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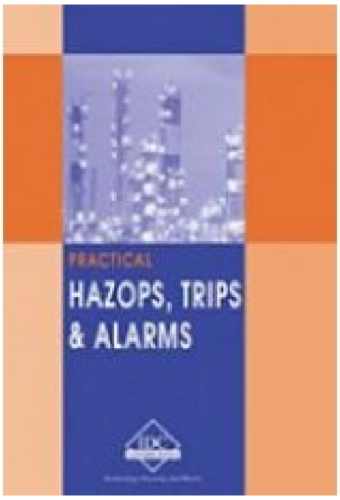
HO-E - Hazops, Trips and Alarms



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Short Description

This manual concentrates on awareness level training for managers, engineers and technicians in the practical application of hazard and operability studies (known as HAZOPS). Hazops are widely used for identifying deviations from design intent in manufacturing processes and for assessing the potential consequences, particularly where there are risks of harm to persons, then environment or assets.

Description

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The techniques are fully recognised and recommended by legislators, regulators, insurance companies and other professional institutions. Hazops are applicable at both the design stage and throughout the life of an operational plant where they support the validation of the plant safety case. Hazops are a valuable tool when considering modifications and upgrades to existing plant. This manual introduces the basics of hazard study methods and includes training in risk assessment methods using FMEA and Fault Tree Analysis (FTA).

It presents Hazops in the context of related plant and control system design activities. Later stages of the manual introduce the principles of alarm management and safety instrumented systems to promote an integrated approach to protection systems. Consequently this manual will be of interest to process engineers and instrumentation specialists alike.

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Practical Hazardous Areas for Engineers and Technicians - Introduction

1 Introduction

This manual accompanies the Hazardous Areas training course presented by IDC Technologies. In this first Chapter we begin by examining the legacy of learning from previous accidents. We present an overview of the background and history of Explosion Protection.

Learning objectives

- To learn from previous disasters
- To realise the risk posed by electrical equipment in hazardous areas
- To understand the need for the development of Standards

1.1 Introduction

Any threat to ‘life, property and investment’ is said to constitute a ‘hazard’. In modern manufacturing industries there are many types of hazard. These are encountered in various ways. Each hazard poses a different level of threat.

Where materials that can be ignited are used as part of any industrial process, they are referred to as ‘flammable materials’ and precautions must be taken to prevent the inadvertent occurrence of explosion and fire.

In the design of a plant, the flammable material which may be in the form of a gas, vapour, mist or dust, can be confined, transported, processed or possibly released under different circumstances. In each situation, if it can form a ‘potentially explosive atmosphere’ (PEA) by mixing with air then the simultaneous presence of sources of ignition must be eliminated or adequately controlled. The design of an industrial plant or facility and the equipment and procedures used must render the plant as safe as is reasonably practicable.

The combination of scientific research, technological development and practical experience are the three key considerations in human endeavour to minimise risk. Risk Assessment is the process by which this learning is applied to the concept of safety to achieve what is judged to be at an acceptable level.

This course will study current thinking and practise on the protection of industrial plants to train delegates on the technical and organisational measures required for safety purposes. It focuses on the use of explosion protected equipment operating in hazardous areas. It is suitable for personnel involved in the following activities on industrial plant and equipment:-

- Process Design
- Selection
- Installation
- Operation
- Inspection
- Maintenance
- Repair and overhaul and
- Troubleshooting

1.2 Definitions

It is important to define and understand some of the key terms used in this subject:-

1.2.1 Fire and explosion

FIRE (Combustion) is the process of a flammable material undergoing a rapid oxidation reaction that results in the production of heat (and, generally, visible light).

EXPLOSION is the violent and sudden expansion of gases produced by rapid combustion. It is a strong force, producing noise and supersonic shock waves that can cause extensive mechanical damage by the uncontrolled release of energy.

Examples are: -

- boiler explosion
- combustion of a gas/air mixture
- detonation of explosives

1.2.2 Hazard

Hazards are of two types, either 'Natural' or 'Manmade'.

Natural 'Hazards', such as blizzards, flash floods, earthquakes, heat waves, hurricanes, tornadoes, volcanic eruption etc, cannot be prevented. Countermeasures can only be taken to minimise the consequences.

Manmade 'Hazards', such as the potential occurrence of explosion and fire in industrial situations, are that which this course seeks to address.

1.2.3 Hazardous area

A HAZARDOUS AREA in the context of this subject is:-

- An area in which a flammable gas or vapour may be present in sufficient quantity to form a 'potentially explosive atmosphere'

One is reminded that this may be only one of many 'areas' on an industrial site which might be prone to an accident or the onset of a potentially dangerous situation in a defined region, owing to the presence of other predominant risks. The 'hazard' about which this subject is concerned is for when a 'fuel' in the form of a gas, vapour mist or dust is present in 'atmospheric air' and a 'source of ignition' caused by the presence of electrical equipment occurs simultaneously.

1.2.4 Hazard

An explosion occurs when there is a convergence of three basic ingredients as depicted in the classic Fire Triangle analogy (see Figure 1.1):-

- Fuel, any combustible material
- Air with 21% Oxygen
- Ignition source

Where electricity is in use, it is known that heat and sparking at sufficient levels can provide an adequate source of ignition.

Wherever combustible or flammable materials are stored, handled or processed there is an increased likelihood of leakage or ‘availability’ of the fuel and so it is necessary to be able to predict the circumstances of presence of the elements of the fire triangle. This is a form of Risk Assessment. Proper application is necessary to manage the hazard safely.

In practical terms, with the abundance of air around a process plant, adequate control must be exerted over the other two elements to reduce risk of explosion to acceptable levels.

Figure 1.1

The explosion triangle

1.2.5 Risk assessment

The process of Risk Assessment applied to Hazardous Areas is to define its nature and presence in a given location. Electricity is essential to industry but its use can generate heat or sparks that can ignite a potentially flammable atmosphere. Once defined, equipment and procedures suitable for use in such a hazard can be selected and operated safely. Examination of the issues and acceptable solutions are discussed in this course. The use of electrical equipment protection measures are well established but risk from non-electrical sources are now being included into Standards to be discussed.

Risk assessment must cover all sources of ignition.

After the occurrence of accidents and disasters, the human quest for safety forces thorough investigation by diligent scientific means to reveal likely or actual causes. “Root Cause Analysis” ensures that the set of conditions that has occurred to cause the disaster, are adequately understood. Appropriate precautions can then be taken to ensure that they cannot occur under the same circumstances again. In this way risk is managed and reduced.

The investigation must also take into account the actions of humans in relation to the circumstances of the accident. Causes of accidents have been shown to be by:-

- Improper installation and selection
- Lack of proper maintenance
- Improper use
- Carelessness or oversight
- Ignoring warning signs of failure
- Inadequate training and supervision

Such foreseeable and avoidable human errors must therefore be the subject of scrutiny and prevention.

1.3 Investigation after accidents and disasters

Industrial accidents involving explosion and fire will always be the subject of investigation. Lessons can be learned and so prevention knowledge and techniques can be further developed and improved. Cumulative knowledge now helps to fertilise the thinking processes and the approach taken on an international footing.

The Piper Alpha oil platform disaster occurred on 1st June 1988 in the North Sea off the coast of Scotland and is shown in Figure 1.2. The subsequent investigation uncovered how and why it happened exposing many bad practices owing to poor management. The report was responsible for initiating a dramatic change in the oil and petrochemical industries attitude to the management of safety.

Figure 1.2

The explosion triangle

This is one of many risks that the Owner of any industrial process on commercial premises must consider. The Owner, often referred to as the 'Duty-holder' in Law, must ensure that risks are adequately understood and therefore adequate precautions are in place to ensure safety to life, property and investment.

The term 'Loss Prevention' is a modern title applied to any body within an organisation responsible for overseeing the wider implementation of safety. The 'loss' could be to any one or more of the three critical values of life, property and investment.

Accidents in the mining industry are still common with other recent deaths in

China and other Far Eastern countries. Closer to home in the UK, the Senghenydd disaster, in South Wales on 14th October 1913, killed 439 miners. Investigation into this disaster and the subsequent research taught the mining industry a great lesson that was passed on internationally.

This has led to extensive research and detailed studies to assimilate knowledge in order to prevent explosions and fires in all types of industrial, commercial and domestic circumstances. 'Hazardous environment' found in various industries.

Globally, expertise is now shared to educate and prevent accidents. This is culminated in the International Standards to which industries work to maintain safety. The technology is currently based on the identification of the risk of an explosive atmosphere being present in a particular place. This is coupled with the identification of the likelihood of electrical equipment within the explosive atmosphere malfunctioning in a way that would cause it to become a source of ignition coincident with the presence of that explosive atmosphere. The objectives are not just to identify these coincidences but to utilise the information so obtained to influence the design of particular process plants and similar operational situations. This will help to minimize the risk of an explosion due to electrical installations. In this approach, the areas normally prone to have an explosive atmosphere due to the requirement of varies processes involved, are identified. Similarly, the areas where its likelihood is low but identifiable are marked up. It is needless to say that this is not an end in itself but should be deployed as a part of 'Overall Safety Strategy' for the plant.

1.3.1 Emergence of standards

The ability of electricity to cause ignition and trigger explosions has been understood since the turn of the twentieth century. Measures to control and minimise the risks have become part of the engineering discipline of design and to meet legislation for safety ever since.

Initially, countries developed their own regional practices independently of each other. The types of industry which were developed in that region depended on the natural resources available and hence the development of local expertise to deal with the hazards. In those early days the rules or practices were created by different organisations often depending on the system of Law in the country.

These have evolved into 'Standards' which will be introduced and discussed in this manual. Local Standards such as British Standards have merged into Regional Standards such as from Europe and then have become International Standards. This is discussed in detail in the Chapter on Standards. Examples are:-

UK: BS5501

North America: NFPA70 – NEC Article 500

Europe: CENELEC EN50 Series

Global: International Electrotechnical Commission: IEC 79 Series

1.3.2 Methodology

The Standards impose a methodology that looks not only at technical issues but management and control issues. Under the European ATEX Directives, discussed in detail later and adopted by many institutes, the route to safe analysis is based on:-

- First step : identification of the risk of an explosive atmosphere being present in a particular area
- Second step : eliminating the use of electrical equipment in such areas
- Third step : if installation becomes essential: identify the likelihood of electrical equipment malfunctioning

Thus precautions can be taken to assess and prevent ignition occurring in such areas in the most logical and effective way.

An overall plant safety strategy must be developed of which Area Classification, the outcome of the risk assessment, must be part to ensure safety. Thus Explosion Protection techniques can be applied where equipment must function in the possible presence of a hazard.

1.4 History

The use of electricity in a potentially explosive atmosphere was first encountered in the coal mining industry and it is there where the first precautions were developed and implemented. Even before this the hazard of ‘fire-damp’ [methane] was recognised.

Miners observed that the presence of fire-damp would make the flames of the miners’ naked-flame lighting sources (oil lamps and candles) burn a different colour. This was also inadvertently the original hydrocarbon ‘gas detector’. Unfortunately, this was also the source of ignition causing many deaths. The mining authorities realised that burning off the methane collected in the seams of the mines would deal with the immediate problem at the start of a shift. Young miners were covered in wet sacking and would be induced to crawl down the tunnels with a long lighted taper held up towards the ceiling in the highest points thereby setting light to the gas. In later years, penitents, prisoners for serious crimes, were released to perform this service. This made the mines safe for miners to work. Although this was an effective method, it was somewhat barbaric in nature and fell into disrepute. Subsequently, methane and other noxious gasses were removed by improving ventilation.

After a disaster at the Feeling Coal Mine in Northumberland, UK on 25th May 1815 during which 92 miners died, Sir Humphry Davy (assisted by the young Michael Faraday) invented the Davy Safety Lamp (see Figure 1.3) which was first tested underground in the Hepburn Colliery, Tyne and Wear, on the 9th January 1816. This invention must have saved innumerable lives over the years.

Figure 1.3

Davy Safety lamp designs

Around the late nineteenth century and in the early part of the twentieth century the use of electricity in mining began, using d.c. supplies for lighting and motive power. The early equipment produced sparks and some explosions were caused, igniting methane and coal dust. Before World War II, extensive research work was done in Germany and the UK to prevent this and so came the development of a crude form of ‘flameproof enclosure’ suitable for sparking equipment. As a result of the Welsh Mining Disaster, mentioned earlier, the ignition capability of control and signalling systems was realised and so the concept of energy limited circuits became understood and was developed. The concept of ‘Flameproofing’ was to contain an ignition, preventing it from propagating into a hazardous area. Scientists and engineers, however, also knew that if the power and energy levels in circuits were regulated and limited then it could not cause ignition. This subsequently became known as ‘Intrinsic Safety’.

Originally these crude types of protection were developed specifically for the mining industry to be safe in methane and coal dust, but it was realised that the same approach could be used for the developing surface industry.

1.4.1 ‘Surface’ industries and area classification

It became apparent over time that, whereas in mines only coal dust and methane gas presented the hazardous conditions, on the surface a myriad of situations depending upon the type of industry and processes used. To ensure that appropriate precautions were taken, a risk assessment technique evolved to classify each ‘Hazardous Area’. This led to the process of ‘area classification’, that of defining where the hazard might be present, and equipment classification. This was to identify the risks associated with each type of explosive atmosphere and to choose equipment that was known to be safe in those areas.

1.4.2 UK and Europe

In the United Kingdom the first legislation covering the use of electrical equipment in explosive atmospheres came into being through ‘The Electricity (Factories Act) Special Regulations 1908 and 1944, Regulation 27, which states that –

‘All conductors and apparatus exposed to the weather, wet, corrosion, inflammable surroundings or explosive atmosphere, or used in any process or for any special purpose other than for lighting or power, shall be so constructed or protected, and such special precautions shall be taken as may be necessary adequately to prevent danger in view of such exposure or use.’

Even Regulation 6 of ‘Electricity at Work Regulation 1989’ is in the same spirit of placing the responsibility of achieving the objective on the owner of industry without specifying the methods to be adopted. In the UK, it was legal to use uncertified equipment in hazardous areas provided that it could be shown to be safe. Thus, as long as owner maintains adequate records of plant safety this clause gets satisfied.

This is in variance to the one being followed in USA and Germany and other parts of Europe, where specifics are also formulated. Both approaches have withstood the test of time and there is not much evidence of putting one method over the other.

In the UK much work has been done in the area of electrical installation safety in hazardous atmosphere by the Safety in Mines Research Establishment, the Electrical Research Association [now ERA Technology Ltd.], the Fire Protection Association, Institution of Fire Engineers, Loss Prevention Council and The Institute of Petroleum.

With the advent of automobiles and airplanes in the early 1920s, fuel refining began and increased in capacity very quickly. Volatile vapours from oil by-products and electrical sparks and heat did not mix safely! Fires and explosions were common in the industry. So the first hazardous area classification was invented about this time but it is thought that the Imperial Chemical Industries (ICI) Company had started to evolve the notion of Divisions. Division 1 described areas being normally hazardous.

In the wake of the mining disaster in South Wales, investigation into the cause and then further research pioneered by Newcastle University began the understanding of how Explosion Protection could be harnessed. Thus, a new industry with the goal of protecting electrical equipment in hazardous areas was born. Flameproof enclosures and simple intrinsically safe circuits were now being used, the first Standard for FLP (BS229) equipment being issued in 1928. Oil immersion followed and, together, these were the first types of protection developed.

World War II brought many changes in Europe and North America. Metal shortages in Europe prompted more plastic use in electrical equipment, and the first construction standards for explosion-protected electrical equipment appeared in Germany.

At about the same time, North American industries determined that hazardous area classifications needed to be expanded. A Division 2 was needed to describe locations that were not normally hazardous to allow use of less expensive equipment and less restrictive wiring methods.

1.4.3 The USA

In the United States of America the NFPA (National Fire Protection Association) was formed in 1896 with the aim to reduce the burden of fire on quality of life by advocating scientifically based consensus codes and standards. It also carries out research and education for fire and related safety issues. The Association was incorporated in 1930 under laws of the Commonwealth of Massachusetts.

The Electrical section was added in 1948. The National Electricity Code (NEC) under NFPA 70 defines rules and regulations regarding use of electrical equipment. The sections 500 through to 517 deal with installation, testing, operation and maintenance of electrical equipment in hazardous area.

In addition, various government laboratories, university laboratories, private and industrial laboratories do research and education in USA. One of the most prominent is the Underwriters Laboratories Inc. This was founded in 1894. It was originally conceived to serve the insurance industry as an arbitrator for safe practice but is now a not-for-profit corporation having as its sole objective the promotion of public safety through the conduct of –

"…scientific investigation, study, experiments, and tests, to determine the revelation of various materials, devices, products, equipment, constructions, methods, and systems to hazards appurtenant thereto or to the use thereof affecting life and property and to ascertain, define, and publish standards, classifications, and specifications for materials, devices, products, equipment, constructions, methods, and systems affecting such hazards, and other information tending to reduce or prevent bodily injury, loss of life, and property damage from such hazards."

The role of Federal Government was minimal in Fire protection prior to 1974. However, in 1974 Congress passed the Federal Fire Prevention and Control Act. Under this act 12 Executive Branch departments and 10 independent agencies are supposed to administer the various provisions of the Act. The NFPA enjoys a co-operative relationship with these agencies. A number of agencies rely upon NFPA Standards and participate in the NFPA standards-making process.

In 1970, the Congress established the Occupational Safety and Health Administration (OSHA) within Department of Labour to oversee development and implementation of mandatory occupational safety and health standards – rules and regulations applicable at the workplace. The Mine Safety and Health Administration was established in 1977 with a functional scope similar to that of OSHA, but with a focus on mining industry.

In order to understand how the electrical code is evolving and what guides this evolution we need to look back in history and their development till date. In the early 1900s, when contractors were busy electrifying industrial buildings, electrical wires were run through existing gas pipes, resulting in today's conduit system of wiring. This formed the basis of wiring in North America and the codes and standards were made to suit the safety requirement pertinent to these practices.

While this was being done on the American continent, the International Electro technical Commission (IEC) was founded in Switzerland in 1906. The IEC is supposed to be the "United Nations" of the electrical industry. Its ultimate goal is to unify worldwide electrical codes and standards. Few IEC practices were incorporated into the NEC or CEC mainly because North America operated on different voltages and frequencies than most of the rest of the world.

1.4.4 Advent of hazardous area in surface industries

In the 1960s, the European community was founded to establish free trade through Europe. To reach this goal, technical standards needed to be harmonized. As a result, the European Community for Electro technical Standardisation (CENELEC) was established as the Standards writing body for Europe.

By this time the German chemical industry had departed from the traditional conduit or pipe wiring system and migrated towards cable as a less expensive alternative. This wiring-method change led to the zone classification system later adopted in 1972 by most European countries in a publication known as IEC 79-10. This action led to the different methods of classifying hazardous areas as well as protective, wiring, and installation techniques, which form the basis of present IEC classification.

1.5 Equipment certification

It would be a very costly and time-consuming affair to test each electrical installation for safety. Standards could not be written for design validation and conformance of plant as it varies dramatically from one application to another. The nature of the flammable chemicals used would be different. Thus, in Europe, a system of certification evolved for the use of electrical equipment to be installed in a hazardous atmosphere of a Plant.

This technology primarily consists of –

- The classification of the area of the Plant where the electrical equipment is needed.
- The classification of the electrical equipment used in that area of the Plant.

The classification systems used for both must be the same so that it would be easy to determine if a particular piece of equipment would or would not be safe in a given area. The International Standards and Codes of Practice have been developed from the range of those used in individual countries. Obtaining agreement has not been easy. The benefit to the user is to provide a level of confidence for safe operation of electrical equipment under the specified conditions.

These classifications will be explained in some depth in this course, allowing an understanding of the application for given situations.

The certification process merely states conformance with the Construction Standard to which equipment has been assessed. It does not imply that the equipment is safe. A few examples of the marking of equipment are illustrated in Figure 1.4.

Currently, internationally acceptable markings are used to identify Explosion Protected (Ex) equipment. This leads to uniformity in the industry and gives a confidence level to the user, vis-à-vis, the suitability and integrity of quality and design and lessens the work of manufacturer in getting each piece approved all over the globe.

Figure 1.4

Typical certification logos

In Europe, under the ATEX Directives that came into force in member states on 1st July 2003, all ignition-capable equipment (Electrical and NON-electrical) that is sold into or used on plants requires assessment and certification to harmonised Standards if used in a Hazardous Area. The Directives, in line with the Standards, expect Plant management to keep records and documentation of all aspects of safety related plant and equipment so as to be able to demonstrate safety compliance.

The harmonised IEC 79 Series of Standards are recognised as IEC60079 and have been adopted in many countries including the USA who has now incorporated the relevant classification requirements into NEC. In time all countries claiming IEC compliance are expected to follow.

1.6 Conclusion

This chapter has introduced a wide range of subject matter which will be discussed in detail in subsequent chapters.

The overview and brief history of the development of the Standards given here will help to provide an appreciation of the depth of engineering that has been dedicated to the prevention of accidents.

There are many misconceptions on the principles in this subject that can undermine safety unless properly understood. The early separate development of Standards in different countries goes some way to explaining why the industry suffers from terminological inconsistency which has, in part, thought to have exacerbated these misunderstandings.

This Manual focuses on the harmonised International Standards as the primary source of information in an attempt to unify the terminology. There remain regional variations in the approach to Hazardous Area and the implementation of Ex equipment. These are mentioned and clarified where it is felt appropriate.