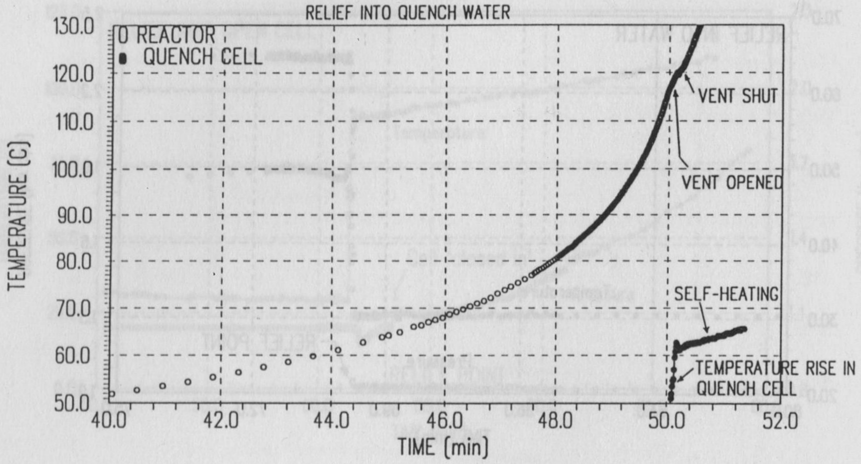
FIG 9 : METHANOL-ACETIC ANHYDRIDE
TEMPERATURE Vs TIME
RELIEF INTO QUENCH WATER



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This paper examines a number of incidents where power failures have occurred. It examines the effects of the failures, the reasons for them and sets out the lessons that can be learned.

SECURITY OF ELECTRICAL SUPPLY SYSTEMS INCLUDING STANDBY SUPPLIES.

All process industries use electrical energy in many forms for the operation of instrumentation and control of their plants. The electrical systems used range from the very simple to the very complex and often incorporate standby supplies. These standby supplies may be diesel engine driven generators, self contained Uninterruptible Power Supplies, on-site steam and gas turbine powered generators or any combination of these.

Experience over the years has shown that in many installation the design criteria for the complete electrical supply system have been flawed.

In this paper I would like to examine some typical incidents and indicate the defects which led to failure and loss of control and/or plant shut-down. The lessons which can be learned from these incidents are valuable from the practical viewpoint,and are possibly more useful than trying to list all the criteria for each and every power supply system that may be found.

INCIDENT 1.

A large site was supplied from two independent Grid Supply Points via separate circuits. The routes of these circuits were totally different. On the site there were additional electrical supplies. These were from on-site steam and standby diesel engine driven generation. The process control system for the whole plant was provided with an alternative electrical supply from a separate stand alone Uninterruptable Power Supply, often referred to as a UPS. (These systems generally comprise a battery system, some form of invertor and rectifier, and either a generator or a means of connection to the mains supply.)

These arrangements would appear to afford a satisfactory degree of redundancy for the electrical supplies.

During adverse weather, a lightning storm, these events took place

1. Each Grid infeed was struck by lightning in separate incidents, some 10 minutes apart. This resulted in total loss of external power supplies.
2. All auxiliary power supplies for the control of the on site steam driven generation were lost when the external power supplies failed and this generation closed down.
3. The diesel powered generation auto-started and ran up to speed. It did not to take up load because an auxiliary relay which controlled the final circuit breaker used to to connect the load failed.
4. The UPS system maintained the process control.
5. There was considerable effluent overflow.

Subsequent investigations revealed the following :-

a) The diesel powered generation was regularly tested but no connections were ever made to a DEAD electrical system so that the generators would carry load, i.e. the final links in the chain were never proved.

b) The site staff lacked adequate knowledge of the on-site power supply system and were unable to take appropriate corrective action.

c) There were no pre-arranged switching procedures available to cope with a total electrical power failure.

d) Electrical equipment was not properly indentified i.e. clearly labelled.

e) There was total loss of air supplies for plant control during the incident because of insufficient storage capacity in the air receivers to cater for a total failure of this kind.

f) The on-site communications proved to be incapable of coping with the information transfers necessary in a major incident of this kind.

g) There were no defined PRIORITY alarms. The control centre was overwhelmed with information and the priority alarms were lost in the mass of data received.

INCIDENT 2.

A large chemical complex supplied part of its electrical load from an on-site generator rated at 24 Megawatts. It was routine to bring the generator on-load, as the site electrical load increased, by manual operation. During this operation the final switch used to connect the generator to the system was closed when the generator and main supply were out-of-phase. The following sequence of events took place:-

1. The main electrical protection used to protect the main incoming switchboard (the bus-zone protection) operated and disconnected all electrical supplies. This was because the electrical system became unstable on the through fault current flow when the final switch was closed out-of-phase.
2. The plant electrical system collapsed due to the loss of all infeeds.
3. All process steam supplies were lost.
4. Process material was flared off.

The subsequent investigations revealed that:-

a) The generator steam turbine speed control was erratic. This was the result of corroded bearings in the sensor unit making it unpredictable.

b) The control centre was overwhelmed with data as there was no priority scheme for alarms.

INCIDENT 3.

The electrical supplies to a plant came via three separate infeeds at 33 kV. It was routine during severe weather warnings e.g. storms to run all on-site gas turbine generation to feed the essential services. These supplies were separated from the rest of the site supplies. At the time of the incident there was a storm warning and the electrical system was operating in this mode. The incident was:-

1. An 11 kV reactor, used to limit the electrical energy flowing into part of the system, suffered a cable termination failure.
2. There was a simultaneous loss of all 110V d.c. supplies which controlled the main 11 kV high voltage switchgear. No circuit breakers could operate to isolate the faulty system. All incoming supplies were lost because the fault was detected by the Electricity Supply Company equipment which operated.

The subsequent investigations revealed that:-

a) The cable termination failure was due to condensation in an unventilated enclosure.

b) The d.c. supply failure was associated with the cable termination failure. The 110V d.c. system was connected to equipment on the faulted reactor.

c) These d.c. supplies were derived from a single 11 kV circuit breaker on the main 11 kV switchboard which consisted of 19 circuit breakers.

d) The 11 kV reactor circuit breaker failed to operate to clear the fault because of the d.c. supply failure.

e) The control room staff were inundated with alarm data as there were no arrangements to prioritise the alarms.

Remedial action was taken to provide independant 110V d.c. control supplies to each section of the main switchboard and a totally separate d.c. supply was provided for the 33/11 kV transformer circuit breakers.

INCIDENT 4.

A process plant was in operation. The electrical supplies were fed from a main high voltage switchboard connected to the Regional Electricity Company. The distribution within the plant was via four other high voltage substations. When a fault occurred on a 3.3 kV motor starter all supplies to the plant were lost. This was because the Regional Electricity Company circuit breaker protection detected the fault and automatically disconnected the supplies. This closed a large part of the complex down.

Investigations revealed that:-

1. The motor starter unit was designed for indoor use, but had been mounted in a semi-enclosed outdoor location.It was found to be water-logged and this caused the initial fault.

2. The main site substation 110 V d.c. control power supply (a battery and charger system) failed and the circuit breaker was not able to open to disconnect the fault.

3. All other 110 V d.c. supplies in all the other substations were found to be faulty due to neglect.

4. Prior to this incident the organisation responsible for the complex had been warned on a number of occasions about the neglect of the 110 V.d.c. control system batteries and chargers.

INCIDENT 5.

A number of large chemical plants were supplied with electricity via a double-circuit 132 kV overhead line supported on steel towers, i.e. two separate circuits carried on common supports. Such a system is normally regarded as providing a firm and secure supply to that area.A fire took place in a yard situated under this overhead line.The following events took place:-

1. Arcing took place on the overhead line due to the smoke and flames.

2. The electrical supplies to the area were erratic for about half an hour as the individual circuits tripped due to the arcing and then reclosed as the arcs stopped.

3. Electrical supplies were then completely lost for a futher 15 minutes or so.

4. Limited supplies were then re-established.

All plants suffered,many due to the severe voltage fluctuations caused by the arcing.In others the battery supplies associated with standby generators became exhausted due to the many attempts to start up during the short supply interruptions.In some cases the on-site generation was running and exporting power to the "Grid".When the faults took place these generators were feeding into the faults and their own electrical protection operated to disconnect them from the system. There was considerable embarassment when several plants lost all communication and could not have called for emergency services had they been needed

INCIDENT 6.

A large petro-chemical complex consisted of three discrete but interconnected plants. The electrical supplies were provided by a double-circuit 132 kV overhead line, on-site generation, and a number of standby generators.The 132 kV overhead line suffered a fault when the conductors were caused to "clash" by a third party.

The effects of the fault were:-

1. Major electrical transients (disturbances) took place. These took the form of violently fluctuating voltage variations on the 132 kV in-feeds to the complex.

2. The electrical protection on the lower voltage in-feeds to the three separate plants detected these variations and disconnected plant number two from the system, but left plants one and three operating.

3. Plant one continued to produce feedstock to plant two. There was insufficient storage capacity, overflows took place and a number of fires were started.

Investigations revealed that :-

a) Plant two standby generation did not start up as the electrical protection having detected the voltage fluctuations inhibited the start up.

b) The control room staff were unable to cope with the volume of alarm data that was presented.

LESSONS TO BE LEARNED

These are not in any particular order of significance.

1. Duplicate infeeds from whatever source are NOT inviolate. Common cause failure is a frequently occurring phenomenon.

2. Batteries and their associated chargers used to start up generators or control switchgear are VITAL items of plant. All too often they become the most important item on site but are frequently the subject of neglect, abuse, and poor design.

3. When standby or other generators are routinely tested for operation it is imperative that the whole system is tried and tested by loading the generator via its own control system.

4. Plant and equipment identification should be clear and unambiguous. Arrangements should be in place to ensure that plant modifications and additions do not compromise the identification.

5. There should be pre-prepared systems and schedules to enable staff to operate and so recover from major and catastrophic electrical power failures.

6. Where there are segregated electrical power supplies the effects of failures and the possible "knock-on" effects of failures should be carefully investigated.

7. Maintenance activity needs to be carefully programmed with active and thorough monitoring of the work that is carried out.

8. Adequate communication facilities are necessary to permit proper action in times of emergency. There needs to be control over non-essential use where there are no segregated emergency facilities.

9. There is always a need to provide priority schemes for alarms to ensure that the operators are presented with the appropriate information. Modern alarm systems provide information at incredible speed and can readily overwhelm operators.

Many investigations reveal other matters which are often overlooked or ignored. These include:-

a) The provision of adequate storage capacity for air supplies for instrumentation and control purposes in the event of total electrical power failure.

b) The provision and maintenance of proper coolant for the prime movers for standby generators.

c) The provision of adequately fault-rated switchboards.

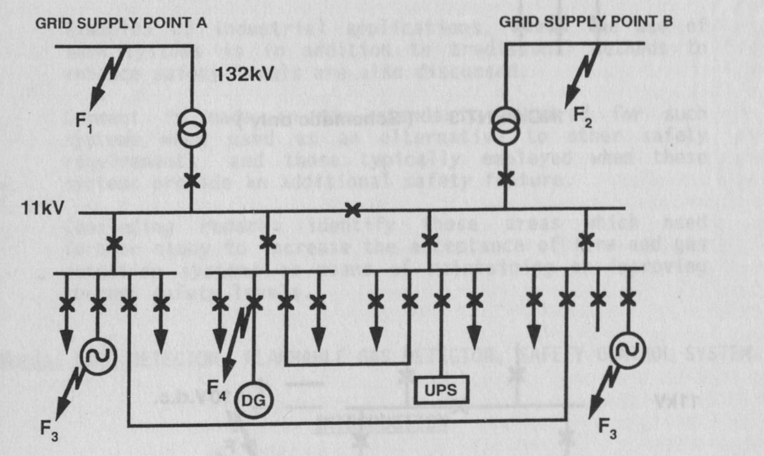
d) The provision and maintenance of electrical protection including fuses on standby systems.

e) Quality control of the installation of all standby facilities e.g. cables connecting Uninterruptible Power Supplies being damaged during laying failing when in service and leading to total destruction of that system.

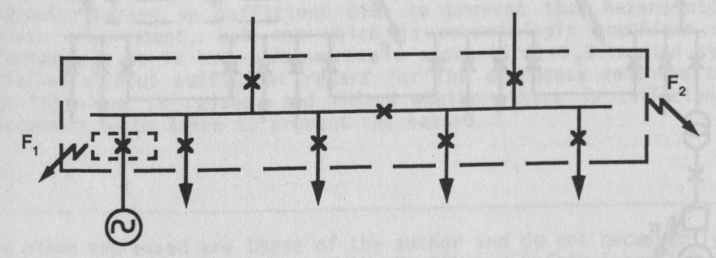
f) The need to segregate all essential electrical supplies and to provide protected routes for those supplies to ensure safe control of the plant in emergencies e.g. DO NOT route cables feeding fire pumps and deluge systems through the main highly flammable process area.

g) The possible effects of the use of mobile radios and telecommunications equipment upon Programmable Electronic Systems used for control purposes.

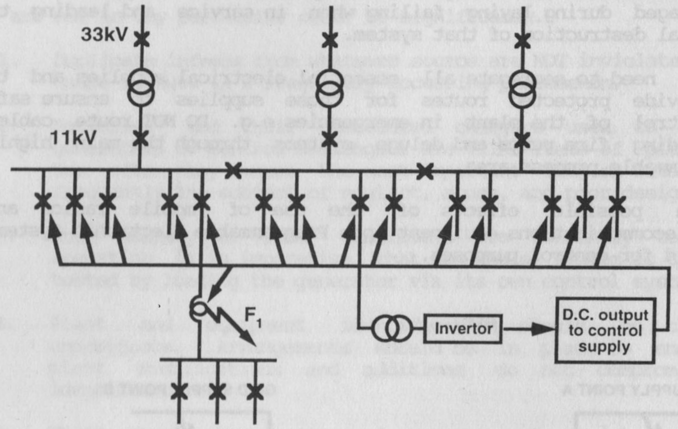
etc.



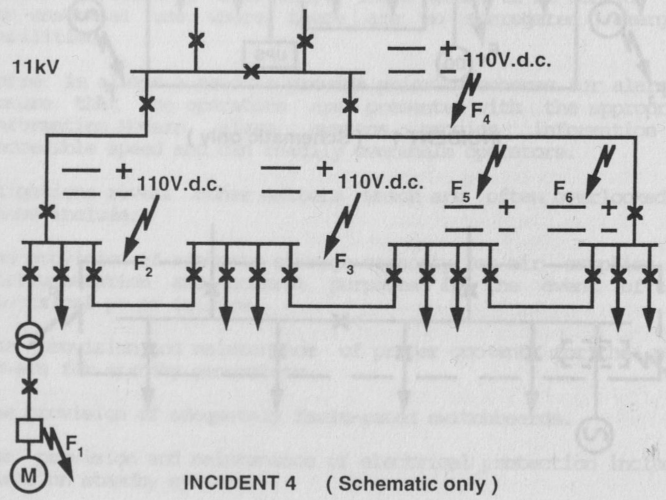
INCIDENT 1 (Schematic only)



INCIDENT 2 (Schematic only)



INCIDENT 3 (Schematic only)



INCIDENT 4 (Schematic only)

THE USE OF FIRE AND GAS DETECTION SYSTEMS AS PART OF THE SAFETY CONTROL PACKAGE

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The paper discusses those areas of industrial safety where the use of fire and gas detection systems are accepted as an alternative to the traditional standards of "passive" means of protection, eg the use of explosion protected electrical equipment in hazardous areas. This is illustrated by examples of the use of such systems in specific operations and processes.

Examples of industrial applications, where the use of such systems is in addition to traditional methods to enhance safety levels are also discussed.

Comment is made on the standards required for such systems when used as an alternative to other safety requirements, and those typically employed when these systems provide an additional safety feature.

Concluding remarks identify those areas which need further study to increase the acceptance of fire and gas detection systems as means of maintaining or improving current safety levels.

Key Words: FIRE DETECTOR, FLAMMABLE GAS DETECTOR, SAFETY CONTROL SYSTEM

INTRODUCTION

Fire and gas detection systems have been around for many years, yet many still question the safety benefits these provide. The objective of installing a fire or gas detection system is to give reliable warning of a developing hazard in sufficient time to prevent that hazard occurring. An obvious requirement, but one which is surprisingly sometimes overlooked. Unfortunately it is not unknown for a sophisticated detection system to be installed without sufficient regard for the emergency response to be taken once the alarm is raised, and indeed whether there is sufficient time for this action to be taken to prevent the hazard.

The views expressed are those of the author and do not necessarily reflect those or the policies of the Health and Safety Executive.