional unbundling that resulted in the formation of two main generation companies, a transmission company and a distribution company in 1996. By 1999, distribution privatization had also been effected. The challenge of disaster management in a liberalized environment was sharply posed to Indian regulators when, within six months of the privatization of three of the four distribution companies, a super cyclone accompanied by an enormous tidal surge hit Orissa causing over 10,000 deaths and immense property damage (United Nations, 1999). A private investor had taken over operations of the fourth distribution company serving the worst affected area only a few weeks prior to the disaster. According to the Chairman of the Orissa Electricity Regulatory Commission, the estimated damage to that company's network was almost three times the price paid by the private investors for ownership of 51 per cent of shares and management. Service was not restored to all customers even after one year.

Particularly hard hit were customers in rural areas, with thousands of villages not reconnected to the grid after more than a year (Roy, 2000).

There were little or no preparations to deal with the disaster. The predecessor entities to the companies that suffered the damage were badly managed and were suffering from losses prior to privatization. One could hardly blame the new management for not setting in place effective preparedness measures in the few months or weeks they controlled the distribution companies. Therefore the focus shifted to effective recovery.

Examination of the licenses issued to the operators showed only one mention of cyclones or other disasters. This was as an exception to the duty to provide service (Orissa Electricity Regulatory Commission, 1997). There were no conditions regarding preparation of, or implementation of, disaster preparedness or recovery plans. Following the crisis of 1999, the Orissa Commission took action to remedy the problem by prescribing responsibilities for contingency planning in the Grid Code in regulations issued in June 2000. The new regulations specify the order of priority of restoration of service, but do not include a comprehensive procedure on disaster management (Roy, 2000).

The extraordinary scale of damage caused by the cyclone clearly justified external assistance. The World Bank extended emergency assistance to the government of Orissa to assist in disaster recovery. At the outset there had been a lack of consensus within government whether this assistance should be extended to private entities such as the newly privatized distribution companies (Roy 2000). However, the funds were in the end made available to the companies.

The regulatory aspects of the response to the cyclone may be seen in the tariff proposals by the distribution companies, the objections filed by interveners and the Commission's rulings. The operators sought to have the higher repair and maintenance costs, and interest payments on the loans taken from the World Bank, to be recognized as part of the rate base for the calculation of the revenue requirement. Some interveners claimed that the repair and maintenance costs were inflated. Others asserted that the company should bear the losses without passing them on to consumers because it failed to take the precaution of purchasing insurance cover. It, however, needs to be borne in mind here that insurance cover in India was also in the public sector and most of the insurance was in the form of life insurance. The insurance sector has also been liberalized about a year ago. The company's response includes a promise to purchase insurance.

The Commission has adopted amortization as the principal method of dealing with the extraordinary costs of restoring the network (Roy, 2000). The actual details of the period and amount of amortization appear to be determined in the context of specific tariff proceedings (Orissa Electricity Regulatory Commission, 2001). Here, the Commission appears to be examining the rationale for specific requests on a case by case basis.

Difficulties identified

The Orissa crisis has had the positive effect of raising awareness among policymakers and related groups of the need to take disaster preparedness and recovery in the liberalized environment seriously. Workshops and discussions have been conducted and research has been undertaken on the experiences of other countries (Hasan, 2000; TERI, 2000). The absence of specific provisions to deal with disaster preparedness and recovery has been noted and remedial action has been initiated as in the case of the Orissa Grid Code.

In a scenario of the kind that exists in the electricity sector in India, the principal challenge to independent regulators is going to be the perception of equity and fairness.

The commissions' handling of these issues is manifest in the tariff orders given.

Consumers are fast recognizing the changes that are being put in place and the rights and opportunities arising from the same. There is thus, already, a severe criticism of the tariff increases that are being affected as these are viewed as a penalty being imposed on the paying consumer to recover costs imposed by the non-paying consumers and inefficient management. An increase in tariffs on account of disaster related expenses would add to this burden on the paying consumer.

As such, issues of treatment of expenditures incurred in restoring disaster damages are being addressed carefully. It appears that amortization has been adopted as the principal short-term solution with, insurance seen as the preferred long-term solution. The question of risk apportionment has been identified and is being addressed by the application of the classic regulatory principle of “used and useful.” For example, in one of its recent tariff orders, the Orissa Commission orders the value of damaged assets to be taken out of the rate base while the new investments are added to it (Orissa Electricity Regulatory Commission, 2001).

8. 8 Overview of costs of blackouts:

Blackouts have impacts that are both direct (the interruption of an activity, function, or service that requires electricity) and indirect (due to the interrupted activities or services). Examples of direct impacts include food spoilage, damage to electronic data, and the inoperability of life-support systems in hospitals and homes. Indirect impacts include property losses resulting from arson and looting, overtime payments to police and fire personnel, and potential increases in insurance rates. Direct and indirect impacts can be characterized by whether they are quantifiable in monetary terms (economic impacts); relate to the interruption of leisure or occupational activities (social impacts); or result in organizational, procedural, and other changes in response to blackout conditions (organizational impacts)

Direct impacts can be avoided if the end-user has backup systems, but these have often proved unreliable.

Indirect impacts may be partially mitigated through contingency planning, improved communications, customer education, social programs, and other planning approaches.

Estimating the costs of electric power outages is difficult and imprecise because the economic value of electric reliability to different customers is not well-understood. Only recently has much progress been made in developing economic values for reliability, including the development of analytical techniques for measuring or estimating the direct and indirect costs of actual and hypothetical outages.

To estimate costs, utilities and public utility commissions (PUCs) rely on either hypothetical cost analysis or reconstruct the level of economic activity that might have occurred had there been no blackout. Both of these methods have inherent uncertainties, and theoretical models have their own shortcomings. Also, indirect and social costs often cannot be quantified but only enumerated.

8.8. 1 *Types of Costs*

The kinds of costs considered in value of reliability estimations include both short-term outage and long-term coping or adaptive response costs.

The true economic cost of any outage is the opportunity value of profit, earnings, leisure, etc. that would have been produced but for the loss.

Therefore, one must ascertain what the lost opportunities were and how they would have been valued by those who suffered the loss. The short-term outage costs are incurred during and shortly afterward, and include product spoilage, lost sales, foregone leisure, and other opportunity costs. Long-term coping costs are incurred when customers invest in equipment to mitigate the effects of a shortfall. Investment in

backup generators, for example, is clearly made to mitigate the impact of future outages. Short- and long-term costs may have both direct and indirect elements.

Direct costs are those suffered by the direct customer, such as spoilage or lost production. Indirect costs include those realized by customers of an impacted firm; they may have to purchase higher cost substitutes, incur additional production costs, or have unrecovered costs. Indirect costs can be several times as large as direct costs because the loss of a single input may retard an entire production process. Other components of indirect costs include the multiplier effect from lost wages and other factors of production and potential social costs stemming from looting and vandalism. Social costs are difficult to quantify and have been generally neglected in estimations. For example, while losses resulting from looting and arson can be identified and assigned dollar values, the secondary or ripple effects often cannot be enumerated. These secondary effects, such as a potential increase in insurance rates, represent long-term and far-reaching economic implications.

8.8. 2 Abstract of IEGC (Indian Electricity Grid Code) relevant clauses

Recovery Procedures

a) Detailed plans and procedures for restoration of the regional grid under partial/total blackout shall be developed by RLDC in consultation with

NLDC, all Users, STU, SLDC, CTU and RPC Secretariat and shall be reviewed / updated annually.

b) Detailed plans and procedures for restoration after partial/total blackout of each User's/STU/CTU system within a Region, will be finalized by the concerned User's/STU/CTU in coordination with the RLDC. The procedure will be reviewed, confirmed and/or revised once every subsequent year. Mock trial runs of the procedure for different subsystems shall be carried out by the Users/CTU/STU at least once every six months under intimation to the RLDC. Diesel Generator sets for black start would be tested on weekly basis and test report shall be sent to RLDC on quarterly basis.

c) List of generating stations with black start facility, inter-State/interregional ties, synchronizing points and essential loads to be restored on priority, shall be prepared and be available with NLDC, RLDC and SLDC.

d) The RLDC is authorized during the restoration process following a black out, to operate with reduced security standards for voltage and frequency as necessary in order to achieve the fastest possible recovery of the grid.

e) All communication channels required for restoration process shall be used for operational communication only, till grid normalcy is restored.