

The Fire Safety of TV Set Enclosure Materials, A Survey of European Statistics

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The composition of enclosure materials used in many TV sets sold on the European market has changed significantly since the early 1990s. To determine the potential impact of this change on TV fire safety, a review of European and US TV set fire statistics has been carried out. TV set fires can have internal electrical causes due to faults not apparent at the time of manufacture, simple wear and tear, or a variety of external causes. Recent detailed statistics suggest that about one third of all TV fires are due to external ignition. Available data show that the significant drop in the rate of TV set fires experienced in Europe during the 1980s is not continuing today. In fact, the rate appears to be increasing in some countries, such as the UK and Sweden. The number of TV set fires in Europe is estimated as 100 fires per million TV sets per year due to internal ignition sources, at least an order of magnitude higher than in the USA where the fire safety classifications for TV set enclosure materials has been historically high. TV set fires have a dramatic impact on life and property. To avoid an increase in TV set fires, fire safety requirements should be increased, and public awareness of the importance of fire safety in TVs heightened. Copyright © 2000 John Wiley & Sons, Ltd.

INTRODUCTION

Since the 1970s the materials used for TV set enclosures have changed significantly. In older models, the box shaped 'housing' was made of wood covered with a layer of natural or synthetic veneer, and the 'backplate' cover was generally made of particle board or plywood. When plastic materials were introduced, it became possible to use other designs, and the backplate shape became more complex.

Concern about the high number of fires in TV sets during the same period of time led to a number of technological improvements to reduce the fire risk associated with these products. Important modifications included the reduction of the energy requirements of a TV and an ensuing reduction in the heat produced by the TV when in use. Even more significant, however, was the adoption of plastic materials with very high fire performance, conforming to the V0 classification of the UL 94 standard,¹ in which a vertical test specimen may not sustain combustion after being contacted with the flame of a gas burner. These materials were produced by the introduction of highly effective halogenated flame retardants into the plastic matrix.

The international standard IEC 65² is the document which specifies the 'safety requirements for mains operated electronic and related apparatus for household and similar general use'. This merely states that enclosure materials should meet the requirements of the HB (Horizontal Burning) classification, although in critical

locations higher performing materials must be used. In the HB test, the flame travelling between two marks on a horizontal test specimen may not burn faster than 38 mm/min for specimens having a thickness of between 3–13 mm. In contrast to V materials that are ignition-resistant, HB materials burn quite easily, although at a slower rate than materials with neither V nor HB ratings.

In contrast, standard requirements in the USA (where UL 1410³ specifies V0 material for TV enclosures) and Japan (which has similar requirements for backplates) are more stringent than those in Europe. In Europe, manufacturers may comply with the IEC 65 standard, or voluntarily use a material with higher fire performance. Many TV set manufacturers in Europe continued to use V classified material for the enclosures until recently when HB classed materials, the lowest classification allowed, became more common. A recent Danish⁴ study has shown that many new TV sets taken at random from the European market will burn fiercely when ignited, confirming that in Europe many enclosure materials only comply to the lowest material fire standards.

In the early 1990s, the anti-halogen stance of some environmentalist groups in Europe saw a number of legislative activities⁵ aimed at restricting the use of certain halogenated flame retardants. This was amplified by certain consumer test magazines which analysed TV set enclosures and downgraded those containing halogenated flame retardant additives. Monitoring of the results reported by these magazines⁶ shows a strong trend away from the use of halogenated additives in plastics (see Fig. 1).

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Meanwhile, numerous studies⁷ were carried out showing that brominated flame retardants can be safely used by society to provide necessary protection from fires.⁸ The draft EU legislative proposal was withdrawn in 1994, in favour of an OECD risk reduction program adopted in the form of a Voluntary Industry Commitment, and all other national legislative activities were dropped.

The consumer test magazines cited above did not test the fire safety performance of the enclosure. Had they done so, their final ratings might have been different. The effect of this monitoring and its explicit criticism of halogens highlights the delicate balance needed when simultaneously addressing environmental and fire safety issues. Producers of consumer products are particularly sensitive to characterization of their products as either unsafe or environmentally unfriendly. TV manufacturers are especially loath to champion the inclusion of flame retardants as this is tantamount to admitting that their product may be dangerous without them. The issue of fire safety is seldom addressed publicly, resulting in the consumer misconception that TVs do not play an important role in fire safety.

The use of materials with poorer flammability properties creates a situation in which the fire safety of new TV sets marketed in Europe now relies almost entirely on the design of internal electrical components, and significantly increases the likelihood of fires caused by consumer misuse. Meanwhile, consumers, quite naturally, believe that higher safety goes hand in hand with technological progress.

The object of this survey is to collate and interpret statistics concerning fires involving TV sets, to identify the relative importance of fires from both internal and external sources, and by implication the impact of enclosure materials fire performance on the occurrence and spread of fires. A comparison between the statistics from various countries gives an opportunity to draw general

conclusions which would be difficult to reach if each country were considered in isolation. This work has been conducted within a research program investigating the incorporation of fire safety considerations into the LCA of a consumer product.⁹

Possible ignition sources will be discussed in the next section and placed in relationship to available fire statistics in the following section, while trends in European fire statistics will then be presented. These data will be compared to available statistics from the USA and conclusions drawn.

IGNITION SOURCES

Internal

A recent and very thorough study, carried out by Sambrook Research International and commissioned by the UK Department of Trade and Industry (DTI),¹⁰ identified the following causes of TV set fires, based on the historical record:

- Solder joints ageing causing arcing
- Mains switch, worn contacts
- Electromechanical stress in 'heavy' components
- Overheating due to circuit component imbalances
- Capacitor failure (one design)
- Line output transformer
- Poor design of circuit layout (early TVs)
- Cathode ray tube (CRT)
- Mains lead
- Standby function, especially in old sets

While design of TVs has undoubtedly improved through the years, it remains an arduous undertaking due to the continually increasing complexity of these products. Indeed, the evidence shows that no design is

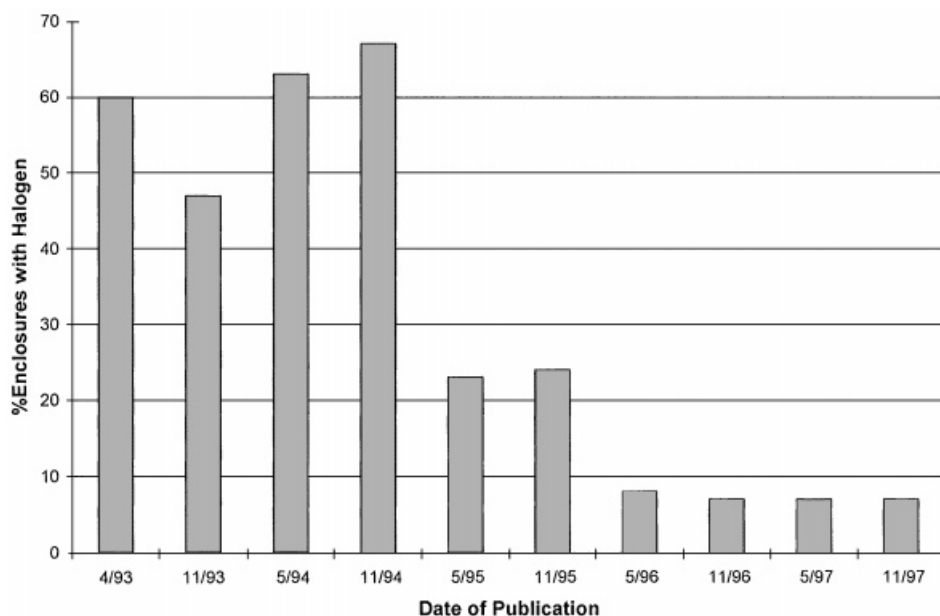


Figure 1. TV set enclosures tested that contained halogens, as reported by Stiftung Warentest (%).

Table 1. Examples of TV set recalls, 1992–1997

Country	Manufacturer	Recall year	Period of manufacture	Number of sets
Denmark	N/A	1992/3	N/A	40 000
France	Philips	1993	1983–1987	40 000
Germany	N/A	1989	N/A	200 000
Netherlands	Philips	1993	1983–1987	300 000
Sweden	Philips	1993	1983–1987	75 000
UK	Sony	1989	1985–86	N/A
UK	A	1993	1983–1986	21 models
UK	B	N/A	1986–1988	1 model
UK	C	1993	N/A	7 models
UK	D	N/A	> 1992	2 models
UK	F	1993	> 1992	2 models
UK	W	1993	1983–86	1 model
UK	Dixons/Matsui	1997	1993	'1000s

totally safe. As reported in the DTI study, the history of television sets recalled by their manufacturers due to faulty design or construction, summarized in Table 1, testifies to this fact. This table is indicative rather than comprehensive as no systematic record of TV set recalls is kept in any country. This example from the UK demonstrates that recalls are not uncommon.

In one study,⁴ 35 used TV sets (aged 3 to 20 years) were examined for signs of damage that would increase the likelihood of fire. They represented a cross-section of sets collected from customers after rental or the purchase of a new TV set. Nearly one-third showed signs of incipient damage which the authors believed reduced the level of fire safety: cracks in electric cables, deficient solder joints, signs of breakdown of components, signs of increased heat development, and significant dust accumulation. A majority showed signs of damage: 40% showed interior damage, and 26% showed minor visible damage.

The study concluded that faults not apparent at the time of manufacture, and inevitable wear and tear present a fire hazard. Available statistics also indicate that fires in TV sets due to internal ignition sources are most common when the appliance is > 10 years old.

External

Statistics usually exclude these TV set fires if they are not clearly the origin of the fire. The following external sources of TV set fires were identified in previous studies:^{10,11}

- Night-lights left burning without stands
- Christmas decorations
- Candles falling on the top or standing next to the set
- Lightning

The use of candles is particularly popular in Nordic countries. There is plenty of anecdotal evidence that consumers do not recognise the danger of placing a naked flame near a TV set, and when a fire occurs, the actual cause may not find its way into the statistics. One article¹² tells the story of a fire in a flat where the television had caught fire, but among the debris of the burnt television, traces of two tinned candles ('flambeaux') were found. The person who lived in the flat had

not said a word about them when he explained how the television had 'suddenly' burst into flames. A slight seasonal increase in TV set fires in December might be due to this tradition of setting naked lights (candles, paraffin lamps, etc) on top of or close to TV sets.

Too often TV sets are treated like any other piece of furniture and decorated with a plant, a lamp or even a candle. TV sets can contribute significantly to the amount of combustible material available in a fire. It is estimated that a modern TV can contribute approximately 165 MJ to a fire. This is equivalent to 5 litres of gasoline.

Consumer misuse

Manufacturers and fire brigades inform consumers about the safe use of TV sets. They are warned against using the top of the TV set as a shelf, for supporting vases, candles, or a cloth that could reduce ventilation. Consumers are warned about inadequate ventilation if the set is placed inside furniture.¹³ Nevertheless, there is evidence¹⁴ that most consumers do not read the manual for their TV sets, least of all the safety precautions.

Fire brigades indicate the following causes of fire due to consumer misuse:^{1,10,11}

- Lack of ventilation, especially when the TV sets are 'boxed in' furniture
- Lack of maintenance, to remove accumulated dust (dampness can lead to electrical failure in case of dust accumulation)
- Extensive use of the standby function, especially by families with children

TV SET FIRE STATISTICS

The criteria under which fires are counted as TV set fires can vary significantly from one country or from one statistics collecting organization to another.

To compare statistics, Sambrook defined a TV set fire as follows:

'A TV fire is a fire where the first point of ignition is from within the structure of the TV or ancillary

equipment that forms a part of the TV, [such as] a video recorder or satellite system. [...] The resultant fire will have breached the envelope of the TV [...]. Specifically excluded are acts of vandalism, criminal damage, ignition caused by the use of accelerants and electrocution as a result of tampering.'

This is in accordance with the safety standards as defined by IEC 65 and is the definition used by National Electrical Safety Boards throughout Europe.

This definition tends to narrow statistics to fires of electrical origin, excluding most other causes. Significantly, fires that are contained within a TV set's enclosure are ignored, highlighting the important role enclosures play by providing the last barrier to any internal fire spreading outside the TV set. In addition, this definition excludes external causes such as candles.

Fire brigades and insurance companies, on the other hand, tend to report higher figures due to a broader definition of TV set fires that includes fires initiated externally. Insurance companies are generally more inclusive than other organizations in their definition of a TV fire. A recent detailed investigation of Insurance Company statistics in Sweden¹⁵ found that approximately 50% of all TV fires as defined by insurance companies in Sweden would not qualify as TV fires according to the Sambrook definition. The discrepancy arises from the fact that fires contained to within a TV set enclosure are included in the insurance company figures. Data from Sweden will be discussed in more detail below as a very detailed study of TV fires in homes was recently completed in Stockholm and extrapolated to the whole of Sweden. This study gives more detailed information than that available in any other European country. Significantly, the Sambrook study has concluded that the occurrence of fires throughout Europe seems to be essentially the same (normalized per million TV sets) in each individual country. The Sambrook study relies on statistics from similar sources in each country. Assuming that

the Sambrook conclusion is correct in indicating this similarity in fire behaviour the Swedish data can be used as a model for Europe.

At the time of the study by Sambrook the Swedish data were not available. Therefore, Sambrook has accounted for the inclusion of 'fires' due to external ignition sources, or due to incorrect classification of the type described above, by estimating these effects in each country studied. To this end they adjusted the reported rate of TV set fires in Denmark by subtracting 35–45% to account for fires involving candles, and for the lower rate of TV fires in smaller towns, which were extrapolated from the statistics of larger cities. An additional 25% was subtracted to account for small fires that self-extinguish. Similar adjustments were made for France (–15% and –25%), Germany (–34%), Italy (–33%), The Netherlands (–15%), Sweden (–20%), and the UK (–24%). The conclusions of the Sambrook survey suggest that about two thirds of the total number of TV set fires reported are due to internal/electrical causes and about one third to external causes.

Based on their purposely conservative definition of TV set fires, Sambrook concludes that there are approximately 2208 fires in Europe per year, or 12.2 TV fires per million TV sets. They further conclude that another 6 TV fires per million TV sets are caused by external ignition.

THE CASE OF SWEDEN

Sweden is the first European country to make a concerted effort to reconcile the differences between fires statistics for TV fires from different sources. In the 1990s the Insurance Federation reported approximately 6000 electrical fires per year. In 1994 (a typical year) approximately 42% of these were due to audio/visual equipment, the vast majority of which (>90%) were TV fires. This corresponds to approximately 2500 TV fires that year. At

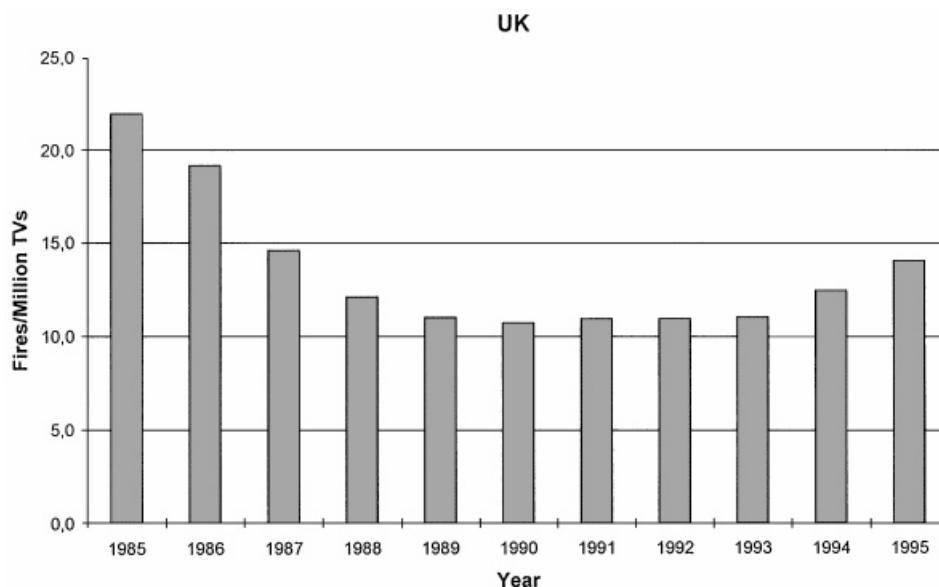


Figure 2. Trends in number of TV fires in the UK. Source: Home Office Statistical Bulletin, Summary Fire Statistics, UK (normalized per million TVs).

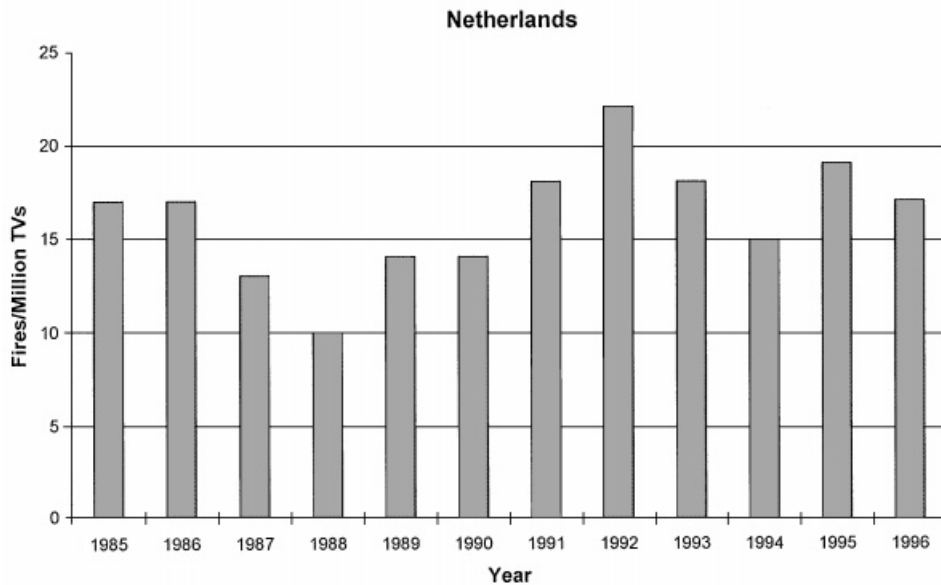


Figure 3. Trends in number of TV fires in the Netherlands. Source: CBS Brandweerstatistiek (normalized per million TVs).

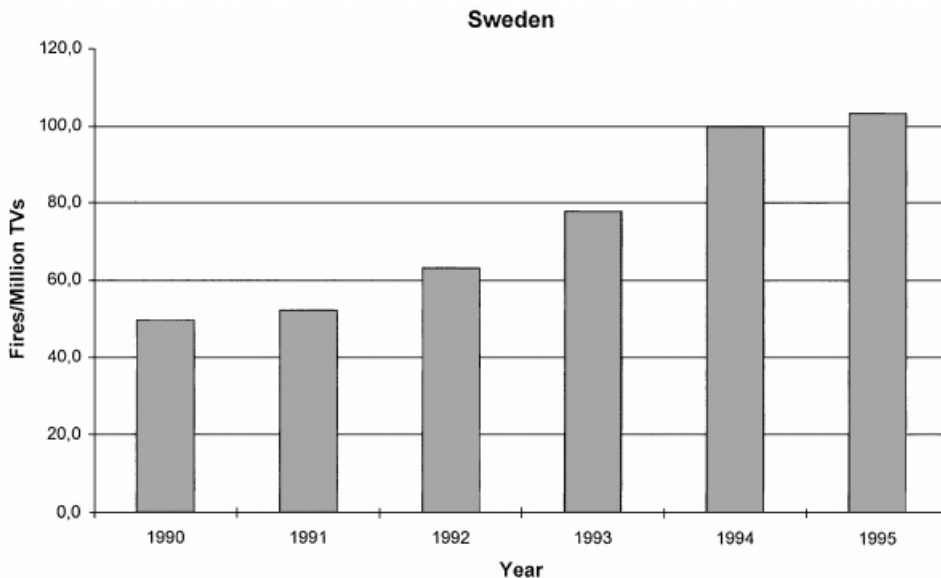


Figure 4. Trends in number of TV fires in Sweden. Source: Vällingby 1994 data and Swedish Insurance Federation (normalized per million TVs).

the same time the Swedish National Electrical Safety Board (SEMKO) officially estimated the total number of electrical fires to be less than 2500 (i.e. the number of TV fires according to the Insurance Federation) and the number of TV fires to be approximately 150–250 per year. In order to determine which number was most realistic an in-depth study was initiated centred around the Stockholm suburb of Vällingby. Over a 14 month period all electrical fires were investigated in detail by experts from SEMKO. The results of their findings were extrapolated to cover the whole of Sweden.

Two findings were particularly interesting. First, the Insurance federation grossly overestimated the total number of electrical fires and in particular the number

of TV fires, and second, SEMKO had previously underestimated the total number of TV fires. Using SEMKO's definition, the Vällingby study estimated that approximately 750 (or between 600–900) audio/visual fires occur per year in Sweden. These fires were all large enough to have breached the TV enclosure SEMKO concluded that the additional 1750 fires reported by the Insurance Federation were either wrongly classified, e.g. so small that they had not breached the enclosure, or were caused by an external ignition source. Assuming that approximately half of the Insurance Federation fires did not breach the housing would leave approximately 500 due to external ignition sources. These data correspond to approximately 100 TV

fires/million TVs in Sweden due to internal ignition and 65 TV fires/million TVs due to external ignition, and an additional 160 TV fires/million where the fire does not breach the enclosure.

Usually, only the most severe TV set fires find their way into electrical safety board or fire brigade statistics. The authors suggest that the Vällingby project results, because of the thoroughness of the methodology, are more representative of a wider European reality. Understandably, consumers would have a financial incentive to report small TV set fires to insurance companies, while only in the event of a major fire would the consumer call the fire brigade. Therefore, it is not surprising that the Vällingby data are closer to Insurance Federation numbers than those reported in the statistics of fire protection agencies. Similarly, electrical safety boards are presumably only interested by fires of clearly electrical origin, to the exclusion of other causes like the ignitability of enclosure materials.

In conclusion, the Sambrook study provides a sound basis for comparison of fire statistics from different European countries, but it is too conservative in its estimate of the frequency of TV fires. The Vällingby data provides a better model for European TV set fire behaviour.

TRENDS

Between the mid 1980s and the mid-1990s, the number of TV set fires fell by as much as 50%. This trend coincided with improvements in design, manufacture, decreased power consumption and the use of effective flame retardant additives in enclosure materials. To facilitate country-to-country comparison of recent TV fire statistics, the data in Figs 2–4 are presented as number of fires per million TV sets.

To make certain that the most conservative figures are used, the 1994 Vällingby data are taken as a reference, and the trend reported by the Swedish Insurance Federation is applied. The two sets of data, as discussed above, set the limits of the range of TV set fires per million sets reported in Europe.

The increase in the rate of TV set fires observed in the UK (+39%) and in Sweden (+101%) during the 5 year period after the mid-1990s 'valley' is disturbing. The number of TV set fires reported by the Dutch fire brigades is in the same range as the UK. While the year-to-year data from The Netherlands are slightly more erratic due to their smaller statistical base, an upward trend starting in 1989 is evident.

US TV SET FIRES STATISTICS

Although the methods of collecting fire data in the USA may be different to those in Europe, a comparison with European statistics can be expected to give insight into the effect of using high fire performance enclosure materials.

USA statistics combine all home entertainment equipment such as TVs, tape recorders, VCRs and CD players. According to a recent study, 'there were an average of 29

civilian deaths, 162 civilian injuries and \$34.5 million in direct property damage per year resulting from the estimated 2200 home structure fires per year associated with this equipment' during the 1990–94 period.¹⁶ Of this total, we can assume that approximately 70% are due to TV sets as this is the percentage of TV set fires relative to TV + sound + video in other countries where detailed statistics are kept. This leaves us with 1540 TV fires, or approximately 13 TV fires/million TVs in the USA. This includes both internal and external ignitions.

It is reasonable to assume that any external ignition of TVs in the USA must either pertain to a large external ignition source, or are due to the presence of a small but significant number of TV sets with HB enclosure material. This assumption is based on recent work concerning the real scale fire behaviour of V0 enclosure material.^{17,18} Thus, to make the US statistics comparable to the European statistics one can assume that internal ignition will provide a high estimate of the number of fires associated with TV set housed with V0 enclosure material. This corresponds to a total of 5 TV fires/million TVs each year. Again, based on experimental evidence of the fire behaviour of V0 enclosure material one can assume that these fires are essentially minor with little damage to material other than the TV of origin.

This is more than an order of magnitude lower than in Europe (165 TV fires/million). This dramatic difference provides compelling evidence that the higher fire safety classification of enclosure materials typically used in the manufacture of TV sets sold in the USA does have a significant and beneficial impact on fire safety.

SEVERITY OF TV SET FIRES

As discussed above, there is a relationship between the severity of a TV set fire and its likelihood of being reported to the different organizations that collect statistics. Consumers tend to report more fires if they have a financial incentive, explaining why the number of TV set fires reported by insurance companies is one order of magnitude greater than that reported by fire brigades or by electrical safety boards.

As long as the damage is limited to the TV set itself, the maximum cost will be the value of the TV set. Fires that spread outside of the TV set will cause the consumer to call the fire brigade. Depending on the speed of intervention (more than 60% of fires were estimated by firemen to be discovered within 5 minutes of ignition), the damage to the furniture, the room in which the TV set was located and the entire dwelling, will vary. Fortunately, only a small percentage of TV set fires totally destroy dwellings, but such cases nevertheless attract much media attention, suggesting that public opinion does not consider them to be an acceptable risk associated with modern technology.

Detailed information was collected in Denmark, Germany, the Netherlands, Sweden and the UK about the severity of TV set fires, but an exact relationship between the number of fires due to TVs and their severity is not always readily available. The German statistics (shown in Table 2) are probably a representative example.

Table 2. Severity of TV set fires in Germany

Severity	Frequency (%)	Cost of Damage (DEM)
Fire restricted to the TV	30–40	2000
Fire spread beyond the TV and causing damage to the property	40–60	10 000–50 000
Fire causing severe damage to the room and property	< 5	150 000
Fire causing major damage to the entire dwelling	< 5	500 000
Fire completely destroying the building	< 2	500 000–1 000 000

Assuming an exponential relation between cost and the distribution of fires according to severity, the total annual cost to Germany of TV set fires is approximately DEM 25 million. In addition to the cost to the owner of the TV set and the dwelling, there is an associated minimum cost to society of DEM 1400–2000 per call-out for the fire brigade, which increases to DEM 50 000 for large fires. Based on 574 TV fires in Germany in 1994, the corresponding cost for intervention is about DEM 1 million. By comparison, in the UK the annual cost to society of TV set fires is estimated to be less than DEM 3 million per year based on 333 cases. The difference between the UK and Germany is probably due to accounting methods, although estimates do provide helpful orders of magnitude indications of these costs. The estimations for Germany and the UK give an idea of the magnitude of the issue.

Once the fire spreads to the furniture, flash-over (i.e. the rapid spread of the fire to the entire room) can occur within minutes. Some deaths in retirement homes have been reported, suggesting that persons of impaired mobility are often unable to raise alarm, or to escape during the development of the fire. In 1991, four people died as a result of a TV set fire in a retirement home in Belgium. Two women, aged 84 and 96, died in 1996 in a retirement home as a result of a TV set fire, again in Belgium. In the UK, 13% and 36% of persons either killed or injured in a TV set fire were less than 5 years old, or more than 60 years old respectively. Sambrook report an average of 16 deaths per year in Europe due to TV set fires. The Swedish figures of fire deaths due to TV set fires are even higher at 5–10 per year relative to the estimated 7–8 million TV sets in that country. Again, this might indicate that TV set fires are under-reported in other countries.

In conclusion, the severity of TV set fires should not be underestimated, both in terms of economic cost and of lives. Once a TV set has caught fire, there is little time left to intervene before catastrophic spread to furniture and the dwelling.

CONCLUSIONS

After dropping for several years, the number of TV set fires in Europe has recently stopped decreasing. In some countries, such as the UK, Sweden and The Netherlands, where detailed statistics are kept there is direct evidence that the number of TV set fires is actually increasing. The European CE mark requires compliance to the local equivalent of the IEC65 standard, which allows HB classified materials to be used for enclosures. HB classified materials are much more easily ignited than those with the more stringent V0 classification, and are therefore much more susceptible to fires resulting from design errors, manufacturing defects, misuse, external causes or the effect of ageing and normal deterioration. Enclosures made from HB classified materials may not provide sufficient protection to consumers, especially children and the elderly, or to their property.

Other countries, such as Japan or the USA require higher fire safety ratings than Europe. The technology to achieve that higher fire safety has been a normal commercial practice for several years. Based on the results of this survey, a return to the use of materials with high levels of fire safety may be necessary to provide adequate protection to European consumers. It is in the interest of society, due to loss of life and property, to take measures to lower the incidence of fire by analysing and acting upon the elements that contribute to fire safety, i.e. materials fire performance, design and consumer education. Thus, making materials less fire-safe is obviously not a move in the right direction.

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