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BURNING CHARACTERISTICS OF ELECTRICAL EQUIPMENT AND EXTINGUISHING FIRES CAUSED BY ELECTRICAL EQUIPMENT

Summary of an experimental study

TUKES
SAFETY TECHNOLOGY AUTHORITY

BACKGROUND

The project was carried out as part of the research programme on fire safety in connection with electricity that the Safety Technology Authority (TUKES) started in 1996. The aim of the project was to acquire new information on what to do if electrical equipment catches fire. The project was financed by, in addition to the Safety Technology Authority, the Fire Protection Fund and the Federation of Finnish Insurance Companies.

The study consisted of three parts: 1) literature research, 2) burning experiments and 3) extinguishing tests. The literature research and the burning tests were carried out at the laboratory of VTT Building Technology / Fire Technology in Espoo. The reports of these results were completed by Mr. Jukka Hietaniemi, a special researcher, Mr. Johan Mangs, a special researcher, and by Ms. Tuula Hakkarainen, a researcher. The extinguishing tests were carried out in the practice area of the Emergency Services College in Kuopio. The responsible people for the reports of the extinguishing tests and for the planning and conclusions of the entire research project are Mr. Veli-Pekka Nurmi, the project director, Mr. Veli-Matti Sääskilahti, a safety engineer, and Mr. Mikko Törmänen, a safety engineer, all from TUKES.

The control group of the project includes Mr. Veli-Pekka Nurmi, Mr. Veli-Matti Sääskilahti and Mr. Mikko Törmänen from the Safety Technology Authority, Mr. Jukka Hietaniemi from the Technical Research Centre of Finland (VTT) and Mr. Jari Pouta, fire inspector from the Rescue Services Sector of Vantaa, Mr. Seppo Pekurinen, manager loss prevention from the Federation of Finnish Insurance Companies, Mr. Timo Loponen, a teacher from the Emergency Services College and Mr. Kai Sjöholm, a forensic scientist from the National Bureau of Investigation.

TESTS

The study consisted of a total of 14 burning test and 11 extinguishing tests with television sets, dish washers, washing machines and fridge freezers. The burning tests were completed in Espoo, at the testing hall of VTT Building Technology / Fire Technology between the 10th and the 19th of April 2000. The extinguishing tests were completed in the training area of the Emergency Services College in Kuopio between the 12th and the 14th of June 2000.

All washing machines and some of the television sets, dish washers and refrigeration equipment were burnt in an open place on an incombustible base. In some of the tests, the dish washers and refrigeration equipment had been placed inside a cupboard and the television sets on a bookshelf, so as to make the situation similar to a conventional usage situation. The cupboards were made of melamine-coated chipboard. When burnt, the equipment was not connected to the electricity supply. The washing machines, dish washers and refrigeration equipment were empty during the test.

Picture 1. The ignition flame

In the burning tests, the equipment was ignited with a 100 mm propane gas burner, touching the point to be ignited with its 70-100 mm high flame (picture 1). In the extinguishing tests, the equipment was ignited with a corresponding liquid gas burner. The typical power output of the burner was about 1 kW. The equipment was set on fire with a flame, because the purpose of the tests was to investigate how the fire in electrical equipment progresses after a fault in equipment has gone far enough to cause a fire. Different fault mechanisms and smouldering connected to them were not examined.

In the extinguishing tests, first-aid extinguishing with a smothering blanket, with a kettle of water and with a 6 kg dry powder extinguisher were examined. The intention was to cover the ignited device with the smothering blanket as tightly as possible. The extinguishing attempt with water or with a dry powder extinguisher was repeated a few times, depending on the extinguishing result. When extinguishing with dry powder, either part or all of the extinguishing material was used at one time. The last resort in the extinguishing tests was to extinguish the fire with a blast from the high pressure hose of an emergency tender, if the earlier methods of initial extinguishing did not lead to any results.

RESULTS

Among the examined electrical equipment, the refrigerating equipment produced the highest burning rate. Their highest burning rates were as high as 2000 kW, which is a very high burning rate in a room the size of a typical kitchen. The burning rate achieved by dish washers was also quite high, 350-750 kW. The burning rate of washing machines was a little lower than that of dish washers (maximum burning rates 300-450 kW). Compared to small bathrooms, where fires caused by washing machines mostly occur, the burning rate is still very high. The burning rates of television sets reached a maximum of 250-300 kW. Refrigerating equipment includes relatively high amounts of polyurethane as insulation, as well as plastic surfaces and compartments which caused the clearly highest burning rates in the test series.

For all devices, a clear delay was found from ignition until the moment when the device started burning strongly. A typical delay for washing machines was 10-20 minutes, depending on the ignition method. For dish washers and washing machines, the delay was about 5-10 minutes. For television sets, the delay was usually only about 1.5 minutes.

Smoke formation per burnt mass unit was strongest for television sets: approximately 120 g of smoke for one kilogram of burnt material. Smoke formation levels were approximately as high as those measured for both refrigeration equipment burnt in an open place and in a cupboard: about 40-50 g/kg. For dish washers, the smoke formation varied depending on the burning method used: nearly 40 g/kg for devices burnt in an open place, and about 20 g/kg for devices burnt in a cupboard. This is probably a result of the fact that the proportion of cupboard material producing a relatively small amount of smoke was more significant in the tests of dish washers than in those of refrigeration equipment. Of the electrical equipment burnt in an open place, washing machines produced the smallest amount of smoke: about 20 g/

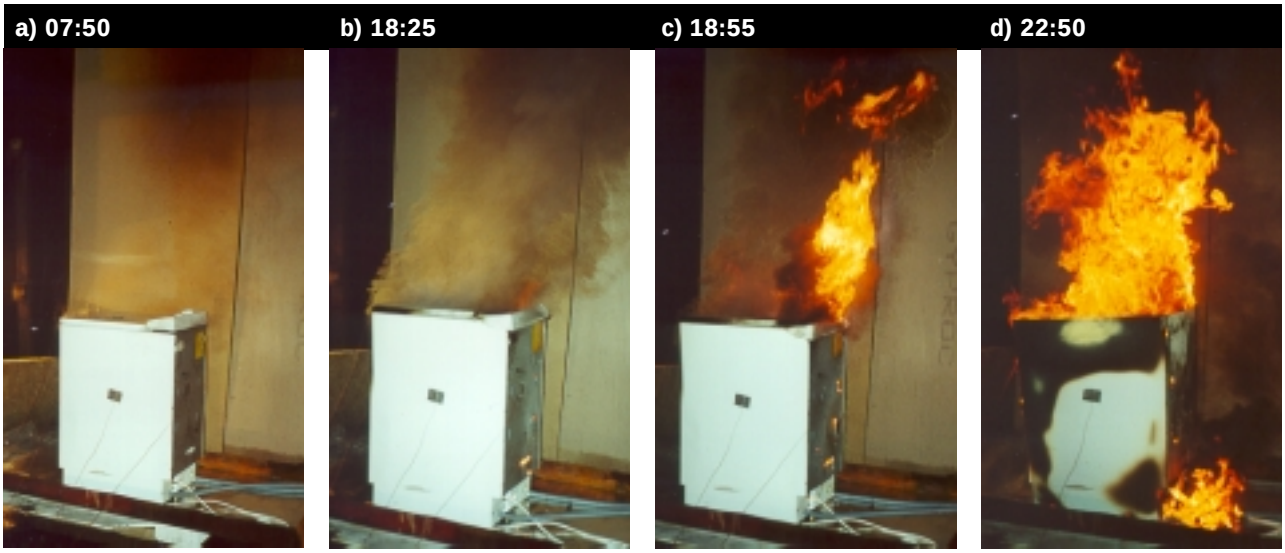
kg. When the speed of smoke production is considered (g/s), refrigeration equipment produced clearly the largest amount of smoke, 2-6 g per second when the equipment was burnt with their maximum burning rate.

When burning, the electrical equipment produced the following amounts of carbon monoxide: television sets 1 g/s, washing machines 0,4 g/s, dish washers in an open place 0.7 g/s and in a cupboard 0.9 g/s, and refrigerating equipment in an open place 5 g/s and in a cupboard 3.5 g/s. If expressed as amounts per burnt mass unit, the CO production levels were: television sets 70 g/kg, washing machines 40 g/kg, dish washers in an open place 70 g/kg and in a cupboard 50 g/kg and refrigeration equipment 50 g/kg both in an open place and in a cupboard. The differences in CO production are mainly due to differences in the ways the devices burn, not e.g. to differences of the materials with regard to CO production.

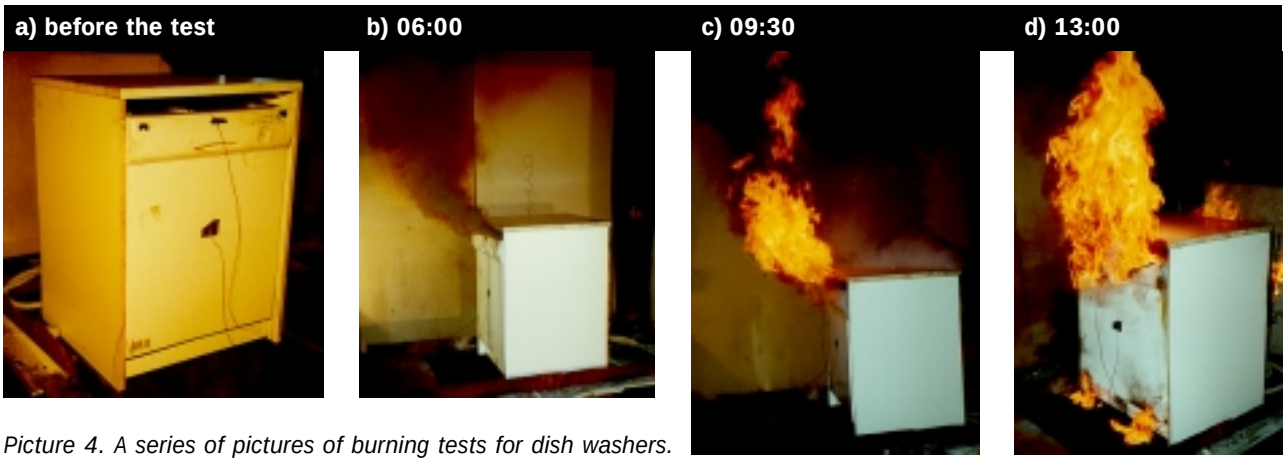
The carbon dioxide production levels, 2.3-2.8 kg/kg for devices burnt in an open place, corresponds to typical values of plastic materials (e.g. polystyrene Y_{CO2} = 2.33 kg/kg and polypropylene 2.79 kg/kg).

PHOTOGRAPHS

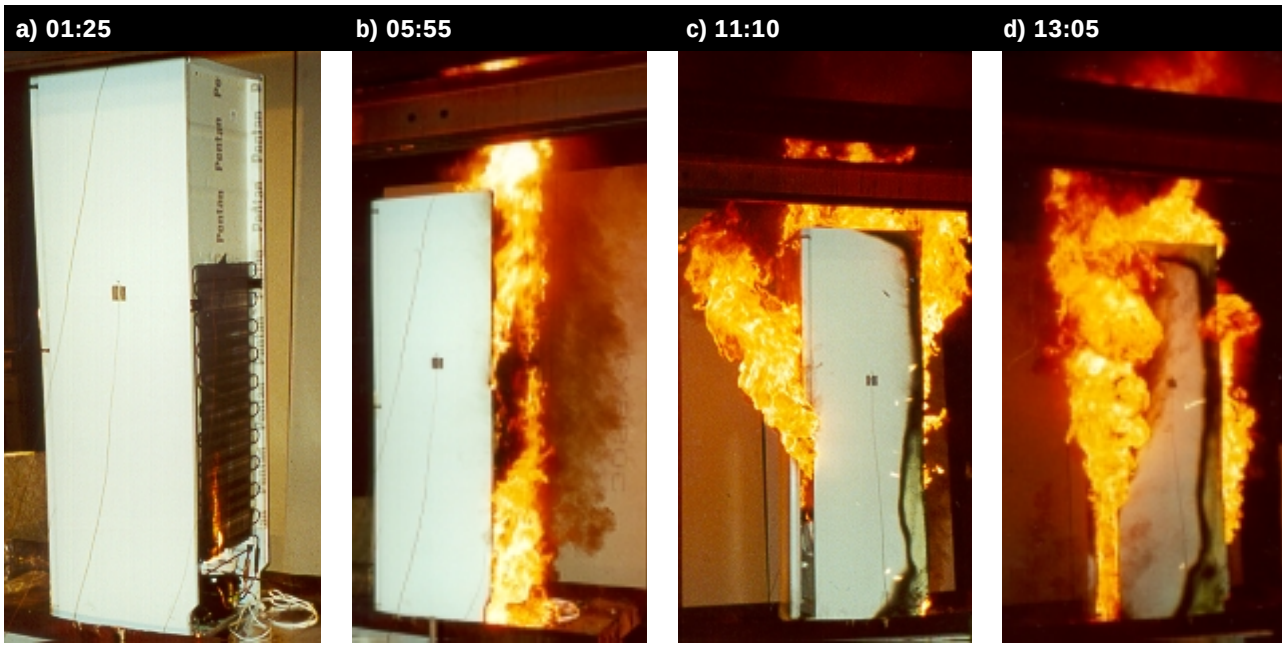
Picture 2. A series of pictures of burning tests for television sets.



Picture 3. A series of pictures of burning tests for washing machines.



Picture 4. A series of pictures of burning tests for dish washers.



Picture 5. A series of pictures for fridge freezers.

CONCLUSIONS

Refrigerating equipment, washing machines (for both dishes and laundry) and television sets burn with a high efficiency, in relation to a typical room size and to the combustible materials included in them, and produce large amounts of dangerous smoke. In most cases, a fire develops very quickly, in particular if compared to the targets for fire brigade operational readiness time and to the actual operational readiness times. The combustible element of electrical equipment consists mainly of the plastic materials included in such equipment.

As for fires caused by television sets, a typical time for efficient initial extinguishing after the fire ignition is approximately one minute. In fires caused by washing machines and refrigeration equipment, initial extinguishing may be successful if it is started in clearly less than ten minutes after the fire first takes hold. In a home environment, a smoke detector is usually the only tool that facilitates the recognition of a fire at an early stage.

The very first measure in fires, caused by electrical equipment, is to disconnect the equipment on fire from the electricity supply. This can even put out a fire in its early stages. If a fire, caused by electrical equipment, is noticed at an early stage of the fire, initial extinguishing measures are worth trying, but personal safety should not be endangered. In particular, the smoke produced by the fire may cause serious consequences for a wild and unskilled extinguisher. If the fire is recognised a little later, one should concentrate on saving other people and oneself.

If the fire has reached the surrounding structures and other materials, or if there is smoke at head height, the fire has reached such a stage that extinguishing measures are unlikely to be successful, so that one should concentrate on saving oneself, restricting the fire and calling the fire brigade.

By using a smothering blanket, more time can be bought for saving oneself and others, for calling for help, and for more efficient first-aid extinguishing. In the extinguishing tests, water turned out efficient in the extinguishing of electrical devices at the early stage of a fire. Even a small amount of water (less than 2 litres) produced good results, as long as one could throw the water straight to the seat of the fire. Before using water, one must not forget to disconnect the device from the electricity outlet, in order to avoid an electric shock.

The best tool for first-aid extinguishing is a portable fire extinguisher. Particularly in fires that have developed beyond the initial stage it is the only tool that makes it possible to put out the fire. During a fire, surfaces get hot and easily catch fire again after the extinguishing. So as to put out the fire entirely, there should be enough extinguishing material for several extinguishing attempts. Therefore, the extinguisher should be big enough, for example, an at least 6 kg dry powder extinguisher.

In the operative task, fire brigades should take into account the high burning rate of electrical devices, and refrigerating equipment in particular, sufficient to cause a general conflagration in a room.

Because the violent nature of the fires surprised even the experts during the tests, accurate information on this matter is necessary, in order to make people aware of the dangers and able to prepare themselves for the dangerous situations. To reduce the risk of fires, connected to electrical devices, it is important to use and maintain the devices according to their operation instructions. The manufacturers and sellers of devices should ensure that devices always have clear operation instructions.

Rescue plans to prepare for accidents are not only recommended for business premises, but also for the home environment. When completing the plans, it should be taken into account that electrical devices may catch fire, and it should be worked out how electrical devices, when necessary, are quickly disconnected from the electricity supply. At home, children should also be advised about the correct use of electrical equipment and about the operating methods in hazardous situations. Learning to act correctly and to use first-aid extinguishing tools is important, in order to improve fire safety.

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