HAZARDOUS WASTE INCINERATION-
THE GROWING CONCERNS

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Introduction

Incineration is advertised by its proponents as an ultra-modern, cost-effective, efficient and final solution to waste disposal, equally suited to the destruction of both municipal and hazardous wastes. However, incineration does not destroy all the waste fed to it and in fact releases a wide range of pollutants to the environment. Britain's municipal incinerators are now known to be far from satisfactory. Emissions of carbon monoxide, particulates, hydrogen chloride, and toxic metals are generally well above the levels set by the 1989 EEC Directive and none of the 34 municipal incinerators in the UK are likely to meet the EEC standard for mercury. There are currently no EEC limits for the notorious dioxins and furans, but it is highly unlikely that any UK municipal incinerators are capable of meeting the standards already adopted by, for example, Germany. Of course, all such standards are somewhat arbitrary, being based as they are on a far from complete understanding of the toxicity of many of the compounds emitted from incinerators. Even where facilities do meet legal standards, there is no guarantee of protection of health and environment. If Britain's municipal waste incinerators are in such a sorry state, what of their close relations, hazardous waste incinerators?

Hazardous waste incinerators in the UK

There are currently four merchant hazardous waste incinerators operating in the UK, with a combined capacity of 130,000 tonnes per year. Proposals have been put forward for a further seven new developments, with a projected additional capacity of almost 165,000 tonnes per year. Some 60 small in-house hazardous waste incinerators are located at industrial and manufacturing facilities with a capacity of 85,000 tonnes per year which is expected to rise to some 165,000 tonnes per year. A small number of cement kilns are licensed to handle hazardous waste and two solvent recycling companies operate small incinerators which take waste from outside waste generators. Incineration is clearly widespread and growing despite increasing disquiet about their environmental safety.

Health and safety implications of emissions

The emissions from an incinerator arise by three major routes; fugitive emissions, accidental releases and process effluents. All are of potential significance to human and environmental health.

Fugitive emissions

All hazardous waste incinerator systems will give rise to some fugitive emissions of the material being handled. The chlorinated solvents are a good example of wastes potentially hazardous to public health and the environment and they make up a significant proportion of incinerable liquid wastes. They include greenhouse gases, ozone depleters and some compounds implicated in the large scale forest damage taking place in Europe. Some also cause liver and kidney damage in those occupationally exposed and moreover, some are suspected carcinogens. The public health risks resulting from long term low level exposure to these compounds are largely unknown. Fugitive emissions, from storage and handling operations may be proportionally larger from the smaller and perhaps less consistently operated on-site incinerators although there will be constant releases from any incineration facility.

Accidental spillage

The potential for catastrophic accidental releases is naturally increased as waste needs to be transported over greater distances with greatest risks in those areas where large merchant facilities are sited. A recent accident in the South of England where a tanker shed part of its load of relatively innocuous waste resulted in some 500 people being evacuated from their homes with 14 being hospitalised overnight.

Effluents and residues

i) Stack emissions

The emissions from the stack of a hazardous waste incinerator have never been fully characterised. In addition to the acid gases and heavy metals, an entire array of potentially toxic chlorinated and nonchlorinated organic compounds are present. These are unburned components of the original feedstock along with compounds produced in the incineration process, known collectively as products of incomplete combustion (PICs). The most well-known of these are the chlorinated dioxins and furans. The majority of these compounds emitted are formed as the off gases cool on leaving the furnace. The amount of dioxin formed cannot be predicted, but a number of factors are known to be involved. Significant among these are the type of waste being burned, the presence of catalysing metals such as copper and the temperature profile of the equipment in the post-combustion zone. Temperatures in the region of 300-500^{o}C are known to be highly favourable for dioxin formation.

Current EEC limits for incinerators are set for particulates, carbon monoxide, hydrogen chloride, sulphur dioxide and the toxic metals nickel, cadmium, lead and mercury. Dioxins are not covered, though the forthcoming EEC draft directive for hazardous waste incinerators is expected to contain some limits. However, because of the extreme difficulty and expense of measuring dioxins, it is unlikely that routine dioxin monitoring will be conducted at any but the largest sites.

ii) Scrubber effluents

Water-based scrubber effluents are discharged either to a river or to the public sewerage system. As with atmospheric emissions, great difficulties exist in characterising and regulating the complex mixture of chemicals that they contain. The necessary analyses are expensive, likely to be sporadic and give only a poor indication of the true content and total toxicity of a discharge.

ii) Fly and bottom ashes

By far the greatest mass of pollutants is found in the ashes produced by every incinerator. The weight of ash generated may be as much as 9% of the original mass for liquid hazardous waste. These ashes contain the greater proportion of the heavy metals, although some volatile ones such as mercury will largely be lost to the atmosphere. The ash, especially fly ash, also contains the largest concentration of dioxins of any of the effluents. Their formation is catalysed on the surface of dust particles as the off gases cool often in heat exchange equipment. This allows more time within the critical temperature range best suited to dioxin formation. The contaminated ashes are largely removed from the gas stream by the scrubbers but further dioxin synthesis is known to take place in electrostatic precipitators.

Most slags and ashes are landfilled. In the course of time, leaching can mobilise the contaminants into ground and surface waters and they can escape through the landfill cap to the atmosphere. There may thus be public health concerns in the vicinity of landfills accepting incinerator ashes.

Monitoring and control.

A common misconception concerning hazardous waste incinerators is that risks to health and the environment can be prevented by monitoring the emissions from the plant and controlling the operating conditions and efficiency. If, as is the case, the actual chemicals being emitted are largely unknown, then it is impossible to state that they are safe. Further, the techniques used to estimate the efficiency of an incinerator are themselves subject to considerable doubt.

The two main parameters used to assess incinerator efficiency are combustion efficiency (CE) and destruction and removal efficiency (DRE). Neither are capable of fully quantifying the toxicity of the material in the stack gases.

DRE is usually determined primarily during test burns when the incinerator is first being commissioned. Great care is taken to optimise the operational parameters to achieve high efficiencies. These tests are infrequently repeated at intervals of months to years. Disruptions in ideal conditions are often disregarded although common in routine operation. Other variables may arise during normal operation and thus test burn figures are unlikely to reflect the day to day efficiency of the installation.

DRE compares the concentration of a given target compound present in the waste feed with its concentration in the stack gases. However, with progressively more efficient flue gas cleaning devices, it is possible that the removal of unburned target compound by scrubbers gives the false impression that waste is being efficiently broken down when in fact it is leaving the incinerator in the ash or liquid effluents. This technique also disregards the products of incomplete combustion created within the incinerator; the calculation is based only on the amount of the target compound that passes through the entire plant unaltered.

Combustion efficiency is based on the ratio of carbon monoxide to carbon dioxide; an extremely crude and indirect measure of the extent to which the organic carbon present in the waste has been fully oxidised. This parameter is usually monitored continuously, together with a determination of total organic carbon present. Neither measurement gives any clue as to the types or quantities of materials being emitted.

These calculations are further flawed in that it is simply not valid to calculate an incinerator's CE or DRE to seven- or eight-figure precision (eg 99.99999% DRE) based on data which at best can be measured to two or three figures. Uncertainties in the concentrations of organic contaminants in waste and flue gases for the calculations of DRE are particularly large. This can lead to margins of error the calculated result of up to 20%.

Small wonder then, that in a recent article written from the industry viewpoint, the operation of a modern hazardous waste incinerator was described as more of an art than an exact science.

Changing environmental policy

Environmental protection policies are moving in the direction of pollution prevention as opposed to pollution control. This is embodied in the concepts of the precautionary principle and clean production. The precautionary principle and clean production have been adopted by a number of international fora including the United Nations Environment programme as guiding principles. Clean production envisages manufacturing and consumption tailored such that all releases, including products, can be returned to use or to the environment without harm. The production and incineration of hazardous waste is at odds with both of these guiding principles. The licensing authority must weigh the intangible potential costs in human and environmental terms against any perceived material benefits from the plant. Incineration encourages the generation of hazardous waste, fails to protect the environment and carries with it an as yet unquantifiable, though undoubtedly finite risk. These factors will inevitably lead ultimately to its demise.