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Fires and Explosions at Power Plants

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Abstract

Power generation industry is beset with high level of fire and explosion risk as demonstrated by recent fires and explosions involving our power plants and several serious accidents abroad. An attempt has been made here to describe the nature of the risk and discuss strategy to combat these hazards. This would help in the better management of risk and prevention of losses in the industry.

Introduction

Energy is our most crucial challenge today. Electrical power generation is the backbone for the industrial progress. While discussing fire and explosion hazards in the power industry, attention would naturally be focussed on conventional thermal (coal) and nuclear power plants as these are presently the mainstay of power generation in the country. Fire and explosions constitute a serious threat to safety of these plants and a challenge to fire protection engineers. The fire hazard in the industry is not only serious but also unique in many respects. The subject of fire and explosion hazards at power plants' calls for detailed discussions and critical analysis. Such deliberations would help fire protection and power engineers in arriving at fire protection programme of satisfactory degree which in turn would help in fire accident prevention and loss minimization in the industry.

Major Accidents

Some of the salient and relevant characteristics of the power generation industry are immediately clear to us. It is crucial industry in the overall economy of the nation. Technology of power generation and transmission is quite complex demanding services of specialised personnel and machinery. There is no easy replacement or substitute of them. The industry is capital intensive, using heavy and costly equipment and stores. And by the very nature of the process involved, there exists 'high-level' of fire and explosion risk. The number of fire accidents that have occurred in the industry is a matter of serious concern. During the last five years or so the industry had witnessed explosion in Baroda Heavy Water Plant (Dec. 1977), fire in Nuclear Fuel Complex at Hydera-(1979), fire at Badapur Thermal Power Plant (March 1981) and explosion at Panki Thermal Power Plant (Aug. 1981).

Magnitude and Peculiarities of Hazard

Because capital investment and concentrations of value in the plant are very high, direct property loss amount to several crores of rupees in case of a serious fire. Replacement of lost material at times is a formidable problem. There is a considerable risk to the life of operating personnel. Resulting power interruption play havoc with agricultural and industrial activities and normal life of the people. These consequential losses are very huge indeed which can far exceed the direct losses, though it is not practically feasible to estimate them within a narrow range. Some secondry losses of latent nature are felt long after the incident. Accidents at power plants are unique in that they cripple business activities elsewhere due to power outage. It appears that the damage multiply and propagate. The need of highest level of industrial safety is all the more obvious. Society pays very dearly for such accidents. During power scarcity and diminishing conventional sources of energy, we can ill-afford fires at generating sites.

The matter does not end here. Fire and explosion at nuclear power station pose more serious and complicated problems not only for power and safety engineers but also for policy framers. Here, apart from intensive property damage and business interruption, public fears are very important. Any accident at Nuclear Station has the potential to radically affect the public opinion about the use of nuclear energy. While formulating policy and strategy in the area of nuclear power generation people's anxiety cannot be brushed aside. What makes the matter worse here is the probability of leakage of radioactivity to the atmosphere in case of a fire or explosion. It can be argued that such a leak not only expose the population to radiation hazards but also contaminate every thing. Eatables become unfit for consumption and any material unit for contact. Some dreaded diseases, genetical deformities, psychological disorders etc. are also feared to be associated with radioactive exposure. Even salvage and rescue operations become difficult due to radioactive environment. If a fire or explosion occurs in a nuclear power plant shock-and-horror take over public mind. This explains the deeper implications of and public outburst at a serious fire accident involving nuclear plant. Policy and decision makers cannot afford to ignore the real or imaginary public fears. Thus stakes in the safe operation of the generating stations are really very high. Power plants are our valuable assets and 'fire protection programme' for them should be approached with right earnest and on professional lines.

The Problem

It is not to suggest that fire protection measures have not been taken or are not being taken at these plants. In nuclear plants safety remains the first occupation. However, the need for still higher degree of fire protection for the industry and a concrete action in this regard can hardly be disputed. Recent fire at Badarpur and explosion at Panki Power Plants are pointers in this direction. Both the accidents have occurred in the first eight months of the year 1981. An assessment of all aspects of fire safety is required both at the in-service and up-coming plants. Updating measures can and should be initiated where vulnerable points from the fire safety point of view are observed. More efficient and effective technical means of fire and explosion prevention must be identified for the industry.

Evaluation of Hazard

If we examine major constituent parts of a power plant a bit closely, we can appreciate the 'high-level' of fire and explosion risk. Turbogenerators and grouped cables are common constituents of a conventional thermal and nuclear power plant. Let us first analyse fire and explosion hazards associated with these common components.

Fire risk and concentration of value are very high in the turbogenerator system of a power station. The fire risk arises from the large quantities of combustible lubricant and turbine oil. As oil is under pressure, it can escape as spray of fine particles onto the hot surfaces of steam pipes or other ignition sources such as sparks, open flames friction, electrical equipment etc. causing intense fire. Auto-ignition temperature of oil can be as low as 500°F while steam pressures and temperatures at which modern turbine operate can be as high as 4500 psi and 1100°F respecitively[2]. Thus escaping oil may get ignited very easily as instanced by the two power plant fires one in Switzerland and another in France when oil got spilled onto hot steam pipes[3]. Accumulated rubbish is exposed to accidential ignition equally dangerously. Hydrogen being used as coolant for the windings of turbogenerator give rise to an explosion risk. Hydrogen under pressure may leak to the atmosphere to from an explosive mixture. An explosion may lead to mechanical failure. Davies and Foulsham point out to the dangerous build-up of coal dust on cables in coal fired power stations and to the possibility of spontaneous combustion besides the chances of ignition from external sources[4].

Malfunctioning of cables and electrical wires is a well recognised fire threat. The problem becomes acute when cables are used in groups. There exists a critical value of cablemass per unit length above which grouped cables propagate fires though they may not propagate it individually. From the large number of long horizontal and vertical shafts containing cables, we can visualise the magnitude of the risk in the plant on this score. The cable ducts provide routes to fire from one compartment to another. Fire at Browns Ferry power plant where the direct property loss alone was estimated to be ten million dollars, spread along these cable tunnels.[5] In contrast, cable feeding the control circuits of the plant must endure severe fire conditions for sometime since all the processes are under remote control and it is essential to shut-down the plant properly and safely in the event of a fire. Any malfunction of the control cables and instrumentation in an emergency spell a disaster. As grouped cables constitute a risk in themselves, the stringent demand of fire resistivity can be met only by following the fire safe design for cable installations and using fire retardant cables. Monitor and control circuits also must not loose their integrity unless the plant has been shut-down properly.

In nuclear plants, reactor vessel is built and housed with special safety and protection measures. However, a reactor fire can be caused due to a variety of reasons. Light (heavy) water decomposes into hydrogen (deuterium) and oxygen due to neutron irradiation. These gases can mix-up in hazardous proportions. Sodium used as heat transfer medium, is combustible in air and ignite spontaneously in contact with moisture. Also due to loss of coolant or inoperatin of control rods, sufficient heat might be generated to cause melting of fuel elements. This may result in a serious fire.

Hazards at Construction and Commissioning Stage

The period of construction and commissioning is all the more critical. Construction activities span over several years and in this period planned protection of cable system, equipment, machinery and structures is generally lacking. Rubbish accumulate and hazardous activities of welding, cutting etc. take place. Two fires one in a 60MW power station in Germany[6] and another in Peach Bottom Atomic Station in United States[7] which occurred at the construction stage have been widely discussed. In fact the later accident simulated intensive testing of control cables in trays. Special fire protection safeguards must be taken at this stage.

Professional Approach for Updating Fire Safety

Mere provision of fire protection devices throughout the plant would not suffice. There ought to be a fire protection programme for the industry drawn up by the professional fire safety engineers. The programme would aim at safe design, safe operating conditions and selection of safe material and balance the cost of preventive measures against the risk involved. The build-in safety features, that is the necessary steps taken at the design stage pay the highest dividents. The fight against fire begins at the design stage itself. Workers like Foulsham[8] and McAllister[9] have discussed some design aspects of reducing power plant fire loss in respect of cable installations. Care must be taken to incorporate the necessary steps and requirements of safe design with respect to all the constituents parts of the plant. Clear safe design criteria have to be developed where they are lacking by mutual co-operative efforts. Similarly the advice of fire protection engineers is of vital importance in the selection of fire safe material going into the making of the plant and in observing the operating conditions which are safe from the fire and explosion point of view. Fire safety during construction is vitally important.

Areas of Mutual Co-operation

To meet the goal of enhanced safety power engineers and fire protection specialists have to make co-operative efforts. Some specific areas are readily identifiable where joint actions are clearly warranted. Plants' safety engineers from their experience of actual fires can give types of fuels and fires which are most likely to be encountered. Test facilities at fire research laboratory (FRL), Central Building Research Institute (CBRI) can be used to evaluate suitability of various types of fire detection and extinguishing systems to deal with such fires in cable ducts, boiler room, control room, turbine area etc. Going further down, for instance, the behaviour of automatic detectors in a cable tunnel depends upon many factors such as degree of partitioning and ventilation in it. In control or computer rooms air-conditioning may effect the response of automatic fire detection system. Only tests in FRL can sort out such application problems and other specific questions. Design and testing of cable installations is another important and fairly wide area readily open for mutual co-operation. In FRL cables, in groups and individually, can be evaluated as per relevant standards with respect to flammability ratings and production of smoke. Other checks like laboratory flame tests and practical installation testing may also be desired and can be performed. Fire protection specialists of the laboratory can similarly help in selecting the safer material for the plant.

Conclusion

Our power plants can and should be designed to highest degree of fire safety. Power and fire protection engineers should work-out a concrete action plan incorporating long term and short term objectives and evolve a fire protection programme which can be called of satisfactory degree for the industry. The problem needs to be tackled on professional lines. Co-operative efforts must be initiated immediately in the problem areas which calls for joint action.

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