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FINAL REPORT – RISK CRITERIA & COST-EFFECTIVENESS GUIDELINES

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Final Interim Report
12/05/97
By
ENTEC

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Report Issued By:
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12/05/97

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REPORT RELEASE SHEET

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EXECUTIVE SUMMARY

When a disaster occurs there is a major reaction by many groups in society - public, media, regulatory agencies, government. A great deal of money and time is spent in reacting to events and preventing recurrence. However, except where an activity can be curtailed, it is not always possible to eliminate all forms of risk to life from human activities. However, there remains the demand to make most activities "safe".

In order to allocate resources, or determine when activities are sufficiently "safe", decisions have to be made on how to balance the risks, society's concerns and what society is willing and able to pay to reduce these risks. If there is no absolute protection against harm then how safe is safe enough'? In the absence of other criteria, the decision on what is "safe enough" is often based on a judgement of social and political expectations at the time of the decision.

A set of risk criteria and guidelines regarding cost-effectiveness have been developed in this report to help make decisions on the reduction of risk from fire in buildings and other occupied structures. The aim is to provide an explicit and testable framework for decision-making which can be used to plan levels of fire cover and fire safety in a proactive manner, as well as to guide Governmental reactions to disasters.

In this report we are focusing on death, or at least situations which are life threatening, so our definition of "risk" in this report is the frequency of death. The frequency may be expressed in terms such as the chance of death per year (such as one in a thousand per year) or the number of deaths in a much longer period (1,000 in a million years). This report considers neither occupational risk to fire-fighters nor environmental risks associated with fire fighting operations

Well developed decision making frameworks regarding the control of risk already exist in the UK. An attempt is made in this report to transfer the logic of setting criteria from well studied area, to the area of fire risk in the home and other occupied buildings, taking account of the apparent public response to fire and existing levels of fire risk. In the area of occupational health and safety a set of principles and criteria have been developed in support of the legal requirement to reduce risks "as low as reasonably practicable" (ALARP). This has been interpreted by the courts to imply that safety improvements should continue to be made until the costs of further improvement are "grossly disproportional" to the expected benefits. These principles in particular have been drawn on, and diverged from as appropriate, in this report to derive criteria for the planning of fire cover and fire safety.

The Health and Safety Executive (FISE) have given their views on ALARP and have defined extremely high risks to be "intolerable". For such high risks safety should be improved regardless of costs, or the activity prohibited. Examples of activities which have been prohibited are:

- passenger transport by hydrogen filled airships;
- use of gas heating in multi-storey system built flats;
- use of certain forms of asbestos;
- building houses "too close" to major hazard sites;

- dangerous goods transport through tunnels;
- transoceanic passenger flights by two engined aircraft (until recently).

The first three were reactions to major loss of life and not based on a risk assessment. The last three were based on, or supported by risk analysis, in particular the recent approval of two engine aircraft for transoceanic passenger flights was based upon improved engine and systems reliability demonstrated by analysis.

At the other end of the scale the HSE define a level of risk from a particular hazard which would generally be considered to be "negligible", based upon it being only a fraction of the total risk to which individuals are exposed. Between these extremes (intolerable and negligible risk) the HSE look for the application of the ALARP principle. It is reasonable to expect a higher level of expenditure to reduce the higher risks within this region. Risk analysis and assessments can be used to set priorities and also demonstrate, through cost benefit analysis, where the available resources are best allocated. In many cases it has been demonstrated that spending on risk reduction measures can save money overall because the total costs of accidents are extremely high (involving not only property damage but diversion of resources, business interruption, loss of public confidence, legal costs, fines and many non-insurable expenses).

There are two common measures of risk used in the analysis of accidents. They attempt to measure the different way that people respond to accidents that may affect them or others in their community (which may be a small district or a whole country):

- Individual Risk measures the risk to a single person, real or hypothetical, from the hazard under consideration. This person may be representative of a group (such as the workers on a plant with a typical range of activities and locations) or it may be a theoretical marker such as the risk to a person spending 100% of their time at a fixed location (such as the boundary fence of a potentially hazardous facility, or a room within an old persons home).
- Societal Risk measures the risk of multiple fatalities and so takes account of the presence of large numbers of people who may be affected and the public response to disasters. The societal risk from an activity or type of hazard is normally expressed as a cumulative risk, that is plotted as the frequency of accidents causing N or more fatalities against N.

These measures are not mutually exclusive, rather they supplement one another. An example of this would be the analysis of the risk of dangerous goods transport (flammable and toxic hazards) by road. The nearest residents on a typical route might be exposed to a risk of death of one in five million per year, for example, normally considered to be a negligible level of risk. However, if the route was about 200 km long then there might be a risk of an accident affecting a populated area of one in ten thousand per year, such a major accident might result in tens of deaths amongst road users, as well as the local population. One hundred deaths at a frequency of one in ten thousand per year would be above the negligible level and well into the ALARP region suggested by the HSE for societal risk, from this type of hazard. Clearly the Societal Risk criteria should be given higher priority. Conversely a group of one or two houses close to a major hazard site may give rise to individual risks close to the tolerability limit, say a risk of one in ten thousand per year, but the Societal Risk may be 3 or more deaths once in ten thousand years, close to the lower boundary of the ALARP region. In this latter case the individual risk is normally considered to be more important.

In order to arrive at a set of fire risk criteria it is necessary to take account of society's perception of fire risks as well as the objective measurement of risk and the accountant's view of cost-benefit. We have considered it is reasonable to study the present situation relating to the risk of fire death and the country's response to fatalities in fires. In line with studies on other risks it appears that an individual risk of death due to fire of one in a million per year would be considered negligible. The upper limit of tolerability is more difficult to define as there is a wide variation between geographical area, social class and different age groups for existing risks. Given that there are currently several initiatives to reduce the risks to the most vulnerable it might be assumed that some current individual risks from fire are not tolerable. Setting an upper limit of tolerability of individual risk from fire of between one in a hundred thousand and one in fifty thousand per year (corresponding to just less than the existing risk from fire in England/Wales and Scotland respectively) would mean that the occupants of HM0s, persons aged over 80 and children in Social Class V would all be above the limit. A limit of one in ten thousand per year (often cited as a reasonable maximum tolerable limit for all forms of accidental death for workers in most industries) would mean that all identifiable groups are within the tolerable level.

The public response to multiple fatalities in fires has been expressed in terms of government and organisation responses, with regulations and major improvement programmes respectively. An example of the latter is the elimination of combustible materials underground by London Underground following the Kings Cross fire. Given that the current rate of fires causing more than ten fatalities is about one every three years in the UK (average over the last two decades) and the responses to these have been intended to prevent a repetition, this frequency of such events could be taken as the limit of tolerability. Although there may be 700,000 to 1,300,000 registered places of work, fire certificated properties or other registered premised it is assumed here that only about 500,000 may have the potential for ten or more deaths. This would suggest that a societal risk (upper) tolerability criteria for the whole of the UK of ten or more deaths once every two years or less translates to a risk per building of one in a million per year. This is much lower than other societal risk criteria per activity because there are so many buildings occupied by significant numbers of people. For the risk of a major loss of life to be considered negligible, it is suggested that the frequency should be less than 1 in 10m per year per building.

It is likely that the most appropriate use of individual risk will be for private dwellings and societal criteria are best suited where large numbers of people may be present. Both types of criteria should be used when considering levels of fire cover and fire safety initiatives.

Whilst is not possible to place a value on some one's life people do continue in certain activities in the knowledge that they will experience a risk, and are willing to spend certain amounts of money to reduce this risk. The amount that people are willing to spend appears to vary according to many factors, including the vulnerability of the victim and type of hazard. Accordingly, rather than postulating any single "value of life", we have proposed a sliding scale of cost-effectiveness against which to judge safety measures on a case by case basis, allowing account to be taken of varying perceptions of risks.

Risk criteria are simply an expression of societal expectation, moderated by the judgement of Government. This reports provides an interpretation of societal expectations, based on an impartial view of apparent public response to fire, and thereby provides a basis on which fire authorities and related agencies can form a view on the limits of tolerability and cost-effectiveness.

1. BACKGROUND DISCUSSION

1.1 Introduction

Risk criteria are important for a number of reasons. Firstly, they provide a framework of guidelines for identifying in a proactive manner priorities for improved safety. Secondly, they provide an explicit basis on which to evaluate the cost-effectiveness of proposals, making the decision making process transparent. Thirdly, criteria regarding what is and is not a tolerable level of risk determines the approach taken to the survey of premises and the level of protection, in the form of fire safety and fire cover, required. Clearly, the estimation of levels of risk is only one part of the risk assessment process. Having gained an estimate of risk the question of what should be done about the risk arises. Answers can range from nothing, through implementation of some form of risk management to prohibition of the activity or substance creating the risk.

Explicit criteria for the consideration of the tolerability of risk and the practicality of acting on the risk have been developed and applied in many sectors. These criteria take the form of "Risk Criteria" and "Willingness to Pay" values. This section provides:

- an explanation of the general principles on which risk criteria for the fire service can be founded and the role such criteria can play in decision making,
- the basis on which "values of life" can be founded and their role in fire service decision making, including the interplay between risk criteria and the amount that might reasonably be expended to reduce risk and;
- proposed criteria and guidelines for the assessment of the tolerability of risks dealt with by the fire service and the cost-effectiveness of risk reduction options under the control of the fire service and/or related agencies.

Neither occupational risk to fire-fighters nor environmental risks associated with fire fighting operations have been considered in this interim report.

These criteria are intended to play a role first and foremost in decisions at a national level regarding fire safety regulation and enforcement, fire cover and fire safety education. The need for such criteria within the fire service is perhaps more pronounced now than in the past given the increased focus of attention on life risk, particularly the prevention of single fatality fires vs the prevention of large loss incidents and control of conflagration. The focus on life risk here should not be taken as a suggestion that protection of property is of no importance. Rather, it is presumed that the role of the fire service in minimising loss of property and protecting against conflagration between buildings is already well understood and does not need to be exhaustively re-examined.

1.2 What are risk criteria?

Risk criteria are expressions of broadly held views within society of what can and cannot be construed to be tolerable levels of risk. Criteria can be expressed in quantitative terms as well as in qualitative terms.

Criteria can be expressed for many types of risk such as:

- the likelihood of any single incident causing a major loss of life, many injuries and/or disruption and damage - this type of criteria is often referred to as a "Societal Risk" criteria as it refers to the possibility of an event affecting any part of society. Societal Risk relates to risks which would cause a social-political impact and whose consequences are greater than the sum of the harm caused to the individuals involved. Societal Risk criteria are usually expressed in terms of the likelihood per year of an event causing, or exceeding, a certain number of deaths or damage, such as the likelihood per year of any single accident causing (say) 10 or more deaths. Such criteria may be defined for a nation or for defined parts of a nation, such as the frequency of a certain type of major disaster anywhere in the country should not exceed X per year.

- the likelihood that a typical member of a defined part of the population will suffer fatal or non-fatal injuries - this type of criteria are often referred to as "Individual Risk" criteria as it refers to the likelihood of an individual being harmed and are expressed in terms such as the likelihood of death per person per year or likelihood of death per million head of population. Such criteria are usually defined for subsections of the population, such as employees versus train passengers versus the general public, and may relate to the risk associated from all hazards or from a defined range of hazards, as in the case of railway related hazards for train passengers.

Individual and Societal Risk Criteria are widely used in the UK by both Government and industry in the major hazard industries, such as petrochemicals, railway industry, hazardous materials transportation, nuclear power, for considering risk of death or injury form accidental causes, They are also used by other Governments in regulation of public food and drug safety, where for example, the US Food and Drug Agency regard a risk of 1 in 1,000,000 per person of harm from a drug to be the targeted negligible level of risk.

A somewhat different form of risk criteria is exhibited by the commercial aviation industry goal of increasing the number of flights and passenger journeys without any corresponding increase in the number of crashes or deaths. Such a criteria demands a reduction in the rate of accident per aircraft journey and reflects a wish to avoid large loss of life in society as well as poor publicity.

A broadly comparable form of criteria has been developed for the purposes of environmental regulation the UK, namely the concept of applying the "Best Available Technology Not Entailing Excessive Cost". Subsequent to identifying an environmental hazard and determining an exposure level which should not cause harm, the best available technology for the control of the hazard is identified. Clearly, in deciding whether the cost is excessive consideration is given to the level of risk and cost-effectiveness of the technology. Also, rather than proscribing a

hazard entirely, a level of exposure which is believed to have no adverse effects is permitted, despite the possibility that further research and experience may reveal adverse effects. This is in effect the same as an Individual Risk Criteria which states that the risk of harm must be negligible for that risk to be tolerated.

The use of risk criteria presumes that it is impossible to eliminate risk and that a judgement is required of the level of risk which society and individuals are willing to tolerate in order to derive the benefit from the activity which creates the risk. This philosophy stands in contrast to the view that exposure to certain hazards is unacceptable and that a zero level of risk must be attained. Advocates of the use of risk assessment and risk criteria would contend that, unless the substance or activity creating a risk is eliminated, claims to have attained zero risk are a fallacy and that a possibility of harm always remains however remote that possibility might be.

1.3 What is meant by the terms "willingness to pay" and "value of life"?

The terms "value of life", "value of a statistical life" and "willingness to pay" (WTP) have all been used to refer to nominal maximum levels of expenditure which can be justified to avert a death from accidental causes. The value of £750,000 per life (£784,000 in 1994/95 prices) as used by the Department of Transport in the evaluation of road safety schemes is commonly mentioned as an example of such a value. Indeed, the value of £750,000 was used by the Audit Commission as a "cost" of fire deaths in the UK (1995, Audit Commission). Values of life are often stated to be the sum that society is willing to pay net of averted damage and loss of business to prevent a death or injury. Such values are contentious as it is argued that attachment of cash values to life denies the unquantifiable quality of life and respect for life.

Nonetheless, while no amount of money can compensate for certain loss of life, people do accept statistical risks in return for financial or other benefits, and are prepared to pay to reduce these statistical risks. Values of life are calculated by examining people's willingness to pay to reduce these risks. The terms "value of a statistical life" and "willingness to pay" are somewhat interchangeable. However, it should not be supposed that values of life are scientifically proven or universally applicable. Rather, these values are meant to represent people's revealed or expressed attitude towards certain hazards, attitudes which can vary across time and between people. In the cases discussed here we are always referring to a "statistical" life not the life of a known individual.

Accordingly, it is argued that such values do not constitute an economic value of a life or even an expression of the financial value which people place on a persons life. Rather, they are taken to constitute nominal estimates of the maximum amount people are willing to spend to avert the possibility of a death or lesser level of harm from a certain type of hazard or cause. Such values are used for the sake of determining whether one or another option gains the greatest saving of life within finite resources. Any single value should not be viewed to be an upper limit or fixed rule regarding what can be expended to avert a death but should be viewed as a guideline on what might be construed to be a reasonable allocation of resources. Where there is particular aversion to or fear of a particular hazard it is possible that a higher value might be a more appropriate expression of societal wishes, particularly if there is a potential for loss of confidence in the safety of a product or service which in turn might give rise to further significant costs. Indeed, whilst attempts have been made elsewhere to derive a single empirically derived "value of life", a consensus has not been reached regarding any single value and it is argued here that no single value will reliably represent how much society is willing to spend to reduce different types of risks.

1.4 What is the role of risk criteria and "willingness to pay" values?

Risk criteria and cost estimates are generally used within "strategic decision making". Some example of their role are given below.

1. identification of high risk priority areas where improvements should be sought. This is usually achieved by examining risk levels alone, with cost of risk reduction not an issue at this stage.

2. evaluation of the case for new, higher, health and safety standards, i.e. does the current level of risk warrant further regulation etc?

3. evaluation of the case for new regulations or revision of existing regulations, i.e. will new proposals be cost-effective?

4. the prioritisation of improvements, i.e. which proposals give the best value in terms of safety benefit?

5. the allocation of finite resources to competing proposals for improvements, i.e. what proposal(s) give the most risk reduction for a given level of expenditure?

6. evaluation of the efficacy of proposed improvements, i.e. which proposal(s) are the most effective in terms of level of risk reduction?

Risk criteria do not tend to play a role in operational decisions, such as whether or not to respond to a specific emergency alert. On receipt of an emergency call it is reasonable to suppose that all resources required to manage the incident will be mobilised, within the limit of what resources are available. Rather risk criteria are intended to guide decisions at the planning stage regarding the types of resources and procedures which can be provided in advance of incidents, given the anticipated level of risk and cost-effectiveness of services or regulations. As part of this process risk assessment may be used to examine the effectiveness of measures to reduce responses to, for example, malicious false alarms. Clearly such decisions will have an impact on the effectiveness of a response to an incident, as the resources available to respond will have been determined by the planning decision.

Again this position presumes that it is both necessary and Justified to match resource levels and safety standards to an anticipated level of risk. On occasion this may lead to a conclusion that the likelihood of a certain severity of incident is insufficient to warrant providing the level or type of resources required (or possible with modem technology and knowledge) to handle such an event if it did occur. Thus, resources levels and standards are provided for the "worst case incident" for which it is reasonably practical to plan for in advance, whether this is via regulations, service standards or prioritisation of advisory services. This position also implies that the level of resource allocated to the protection of different groups of people may vary according to variations in their experience of risk, i.e. more resources are devoted to those sections of the population who are most at risk.

With the above restrictions, values of life are used as a test of whether the cost of a proposal is reasonable or not in terms of whether society is normally willing to pay for such proposals. Clearly the hope would be that lives can be saved at the least cost and accordingly the value is not meant to represent how much should be spent to avert a death. Also, given the uncertainties surrounding the accuracy and validity of such values, some organisations adopt a sliding scale of values against which they place guidelines. The following are generalisations based on criteria known to Entec to be in use in various industrial sectors and public services:-

Where cost exceeds £5m per averted death	=	Option unlikely to be cost-effective -seek alternative, except in exceptional circumstances
Where cost is in region of £1m to £5m	=	Adopt option if no other alternative available, especially if baseline risk is high.
Where cost is in region of £100,000 to £1m	=	Measure is cost-effective and should almost certainly be implemented unless evidence of more effective alternative exists.
Where cost is in region of < £100,000	=	Must implement, obviously "reasonably practicable"

Such sliding scales makes it clear that no single value is placed on a life and that values of life are just guidelines for judging whether the costs involved in averting deaths are normally construed as reasonable by society. The normal use of estimates of the costs involved in averting deaths is to provide a basis for allocating finite resources in such a way that they have maximum benefit, by comparing the cost per averted death of alternative proposals. Thus, proposals are assessed firstly in terms of which averts most deaths per sum expended and secondly in terms of whether the cost per averted death exceeds what society is normally willing to pay.

Finally, experience has tended to show that the majority of safety measures are highly cost-effective. For example, the recent review of ambulance response times suggested that the cost per additional averted death achieved by improved attendance times would be less than £50,000 per life. This figure does not allow for other savings such as reduced loss of earnings by the casualty. Consequently, it is more common to find that improvements in health and safety are restricted by the availability of funds rather than a rejection of their cost-effectiveness. A particular example of this is found in the health service, where services are rationed on the basis of availability of funds rather than on the grounds of cost-effectiveness. This is not to say the values of life do not have a role. But it does suggest that, where all improvements are highly cost-effective, estimates of the costs per averted death are of more use in prioritisation of improvements and rejection of those options which would divert finite resources away from more beneficial options.

1.5 How are risk criteria and "willingness to pay values" developed?

1.5.1 Risk criteria

Given that risk criteria are intended to be an articulation of a broadly held view of tolerability of risk, they tend to be defined by examination of public and/or governmental behaviour towards certain activities and their apparent risks. A risk is construed as being tolerated where cognisant people continue in the activity which gives rise to the risk in knowledge of the possible harm, without exerting great pressure for the risk to be reduced. The practice in other areas of Government has been to set upper limits of tolerability as follows:

1. determine the level of risk experienced by the "most exposed" group of people in a particular sector, such as drill floor operators out of all offshore personnel on oil and gas platforms in the North Sea industry,

2. ascertain whether this level of risk can be construed as being tolerated or not,

3. setting the upper limit of tolerability to be equivalent to this level if it has been tolerated, or lower than this if it has not been tolerated. This might comprise determining the risk experienced by other, less exposed groups of people, until a group is found whose risk appears to be tolerated.

Typical thresholds determined in this way are between 1 in 1000 (intolerable) and 1 in 1,000,000 per person per year (negligible).

Risk criteria tend not to be derived by simply assuming that the rate of death or injury averaged across the population as a whole is a valid marker for two reasons. Firstly, the "average" rate of death or injury may be higher than the rate of death or injury experienced by the majority of the population, due to the disproportionate impact of the much higher rates of death experienced by the "most exposed" people. Secondly, the view is taken that the ultimate goal is to reduce the risk from any single hazard to a level where it no longer makes a significant contribution to a persons overall risk of death or harm from all other "background" risks, such as falls under the control of an individual in the home or being struck by lightning (external natural or accidental event). This negligible level of risk is commonly taken to be a risk of death from any single hazard or activity of 1 in 1,000,000 per year per person, but in some situations has been set as low as 1 in 10,000,000 per persons per year (such as in the Netherlands for risk to individuals "imposed" from activities of third parties).

In examining people's behaviour, experience has shown that there is not a single view of what is a tolerable level of risk from all hazards. Rather people tolerate different levels of risk according to the form of harm, corresponding benefits and other factors. For example, people tend to tolerate lower levels of risk from hazards under the control of other people than from hazards under their own control. Accordingly it can be erroneous to assume that a risk criteria developed in one context for one hazard can be transposed to another context or another hazard. Rather, it is necessary to examine how people view a particular type of hazard in a particular circumstance to derive a valid impression of their perception of the tolerability of the associated risk.

These tendencies are probably rooted in the "value system" and perceptions underlying attitudes towards different causes of harm and our varying level of aversion to different forms of harm and hazards. The "values" are thought to increase our aversion to certain hazards and lead to an expectation that more resources will be devoted to mitigating these hazards than others, and that a lower level of risk will be accepted for these hazards than others. It would appear from the behaviour of people and expressed beliefs that there is an aversion to hazards which have one or more of the following characteristics:

- imposed or involuntary risk - people appear to be averse to hazards which are not under their control, especially where they derive little or no direct benefit from the activity creating the risk. Inversely people are less averse to hazards over which they have control and/or where they gain direct benefit from the activity creating the risk.
- uncertainty - the level of risk is uncertain causing doubt and consternation,
- lack of knowledge - there is an aversion to hazards with which people are unfamiliar, or do not understand,
- potential magnitude of harm - there is an apparent aversion to large scale losses whereby people are willing to spend more to avert a single accident with 100 deaths than 100 accidents each with 1 death. This can lead to controversy as using a higher aversion for multiple fatality risks can divert resources away from the "best value" risk reduction options.
- the victim comprises vulnerable persons, such as children,
- irreversible - such as irreversible destruction of an artefact,
- inadequate or unclear corresponding benefits -
- insidious - where harm happens in unseen ways, such as poisoning.

Indeed, it has been suggested that where people have a choice whether or not to accept a risk and they neither benefit from the activity or source of risk nor have confidence that the true level of risk is known, they tend to accept very little if any risk to themselves, however remote the possibility of harm is said to be. This can lead to view that exposure to the hazard is unacceptable in itself This is particularly true for new hazards where individuals tend to judge severely the suggestion that they should accept an additional risk to all those risks they are already being exposed to, even if the additional risk is by itself very low.

Similarly, these factors also explain what is often a stringent public reaction to new technological systems where large numbers of persons are exposed to a hazard, despite protestations that the new system is safer than past ones. From the public perspective new systems comprise unfamiliar hazards over which they have no control and for which there can be little certainty about the true level of risk, leading to a fear of major accidents.

1.5.2 Willingness to pay values

Estimates of what people are willing to pay are developed in a similar way to risk criteria, namely by examining the behaviour and perceptions of people. In the case of values of life, estimates are developed by surveying individuals actual and hypothesised (i.e. asking how much you would spend) spending behaviour, such as how much they spend to protect themselves against a certain hazard. The amount that people are willing to spend, or have spent, to guard against a specific hazard or cause of harm is then factored by the likelihood of harm to give an estimate of the nominal amount spent to avert the harm. Thus, if each person in a population of a million were prepared to pay £1.00 to reduce their chance of death by a 1 in 1,000,000 per annum, in aggregate that population would have paid £1m and 1 death would have been averted.

As with risk criteria, it is probably inappropriate to assume that any single value of life can be applied to all causes and circumstances of death and harm. Examination of the values used across different sectors reveals a wide range of values reflecting the degree of public aversion to different hazards. Indeed, society's reaction to certain events suggests that "cost" is not regarded to be a legitimate factor when considering how best to prevent repetition of an event, such as the death of large numbers of children, with action limited only by what is technologically feasible and socially acceptable. Thus, whilst the recent review of ambulance response times used the cost of other life saving treatments such as [1]£62,000 as a benchmark, costs in the order of £300m to £400m are expected in connection with the control of handguns in response to the murder of 16 children at Dunblane.

Note: [1]The cost per life year saved of severe angina treatment is quoted at £4,970. This is multiplied here by 12.5, an assumed number of life years saved per person, to get a cost of £62,000 per averted death. Review of Ambulance Performance Standards, NHS Executive, July 1996.

Accordingly values of life vary with, for example, Railtrack adopting a value of £2m for evaluation of safety schemes relating to hazards such as collisions between trains which are seen as being primarily under the control of railway organisations and for which passengers have an aversion but a lower value of £750,000 for level crossing accidents which are seen as being partially under control of the car/road vehicle driver and are akin to any other driving related accident. Thus, the amount that people are "willing to pay" is likely to vary according to their perceptions of the form of harm and the circumstances surrounding the injury, in the same way as perceptions of the tolerability of risk varies between hazards and circumstances. In particular, the amount that is spent to avert harm tends to be less for "natural causes" such as illness than for accidental causes of harm, and more where the victim either does not control the source of harm, is averse to the hazard or gains little direct benefit from the activity associated with the hazard. In addition, higher levels of expenditure may be required for the same level of risk reduction, when the baseline level of risk is high. Thus, risks near the upper tolerable level would warrant greater expenditure than risks near the lower level.

Thus, it is important to ensure that the proposed value of what people are "willing to pay" to avert a statistical death is appropriate for the type of hazard and context of harm under consideration.

Clearly this approach to developing risk criteria presumes that it is valid and appropriate to give weight to public perceptions of risk rather than override such perceptions where they conflict with "objective" levels of risk and lead to a disproportionate response. The latter approach would argue for a single set of risk criteria and "willingness to pay" values of life to be adopted,

based on common economic rationale, and applied across all sectors of life and hazards, thus achieving a maximum level of risk reduction within resources available to society. Rather, the position laid out above presumes that the public perceptions of risk are valid inputs to the public management of risk which should be addressed and incorporated rather than treated as problems which need to be rectified by education. Given that the value of a statistical life is merely an expression of what society is willing to pay to reduce a risk, and is not scientific fact, society's varying perceptions of different hazards needs to be taken into account on a case by case basis.

2. PROPOSED CRITERIA AND GUIDELINES FOR FIRE AND EMERGENCY RELATED HAZARDS

2.1 Proposed basis of criteria

If the historical behaviour of people towards previous fires is taken as a reasonable basis on which to base risk criteria, it may be suggested that people are more averse to some types of fire and emergency incidents than others, as well as being more averse to fire than some other sources of harm. The assertion that people are particularly averse to the hazard of fire is lent some support by the findings of a MORI survey of public attitudes towards risks of trauma (MORI 1994), commissioned by the Home Office. They found that:

- in terms of concern, domestic fires came second only to being burgled - whilst in terms of experience, fire in the home came 8th,
- concern for fire in the home exceeded concern for being in a road accident, although respondents were at least 4 times more likely to have experienced a road accident than a fire in the home.

Thus, it is reasonable to suggest that people are more averse to the hazard of fire than certain other hazards such as road accidents, and accidents in the home (not fire), despite the lower incidence of fire in the home. This is particularly so for households with children, where the parents are especially averse to fire.

Indeed, it is perhaps reasonable to suggest that there has been a demand for what is effectively a zero (or negligible) possibility of certain scenarios, or at least a negligible chance of death or harm arising in certain circumstances. namely,

1. A large loss of life (or many injuries) from fire amongst members of public on premises controlled by other persons, such as shops, railways and schools. This is especially true where new technology and/or vulnerable persons are involved.

2. Exposure of large numbers of the public to chemicals or gases with which they are unfamiliar and which have an uncertain insidious affect, from sources not under their control, such as HAZCHEM and CIMAH site incidents.

With regard to the occurrence of large loss of life in premises open to the public, such as shops hotels and offices, it is reasonable to suggest that the frequency of such event in previous decades was not tolerated and hence that, at the very least, the past frequency of such fires should act as an upper limit of tolerability. Conversely there is relatively little pressure to further reduce the level of life loss in shops offices and hotels, suggesting that the current level of risk in these premises is being tolerated (other than in hotels used as HMOs).

It is probably also reasonable to suggest that people are relatively less averse to the following fire and emergency incidents, given that people continue to use the products and undertake the activities giving rise to these risks:

1. Death of (or harm) 1 or 2 adult persons in their own place of residence arising from a fire associated with an activity under their control and from which they receive a real or supposed benefit, such as cooking or smoking.

2. Death of (or harm) 1 or 2 persons in car accidents where they partially or wholly caused the accident (i.e. they were not passengers in a coach for example).

It should be noted that when a risk is said to be tolerated, this does not imply that it is acceptable for the death or harm to occur, nor does it imply that appropriate action should not be taken in the attempt to avert the death. Indeed, there is a general view that there should be a continuous improvement in fire safety for all sectors of the population. However, it implies that people do not have a strong view that a significantly higher level of resource should be expended than at present to avert harm from hazards to which they are less averse.

However, given that there has been continued pressure exerted to reduce the loss of life in HMOs, amongst children and generally across those parts of the country experiencing rates of death well above the average, the respective levels of risk for these groups may be regarded as being intolerable, or, at best, at the boundary between what is and is not tolerated.

These distinctions are important as they imply that more stringent standards and higher levels of resource are warranted for the least tolerated scenarios than for other scenarios, and that risk criteria can be modelled on the observed levels of risk for each of these. Accordingly it is deduced that the past levels of life loss and injury and the amount of money that has been spent to mitigate these risks can usefully be referred to, as examples of society's expectations, during the formulation of risk criteria and cost-effectiveness guidelines for the fire service.

2.2 Proposed criteria and cost-effectiveness guidelines

It is proposed that risk criteria be based on the following principles and precedents:

1. No part of the UK population should experience a disproportionately high risk of accidental death or injury from fire. The upper limit of tolerability should be below current levels for HMO residents, children and parts of UK, where the risk is high and not currently tolerated, such as in parts of Scotland. This level will differ from the intolerable level set for risks from external sources (such as CIMAH sites) or from natural causes (as used in the health service to determine priorities for treatment availability).

2. Steps should be taken to reduce the level of risk experienced by any part of the population whose level of risk exceeds what is commonly viewed to be a tolerable level, wherever effective actions can be identified. This implies that the cost-effectiveness of actions is not a consideration where the risk is regarded as intolerable.

3. Further steps should be taken to reduce risk for all parts of the population wherever this is practical and effective. This implies that cost-effectiveness of additional measures is an issue where the risk is currently being tolerated.

4. For any risk to be classed as negligible it must not make a significant contribution to a persons overall risk of death from accidental causes. This value should be consistent with those used in other areas of public safety, i.e. 1 in 1,000,000 per person per year.

5. The frequency of large losses of life from fire should, at a minimum, not approach the frequency of such incidents in past recent decades, with further steps taken to reduce risk wherever this is reasonably practical. Indeed, given society's aversion to large scale loss of life, the most effective fire precautions and fire cover should be applied so as to effectively eliminate the risk of major loss of life at any single site, wherever the cost is not prohibitive.

6. The precautionary principle should be applied to all new technologies and unfamiliar hazards where there is a lack of historical experience giving rise to gross uncertainty regarding the level of risk and potential for a major loss of life or property. This principle can take the form of (1) requiring a much lower level of estimated risk for the new structures than past ones and (2) requiring much higher levels of evidence regarding effectiveness of precautions, in the form of tests, and (3) basing fire cover on worst case scenarios, possibly including the application of a higher "willingness to pay" value.

7. Guidance on cost-effectiveness should be in the form of a sliding scale to allow for consideration of varying perceptions of risks as well as varying levels of estimated risk. An upper limit on the cost per averted death should not be set, so that discretion can be exercised on a case by case basis, but there should be some criteria for when this discretion could legitimately be exercised, such as in exceptional circumstances.

8. The sums previously expended to avert fire deaths and injuries in the home should be used as a benchmark of the minimum levels of expenditure which can be considered reasonable for additional fire safety measures in a person's home (using either regulations or fire safety education), although costs in the region of the Department of Transport value of £784,000 should still be regarded as reasonable for normal circumstances. Costs above the latter level should be considered in special circumstances, such as child fatalities and fires involving a large loss of life.

9. The benchmark of cost-effectiveness for fire safety measures aimed at prevention of multiple fatality fires in premises open to the public such as shops and offices, should be similar to values applied in other industrial sectors to the assessment of public safety measures, such as in the rail and major hazard sectors.

10. The benchmark of cost-effectiveness for rescue from Road Traffic Accidents and other special services should be consistent with the Department of Transport value used for road safety schemes. Where costs are comparable with those incurred by other emergency services, such as the ambulance service, such costs should be regarded as very or extremely cost-effective.

11. The benchmark of cost-effectiveness for rescue of people from fire should reflect, at least, the sums which society has to date been willing to pay for emergency life saving services, uplifted as appropriate where there is a potential for a large loss of life, involvement of children or other vulnerable persons or large scale disruption in individual incidents. In cases where the cost per rescue from fire exceed the cost per emergency response to other types of incidents, account should be taken of the public aversion to fire and their willingness to expend more averting fire related injuries.

12. Higher levels of expenditure per "unit" of risk reduction should be considered where the baseline risk is higher.

2.3 Cost-effectiveness guidelines

Guidelines regarding what may be regarded as cost-effective in normal and exceptional circumstances are summarised in Table 2. 1.

Domestic fire safety

The approximate cost per death averted by the use of smoke detectors is taken here as a minimum benchmark of how much people have been "willing to pay" for domestic fire safety improvements and education. As noted in Entec's accompanying report on dwellings (D/97865), the cost per averted death for smoke detectors and the 1988 Furniture and Furnishing Fire Safety Regulations are respectively about £375,000 and £1 to £2m. The figures for smoke detectors are gross of any savings from averted medical costs, damage and loss of earnings.

It is perhaps also pertinent to note the costs per Quality Adjusted Life Years for health treatments, such as £2300 to £4970 per life year for blood vessel disease and angina treatments. These values divide the cost of treatment by the typical number of years of life saved. For example, averting the premature death of a 70 year old person is assumed to save about 12.5 years of life. Thus, for comparable figures to be derived for fire safety interventions it is necessary to also estimate the typical or average number of life years saved, and divide the cost of interventions by this sum. Assuming an average life expectancy of 82.5 years and an average age of fire fatalities of 49.5 years (based on 1995 UK Fire Statistics), each averted death is equivalent to at least 33 life years. Thus, the cost per life year saved by domestic fire safety measures is about £7,000 assuming a typical cost of £350,000 per averted death, and again ignoring averted damage and medical costs. Clearly, if the lives of a larger number of children than elderly persons are saved, the cost per life year of fire safety measures will be lower.

Fire safety in public and commercial premises.

It is proposed that values of about £1m to £2m per averted death are used as a guideline as per London Underground, Railtrack and other "major public life loss" industries.

Rescues

Whilst it is probably valid to use the Department of Transport (DoT) value of £750,000 (£784,000 in 1994/95 prices) per averted death as an upper limit on what may be regarded to be a reasonable cost for averting accidental deaths, it is perhaps more appropriate to use the approximate sums expended on averting deaths in the emergency services as a guide to the "norm" for rescuing people from life threatening situations. Some pertinent examples are noted below:

1. The approximate cost per life saved, by achieving an 8 minute ambulance time, was estimated at around £9,000 to £54,000, depending on whether you took rural or urban areas and whether or not you included people over 70 years of age in the calculation (Chapman, 1996).

2. More generally emergency (life saving) medical care for serious casualties has been estimated at somewhat below £100,000,

Given that people tend to be more averse to fire than other forms of harm, the latter benchmarks should not be regarded as upper limits for rescues from fire. Where the cost of rescues exceeds these levels, consideration should be applied on a case by case basis as to the availability of more cost-effective alternatives or the case for committing a higher level of resources to rescues from fire due to society's aversion to fire. Thus, it is proposed the cost of £50,000 to £300,000 per rescue from fire should be regarded as very cost-effective, hence allowing for society's aversion to fire risks versus other risks, with costs up to £750,000 regarded as "cost-effective" where it can be shown that the measure will avert a death. Costs above £750,000 should be considered in special circumstances, such as planning resources in areas with high numbers of vulnerable persons. (The DoT value of £784,000 is rounded to £800,000 in Table 2. 1).

The current cost of a fire brigade rescue is to all intents and purposes unquantifiable in any reliable manner. This is because the (currently unknown) value of averted property damage should be deducted from service costs to give a net cost per rescue. Also, the number of lives saved and fires prevented due to the fire safety education and fire safety work of the fire service are unknown. For example, if it was assumed that the attendance of the fire service to a fire typically averted £10,000 of damage in occupied buildings alone, this would give a sum of over £1billion in averted damage alone (ie £10,000 X 100,000 fires in occupied buildings). This would account for all but £200m of the national cost of the fire service. With about 4,000 rescues of persons from fires the cost per rescue would be about £50,000. Given that the fire service also extracts many more thousands of persons from Road Traffic Accidents (RTAs) and other life threatening situations as well, the actual cost per rescue is probably well below £50,000.

It is suggested that the implication of this is that the question of "willingness to pay" is only of relevance to the consideration of additional resources or proposed reductions in resource levels, as the typical cost per rescue is probably well within the limits of what is commonly held to be highly cost-effective.

Table 2.1: Guidelines for evaluation of cost-effectiveness of proposals

Cost per averted death (or extraction from imminently life threatening situation)	Guideline	Comments
Less than £50,000	Extremely cost effective	If proposal averts injury and/or incident altogether, then the value of averted medical treatment, fire damage and emergency response is likely to exceed the direct cost of prevention. Proposal should be implemented once funds are available.
£50,000 to £300,000	Very cost effective	If proposal averts damage in sufficient cases to reduce the cost per averted death to £140,000, the cost of these proposals per life year saved are likely to be comparable with typical cost of other life saving interventions such as treatment of heart disease.
£300,000 to £800,000	Cost effective	Should seek to identify or develop alternative risk reduction measures of equal or greater effectiveness but otherwise implement option, especially if it would help avert a high number (such as dozens per year) of casualties or if the proposal would reduce risk amongst a high risk part of the population. Costs of £300,000 to £400,000 to avert a death are comparable to those of smoke detectors.
£800,000 to £2m	Consider in special circumstances.	Should seek to identify or develop alternative risk reduction measures of equal or greater effectiveness. Examine value of averted damage etc to check if proposal can be warranted on grounds of averted damage and disruption. Give greater weight to this proposal if it relates to a risk of major loss of life amongst people on premises controlled by others or amongst special groups such as families. Costs in this region are comparable to those arising from the 1988 furniture fire safety regulations.
Over £2m	Consider in Exceptional Circumstances	Should only be considered in exceptional circumstances such as where the public have extreme fear or aversion which may in itself lead to losses, costs or widespread loss of confidence in a product or service etc, or where there is potential for very large scale losses (dozens) and deaths.

2.4 Risk Criteria

2.4,1 Individual Risk

As previously noted, it is suggested that a risk of death from fire of 1 in 1,000,000 per year per person be taken as the highest level of risk that can be regarded as negligible.

The rates of death for various sectors of the population are presented in Figure 2.1 below. If it is accepted that the current rates of death amongst elderly and children and HMO occupants are not tolerated at present, this would suggest an upper limit of tolerability of about 1 in 70,000 per person per year, based on rates for person aged over 65 and social class IV children. This would imply that the risk experienced by at least 1.4m households in the UK (including a large proportion of the population in Scotland) is currently experiencing an intolerable level. Given that fatality rates vary from year to year, it is suggested that an upper limit of 1 in 50,000 to 100,000 be adopted to give:

- an upper limit of tolerability of 1 in 50,000 to 100,000 per year per person
- a negligible level of risk of 1 in 1,000,000 per year per person.

This would imply that the Individual Risk experienced by the vast majority of persons in "other occupied buildings", such as places of work, is negligible. This does not imply that no further action needs to be taken to reduce risk in such buildings (especially to avoid risk of major life loss fires) but it does suggest that the targeting and cost-effectiveness of any such further action should be very closely examined, and kept in proportion to the risk. As part of this assessment account should be taken of the potential for major life loss fires, which may not be reliably gauged by examination of past losses alone.

Closer consideration of deaths in other occupied buildings indicates that the vast majority occur in places with "sleeping" risk such as hospitals, care homes for elderly and children, hotels and hostels, and place of leisure, such as pubs, clubs and shops. Taking 1993 as an example there were no fire deaths in offices or at transport premises and only 4 deaths in industrial premises. This suggests that the risk from fire whilst commuting to work by means other than car (i.e. by tram, plane or bus) and when at work is even lower than 1 in 1 million per person per year.

This may help to explain the stringent public reaction to loss of life from fire at places of work and transport premises, such as the Kings Cross fire, as such events clearly constitute the only significant source of fire risk outside the home for the vast majority of the population.

If it is accepted that society seeks a continuous improvement in safety, it is reasonable to suggest that the current risk in other occupied buildings should not be exceeded. This would imply that the risk of death from fire in any single place of work, leisure or transport should not exceed about 1 in 1 million, i.e. something close to a negligible level of risk.

Figure 2.1 Rates of death in the UK.

FIRE LIFE RISK RANKING	SECTOR OF POPULATION	RATE OF DEATH FROM FIRE PER YEAR PER PERSON
1	[4]Social class V children aged 1-4	1 in 14,000
2	[1]Persons aged over 80 (in the home)	1 in 18,900
3	[3]Social class V children aged 0 - 15	1 in 30,500
4	[2]HMO occupants (all ages)	1 in 32,000
5	[3]Social class IV children aged 0 -15	1 in 61,000
6	[1]Persons aged 65 -79 (in the home)	1 in 62,500
7	[1]Persons aged 17 to 64 (in the home)	1 in 185,000
8	[3]Social classes II to III m aged 0 - 15	1 in 196,000
9	[3]Social class I children aged 0 - 15	1 in 300,000
10	[1]Persons aged 17 to 64 (in the home, excluding HMOs)	1 in 300,000
11	[1]Persons aged 80+ (in other occupied buildings)	1 in 590,000
12	[5]Persons aged 65-79 in other occupied buildings	1 in 900,000
13	[5]Persons of all ages in other occupied buildings	1 in 1,100,000
14	[1]Persons aged 17 - 64 in other occupied buildings	1 in 1,160,000
15	[1]Persons aged 0-16 in other occupied buildings	1 in 3,000,000

NOTE: Rates of death from fire in Scotland is 1 in 40,000, and 1 in 90,000 in England and Wales for population as a whole in 1993.

NOTE: [1] Home Office 1993 UK Fire Statistics, [2]Department of the Environment (1992), [3]Institute of Child Health and [4]is derived from Institute of Child Health and Home Office statistics.

NOTE: [5]Based on approximate rate in non-residential care buildings.

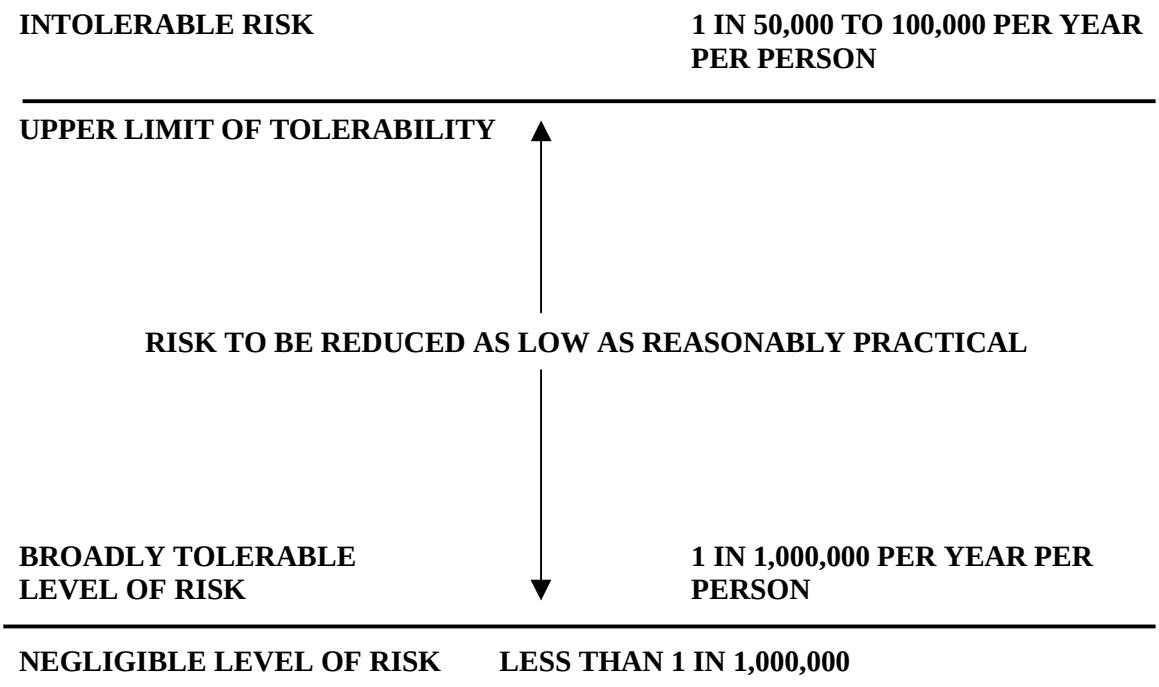
The risk experienced by the majority of the population when at home (namely adults aged 1864) falls somewhere between the upper limits of tolerability and what can be regarded as a negligible level of risk. This risk should be reduced, wherever a practical and effective proposal which does not incur excessive costs can be identified.

Similarly, any potential for harm to households arising from fires in adjacent commercial or public properties should also be reviewed strictly as again, any risk greater than 1 in 1 million per year from such fires will constitute the main source of fire risk for people from outside their homes.

In considering these figures it should be noted that there are a number of different types of premises encompassed by the term HMO, ranging from bedsits to shared houses, hostels and houses converted to self contained flats. If it is accepted that the risk in certain types of HMOs such as bedsits is higher than in other types of HNI0s the fatality risk for these will exceed the stated value.

Similarly, in considering the rate of death for 18-64 year olds in the home, account needs to be taken of the observation that a large proportion of deaths involve persons under the influence of alcohol or drugs, or involve persons with mental or physical impairment. The FRDG study estimated that 23.6% of such deaths involved alcohol, drugs or impairment. If it is assumed that less than 23.6 % of the general adult population are heavy drinkers, drug takers or impaired, the fatality rate for the general adult population in the home will be even less than the figure given here, i.e. below 1 in 300,000 per year per person.

Figure 2.1: Proposed boundaries of tolerability individual risk



2.4.2 Societal Risk

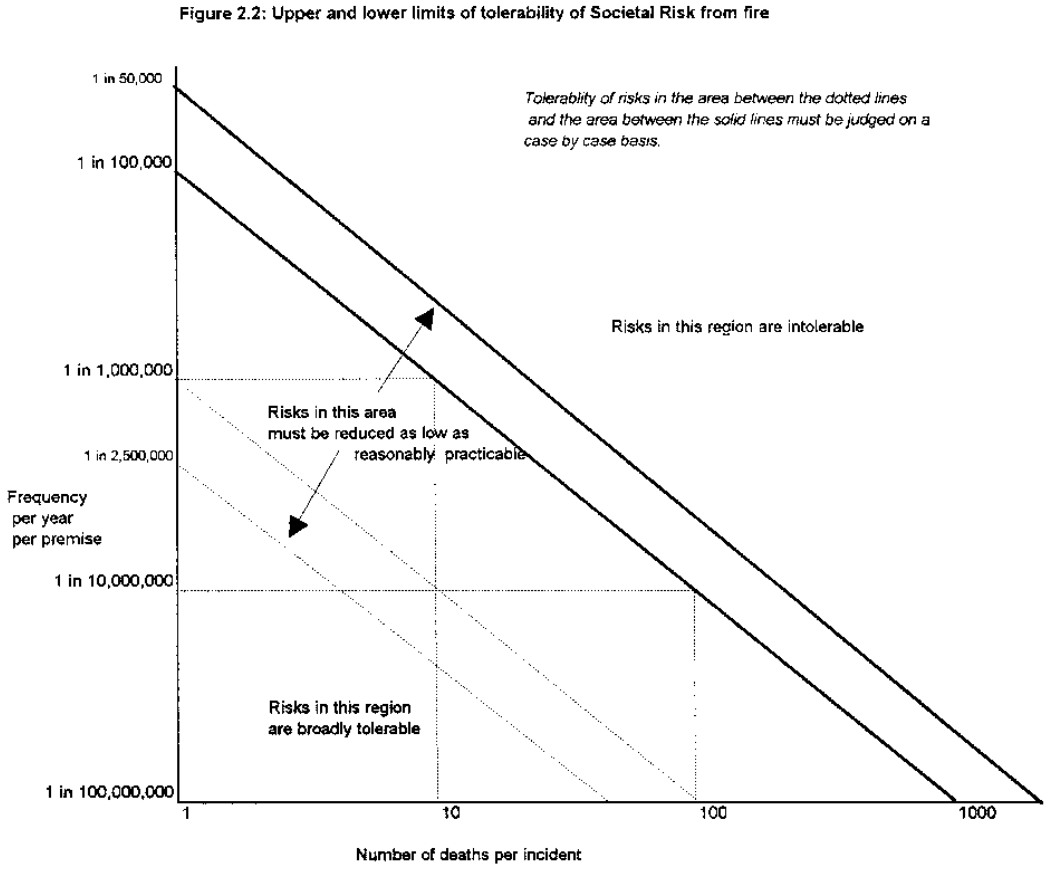
As previously noted, the frequency of multiple fatality fires shown in Table 2.2, particularly those occurring on public and commercial premises, involving over 5 or 6 deaths, was not tolerated in the 1970's or 1980's, whilst the current (1990's) rate and number of deaths in multiple fatality fires is broadly speaking being tolerated. Clearly there are some exceptions such of fire risk in HMOs, and these exceptions need to be taken into account here.

There are 2 ways of developing Societal Risk criteria, as below. It is suggested that the criteria derived by the two methods are broadly comparable, with an upper limit of tolerability of large life loss fires of about 1 in 1 million to 1 in 2.5 million per year per premise. The proposed Societal Risk criteria is shown in Figure 2.2, denoting an upper level beyond which risk is intolerable and a lower level under which risk is broadly tolerable. However, rather than proposing a single lower limit and a single upper limit, the upper and lower limits are shown as areas by solid and dotted lines respectively. This recognises the uncertainty that exists regarding the tolerability of risks and allows for some account to be taken of special factors, such as demanding higher levels of safety for new structures. Thus, whilst risks which fall below the lower dotted line are almost certainly negligible, risks within the dotted lines should be judged on a case by case basis. Similarly, any risks above the upper solid line are almost certainly intolerable, whilst risks within the solid lines are probably intolerable but require a case by case assessment. Risks falling between the lower solid line and upper dotted line are tolerable but must be reduced where practicable.

Although it may appear impractical to test whether a specific building meets with such a standard by reliably quantifying the likelihood of such low frequency events, the figures given are the logical deductions to be made when the implications of society's reactions to past losses are explicitly stated. In addition, it is suggested that such criteria are used first and foremost to inform decisions at a national level regarding fire safety and fire cover policy, and secondly to consider the tolerability of risk associated with new large scale undertakings such as high rise offices, and major railway terminals where it is economical to produce numerical risk assessments for comparison with such quantitative criteria. In premises where it is considered possible for a large number of persons to be trapped in an imminently life threatening situation, the implication of this risk criteria is that the fire cover should provide a response capable of averting a major loss of life in the time available before multiple deaths are likely to occur. This level of response should be available for all fire calls to such premises.

The Health and Safety Commission study, completed by the Advisory Committee on Dangerous Substances (1991), of major hazard aspects of the transport of dangerous substances proposed a national societal risk tolerability criteria for the risk across the whole country from a particular activity (such as the shipment of dangerous goods through ports). This work suggested that the risk of 10 or more deaths in a single incident somewhere in the UK should be at a frequency of no more than 0.7 per year to be within the (ALARP) region of tolerability. This is not directly comparable with the analysis below as the majority of those fatalities would be amongst those at work in the activity concerned. By implication the level of intolerable risk will be higher for those encountering "occupational risk" and thereby gaining more benefit from the activity than it will be for fatalities amongst the "general public".

Figure 2.2: Upper and lower limits of tolerability of Societal Risk from fire



Historical precedents

It is suggested that, considering reactions to previous large loss fires in occupied buildings, a risk of fires involving 10 or more deaths somewhere in the UK exceeding one every 2 to 3 years is intolerable, and that the rate of fires with over 10 deaths must be significantly less than this to be regarded to be tolerable. There are about 1.3 million shops, offices, factories, section 72 flats etc in the UK, which falls to about 700,000 if non-certificated shops, offices arid factories are excluded. There were 7 fires causing 10 or more deaths in the 1980's, 2 of which occurred in a house and an aircraft respectively. If the house and aircraft fires are excluded, this gives a rate of 1 fire in an occupied building (excluding houses) causing 10 or more deaths every 2 years in the 1980's. With 700,000 to 1.3 million premises this gives an annual rate per premise of between 1 in 1 million to 1 in 2.5 million of fire causing 10 or more fatalities. From this it is suggested that the likelihood of a major loss of life (i.e. 10 or more at any single site) cannot exceed about 1 in 1 million to 1 in 2.5 million per year per premise if it is to be regarded as tolerable, and should be below 1 in 10,000,000 to 1 in 25,000,000 per year per premises to be regarded as negligible.

Table 2.2 Number of deaths per fire (n), frequency of fires per with (n) deaths per year (Source, Home Office Fire Statistics).

Number of deaths per fire (n)	1990 to 1995	1980 to 1989	1976 to 1979
1	607	716	682
[1]2-4	51	60	60
[2]5-9	2	3	3
10-19	0.16	0.3 (1 in 3 years)	0.75 (1 in 16 months)
20-29	0	0	0
30-39	0	0.2 (1 in 5 years)	0
40-49	0	0	0
50-59	0	0.2 (1 in 5 years)	0
10 or more	1 in 6 years	0.7 (1 every 17 months)	0.75 (1 every 16 months)

[1]Assumes 3 deaths per fire.
[2]Assumes 7 deaths per fire.

Fires causing 10 or more deaths:-

1977 11 deaths in an old peoples' home in Hessle
1978 12 deaths in a train near Taunton
1979 10 deaths in a shop in Manchester
1980 10 deaths in a hostel in Kilburn
1980 37 deaths in unlicensed drinking club in Soho
1981 13 deaths in a house in Deptford
1984 16 deaths at Abbeystead waterpumping station
1985 55 deaths at Manchester Airport in an aircraft
1985 56 deaths at Bradford City football ground station
1995 12 deaths in an aircraft fire

If past ratios of fires with 5 - 9 deaths vs fires with 10 or more deaths were to be repeated in the 1990s (i.e 4.3 to 1) one would expect one fire with 10 or more deaths every 2 years in the 1990s. Avoidance of such fires would suggest that fire safety and fire cover levels have effectively mitigated such fires to date in the 1990's.

Comparison with single fatality fire rates.

If it is accepted that (1) the upper unit of tolerability of single fatality fires is 1 in 100,000 per person per year and (2) that a rate of 1 in 1,000,000 per year in the occupied dwellings is negligible and (3) that the likelihood of fires with 10 or more deaths must be disproportionately lower, then the upper and lower limits of tolerability for fires per year per building with 10 or more deaths would be:

No more than: 1 in 1,000,000 and

1 in 10,000,000 respectively

Clearly, a likelihood of not more than 1 in 10,000,000 per year per premise is so small to be effectively "zero" risk of fires with 10 or more deaths in any premise occupied by 10 or more persons, and implies that everything that is practical and effective should be done to achieve such a standard.

2.5 Proposed role of criteria in the fire service

Risk criteria have been developed in the process, nuclear and aerospace industries. These criteria are used to assess the standard of physical and management control exerted over operations directly and, usually, solely their control. Clearly this is not the case in the context of the fire services' efforts to reduce the loss of life and property in the public and commercial domain. Nevertheless, such criteria can play a number of roles in decision making regarding public safety, as exemplified by the use of "willingness to pay" values by the Department of Transport for road safety schemes. Our suggestions for the use of criteria in the Fire Service are outlined below:

1. Identification, at a national level, of the most at risk groups which fire authorities should target for the purposes of safety education and other preventive initiatives. The apparent increase in the rate of death amongst social class V children despite a general reduction in rate of child deaths, is a clear example of where risk criteria might highlight disparities in fire safety.

2. Definition of national fire cover standards and evaluation of proposed changes in fire cover standards on basis of both societal and individual risk.

3. Identification and evaluation of priority areas for new or revised fire safety and building control regulations and codes, including assessment of cost-effectiveness of statutory requirements and their affect on both societal and individual risk.

4. Evaluation of risk associated with new types of premises or systems, such as railway tunnels, and their effect on both societal and individual risk.

Given that the net cost of the fire service, after deducting the value of averted property damage, may well be very low, zero or even a net saver, the question is not necessarily how much more or less is society willing to spend for rescue of persons and/or aversion of fire casualties. Rather, the question is how much more or less is society willing to spend to save additional life/injury, or willing to incur marginally more deaths and injury due to (for example) development of new industries and technology. Thus, "values of life" are still relevant for looking at additional costs of new fire safety regulations and education efforts.