Safety of hair dryers

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Contents

Safety of hair dryers

Abstract

Again and again fatal accidents in connection with the use of hand-held hair dryers are reported in Germany and other countries. Both adults and children are affected. The reason can lie in the hair dryer's unsatisfactory safety level. This expert's report is intended to clarify the situation. In the course of this:

- statistical data on accidents with hair dryers are collected (for Germany, selected European and non-European countries),
- the safety solutions for hair dryers available on the market today (for Germany, selected European and non-European countries) are evaluated from a safety aspect,
- the available safety solutions ("state of the art of science and technology") are determined and evaluated, and
- a technical solution is derived for "hair dryers with a safety function".

The current method for recording accident data is described. Data on accidents with hair dryers are derived from an analysis of publically available databases and supplemented through research in public media and literature sources. A comparison of the accident situation with hair dryers in Germany and in the USA is carried out.
In the safety considerations regarding the hand-held hair dryer only measures for protection against electric shock are examined in detail. The present safety solution in Europe for this protection in hair dryers is considered critically. Because at present the safety measure involving a residual-current circuit-breaker (RCD) in the building's electrical installation is included in the hair dryer's safety concept, fitting buildings with this equipment and the residual risks are examined. A further possibility for reducing the potential risk of the electrical current – polarised domestic plugs – is described.
It is shown that the USA already applies better technical solutions for protection against electric shock than Europe.
A technical solution for "hair dryers with a safety function" is described that was developed and tested based on theoretical considerations in the technical literature in Germany. This solution requires the amendment of standards.
Recommendations for improving the present situation are given in the conclusions.

Key words:

hairdryer, product safety, consumer protection, harmonised standards, residual installation systems, current device, fault protection, additional protection, electric shock, electrical accident

Sicherheit von Haartrocknern

Kurzreferat

Immer wieder werden tödliche Unfälle im Zusammenhang mit der Benutzung von handgeführten Haartrocknern in Deutschland und anderen Staaten gemeldet. Dabei sind sowohl Erwachsene als auch Kinder betroffen. Die Ursache dafür kann im ungenügenden Sicherheitsniveau des Haartrockners liegen. Dieses Gutachten soll die Sachlage klären. Dabei werden:

- statistische Daten zu Unfällen mit Haartrocknern (für Deutschland, ausgewählte europäische und außereuropäische Staaten) erhoben,
- die heute am Markt erhältlichen sicherheitstechnischen Lösungen für Haartrockner (für Deutschland, ausgewählte europäische und außereuropäische Staaten) aus sicherheitstechnischer Sicht bewertet,
- die verfügbaren sicherheitstechnischen Lösungen („Stand der Wissenschaft und Technik“) ermittelt und bewertet sowie
- eine technische Lösung für den „Haartrockner mit Sicherheitsfunktion“ abgeleitet.

Die derzeitige Methode der Erfassung der Unfalldaten wird beschrieben. Die Unfalldaten mit Haartrocknern werden aus der Analyse der öffentlich verfügbaren Datenbanken abgeleitet und durch die Recherche von öffentlichen Medien- und Literaturquellen ergänzt. Es erfolgt ein Vergleich der Unfallsituation mit Haartrocknern in Deutschland und in den USA.
Bei den sicherheitstechnischen Betrachtungen des handgeführten Haartrockners werden nur die Maßnahmen des Schutzes gegen elektrischen Schlag ausführlich untersucht. Die derzeitige sicherheitstechnische Lösung dieses Schutzes im Haartrockner für Europa wird kritisch betrachtet. Da gegenwärtig die Sicherheitsvorkehrung Fehlerstrom-Schutzschalter (RCD) der elektrischen Anlage des Gebäudes in das Sicherheitskonzept des Haartrockners einbezogen ist, werden die Ausrüstung von Gebäuden mit diesem Gerät und seine Restrisiken geprüft. Auch eine weitere Möglichkeit zur Senkung des Gefährdungspotentials des elektrischen Stroms – gepolte Haushaltssteckverbindungen – wird beschrieben.
Es wird gezeigt, dass in den USA schon jetzt bessere technische Lösungen des Schutzes gegen elektrischen Schlag als in Europa angewendet werden.
Eine technische Lösung für den „Haartrockner mit Sicherheitsfunktion“, die basierend auf den theoretischen Überlegungen in der deutschen Fachliteratur entwickelt und erprobt wurde, wird beschrieben. Diese Lösung verlangt Korrekturen von Normen.
In den Schlussfolgerungen werden die Empfehlungen zur Verbesserung der gegenwärtigen Situation gegeben.

Schlagwörter:

Haartrockner, Produktsicherheit, Verbraucherschutz, Harmonisierte Normen, Installationsanlagen, FI-Schutzschalter, Fehlerschutz, Zusatzschutz, Elektrischer Schlag, Elektrischer Unfall, Elektrounfall

Summary of the results

The following results were achieved in the expert's report:

Collecting statistical data on accidents with hair dryers (for Germany, selected European and non-European countries)

In Germany and in other countries, with the exception of the USA, official statistics on fatal accidents with a hair dryer are not collected. In extensive research in available official statistical databases and in public media and literature sources it was found that there were 4 fatalities per year in connection with a hair dryer on average in Germany in a period of 30 years (1981 - 2010). This average figure remained relatively constant over the years examined.

For 27 registered countries in Europe extrapolation results in a probable 62 fatal accidents per year with a hair dryer.

In the USA the number of fatal accidents with a hair dryer of 15.7 per year in the 1980s was reduced to the current 0.3 per year as a result of the technical safety measures that were taken.

Determining and evaluating the safety solutions for hair dryers available on the market today (for Germany, selected European and non-European countries)

Hand-held dryers available for private use in Germany and in Europe are manufactured in accordance with the harmonised product standard DIN EN 60335-2-23 (VDE 0700-23).
With the main use taking place in the bathroom it cannot be ruled out that a hand-held hair dryer will come into contact with water. If this happens, the safety measures provided in the product standard against the risk of electric shock (double and reinforced insulation) become ineffective. At present, there are no technical safety measures planned on or in the hair dryer itself against danger in connection with water. Only an appropriate warning sign (bathtub/shower struck out) indicates this danger.
Integration of a residual-current circuit-breaker (RCD) in the existing electrical installation in the living area is recommended as an additional safety measure. Research shows that only approx. 50% of private residences in Germany are equipped with RCD; there is no obligation to retrofit in Germany.

Taking into consideration the product properties, the space situation in bathrooms and the behaviour of users, based on the current state of the art hand-held hair dryers are dangerous products.
This statement was also made in the USA by the consumer protection organisation CPSC. Since 2011-07-28, hand-held hair dryers have been on the list of substantially dangerous products and may not be sold without the required safety measures (immersion protection).
http://www.gpo.gov/fdsys/pkg/FR-2011-06-28/html/2011-15981.htm

Determination and evaluation of available safety solutions (“state of the art of science and technology”)

In the USA it is required that safety measures against electric shock that retain their function even on immersion in water are allocated directly to the hand-held hair dryer. The technical solutions are realised through the use of a residual-current circuit-breaker with a triggering current of 6 mA and an “immersion sensor”.

Since the 1980s, safety concepts that use the protective effect of an earthed conductor on immersion of the hair dryer into water have been shown in the German technical press. These concepts have not been realised in practice.

The threat of an electric shock could be reduced at present as well if polarised plug-in connection systems (plug and socket) were used in Germany as in many countries (eg France, Great Britain). The reason for this is the common use of single-pole on and off switches in the handle of the hair dryer. With polarised plug-and-socket connection systems, insulation would be ensured in a switched-off state. See Section 3.6 on this.

Deriving suggestions for solutions

A technical solution that uses the safety effect of the protective earth conductor that is connected with a conductive protective shield that is integrated in the hair dryer was realised for the hand-held hair dryer and tested in practical experiments. The appliance even achieves a better protective effect than the American models, because it was verified that protection against electric shock is guaranteed on connection to a shock-proof plug even without an RCD. An RCD with a rated differential current of 10 mA integrated, for example, in the plug, must be allocated to the appliance as additional protection against other possible faults (eg break in the protective earth conductor).

The practical realisation of the tested solution for “hair dryers with safety functions” requires a revision of the current hair dryer concept, which is reflected in the product standard (DIN EN 60335-2-23 (VDE 0700-23)). Water contact is to be included in the risk assessment here.

The conclusions are compiled in Section 6.

1 Introduction

Again and again fatal accidents in connection with the use of hand-held hair dryers (referred to below as hair dryers) are reported. Both adults and children are affected.

The expert's report examines the following questions:

- Collecting statistical data on accidents with hair dryers (for Germany, selected European and non-European countries),
- Determination and evaluation of safety solutions for hair dryers available on the market today (for Germany, selected European and non-European countries),
- Determination and evaluation of available safety solutions ("state of the art of science and technology")
- Deriving proposals for solutions.

The objective of the expert's report "Hair Dryers with a Safety Function" is to examine whether the risks that are to be considered can be countered with technical solutions or other measures.

Because a safety evaluation of electrical equipment must always be carried out in interplay with the electrical installation to which it is connected, an evaluation of safety measures against electric shock must also be carried out in electrical installations. Here, an important part is played by the development of measures for earthing, equipotential bonding, the use of residual current circuit-breakers (referred to below as RCD) and the development of safe plug systems.

2 Collecting statistical data on accidents with hair dryers (for Germany, selected European and non-European countries)

For several decades the problem area of practical statistics was discussed with regard to accidents involving electricity and in particular accidents with hair dryers.

Meaningful statistics are essential for comparability and also for the detection of the causes of accidents involving electricity and the development of suitable measures to prevent them.

Fatalities as a result of accidents involving electricity are registered worldwide. These, and accidents involving electricity that do not lead to fatalities, are recorded and made available to the public in different ways in the countries involved, in spite of the existing classification by the World Health Organisation (WHO).

Since 1980 the WHO has requested member states to record fatalities in accordance with classification ICD-9 (in force 1980 - 1997) and to forward them to the WHO. The classification ICD-9 was mainly structured in accordance with medical diagnoses and permitted practically no conclusions as to which electrical appliance had triggered the fatal accident.

Following the change of classification by the WHO, new characteristics that enable conclusions to be drawn regarding causes of some accidents were included in ICD-10 from 1998.

It was not possible to determine separate data on fatal accidents through hair dryers in the official statistics that were researched.

2.1 Hairdryer accidents in Germany derived from the GBE database

The online database of the Federal Government’s Health Reports (GBE) brings together health data and health information from over 100 different sources at a central position, including many surveys by the Federal Statistical Office and the statistical services of the German federal states, but also surveys by numerous other institutions from the health area.

However, the GBE database does not permit any detailed statements on particular accidents, such as, for example, through hair dryers, although some other appliances are listed separately (eg lawn mowers, group W28). Accidents that are caused by electrical appliances are assigned to the other groups shown below. What makes things more difficult is that in Germany in case of death the allocation of the cause of death is done through the official death certificate and doctors are not always able to determine the actual cause of death. In addition, there are no standard forms in the federal states.

The following groups are of interest in the GBE database:
W29 Accidents caused by other hand tools with power drive or electrical household appliances,
W85 Exposure to electric cable systems,
W86 Exposure to other specified electric current,
W87 Exposure to unspecified electric current,
each with the same subgroups:

WXX.0	Exposure at home (eg W85.0),
WXX.2	Exposure in schools, other public buildings,
WXX.3	Exposure in sports facilities,
WXX.8	Exposure in specified locations,
WXX.9	Exposure in unspecified locations.

Criminal offences in connection with electricity are not shown separately in the statistics either. It is to be assumed that these are assigned to one of the above-mentioned groups.

The GBE database differentiates between the categories: accidents at work, accidents in school, road traffic accidents, accidents in the home and in leisure time, and all accident types.
Between 1998 and 2009 a total of 511 fatal electrical accidents were registered in the category “home and leisure time accident”:

Tab. 2.1 Fatal electrical accidents in the home and leisure area

Years	W29	W85	W86	W87	Total
1998 - 2009	50	94	163	304	511

As shown in Fig. 2.1, the number of accidents in the groups involving the home has remained as high as ever.

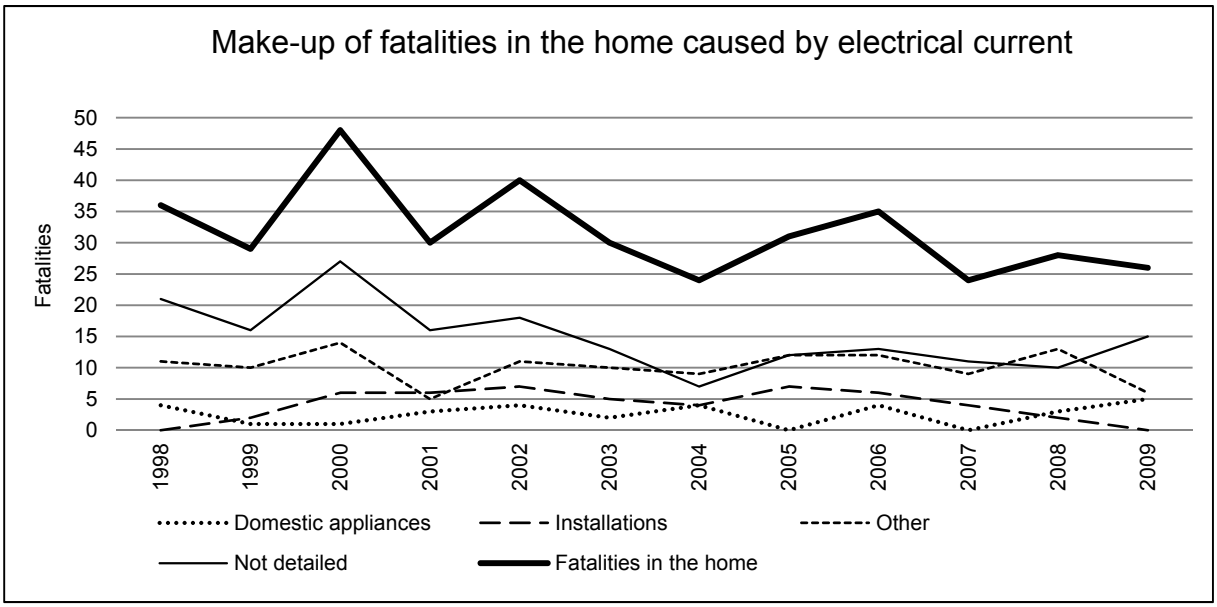

Fig. 2.1 Fatal electrical accidents in the home according to the GBE database

Additional publications were included to enable the fatal accidents with hair dryers to be derived from the figures from the GBE database.

A research report by ALTMANN in 2009 states that approx. 40% of domestic accidents occur in the bathroom. According to ALTMANN, about 63% of these are accidents with hair dryers, or 77% according to ZÜRNECK (in ALTMANN et al. 2002). This shows that 28% of all domestic electrical accidents occur in the bathroom with hair dryers. If the total number of 511 officially recorded accidents is weighted with this, around 144 fatalities with hair dryers can be assumed in the above period, 1998 to 2009, or an average of 12 accidents per year. This means that an assumed fatal accident rate of 4 accidents with hair dryers each year can be derived from the ratio of domestic accidents to criminal offences of about 1:2 determined by ALTMANN.

2.2 Hairdryer accidents in Germany derived from research and reports

Access was had to public media in order to be able to verify figures for fatal electrical accidents with hair dryers. In this research, it was possible to determine fatal and non-fatal accidents. It was also possible to determine criminal offences in connection with hair dryers. In addition, in the framework of this expert's report an INTERNET SURVEY (2011) was carried out on BAuA Internet sites with the aim of acquiring additional data.

The figures that were determined from sources and media in the public domain were summarised and assigned to the corresponding periods. The results are shown in Fig. 2.2.

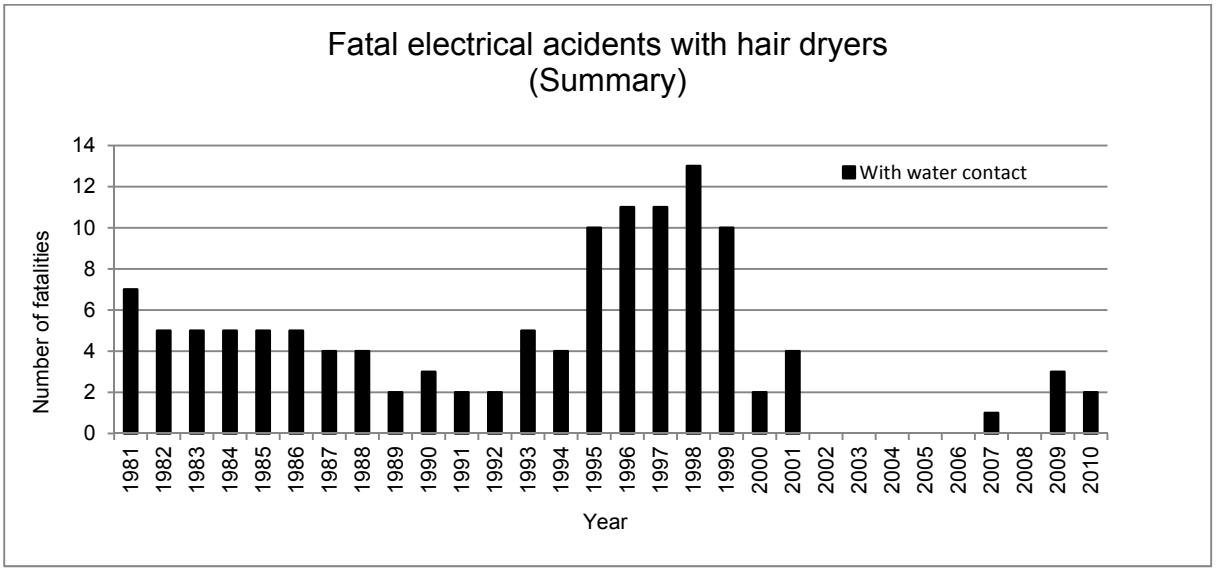

Fig. 2.2 Fatalities in Germany from individual research and publications

Indications of fatalities in the bathroom with hair dryers could not be determined for the years 2002 to 2006 and 2008.

The following sources were available:

- Research reports by LAUERER (1972), ALTMANN et al. (2002) and ALTMANN (2005) from which figures were taken for accidents in the bathroom with hair dryers in the period before 1998.

- BONDE et al. (1986) disclosed in the journal *Rechtsmedizin* that in the period 1972 – 1986 the forensic medicine institutes for Düsseldorf and Göttingen processed 48 cases involving electrocution in the bath. This number contains 19 cases of suicide.

- In 2003, BOCKHOLDT and SCHNEIDER, who carried out examinations in the Forensic Medicine Institute at the Benjamin Franklin University Clinic of the Free University in Berlin (Institut für Gerichtliche Medizin des Universitätsklinikum Benjamin Franklin der Freien Universität Berlin), disclosed that from 1995 to 1999 41 cases of death by electrocution in the bath were examined. Of these, 75% were caused by a hair dryer. One case involved two hair dryers; there were 30 cases of suicide and one case was regarded as murder.

In addition to the above-mentioned sources, further research resulted in the following:

- The authors discovered 25 cases of the effect of electricity in the bathroom in Germany from 1981 to 2010 in freely available online newspaper articles. In 20 cases hair dryers were mentioned and in 5 cases other electrical appliances, such as, for example, a fan heater or lamp.
  In six cases, involving 8 persons, the victims survived electrocution. Twenty-six suffered a fatal accident, 20 of whom when using a hair dryer. It is noticeable here that in many cases small children and children under 14 were involved.

- ALTMANN (2009) states that in the reporting period of 1972 – 2001 there were 713 fatal electrical accidents in east Germany, which are broken down as follows:
  - 250 no further details,
  - 262 suicides,
  - 80 industrial accidents and
  - 121 domestic accidents, of which 49 were bathroom accidents, of which 31 involved hair dryers.

- According to ZÜRNECK (in ALTMANN et al. 2002), in the same period in west Germany 707 fatal electrical accidents are indicated, with 18.4% in industry and 57.4% in the home and the office. Accidents in the bathroom are given with 40%, which, according to ZÜRNECK (in ALTMANN et al. 2002), results in 30 fatalities with hair dryers in 39 bathroom accidents.

Our own INTERNET SURVEY (2011) on the BAuA Internet sites did not result in any additional figures.

It can be seen from the figures up to the year 2001 that death through hair dryers in the bath is not as rare as is possibly often assumed to be. The average rate for 1980 - 2001 is 5.7 fatalities per year, and 4 fatalities in the period from 1980 to 2010.

No contradictions can be ascertained in the comparison of the values that were acquired in public media for accidents with hair dryers for the period 1980 - 2001 with the values that were derived from the GBE database for 1998 - 2009.

On average in the last 30 years in Germany there is an accident rate of approx. 4 users per year resulting in death in connection with the use of hair dryers. Converted to the population in Germany the annual rate is 0.005 per 100,000 inhabitants.

Although Germany has a high safety level in Europe and accident figures are low in relation to the population, the fatal accident rate when hair dryers are used is almost 40 times higher than in the USA (see Section 2.3).

The conclusion is that further measures are required for hair dryers and their use in the bathroom in order to increase safety and reduce the number of fatal accidents.
It must also be taken into account in addition that not all electrical accidents end with death, but they can often lead to physical and mental disabilities for victims for the rest of their lives.

Studies in Australia (POINTER et al., 2007) for example show that the ratio of fatal to non-fatal accidents that were medically treated is 1:10.

The economic consequences of these accidents as a whole are considerable. At the 55th conference of the WHO Regional Committee for Europe 2005 (EUR/RC55/10) it was roughly estimated "*that health care for injuries that ended with death costs between €1bn and €6bn, and that care for non-fatal injuries costs between €80bn and €290bn*."

2.3 Hairdryer accidents in the USA

In the USA, fatalities caused by accidents are recorded in accordance with the WHO classification. Both the Occupational Safety and Health Administration (OSHA) and the National Fire Protection Association (NFPA) are responsible here for collecting data.

In contrast to Germany, there is still an organisation structure for the private sector as well, the Consumer Product Safety Commission (CPSC), which keeps continuous detailed statistics on electrical accidents and other accidents with consumer products, tests these products in Underwriters Laboratories (UL) and not only publishes recommendations for technical solutions for enhancing product safety but also has the right to issue product warnings. Although the CPSC only issues recommendations, because of the more stringent interpretation of the law and the high liability claims in cases of accidents, these are regarded and applied as practically the same as laws and regulations.

According to the CPSC, in the early 1980s in the USA there were on average 15.7 fatal accidents each year with “hand-supported hair dryers” (HAND-SUPPORTED HAIR DRYERS 2011). In 1990 only five electrical accidents with “hand-supported hair dryers” were registered. From 1992 to 2009 only one or two accidents can be observed sporadically each year (see Fig. 2.3).

In 2010 the CPSC published a memorandum on hair dryers (MEMORANDUM CSPC). This shows in detail both the development of fatal accidents and the measures that were implemented and the technical development of the appliances with regard to improving safety. In this, both the use for the intended purpose and the typical behaviour of users in bathrooms, which can deviate considerably from the former, were taken into account.

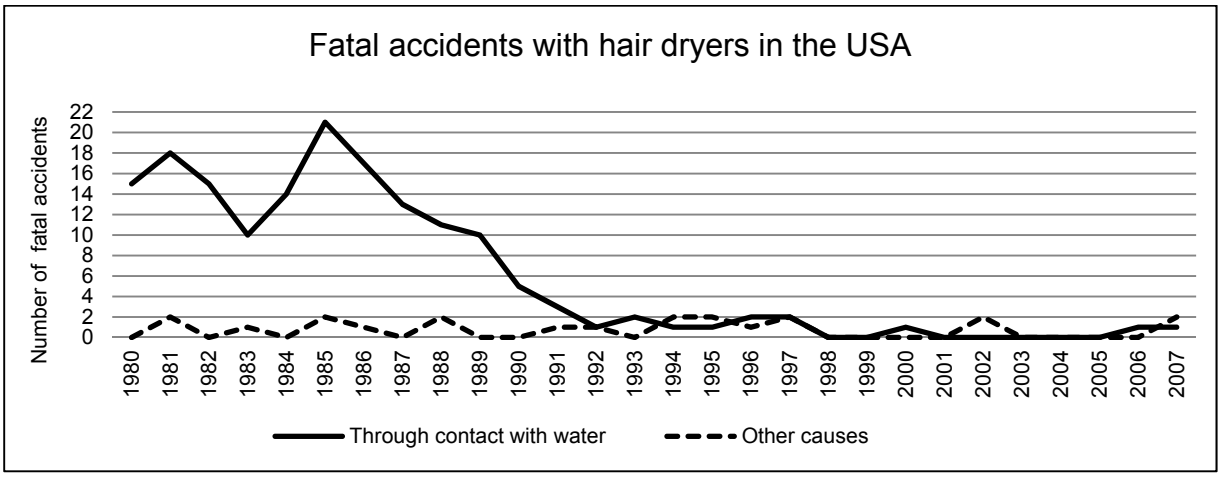

Fig. 2.3 Fatalities in the USA according to CPSC statistics

The integration of immersion protection in “hand-supported hair dryers” was implemented as the most important technical measure. As a result of the safety measures being allocated to the appliance, the number of fatal accidents was reduced to 3 in the whole of the period 1998 - 2007. Taking the population into account, a value for the accident rate of 0.000125 per 100,000 inhabitants was achieved.

Since 2011-07-28 “hand-supported hair dryers” without integrated immersion protection have been regarded as substantially hazardous products. Manufacturing and marketing such “hand-supported hair dryers” without immersion protection in the USA is prohibited (HAND-SUPPORTED HAIR DRYERS 2011).

2.4 Accidents with hair dryers in other European countries

An evaluation of the researched sources in the countries referred to below resulted in an uncertain data situation, which means that a reliable interpretation is possible only with difficulty.
Participation of EU Member States in the WHO’s statistics and the accuracy of data recording is regarded with different levels of importance in individual countries. As far as could be seen, an accident recording system that functions as well as in the USA was not found in any other country.

Only individual fatal accidents through hair dryers could be determined in other countries, eg Austria, Switzerland, Romania and France.

Under the assumption that

- because of similar behaviour patterns of users in EU Member States the situations with regard to accidents with hair dryers are similar to Germany as well,
- the ratio of all fatal accidents to fatal electrical accidents through hair dryers is similar to Germany,

the authors calculated a fatality risk for Europe 2.5 times higher than in Germany on the basis of Eurostat data. This results in a rate of fatal accidents through hair dryers of 0.0125 for every 100,000 inhabitants in Europe.

Converted to the populations of all 27 EU Member States and non-EU states recorded in the Eurostat statistics with 501 million inhabitants, this results for Europe in a suspected number of approx. 62 deaths per year caused by the use of hair dryers. Multiplied by the factor of 300 (number of accidents to number of fatal accidents) given by the WHO at its 55th Conference of the Regional Committee for Europe EUR/RC55/10 (2005), this would mean around 18,600 electrical accidents annually.

3 Investigation and evaluation of safety solutions for hair dryers available on the market today (for Germany, selected European and non-European countries)

3.1 Description of general hazards

3.1.1 Electrical hazard

Hair dryers pose the hazard of an electric shock. As the statistics show, this hazard is particularly great during use where there is water. In the USA this fact is taken into account for the hazard assessment (see section 2.3).

3.1.2 Fire hazard

Apart from an electrical hazard, hair dryers can also be a fire hazard. Although the subject of fire is not intended to play a part in this expert's report, the authors point out that there are frequent reports of fires in connection with hair dryers (STIFTUNG WARENTEST 2009). Cases of hair dryers bursting into flames became known as well in the framework of the survey carried out for this expert's report (INTERNET SURVEY 2011).

3.1.3 Hazard caused by product defects

In the EU requirements for product safety are stipulated in appropriate Directives. According to these, hair dryers available on the European single market must show the CE mark. This indicates that the manufacturer or importer has complied with all legal and technical provisions in Europe.

In many cases hair dryers also display safety signs, such as, for example, the GS mark - "Tested Safety". GS certification presupposes among other things that an independent testing body has checked the appliance's conformity with safety and health protection requirements.

In spite of this, many appliances that are available on the market are defective, as Stiftung Warentest proves (STIFTUNG WARENTEST 2009). In 2009, 16 hair dryers were tested that had the CE mark, and 15 of which had the GS mark as well. The defects that were discovered were, among others, the appliance bursting into flames, generation of flashes, the plastic housing or safety guard becoming deformed or dropping off, broken wires in the terminal lead, or the housing splitting open in the drop test.

Unfortunately, the tests carried out by the Stiftung Warentest did not take into account the case that a hair dryer can also come into contact with water. This meant that the electrical hazard on incorrect handling and the resulting fatalities were precluded from the tests. If there had been a **water test all hair dryers would have failed**!

3.2 Hazard caused by hair dryers where water is found

Where moisture has an effect, hair dryers cause a fire hazard if they are plugged in. Moisture can cause a short circuit, the appliance overheats and starts to burn – even if the appliance is switched off. A hair dryer that is connected to the electricity supply can be **live** even in the “OFF” position, depending on the plug position.

If a hair dryer falls into the water there is a risk of an electric shock for a person if they touch the appliance or the water and at the same time a low-resistance connection to the ground (eg an earthed object such as a water tap). Because hair dryers that are currently standard in the EU conform to the harmonised standards DIN EN 60335-1 (VDE 0700-1):2012-10 and DIN EN 60335-2-23 (VDE 0700-23):2011-04 (product standard), they have the degree of protection IP 20. This means that these appliances do not possess any protection against water entry.
Another reason for the current situation is the restrictive stipulation of the protection class for hair dryers for domestic use in the above-mentioned product standard, which does not take account of the requirements of the basic safety standard for protection against electric shock DIN EN 61140 (VDE 0140-1).

The presence of water, including splashing water and condensation, has to be reckoned with during the usual use of a hair dryer in the bathroom. A hazard that results from this will not be eliminated by a warning sign on the appliance or degree of protection IP 20 and protection class II that are currently prescribed in the standard.

The result is that construction and technological measures on the appliance in interplay with the safety measures of the fixed electrical system are necessary to eliminate the above-mentioned hazards.

3.3 Normative safety concept against electric shock

The starting point for the safety concept for electrical appliances is the hazard assessment, which takes account of the safety and health protection requirements in the appropriate EU Directives (implemented in Germany in *ProdSG* and *1. ProdSV*). When safety measures are selected, the general findings on protection against electric shock for electrical equipment and installations are to be applied that are described in DIN EN 61140 (VDE 0140-1).

The basic principle for protection against electric shock reads: dangerous live parts must not be exposed and exposed conductive parts must not be dangerously live under normal conditions or under individual fault conditions.

The **concept of three-stage protection** was developed from this:

Protection under normal conditions is achieved through **basic protective measures**. The term “protection against direct contact” was previously used for this.

In individual fault conditions **fault protection** (previously “protection against indirect contact”) should be provided.

Alternatively, a consolidated protective measure is provided that realises protection not only under normal conditions but also under individual fault conditions.

Supplementary measures are to be provided in cases in which basic protection or fault protection can fail, or cannot protect because of the fault situation.

It is important that protection must consist of at least two independent protective measures or of a strengthened protective measure that provides not only basic protection but also fault protection.

In general the following are permitted:
- Basic insulation and protection through automatic switching off,
- Protection through double or reinforced insulation,
- Basic insulation and protection through protection separation for the supply of equipment,
- Protection through low voltage.

In cases in which these measures are insufficient, **additional safety measures** are to be applied, eg use of RCDs with a rated differential current of ≤ 30 mA in installations and special types of rooms in accordance with DIN VDE 0100-701.

3.4 Evaluation of hair dryers available on the market

The evaluation of hair dryers available at present on the market results in the following:
Basic insulation requires complete covering of all parts that are live in normal operations. It must be possible to remove them only with the use of special tools.
A cover made of insulating material, such as those used in hair dryers to prevent direct contact with conductive parts, surrounds the live parts partly directly or with the necessary clearance.

Because the hair dryer's heating coil is not covered with insulation due to its function there is no basic protection through fixed insulation. Safety is guaranteed in a dry state by means of a clearance (air insulation) between the heating coil and the surrounding housing. Owing to its function, the housing has openings for the air inlet and the air outlet. Access to live parts is prevented by an insulated fixed mesh. If moisture or water (conductive liquid) penetrates through to live parts the air insulation is bridged and the hair dryer loses **all** the safety measures realised in it. On contact of the appliance in the water by persons, leakage current is passed through the human body to the earth potential. The person suffers a more or less intensive electric shock, depending on the resistance value to the earth potential. **Equivalence** of the current constructive solution for hair dryers with the protective measure of **double or reinforced insulation**, as is demanded in alternative standards, **is not given when water penetrates**.

Because the protective measure of double or reinforced insulation fails in hair dryers that are used near conductive liquids, and on the reasonably foreseeable dropping of the appliance into this liquid, the required protection for the user must be realised by additional or more suitable technical measures.

During use for the intended purpose without water being present the safety measures stipulated in the product standard DIN EN 60335-2-23 achieve their protection target. However, the **product standard** does **not** specify **a technical solution** that protects users in the critical case - **hair dryer in the water**. **In fact, this situation is excluded from the considerations!** Users are informed by a warning in the instructions for use and a pictogram on the appliance that it is forbidden to use the hair dryer near and in water. These pictograms are usually engraved into the housing in the same colour and are difficult to recognise.

The attempt to warn users of hazards through information in the instructions for use and safety marks on the appliance does not achieve the protection target, because experience shows that the simplicity of the appliance means that the instructions for use are ignored, or only skipped through. Given the usual size of bathrooms and the presence of several persons as well, unintentional contact of the hair dryer with water cannot be ruled out. The standard lengths of the terminal leads of 2-3 m increase the probability of an accident.

In Section 4.3 the basic safety standard DIN EN 61140 (VDE 0140-1) already requires the following today:
“If the intended use contains an increased risk, eg for areas with low-impedance connection of persons with the earth potential, Technical Committees must consider the necessity of stipulating additional protection. Such additional protection may be provided in the installation, the system or the equipment.
NOTE: In low-voltage installations and equipment the use of residual current operated devices (RCDs) with a rated differential current of ≤ 30 mA as additional protection against electric shock is accepted in cases in which basic protection and/or fault protection are not effective and/or in case of the users’ carelessness.”

In the product standard for hair dryers DIN EN 60335-2-23 (VDE 0700-23), Section 7.12 as well it is **recommended** that RCDs with a rated differential current of ≤ 30 mA be installed. This additional protective measure serves to increase safety.

The construction standard DIN VDE 0100-701 for special types of rooms with bathtubs or showers requires that the bathroom’s electric circuits must be equipped with an RCD with a rated differential current of ≤ 30 mA in case of new builds or a material alteration to the electrical installation in the house. In this way, this additional protective measure for hair dryers is realised in the house’s electrical installation. However, there is no requirement to retrofit existing electrical installations. For this reason, this additional protective measure is not yet found in many households.

At present, neither the requirements of the construction standard nor the product standard can completely eliminate the danger of an electric shock with fatal consequences if the hair dryer falls into the water.
The necessary protection for users must be realised through further or more suitable technical measures.

For over 20 years there have been technical suggestions (eg LAUERER, 1982, LAUERER, 1990) that offer solutions for reducing the electrical hazard involved in using a hair dryer. One of the solutions has been realised in the USA and represents the state of the art (MEMORANDUM CPSC, 2010).

A suggestion for reducing the electrical hazard by including the protective earth conductor in the hair dryer's protective measure was published in the German trade press by Biegelmeier in 2002 in BACHL et al. (2002) (see Section 4.7).

Since 2010 there have been suggestions by BAUMHÖFER (2010) (see Section 4.8), LOCHNER (2010) (see Section 4.9) and BÖDECKER (2011) that also include the protective earth conductor in the hair dryer's protective measure.

In accordance with these suggestions, the electrical hazard coming from hair dryers on improper but foreseeable usage (eg hair dryer falls into the water) can be reduced.

The protection class II for "hair dryers for domestic use" stipulated in DIN EN 60335-2-23 (VDE 0700-23), Section 6.1 is an obstacle to these solutions. In contrast, solutions on the basis of protection class I using the protective earth conductor are realisable in the commercial sector.

It **must be examined** whether a **normative specification of the protection class** that restricts the selection of safety measures is **permissible**.

3.5 Realising protection against electric shock in electrical installations

As mentioned in Section 3.4, additional protection of electric circuits for bathrooms and showers with RCDs with a rated differential current of ≤ 30 mA has been required by the construction standard DIN VDE 0100-701 for special types of rooms since 1984 for new builds and material changes to the electrical installation in the house.

Because realisation of electrical engineering construction standards depends on the development of the property market (new builds/renovation/reconstruction), the nationwide realisation of new protection requirements is not to be expected for decades.
As estimated from the construction statistics for new builds and reconstructed housing, additional protection through RCDs is probably only present in about 50% of private housing and bathrooms. In our own survey (INTERNET SURVEY 2011) we found 60%. Surveys by individual experts resulted in estimates of around 40%. This means that this protective measure is not sufficiently realised in buildings.

In addition, it must still be assumed that some private households still have obsolete 2-pole conductors without earthed sockets, because these were only no longer permissible for new installations from around 1970 in west Germany and 1990 in east Germany.

Households that are not equipped with RCDs have screwable fuses or circuit breakers. Currents in the two- and three-digit ampere range are required to trigger these protective devices, which do not provide protection against electric shock if a person touches an appliance during a fault (eg short circuit).

In order to profit more quickly from the positive protective effect of RCDs in the electrical installation, RCDs (compact sockets) or portable RCDs (portable residual current device (PRCD-S)) integrated in sockets could be used, and RCDs integrated in extension cords, which are available on the market. The public is insufficiently aware of these possibilities.

However, the protective measure RCD with a rated differential current of ≤ 30 mA entails a **residual risk** (BÖDEKER, 2011; TRIBIUS, 2011).

An **RCD does not prevent an electric shock** if a person is in the electrical circuit, but **limits the duration of flow of the residual current**. The higher the residual current, the quicker the RCD switches it off. But, the higher the current, the greater is the danger to the person.

Even if the electric shock does not have a fatal consequence, physiological effects of the electric current on the person, for example, muscle contractions and respiratory problems, can start even with alternating currents from 10 mA. Because RCDs with a rated differential current of ≤ 30 mA have a permissible tolerance range for triggering in accordance with DIN EN 61008-2-1 (VDE 0664-11) of between 15 and 30 mA, these effects can lead to secondary accidents through fright, falling and shock, or the person can be prevented from leaving the danger zone (eg bathtub).

This residual hazard can be minimised through the use of RCDs with a rated differential current of 10 mA. In general, these RCDs switch much faster. Switch-off times of less than 10 ms can be achieved. The probability of electricity flowing in the heart's vulnerable phase is reduced to 20% to 50% in comparison with RCDs with a rated differential current of ≤ 30 mA.
Because the measures provided for the installation side are insufficient (circuit-breaker does not always switch off, RCD not always existent and has residual risks), it would be practical to realise the necessary safety measures in the hair dryer (eg RCD with a rated differential current of ≤ 10 mA). This path has been taken successfully for hair dryers in the USA.

Apart from hand-held hair dryers there are other constructions for hair dryers that are described in Sections 4.1 to 4.5.

3.6 Safety concepts against electric shock for hair dryers in Europe

In various countries there are additional measures for protection against electric shock that, for example, are referred to in the national annexes to HD 60364-7-701 (VDE 0100-701).

There are actual prohibitions on the installation of wall sockets in bathrooms because the clearances from permissibly installed wall sockets exceed the room dimensions for bathrooms in these countries, eg in Great Britain, Ireland and Denmark.
However, this measure can be bypassed through the use of extension cords.

To implement the demands for safer electrical installations in Italy a law was enacted in 1990 (LEGGE, 1900) with implementation regulations 1991 (DECRETO DEL PRESIDENTE DELLA REPUBBLICA, 1992). According to this, fitting new electrical installations and retrofitting with an RCD ≤ 1 A for compliance with the switch-off conditions was to be carried out within 3 years. The check of retrofitting, which was carried out through a survey in the journal “elettrificazione” (MACCAPANNI, 1997), showed that since 1990 only 28% of rented properties and 59% of owner-occupied properties were equipped with an RCD. This shows that safety requirements cannot be realised simply by enacting laws.

The requirement for retrofitting with RCDs with a rated differential current of 30 mA did not take place until 2008 (DECRETO, 2008).

The use of the combination of **polarised plugs** on the appliance’s power cord and **polarised wall sockets** in electrical installations, such as are found in a great number of European countries (eg Great Britain, France, Czech Republic, Switzerland), must be mentioned as a possible measure that considerably reduces the danger of electric shock. This combination lets an electrical contact in the plug connection be established in a defined position only.
It is known (eg BACHL et al., 2002), not disputed among experts, that the electrical hazard potential of a hair dryer depends on the plug position of the appliance’s power cord in the wall socket. This is caused by the appliance’s single-pole switches, which interrupt only one of the wires of the appliance’s power cord. With one position of the plug in the wall socket the phase (L conductor, which is live) is interrupted by the on-off switch and the appliance is off circuit, even if the plug is still in the wall socket. If the plug is turned by 180° and inserted into the wall socket, the switched-off appliance does not function, but the mains voltage is applied to the internal components because the connection to the live conductor is not interrupted.
It is useful, as is usual in some countries (eg Great Britain and Cyprus), to locate a **miniature fuse** in the hair dryer’s polarised plug as appliance protection in case of an appliance fault. The fuse/circuit-breaker in the electrical installation achieves line protection only, but not appliance protection in each and every case.

3.7 Safety concepts against electric shock on hair dryers in the USA

On the basis of the more exact examinations of the causes of accidents in the USA (MEMORANDUM CPSC, 2010) it was ascertained that particular attention is to be paid to fatalities on contact of a hair dryer with water. Following this, measures were stipulated that have contributed to increasing hair dryer safety. According to the CPSC, the figure of approx. 15.7 fatalities per year with hair dryers (1980 - 1986) was reduced to 0.3 per year at present.
This result was brought about by means of the following measures required in UL standards:

- Equipping the appliances with highly visible and durable signs on the plug that warn of hazards and provide information on use,

- Technical improvements through the use of the safety measures **“**ground fault circuit interrupter - GFCI” (corresponds to RCD) in the plug (ALCI hair dryers) and both a GFCI and an “immersion sensor” in IDCI hair dryers,

and the

- “water test” for hair dryers. Appliances pass this test only if the discharge current does not exceed 5 mA. This results in the requirement for using an RCD in the plug with a rated differential current of 6 mA for ALCI and IDCI appliances.

The advantage of the strategy of combining safety measures directly with the appliance lies in the shorter realisation period and the effectiveness of the measure, because the standard lifetime of “hand-supported dryers” is between 4 and 7 years. Safety measures for permanent installations require a period that is at least 7 times as long before they are realised nationwide (BAUGENEHMIGUNGEN, 2010).
A further advantage is that users can assess the effectiveness of the safety measure directly on use and test it easily.

Since 2011-07-28 “hand-supported hair dryers” have been included in the list of substantially hazardous products and may not be produced and placed on the market without the required safety measures (see Section 2.3).

4 Determining and evaluating available safety solutions (“state-of-the-art science and technology”)

4.1 Hand-held hair dryers (including with ionic technology)

Hair dryers, also known as blow dryers, are electrical appliances that are intended for drying wet hair. The main place in which they are used is the bathroom.

Hair dryers with different attachments and in different power classes from 400 Watt to 2400 Watt are available for domestic use. One particular type is the ionic blow dryer (since 2000). The generation of high voltage in the appliance generates in addition ionisation of the air flow, which prevents electrisation of the hair. The voltage generated for this purpose can be up to 5000 Volt.

The safety measures stipulated in the product standard DIN EN 60335-2-23 are effective on use for the intended purpose in dry rooms.

During the usual and foreseeable usage of the hair dryer in the bathroom there is a possibility of direct contact of the hair dryer with water because of the long power cord. This creates the considerable danger of an electric shock for the user and third persons, because water entry makes the normative safety measures ineffective.

Because at present the design of hair dryers for domestic use in protection class I is not provided for in the product standard, the protective conductor cannot be used to form an internal protective measure in the appliance.

The product standard contains only a warning with regard to the possible entry of water and its consequences. This means that the requirement of section 3 (2) German Product Safety Act that a product may
“[...] only be made available on the market if it does not endanger the safety and health of persons when used for the intended or foreseeable purpose”
is **not** taken into account for the hazard assessment.

There is an increased hazard in properties with electrical installations that are not equipped or retrofitted with an RCD.

Because of their technical design, hair dryers have a degree of protection that fulfils their safety function to a limited extent only.
Based on the German Product Safety Act and the known fatalities caused by the use of hair dryers, these are to be regarded as a potentially hazardous product.

4.2 Hair dryers with a “dead man’s button”

Hair dryers with a dead man’s button conform to hand-held hair dryers in a dry environment with regard to their electrical mode of operation and hazard. An improved protective effect in comparison with the latter is achieved in that, when the hair dryer

is used, a so-called dead man's button must be pressed that causes the appliance to be switched off when the user no longer presses the button. Its application offers improved fire protection. The risk of a fatal electric shock remains with regard to the electrical hazard, in particular on exposure to humidity or liquids.

When these hair dryers are used a slight restriction of movement is detected due to operating the dead man's button. Although these hair dryers are used in many hotels and swimming baths, they have not been able to gain acceptance for domestic use because of their handling, which takes getting used to.

4.3 Wall-mounted hair dryers with non-detachable connection

There are 3 variants that are to be evaluated differently.

Wall-mounted appliances with direct air flow (public swimming baths):
This appliance cannot come into contact with water with correct wall-mounting (sufficient clearance from water sources) and normal behaviour of users or third persons.
The appliance is safe but is not used for domestic purposes.

Wall-mounted appliances with air hose:
This appliance cannot come into contact with water either with correct wall-mounting (sufficient clearance from water sources) and correct behaviour.
The appliance is safe but is not used for domestic purposes.

Wall mounting with hair dryer (in some cases in hotels):
The power cord of these appliances is permanently connected to the building installation (no plug). Contact with water is possible, depending on the construction of the room and the length of the hair dryer's power cord. The hazards are then the same as with hand-held hair dryers.
Depending on the conditions, these appliances are not safe.

4.4 Hair dryers with protective separation as the protective measure

The protective effect in comparison with normal supply is caused by the insulating transformer, which guarantees galvanic insulation from the mains.
The protective separation is basically limited in that only one appliance may be operated per circuit. Use in the bathroom with several outlets is practically not possible with simultaneous conformity to the equipment standard (RAL-RG 678, 2011). A separate transformer would then be required in the distribution box for each circuit. With an energy requirement for hair dryers of over 2000 W and up to 3000 W for washing machines and dryers each of these transformers would have dimensions of approx. 20 cm x 20 cm x 20 cm and a mass of around 20 kg. Along with the considerable costs, this requires a distribution box of a size that would not fit into a flat or a private house.

If water is present, there are usually multiple contacts of the circuit with water, which makes the protective measure ineffective.
Use of this protective measure for high-powered appliances is not economical.

4.5 Hair dryers using protective extra low voltage

The protective effect consists of limiting the voltage to non-hazardous low values.
Because of the low voltage on the transformer's load side, given the above-mentioned energy requirement of 2000 W to 3500 W, considerably higher currents of up to 80 A would be necessary to supply the hair dryers, which leads to problems for the fuse and the required cable cross-sections. The required power cord to the hair dryer would then have a diameter of several centimetres with a high weight corresponding to the length and would no longer be operable as a mobile appliance.
Use of this protective measure is safe but not economical.

4.6 Evaluation of publications by Lauerer

There are several publications by Lauerer on the subject of increasing the safety of hair dryers from the period 1958 - 1998 and many patents, all of which have since been made public (eg LAUERER, 1972; LAUERER, 1982; LAUERER, 1990). These patents and his publications were analysed for the evaluation.

The technical solutions that he describes are based on two main ideas:

- Lowering the contact voltage at the hair dryer on exposure to water through design measures,

- Quick switching off or over of the hair dryers on exposure to water through a protective device assigned to the appliance that he developed for this purpose.

In accordance with the objectives of his inventions he assumes in principle that there is an RCD in the installation's circuit and that, in accordance with the appliance standard, there is no protective conductor in the terminal lead.

Additional variants emerge from the two basic ideas. Some solutions are not thought through consistently (eg the reduced contact voltage does not reach the values that are non-hazardous for people on exposure to water). The other solutions involve a high level of expenditure that is impossible to estimate, because the necessary water-proofness and permanent functional safety of components were not taken into consideration.
The possible success of Lauerer's proposals is theoretical, because no convincing results of experiments were submitted.

It has to be acknowledged that his solutions possibly represent an improvement of hair dryer safety on contact with water, but do not achieve the necessary protection target in every case. The current availability of RCDs with a rated differential current of ≤ 10 mA as a transportable safety appliance makes his solutions obsolete.

From the authors' professional viewpoint, his basic idea of improving the safety measures in the appliance should be pursued further.

4.7 Evaluation of publications by Biegelmeier

In the publication "Der Tod in der Badewanne" ("Death in the Bathtub") (BACHL et al., 2002) Biegelmeier analyses and describes processes during an accident with a hair dryer and the resulting approaches.

An integrated consideration of the situation is assumed in the risk analysis of the accident. The causes of the accident can lie either in the portable electrical appliance (hair dryer), in the existing electrical installation or in the user's behaviour. It is emphasised here that steps towards greater safety must be taken for all three of these causes of accidents.

The examinations showed that

- The electrical resistance in the human body in water is only approx. 50 Ohm. This means that considerably higher currents are possible on flow through the body than in a dry state, even with low contact voltages.
- The position of the plug in the outlet is an essential factor for the evaluation of the electric shock hazard.

- The protective measure "protective insulation" of the hair dryer is disadvantageous on contact with water.
- The installation of parts **inside the appliance** earthed by a **protective conductor could prevent** hazardous contact voltages occurring in the bathtub.

However, this finding remained theoretical. No experiments and results of the realisation of this finding became known.

4.8 Evaluation of publication by Baumhöfer

On 25.02.2010 BAUMHÖFER (2010) published his recommendation on the Internet at www.diesteckdose.net ("Eine unendliche Geschichte, Haartrockner in der Badewanne" ("A never-ending story, hair dryers in the bath tub")).
Using the possibility of additional mobile RCDs and a protective conductor (installation in the hair dryer) he describes his solution:
"The **third conductor** is installed as the **protective earth conductor PE**, the plug is therefore extended to three poles. The bare end of this conductor is immersed into the water. The required differential current is achieved through this measure. The circuit breaker triggers immediately!"

The required protection was improved with this solution. In the end it is a practical realisation of the approach by BACHL et al. (2002).
However, the proposed constructive design does not completely eliminate the electric shock hazard, because it is not guaranteed that the installed protective conductor is always the first to come into contact with the water.

4.9 Evaluation of publication by Friese, Lochner

Based on a solution suggested by BAUMHÖFER (2010), LOCHNER (2010), and FRIESE and LOCHNER (2010), suggested a practical solution for a hair dryer with a safety function. In this, they took up an idea from BÖDEKER that was published on the Internet forum www.diesteckdose.net and in BÖDEKER (2011). A protective shield was developed that is connected to the protective earth conductor. This surrounds all the hair dryer's conductive parts.
In addition, the hazards in the bathroom caused by the interplay of the safety measures in the hair dryer and the electrical installation were taken into consideration.
The constructive solution was tested and released in FRIESE et al. (2011).

The simulated fault (hair dryer with installed conductive protective screen that is connected to the protective conductor falls into the bathtub) did not result in an electric shock hazard if the connection was made to an earthed outlet. This statement still applies if **an RCD** is **not** installed in the bathroom circuit.

This proved that a hair dryer with safety functions can be created with simple means and uncomplicated design changes (**protective shield**, **protective earth conductor** and **earthed wall socket**).

Safety is no longer given only in the absence of an earthed wall socket or failure of the protective conductor function, which leads to the ineffectiveness of all electrical appliances in protection class I. In this case, as the current standards require, an **RCD** is necessary **as additional protection**.

5 Deriving suggestions for solutions

A hair dryer with safety functions must conform to the provisions of the Product Safety Act:
Section 3 (2)
“A product may […] only be made available on the market if it does not endanger the safety and health of persons when used for the intended or foreseeable purpose.”
and
Section 3 (2) No 4
“[…] must be taken into consideration in particular: […] the groups of users that are more endangered than other when using the product.”

A hair dryer that is made available to a consumer must meet these requirements.

Of the technical solutions currently available commercially, only hair dryers as wall-mounted appliances with direct air outflow, wall-mounted appliances with an air hose and hair dryers with protective extra low voltage meet these requirements. However, these solutions are not very practical for domestic use.

The solution for a safe hair dryer described by FRIESE et al. (2010) is based on current standard models for hair dryers (hand-held hair dryers) and fulfils both requirements of the Product Safety Act that are referenced above.

An **electrically conductive protective shield** is installed in the existing hair dryer housing. In this way, the protective measure against electric shock "double or reinforced insulation" is supplemented. In addition, the protective shield must be connected to the **protective earth conductor** that is to be made available. On contact with water, the residual current circuit is closed via the protective shield and the protective earth conductor. In this way, the contact voltage is reduced to a potential that is non-hazardous for people. Those affected can react without danger, eg remove the hair dryer from the water. An appliance with a protective earth conductor and insulated housing is created. The requirements with regard to basic protection and fault protection are satisfied.

On a failure of the protective earth conductor (eg wire break in the power cord) the protective shield’s safety function is nullified. This fault must be controlled by means of an **RCD** assigned to the appliance.

The technical solution using a protective shield-protective earth conductor fulfils the protection objective “protection against electric shock” to the full extent under the following conditions:

- a conductive protective shield must be installed within the hair dryer housing, enclose all live parts and be reliably connected to the protective earth conductor that has to be included in the power cord,
- the protective shield must be enclosed by a non-conductive housing,
- in order to be able to control the case of a “rupture of the protective earth conductor”, an RCD with a rated differential current ≤ 10 mA must be assigned to the hair dryer outside the appliance - preferably in the plug.

The design with a protective shield, a protective earth conductor and an RCD is an improved variant in comparison with US hair dryers with the ALCI or IDCI system, because the inclusion of a protective earth conductor keeps the user outside the residual current circuit. This means that in case of a fault (entry of water) the residual current is diverted inside the appliance.

The protective effect of this technical solution depends on:

- the presence/switching off of the installation's RCD,
- the bathtub being earthed,
- the user's behaviour.

This technical solution has been made public, it can be realised with simple means and satisfies the requirements of the Product Safety Act to the full extent.

The protective effect also obtains in old installations with so-called protective multiple earthing.

If the hair dryer's plug is equipped with a **miniature fuse**, the protective effect is increased further, because if a fault occurs between the electrical conductors, or an overload, the appliance is switched off faster than through a triggering of the fuse in the house's electrical installation.

As described in Section 3.6, if the combination polarised outlet/plug is used, the risk of an electric shock is reduced.
This applies not only to hand-held hair dryers, but to all mobile appliances with single-pole switch-off. For this reason, this possibility of reducing the hazard with regard to an electric shock should be put forward again for discussion.

Application of these measures would be possible if on the one hand a supplier market for this product for voluntary retrofitting is created and, on the other, the use of these polarised outlets is stipulated for new builds or renovations of bathrooms, public facilities and special types of rooms and areas.

Because there are already a large number of earthed plugs (CEE 7/4) for appliances available in Germany and they are compatible with outlets in other countries (eg France, Czech Republic), from this aspect the **installation of polarised outlets** would not be a problem.

6 Conclusions

The considerations and examinations that were carried out show that in principle the safety level of electrical appliances in Germany is high in comparison with many other countries.

Because there is still a considerable number of electrical accidents in spite of this, many of which end in a fatality, great importance must be attached to the use and development of improved appliances, the adaptation of electrical installations and to improved education of users with regard to the hazards of electricity and how to avoid them.

It is recommended that the following be checked:

- to what extent the issue of safety marks (GS) to currently available hair dryers is legally permissible under the circumstances shown,

- to what extent is a combination of measures as described in Section 5 to be permitted,

- to what extent does the legislature, in accordance with the contract between the Federal Republic of Germany and DIN Deutsches Institut für Normung e. V., require the competent bodies to adapt the product standard for hair dryers to the requirements of the Product Safety Act, where applicable at the national level first. An attempt should be made internationally as well to achieve accord with the competent bodies, because here there is a fundamental erroneous assessment of the hazard situation and hair dryers are a European commercial product.

In the experts' opinion the following problems should be clarified and dealt with by the competent bodies:

- which contact voltage is permissible with unclothed bodies in bath water so that a standard is set for the development and use of additional safety measures (such as protective shields),

- which current in mA is permissible with a person of any age in case of contact with conductive liquids and how long may this exposure last before a hazard occurs,

- to what extent the demand for switch-off times with RCDs, eg 50 ms for special types of installations and rooms in accordance with VDE 0100 Group 700, can be increased. At present, only general switch-off times for protection against electric shock of 200 ms in a TT system or 400 ms in a TN system are required in accordance with VDE 0100-410:2007-06,

- which possibly new identification of the protective measure on hair dryers is possible or necessary,

- whether RCDs with a trigger current of 30 mA that can be installed in outlets can still remain in the standard in the longer term as a possibility for retrofitting in outlets in TN-C systems without RCDs in the permanent electrical installation as a provisional solution (adaption requirements in accordance with VDE have expired: west Germany 1973, east Germany 2002),

- how the public can be educated through suitable measures about the advantages of the polarised outlet system in comparison with the present earthing contact system in Germany, so that a market in the private and industrial sector can be developed initially for special rooms,

- how the use of polarised outlets can be realised (realisation of European free trade through offer on the German market),

- whether placing on the market can be facilitated by the award of a special mark “Hair dryer with safety functions” (similar to the “Blue Angel”, for example).

Through these measures it should be possible in principle for electrical accidents with hair dryers to be a thing of the past in future. The fire hazard can be reduced in this way as well. The hair dryer as an instrument for carrying out criminal offences will then no longer exist.

In the authors’ opinion, the following measures that lead to increasing the safety of persons using hair dryers can be realised in practice at little cost:

A temporary suspension of awards of the safety mark (GS mark) for handheld hair dryers would be immediately realisable if test institutions and test organisations refrained voluntarily from issuing it if the hair dryers do not have safety measures against electrical multiple faults (in particular on contact with water or conductive liquids).

Improved information for the public on the hazards that arise when electrotechnical appliances are used near water would be immediately realisable by means of a highly visible warning sign on the power cord near the plug. This has been tried and tested in the USA for over 20 years. Some manufacturers already use this method to mark their products in Germany as well. This measure can be realised voluntarily by manufacturers in the short term at short notice without a directive.

The recommendation to have switch-off times of less than 50 ms for RCDs when triggered with a rated differential current as the permissible limit value for special types of rooms and installations would be realisable without a significant financial effect.
All that is necessary is for the appropriate testers and specialists to be informed and trained through the test organisations, the VdS or the ZVEH. The basis for this immediate realisability is formed by the residual hazards of RCDs that were looked at in the expert’s report. On the basis of this hazard assessment in accordance with the Industrial Safety and Health Regulations all inspectors must realise this suggestion immediately if they are aware of the effects, because danger is at hand.

Practical experience shows that in general with continuous testing of electrical installations approx. 80% of RCDs conform to the 50 ms switch-off time and only bathrooms are affected. For this reason, the short-term increased rate of replacement for RCDs will remain in financially acceptable limits.
What is also immediately realisable is targeted information, for example through Stiftung Warentest, the Federal Ministry of Family Affairs, Senior Citizens, Women and Youth (Bundesministerium für Familie, Senioren, Frauen und Jugend - BMFSFJ) or the Federal Ministry for Economic Affairs and Technology (Bundesministerium für Wirtschaft und Technologie - BMWi), on the use of mobile earthed adapter plugs with a rated differential current of 30 mA and mainly 10 mA in bathrooms as a provisional protective measure in domestic electrical installations without RCDs or as a supplement to an already installed RCD in the domestic electrical installation.
At the same time, this method can be used to educate the public about the regular six-monthly test of the RCDs in the electrical installation. For example, instructively methodological procedures can be used for this purpose, in order to show children the RCDs that are found in schools and to test them with the children, so that they can develop safety consciousness and thus raise their parents' awareness at home.
Directly influencing topics for instructions on safety at work in facilities with employees can also be realised immediately. The DGUV could contribute to this with its recommendations. A discussion can take place on the use of private electrical appliances at work (eg hair dryers in changing rooms) through to testing the RCD in the facility's installation, and transfer of these methods to the home.

Support for the use of polarised outlets for special types of rooms and installations would be realisable immediately as well. All this requires is a recommendation from the Federal Ministry for Economic Affairs (Bundeswirtschaftsministerium) and the Federal Ministry of the Interior (Bundesinnenministerium) to the appropriate State ministries with a message and recommendation that these outlets are prescribed and used in special types of rooms and installations as a supplement to the Building Code.
The ZVEH, the VDE or VdS can support this with regard to the stipulation of the sequence of terminals or a provisional recommendation on the terminals.

For the quick realisation of the above-mentioned recommendations and urgent measures it is necessary to organise cooperation between ministries, public-law institutions and other, including private, organisations. Because of the complexity of the approaches for solutions for increasing electrical safety Federal and State Ministries that are responsible for the following areas should be included:

- Labour and social affairs,
- Economics and technology,
- Building,
- Health,
- Consumer protection,
- Family affairs, senior citizens, women and youth,
- Education and research

as well as private organisations and foundations such as

- Stiftung Warentest,
- VDE - Verband der Elektrotechnik Elektronik Informationstechnik e.V.
- DIN - Deutsches Institut für Normung e.V.
- DKE - Deutsche Kommission Elektrotechnik Elektronik Informationstechnik im DIN und VDE,
- DGUV - Deutsche Gesetzliche Unfallversicherung
- Test organisations such as, for example, TÜV, LGA, KEMA, DEKRA, TOSS,
- ZVEH - Zentralverband der Deutschen Elektro- und Informationstechnischen Handwerke and the associated electrical guilds,
- ZVEI - Zentralverband Elektrotechnik- und Elektronikindustrie e.V. with the affected manufacturers of hair dryers, outlets and RCDs
- GDV - Gesamtverband der Deutschen Versicherungswirtschaft with VdS Schadenverhütung GmbH and in particular the electrical experts they certify.

List of abbreviations

CPSC Consumer Product Safety Commission
US consumer protection organisation

CE CE mark (formerly EC mark = European conformity mark)
The manufacturer/marketer declares independently that the safety requirements of the EU are fulfilled.

DGUV Deutsche Gesetzliche Unfallversicherung
(German statutory accident insurance scheme)

DIN Deutsches Institut für Normung
Issues and publishes standards as a voluntary obligation

DKE Deutsche Kommission Elektrotechnik Elektronik Informationstechnik im DIN und VDE
German Commission for Electrical Engineering, Electronics and Information Technology in DIN and VDE

Eurostat Statistical Office of the European Communities (head office: Luxembourg)

GBE Health reporting (Germany)

GFCI Ground Fault Circuit Interrupter
US designation for residual current operated device

GS “Tested Safety”
Test mark awarded by a recognised testing agency

HES Main earthing rail
Central terminal point of the equipotential bonding

ICD International classification for the uniform representation of data in a database

IP International Protection (DIN EN 60529; VDE 0470-1)
Protection type that indicates the systematic classification of housings, eg IP 20
(1st digit: degree of protection against contact and solid foreign bodies)
(2nd digit: degree of protection against water)

NFPA National Fire Protection Association (USA)

OECD Organisation for Economic Cooperation and Development

OSHA Occupational Safety and Health Administration (USA)

PA Equipotential bonding

RCD Residual current operated device

SK Protection class (DIN EN 61140; VDE 0140-1)
Classifies electrical appliances in accordance with safety measures in 4 classes (SK 0; SK I; SK II; SK III)

UL Underwriters Laboratories
Independent US organisation for testing and certifying products

VDE Verband der Elektrotechnik Elektronik Informationstechnik e.V.
Electrical Engineering Electronics Information Technology Association

VdS Verband der Sachversicherer (Germany)
Association of Property Insurers

WHO World Health Organisation

ZVEH Zentralverband der Deutschen Elektro- und Informationstechnischen Handwerke mit den angeschlossenen Elektroinnungen
Central Association of German Electrical and Information Technology Craft Trades with the associated electrical guilds

ZVEI Zentralverband Elektrotechnik- und Elektronikindustrie e.V.
Central Association of the Electrical Engineering and Electronics Industry

List of references

Altmann, S.; Jühling, J.; Kieback, K.; Zürneck, H.: Elektrounfalle in Deutschland. Schriftenreihe der Bundesanstalt für Arbeitsschutz und Arbeitsmedizin – Forschung Fb 941 Dortmund/Berlin 2002

Altmann, S.: Sicherheits und Unfallforschung - Teil 1: Erfassung und Analyse ausgewählter Elektrounfälle in der ehemaligen DDR und den neuen Bundesländern; Deutsche Telekom; Hochschule für Telekommunikation, Leipzig, own publications 1963 - 2005

Bachl, H.; Biegelmeier, G.; Taubenkorb, F.: Der Tod in der Badewanne (1). Ereignisanalysen von Stromunfällen und neue Denkansätze, de 23 (2002), 39-42

Bachl, H.; Biegelmeier, G.; Taubenkorb, F.: Der Tod in der Badewanne (2). Ereignisanalysen von Stromunfällen und neue Denkansätze, de 24 (2002), 51-53

Baumhöfer, K.: Überleben trotz Föhn in der Badewanne. 17.03.2010. FH Dortmund, http://www.fh-dortmund.de/de/studi/fb/3/personen/ehem/baumhoefer/lehre/foen.php

Baugenehmigungen und -Fertigstellungen neu errichteter Wohnungen in Deutschland, source: Statisitisches Bundesamt, BFW-Research 2010

Bockhold, B.; Schneider, V.: Death by electrocution on bathtub. **БИОМЕДИЦИНСКИЙ ЖУРНАЛ Medline.ru.** ТОМ 4, СТ. X (сс. X) // Апрель, 2003; http://www.medline.ru/public/sudm/a2/art3-2-2.phtml

Bödeker, K.: "Sicherer Haartrockner - auch in der Badwanne"; Elektropraktiker 6/2011; p. 482 ff.

Bonte, W.; Sprung, R.; Huckenbeck, W.: Probleme bei der Beurteilung von Stromtodesfällen in der Badewanne, Z Rechtsmedizin 97 (1986), 7-19

Decreto del Presidente della Repubblica n° 447 del 06/12/1991: Regolamento di attuazione della legge 5 marzo 1990, n. 46, in materia di sicurezza degli impianti), Gazzetta Ufficiale Italiana n° 38 del 15/02/1992;
http://www.provincia.fe.it/calore_pulito/Normativa/DPRn.447del6Dicembre1991.pdf

Decreto 22 gennaio 2008, n. 37: Regolamento concernente l'attuazione dell'articolo 11-quaterdecies, comma 13, lettera a della Legge n. 248, del 2 dicembre 2005, recante riordino delle disposizioni in materia di attività di installazione degli impianti all'interno degli edifici., Gazzetta Ufficiale Italiana n° 61 del 12-3-2008);
http://gazzette.comune.jesi.an.it/2008/61/1.htm

DIN EN 60335-1; **VDE 0700-1**:2012-10: Household and similar electrical appliances - Safety - Part 1: General requirements (IEC 60335-1:2010, modified); German version EN 60335-1:2012

DIN EN 60335-2-23; **VDE 0700-23**:2011-04: Household and similar electrical appliances - Safety - Part 2-23: Particular requirements for appliances for skin and hair care (IEC 60335-2-23:2003 + Cor. 1:2004 + Cor. 2:2008 + A1:2008 + Cor. 3:2007); German version EN 60335-2-23:2003 + A1:2008 + A11:2010

DIN EN 61008-2-1; **VDE 0664-11**:1999-12: Residual current operated circuit-breakers without integral overcurrent protection for household and similar uses (RCCB's) - Part 2-1: Applicability of the general rules to RCCB's functionally independent of line voltage (IEC 61008-2-1:1990); German version EN 61008-2-1:1994 + A11:1998 + Corrigendum March 1999

DIN EN 61140; **VDE 0140-1**:2007-03: Protection against electric shock - Common aspects for installation and equipment (IEC 61140:2001 + A1:2004, modified); German version EN 61140:2002 + A1:2006

DIN VDE 0100-410; **VDE 0100-410**:2007-06: Low-voltage electrical installations - Part 4-41: Protection for safety - Protection against electric shock (IEC 60364-4-41:2005, modified); German implementation HD 60364-4-41:2007

DIN VDE 0100-701; **VDE 0100-701**:2008-10: Low-voltage electrical installations - Part 7-701: Requirements for special installations or locations - Locations containing a bath or shower (IEC 60364-7-701:2006, modified); German implementation HD 60364-7-701:2007

EUR/RC55/10 +EUR/RC55/Conf.Doc/6: 55. Tagung des WHO Regionalkomitees für Europa, Bukarest, Rumänien, 12.–15. September 2005
http://www.euro.who.int/__data/assets/pdf_file/0008/87893/RC55_gdoc10.pdf

Friese, A.; Lochner, C.: Untersuchungsergebnisse für einen Sicheren Föhn. Elektropraktiker 11(2010), 932 -937

Hand-Supported Hair Dryers 2011; CONSUMER PRODUCT SAFETY COMMISSION; Federal Register Volume 76, Number 124 (Tuesday, June 28, 2011); Rules and Regulations; Pages 37636-37641; From the Federal Register Online via the Government Printing Office; www.gpo.gov; FR Doc No: 2011-15981
http://www.gpo.gov/fdsys/pkg/FR-2011-06-28/html/2011-15981.htm

HD 60364-7-701; VDE 0100-701:2007 Errichten von Niederspannungsanlagen - Teil 7-701: Anforderungen für Betriebsstätten, Räume und Anlagen besonderer Art - Räume mit Badewanne oder Dusche (IEC 60364-7-701:2006, modified)

INTERNET SURVEY 2011;
http://www.baua.de/de/Geraete-und-Produktsicherheit/Produktgruppen/Elektrische-Produkte/Umfrage/Umfrage.html (retrieval on 24 February 2014)

Lauerer, F.: Unfallverhütung bei Stromverbraucheranlagen durch empfindliche Fehlerstromschutzschalter, Forschungsbericht F 78, Dortmund 1972, Bundesanstalt für Arbeitsschutz und Unfallforschung, Außenstelle Koblenz

Lauerer, F.: Gibt es einen technischen Schutz gegen den Stromtod in der Badewanne; de, 5 (1982), p. 261 ff

Lauerer, F.: 8033 Krailling, Patent, Titel: Schutzschaltung für schutzisolierte Geräte. Dokumentenidentifikation DE3839048A1 31.05.1990

LEGGE 5 marzo 1990, n.46: Norme per la sicurezza degli impianti, Gazzetta Ufficiale n.59 del 12 marzo 1990
http://www.sicurezzaedile.it/legge_46_90.htm

Lochner, C.: Mehr Sicherheit in der Badewanne. Elektropraktiker 7(2010), 604-605

Maccapanni, L.: La sicurezza negli impianti elettriciti; elettrificazione 9 (1997), p. 72

Memorandum CPSC: Butturini, R.; Howell, R. J.: Substantial Product Hazards Posed by Hand-held Hair Dryers Without Immersion Protection; United States CONSUMER PRODUCT SAFETY COMMISSION; MARYLAND 20814; 2010
http://www.cpsc.gov/library/foia/foia11/brief/periodic.pdf

Pointer, S.; Harrison, J.: Electrical injury and death AIHW National Injury Surveillance Unit, Research Centre for Injury Studies, Flinders University, South Australia; April 2007
http://www.nisu.flinders.edu.au/pubs/reports/2007/injcat99.pdf

ProdSG-Gesetz über Bereitstellung von Produkten auf dem Markt (Produktsicherheitsgesetz - ProdSG) vom 08.11.2011; Bundesgesetzblatt Jahrgang 2011, Teil I, Nr. 57, published in Bonn on 11 November 2011

1.ProdSV- Erste Verordnung zum Produktsicherheitsgesetz (Verordnung über die Bereitstellung elektrischer Betriebsmittel zur Verwendung innerhalb bestimmter Spannungsgrenzen auf dem Markt) vom 11. Juni 1979 (BGBl. I S. 629), die zuletzt durch Artikel 15 des Gesetzes vom 8. November 2011 (BGBl. I S. 2178) geändert worden ist

RAL-**RG 678** Ausstattungsrichtlinie Wohngebäuden; 2011; HEA – Fachgemeinschaft für effiziente Energieanwendung e. V.;
http://www.hea.de/download-extern/hea-ral-678.pdf

Stiftung Warentest: Billigföhn brennt im Test, Test 2009, Heft 10

Tribius, H.: Grenzen der Wirksamkeit von FI-Schutzschaltern. Elektropraktiker 6 (2011), 485-486