Review of *Protection against Substances Hazardous to Health*

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This Guide was produced by a joint working party of the Explosives Industry Group of the Confederation of British Industry, including the Ministry of Defense and the Health and Safety Executive. Its purpose is to provide advice to those who manufacture, store, transport by road, test, supply, use or undertake the disposal of explosives and explosives articles and substances in Great Britain on the selection of personal protective equipment (PPE) to be used against substances hazardous to health.

Of special interest to me is that their statement of purpose goes on to include protection from both the toxic chemicals used in the manufacture of explosives and pyrotechnics and from the smoke and byproducts created during use. As such, this guide supports my personal quest to have protection against these byproducts included in the National Fire Protection Association's (NFPA 1126) *Standard for the Use of Pyrotechnics before a Proximate Audience*.

Regulatory Structure. The Guide places all its recommendations within the regulatory structure in the UK. It provides a flow diagram showing how 10 different laws harmonize with the 1974 British Health and Safety at Work Act (HSWA) and jointly impact all aspects of explosive work.

I found it fascinating to compare the UK rules with those in the US. Most of the rules are similar, but there were some striking differences. For example, our Occupational Safety and Health Administration (OSHA) only addresses protec-

tion for workers while the UK's HSWA places duties on employers and the self employed to protect people other than employees. This may even require employers to provide visitors with personal protective gear, information, instruction and training. US companies are only bound by corporate liability for visitors' injuries.

In another example, the self-employed individual, who in the US has a tendency to slip below some regulatory radar lines, must comply with the UK's Control of Substances Hazardous to Health Regulations as if that person were both an employer and an employee.

However, the crucial and pivotal difference between our laws involves risk assessment.

Risk Assessment. The Guide states that:

> The first duty of the employer under the Management of Health and Safety at Work Regulations 1999 is to undertake a risk assessment to clearly define the source and nature of all potential hazards and people who may be affected by them. This assessment must be performed and significant findings recorded by a person or persons who are adequately trained and competent to perform such duties.

The clear requirement to have a person qualified to make the risk assessment is not included in the US personal protective equipment regulation, which reads:

> 132(d)(1) Hazard assessment and equipment selection.
> (1) The employer shall assess the workplace to determine if hazards are present, or are likely to be present, which necessitate the use of personal protective equipment (PPE).

and

> (2) The employer shall verify that the required workplace hazard assessment has been performed through a written certification that identifies the workplace evaluated, the person certifying that the evaluation has been performed; the date(s) of the hazard assessment; and which identifies the document as a certification of hazard assessment.

I believe that this wording in the US rules explains the common practice of employers choosing the wrong PPE and/or delegating risk assessment and selection of PPE to workers with no formal safety training. In 25 years of workplace inspections, it is rare that I have not seen chemical splash goggles used for impact protection, the wrong gloves used for chemical resistance, and other violations of the PPE rules.

The US Respiratory protection regulations do indicate that training is needed. In 29 CFR 1910.134(c) it states: "The program must be administered by a suitably trained program administrator." However, many schools and theaters, at which I have consulted, interpret this to mean that any trained "administrator" can do the job. I routinely see human resources administrators, technical directors, and teachers doubling as safety directors.

Evidence that OSHA agrees with UK regulators that professionals should be in charge of safety was seen on February 13, 2002 when OSHA announced a settlement agreement with a pyrotechnics and explosives manufacturer. The company, which logged 5 deaths from flash fires since 1991, was fined $832,000. Then OSHA worked out a settlement in which the company would pay only $300,000 in penalties provided the manufacturer:

- hires a third-party certified safety or health professional consultant to audit their workplace every year for the next three years and follows their recommendations;
- hires a full-time safety and health director who has both training and experience in safety and health who will report directly to the company president, and who will have authority to "do whatever is necessary to ensure compliance with applicable OSHA standards including, but not limited to, shutting down operations," and
- meets other compliance program and training rules.[1]

Toxic Substance Exposures. The Guide explains that the UK's Control of Substances Hazardous to Health Regulation (COSHH) defines and sets limits for toxic substance exposure. The COSHH sets two types of limits:

- The Maximum Exposure Limits (MEL), which are set for substances that may cause the most serious health effects such as cancer or occupational asthma and for which "safe" levels of exposure cannot be determined. The workplace air must not exceed this level and it should be reduced as far below this level as reasonably practicable.
- The Occupational Exposure Standards (OES) which are based on current scientific knowledge and which indicate there is no risk to the health of workers exposed to that level of inhalation day after day.

The COSHH defines a toxic substance as:

- a substance listed as dangerous in any of the applicable regulations as very toxic, toxic, harmful, corrosive or irritant,
- substances that have a Maximum Exposure Limit (MEL) or an Occupational Exposure Standard (OES),
- a biological agent,
- dust of any kind when present at a concentration in air equal to or greater than an 8-hour, time weighted average of either 10 mg/m^3 for inhalable dust[2] or 4 mg/m^3 for respirable dust,[2] or
- a substance of any kind that is not mentioned in any of the rules but which creates a hazard to people's health which is comparable with the hazards created by substances mentioned in the acts above. "These will include any substances generated as a by-product of the process."[3]

Selection of Equipment. The UK standards for the use of PPE are covered—respirators, hand protection, eye protection, body and foot protection. And since static electricity can trigger explosions of some pyrotechnic materials, the choice of gear, especially clothing, must also consider this factor.

Training. Users (including visitors) must be trained to wear their PPE whenever and wherever this is required to protect them. Users must also be given appropriate information, instruction and training by a competent person on the requirements and reasons for using PPE, how to obtain and fit PPE, how to store, check, care for, clean and dispose of PPE, and more. Most of these rules are similar to US regulations for PPE and respiratory protective equipment.

Risk Assessment Examples. Annex (Appendix) 3 of the document provides examples of risk assessments. In each case a "Potential Severity Rating" and a "Probability Frequency Rating" are determined and a matrix used to determine the actions that should be taken. The actions often involve personal protective equipment, ventilation, and other engineering controls. There are five case examples:

1) fluon (a fluorocarbon polymer) sieving in an explosives factory
2) manufacture of red phosphorus sheet in an explosives factory
3) firing flash powder effects in a theater
4) cleaning a settlement tank in an explosives factory
5) testing fireworks in an outdoor test facility

Theater Example. While all the risk assessments are useful in understanding the process, Example 3, "firing flash powder in a theater" covers the most diverse problems. The assessment begins by identifying the hazards as:

a) *Hazardous Substances*: The smoke produced on firing a flash powder effect may contain chemicals including carbon monoxide, carbon dioxide, hydrogen chloride, nitrogen [oxides], heavy metals (in the case of coloured flash effects) and aluminum/aluminum oxide dust and fume.

b) *Other Hazards*: On firing, the immediate area around the effect is subject to brief, but intense heating; the flash pot / cartridge may remain smouldering or even catch light after firing; noise on firing, particularly with fine grained flash powder that is used to produce an accompanying report with the flash effect.

It also looks at the people who are affected.

Directly: 10 performers on stage and up to 4 crew members working backstage.

Indirectly: All cast and crew member in addition to the audience.

The frequency and the severity of the exposures are assessed for a sequence that is fired

three times during each performance in daily evening performances and in Wednesday and weekend matinees. It is determined that the OES for respirable aluminum and aluminum oxide dusts could be exceeded causing possible respiratory complaints. Other products in the smoke may cause irritation to the eyes and throat. Heat, noise, potential fires, and electrical hazards are also assessed.

A matrix is set up that ranges from 1 to 36 representing conditions from "Low Risk" (1 to 4) to conditions under which the employer should "Stop Work Immediately" (18 to 36). Without controls, the assessment for this indoor pyrotechnic work is found to be 16, which meant the "Risk is high, [and] immediate corrective action is required."

The next section discusses engineering controls. In this hypothetical theater, there is an extraction fan system in the fly that will draw the smoke away from the audience, up into the fly, and exhaust it from the roof. The risk is reduced from a high risk (16) to 8, a "Medium" risk by insuring that:

- the extraction system is used at all times when the pyrotechnics products are used;
- fire fighting measures are in place;
- insuring electrical firing systems meet guidelines;
- pyrotechnic storage is appropriate and limited to small quantities; and
- all scenery on and around the area is treated with fire-resistant materials, and props (which do not come under the fire-retardant rules) are not positioned near the effects.

A drawing of the theater and the direction of air flow is shown. The Guide also states "The effectiveness of the extraction system is to be tested before and during rehearsals, by test firing the effects that are to be used during the performances. More elaborate smoke tests may be carried out if required."

This kind of exhaust fan system does exist in some US theaters and in some cases, there are fire fans which can be activated under certain circumstances. But in most US theaters, I fear, the risk would still be rated in the "high" range under the UK system.

Summary. This Guide is a clearly written outline of the British safety regulations and protective equipment rules as they apply to pyrotechnics and explosives. Although produced primarily for an overseas audience, the publication contains a wide range of useful information relating to the health protection of those working with explosives. In my opinion, some of these rules should be incorporated into US regulations and standards, including 1) placing the onus on the employer to protect non-workers as well as employees, 2) requiring formal risk assessment by trained safety personnel, and 3) considering the byproducts of the pyrotechnic reaction in any risk assessment.

References

1) *Bureau of National Affairs–Occupational Safety and Health Reporter*, Vol. 32, No. 8 [2-21-02], pp, 159–160.

2) "Inhalable dust" is capable of entering the nose and mouth and available for deposition in the respiratory tract. "Respirable dust" is also capable of penetrating the deep gas exchange region of the lung.

3) Predictive modelling of the products of combustion from some high explosives and propellants is under development. Dr. M. D. Cook, *Predictive Modelling of Products of Combustion of High Explosives and Propellants*. WS3 Chemical Technology Department, Defense Evaluation and Research Agency, Fort Halstead, Sevenoaks, Kent TN14 7BP, UK (in preparation).

Other CBI Guides

Four Guides have been produced by the Confederation of British Industry (CBI). Their titles are:

1) *Fire Protective Clothing: A Guide for Those Who Manufacture or Store Pyrotechnics or Propellants* (November 1995) [ISBN 0 85201 513 5] {Reviewed in *J Pyro.,* Issue 9 (1999)}.
2) *Hearing Protection: A Guide for Those Who Manufacture, Test or Use Explosives* (August 1997) [ISBN 0 85201 548 8] {Reviewed in *J Pyro.,* Issue 10 (1999)}.
3) *Head and Eye Protection: A Guide for Those Who Manufacture, Test or Use Explosives* (May 1999) [ISBN not allocated] {Reviewed in current issue of *J Pyro.*}.
4) *Protection Against Substances Hazardous to Health* (March 2001) [ISBN not allocated] {Reviewed in current issue of *J Pyro.*}.

The guides each cost £11 (approx. US$18). Further details concerning exchange rate, postage, etc. can be obtained by contacting:

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