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COST TU0904

Integrated Fire Engineering and Response

Fire Brigade Reports and Investigations

February 2013

COST- the acronym for European **CO**operation in the field of **S**cientific and **T**echnical Research- is the oldest and widest European intergovernmental network for cooperation in research. Established by the Ministerial Conference in November 1971, COST is presently used by the scientific communities of 35 European countries to cooperate in common research projects supported by national funds.

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PREFACE

Issues concerning safety, including Fire safety, are nationally managed in the European Union, and legal requirements are determined by the specific experiences of each country. While the political motivation for this approach is obvious, and local circumstances vary between countries, this can easily lead to similar processes having to be re-researched and re-invented country-by-country.

In the context of the European Union as a whole, fire safety requirements are based on EU Regulation No 305/2011 [1]. This document of The European Parliament and Council lays down harmonised conditions for the marketing of construction products as an essential requirement for construction works. In Annex I of this Directive, the essential requirements for structural resistance and stability, and for fire safety, are summarised. The construction works must be designed and built in such a way that, in the event of the outbreak of fire:

- The load-bearing capacity of the construction can be assumed for a specific period of time – although this is based on the assumption of a standardised fire time-temperature curve;
- The generation and spread of fire and smoke within the works are limited;
- The spread of the fire to neighbouring construction works is limited;
- Occupants can leave the works or be rescued by other means;
- The safety of rescue teams is taken into consideration.

The load-bearing capacity of the construction may be modelled on the basis of the principles summarised in the parts of the structural Eurocodes which deal with fire. With the introduction of common standards in areas related to fire safety, it seems obvious that in such an important area the sharing of experience and research should be facilitated, and hence the need for networks such as COST TU0904. However, the need for integration has a further dimension. Fire engineering researchers tend to specialise in areas such as fire dynamics, structural fire engineering, active/passive fire protection, environmental protection or human response. Since the background sciences of these disciplines differ there is little interaction between them. Practitioners, including fire engineers, building/fire control authorities, and fire-fighters tend to consider fire safety as a whole, but lack in-depth awareness of recent advances in research and are outside the academic research networks. By encouraging exchange of information on different aspects of fire engineering and response between researchers in different countries, this network intends to create an awareness of the current state of the art, and to avoid repetition of research. The benefit to the non-research community derives from its exposure to advanced research findings, discussion with researchers, and the sharing of best practice. The input from this community makes researchers aware of real-world constraints, and reveals where new research and standards are needed.

The Action divides its membership loosely into three themed Working Groups, although clearly its overall mission of promoting integration means that these groups interact on many key activities. The Working Groups are:

- WG1 Fire Behaviour and Life Safety focuses on the behaviour and effects of fire in buildings, combining this research-based knowledge with the most effective means of protecting human life against the occurrence of fire in the built environment. This includes active measures in fire-fighting with the effects of building form on the inherent risk to inhabitants.
- WG2 Structural safety covers the response of different building types to fires and the rapidly developing research field of structural fire engineering, including new materials and technologies and passive protection measures. Crucial problems of structural fire engineering concern change of use of buildings and the current imperatives of sustainability, energy saving and protection of the environment after fire.
- WG3 Integrated Design brings together design, practice and research across the disciplines of fire in the built environment. In structural design this includes integration of fire resistance with all the other functional requirements of a building, from concept onwards, rather than simply adding fire protection after all other processes are complete. Active input from practitioners, regulators and fire-fighters through this group is vital to the success of the Action.

The Action started in March 2010, and now has 22 nations of the EU participating, as well as researchers from New Zealand. Its first deliverable, the State of the Art Report [2] attempted to bring together the current state of research, mainly in the participating countries but set into the context of knowledge world-wide. The second deliverable, emanating from the Action Conference in Prague in 29 April 2011, allowed all experts in the Action, as well as international researchers in general, to present current research findings in the Conference Proceedings [3]. The third deliverable, a compilation of Case Studies [4] presented current advanced design practice and accumulated knowledge in fire engineering. These included, within the fire engineering applications, explanations of the decision processes, the scientific assumptions and the practical constraints, as well as integration of the different aspects of fire engineering.

This current deliverable, on Fire Brigade Reports and Investigations, consists of a set of contributions from members of Action relating to the organisation of national fire and rescue provision in different EU countries; available statistical data and recommendations for questions to be included in standardised fire fighters' reports to improve the comparability of national statistics, and to lessons to be learned from specific disasters.

František Wald and Ian Burgess

21 Feb 2013

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[2] *Integrated Fire Engineering and Response - State of the Art Report*, Czech Technical University in Prague, Česká technika, 2011, 239 pp., ISBN 978-80-01-04598-5, for download at fire.fsv.cvut.cz/ifer.

[3] *Applications of Structural Fire Engineering*, Czech Technical University in Prague, Česká technika, 2011, 465 pp., ISBN – 978-80-01-04798-9, for download at fire.fsv.cvut.cz/ASFE.

[4] *Integrated Fire Engineering and Response – Case Studies*, Czech Technical University in Prague, Česká technika, 2012, 374 pp., ISBN 978-80-01-05004-0, for download at fire.fsv.cvut.cz/ifer.

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1 FIRE STATISTICS IN EUROPE – AN OVERVIEW AND PRACTICAL DIRECTIONS

Summary

Fire brigades reports and investigations can be useful for many fire safety related "actors" (i.e. construction engineers, scientists, insurance companies etc.). One of the most important and desirable item for many analytical and research purposes is fire statistics. It significantly helps in finding solutions to current problems and in identifying as well as declaring trends related to fire safety. Fire statistics constitutes also important factor in fire risk assessment. But is it available in all European countries? Is it reliable and comparable? Where fire statistical data can be found? What limitations and traps can be met in using it? A paper covers answers for listed above questions and also explains many other practical topics concerning fire statistics in Europe.

1.1 INTRODUCTION

Civilisation development is not neutral for fire safety. Fires still present a real problem. Fire protection is getting more and more complicated area. The costs of fires and other emergencies are enormous throughout the world (each 3 seconds fire breaks out somewhere, each hour 8 people die by fire and dozen get injured, each year „fire costs" amount to 1% of the GNP of global economy).

Reduction of number and consequences of fires is a very important task for all the society. Fire brigades play a crucial role in these "battle". But a real success is possible only when fire brigades cooperate with the whole community. Considerable longer-term benefits in this area could derive from the spirit of cooperation among academia, civil authorities, fire fighters and industry.

Fire brigades around the world produce many reports and investigations, which play significant role, especially in prevention of fires and accidents. These reports and investigations can be useful for many fire safety related actors (construction engineers, fire engineering researchers, insurance companies etc.), as important sources of information, which are at present largely unavailable to them. One of the most vital and desirable item for many practical and research purposes is fire statistics. But before utilizing fire statistics it is necessary to overcome a few barriers and to realize some limitations. At the beginning one should answer following questions:

- Where fire statistics can be found?
- Is fire statistics available in all European Union countries?
- Is it reliable and comparable?

- What limitations and traps can be met in using it?

1.2 PROFILE OF FIRE STATISTICS

Statistics of fire safety, popularly called “fire statistics” comprises data and analyses of different aspects of fire protection (statistics of: fires, fire losses, fire prevention activities, fire equipment and training, economical aspects of fires and many others) and in most countries is collected first of all by fire brigades. Most of this information are useful mainly or only for fire brigades purposes. But beyond a doubt other groups involved in fire protection domain can extract a lot of useful information from records of fire brigades.

Statistics and facts around fires are essential for many professional groups and institutions for different purposes. A few examples were graphically presented in Fig. 1.1.

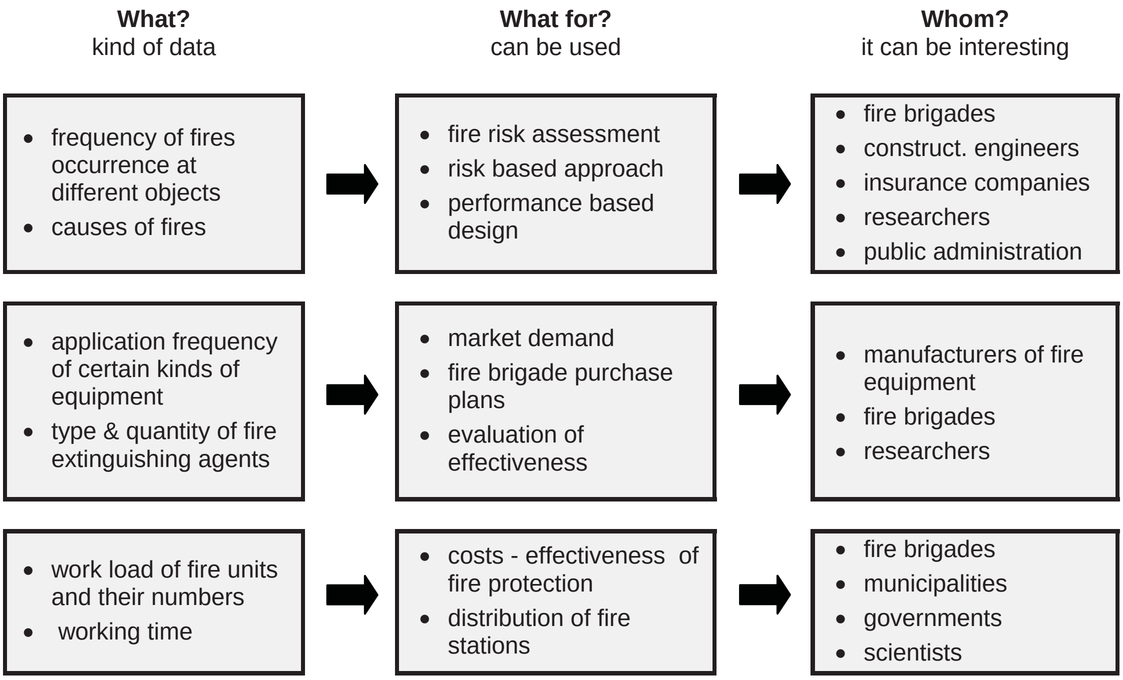

Fig. 1.1 Examples of fire statistics use

Methodological analysis of fire statistics allows to identify and declare trends in many aspects of fire protection. It is also essential item for fire risk assessment. Fire statistics is a tool which can be useful, helpful but in some cases also dangerous. Good and reliable fire statistics may by helpful in solving many problems faced by fire protection. It can be useful while negotiations and lobbing campaigns. However, this lobbing for the matter of fire and disaster protection requires, as every representations of interests the availability of means of argumentation, especially data (instead of emotions). These statistics have often proved of use during national reviews of various aspects of fire-related expenditures or organisation as well as change of law or fire standards. Statements supported by statistics are more appealing and are commonly believed. But fire statistics, same like other groups of data, is a double-edge “weapon”. In some cases it can be also dangerous, as a perfect tool for manipulation.

1.3 COLLECTION OF FIRE STATISTICS

Although tasks of fire brigades (fire & rescue services) in European countries are generally the same, three different models of their organisation are present in Europe:

- municipal (e.g. Austria, Denmark, Spain)
- regional (e.g. Finland, The Netherlands)
- state (e.g. Czech Republic, Poland, Italy, Lithuania, Hungary).

Organisational model of fire brigade is not meaningless for collection of fire statistics. In countries where fire brigade is organised on municipal level only, fire statists collection often “ends” in this point (although in many countries with municipal model of fire brigade, good and reliable fire statistic are available). When fire brigade is regional, municipal’s statistical data are summarised on regional level. If professional fire brigades operate on a state level, full national fire statistics are practically guaranteed. International fire statistics are assembled by summarising national data.

Currently in Europe fire statistics are collected on a following levels: local/municipal, regional, national and international.

1.4 WHERE FIRE STATISTICS CAN BE FOUND?

1.4.1 At the national level

Looking for fire statistics at the national level, first steps should be directed into fire brigade (fire & rescue service). Range of available data depends to a large degree on organisational model of fire & rescue service (see chapter 1.3). Practically good fire statistics is always available where professional fire brigades operate (e.g. big cities).

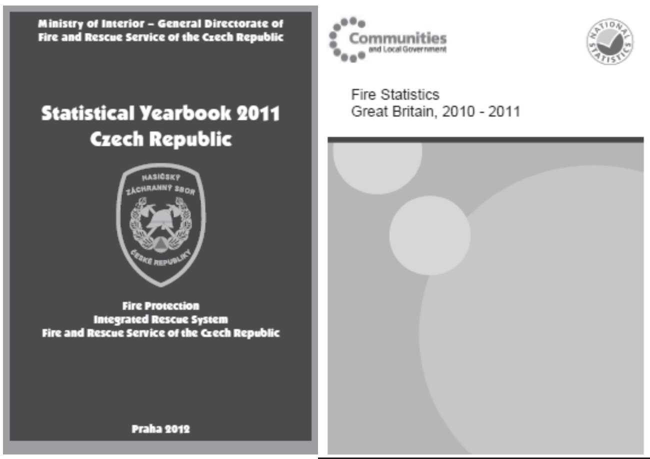

Fig. 1.2 Examples of fire statistics national reports in chosen EU countries

Good address for finding fire statistics at national level can be fire protection related associations, e.g. Irish Chief Fire Officers Association, German Fire Protection Association, The Danish Association of Fire Chiefs etc. A list of main national fire protection associations acting in EU countries is available on: http://www.f-e-u.org/associations.php. These associations are especially important where other than state model of fire & rescue service works.

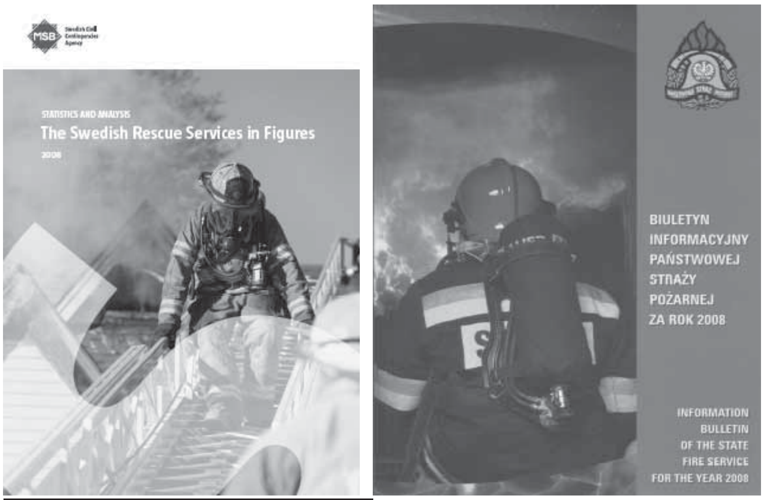

Fig. 1.3 Examples of fire statistics national reports in chosen EU countries

More and more often fire statistics are available on webpages, e.g.:

- in Czech Republic - http://www.hzscr.cz/hasicien/article/statistical-yearbooks.aspx
- in Poland - http://www.straz.gov.pl/page/index.php?str=2743
- in Sweden - https://www.msb.se/RibData/Filer/pdf/25586.pdf
- in UK - http://www.communities.gov.uk/fire/researchandstatistics/firestatistics/firestatisticsuk

Some basic fire statistical data are also available in national statistical offices. A list of national statistical offices in EU member states is available on Eurostat webpage: http://epp.eurostat.ec.europa.eu/portal/page/portal/links/national_statistical_offices .

Finally it should not be forgotten that today nearly everything can be "googled" (find in the internet).

1.4.2 At the international level

At the international level the assembly of fire statistics is mainly carried out by the World Fire Statistics Centre (WFSC) and by the Centre of Fire Statistics (CFS) of the International Association of Fire and Rescue Services (CTIF).

The WFSC was established in 1981. It is acreditated to the UN and affiliated to Geneva Association (international insurance think tank for strategically important insurance and risk management issues). The WFSC analyses the cost of fires, i.e. direct and indirect public losses as a result of fire and all types of fire fighting as well as fire loss prevention and mitigation expenditures. Each year the Centre collects and collates fire cost statistics under seven main headings from a steadily increasing number of leading countries worldwide, mainly from Europe but also including USA, Japan and Canada. The WFSC publishes an annual Information Bulletin, which is available on webpages: www.wfsc.info and www.genevaassociation.org (subscription of the Bulletins is possible). Each annual Bulletin is sent worldwide to relevant government departments, fire protection associations, fire brigades, insurance companies, fire engineers, the trade press and academic fire experts. These statistics have often proved of use during national reviews of various aspects of fire-related expenditure or organisation (e.g. the Audit Commission review of the fire services in England & Wales, a Greek study of building protection, a Norwegian study of the incidence of large fires in industry and a New Zealand examination of the risks of death and injury arising from fire. In addition, the Centre's statistics are often referred to in academic works, for example The Economics of Fire Protection (Prof. G. Ramachandran, Routledge, 1998).

Fig. 1.4 Examples of fire statistics reports of WFSC and CTIF CFS

The CFS of CTIF was organised in 1995. It publishes annual World Fire Statistics Reports, which are the biggest and most comprehensive studies of fire situation in countries all over the world and large cities, plus different aspects of fire services activities in the world. These Reports are printed in Russian, English and German languages and brought large interest among the specialists in the whole world. Some CFS reports are accessible on a CTIF webpage: www.ctif.org .

A certain role in fire statistics collection plays also The World Health Organisation (WHO). WHO assembles data on fire death rates for more countries than any other organisation (see: http://www.genevaassociation.org/Portals/0/WHO_Table2.pdf).

1.5 LIMITATIONS AND TRAPS IN FIRE STATISTICS

The comparison of statements of different countries among one another is connected to the question: How does my country rank in the international comparison? When people see statistical data like in Tab. 1.1, they nearly automatically start benchmarking process. But in this moment difficulties in fact already start. Can statistical statements of different countries be compared so easily? Which definition is hidden behind the analysed figures? Do all states reports present real values?

Tab. 1.1 Trends in fires in the countries of the world in 2006-2010 (source: The CFS of CTIF Report N. 17)

N	Country	Population, thous. inh.	Number of fires					Average	
			2006	2007	2008	2009	2010	per year	per 1000 inh.a year
	Страна	Население, тыс. чел.	Число пожаров					Среднее	
			2006	2007	2008	2009	2010	в год	на 1000 чел.в год
	Staat	Einwohner in 1.000	Gesamtanzahl der Brände in ...					Mittelwert	
			2006	2007	2008	2009	2010	je Jahr	je Jahr und 1.000 Einw.
1	USA	311 537	1 642 500	1 557 500	1 451 500	1 348 500	1331500	1 466 300	4,71
2	Bangladesh	156 000	-	9 196	9 310	12 182	-	10 229	0,07
3	Russia	141 900	220 400	212 600	201 706	187 600	179500	200 361	1,41
4	Vietnam	86 000	2 124	2 668	-	1 948	2231	2 243	0,03
5	Germany	82 218	187 604	186 254	196 713	-	-	190 190	2,31
6	France	65 027	359 300	330 600	312 100	343 300	336867	336 433	5,17
7	UK*	60 776	436 047	384 000	327 448	-	285500	358 249	5,89
8	Italy	58 500	227 014	246 392	236 731	210 548	197166	223 570	3,82
9	Spain	47 021	-	-	-	-	115267	115 267	2,45
10	Ukraine	45 871	49 114	50 583	49 838	44 015	62207	51 151	1,12
11	Poland	38 167	165 353	151 069	161 744	159 122	135555	154 569	4,05
12	Malaysia	24 500	18 913	20 226	-	-	-	19 570	0,80
13	Romania	21 504	12 926	21 784	15 530	15 760	13167	15 833	0,74
14	Netherlands	16 306	-	-	47 327	-	-	47 327	2,90
15	Kazachstan	15 819	18 973	19 111	19 098	17 184	19058	18 685	1,18
16	Greece	11 283	-	32 593	33 976	37 779	-	34 783	3,08
17	Portugal	11 000	-	-	41 624	44 849	26800	37 758	3,43
18	Belgium	10 667	-	-	27 095	-	-	27 095	2,54
19	Czechia	10 517	19 665	21 835	20 406	20 177	17937	20 004	1,90
20	Hungary	9 999	21 829	25 543	19 828	26 357	16756	22 063	2,21
21	Belarus	9 500	11 031	9 498	8 654	-	10023	9 802	1,03
22	Sweden	9 341	27 106	30 005	28 693	29 493	-	28 824	3,09
23	Austria	8 388	30 297	36 756	36 031	36 427	34363	34 775	4,15
24	Switzerland	7 786	16 307	13 408	15 503	15 094	-	15 078	1,94
25	Serbia	7 566	5 712	6 948	6 673	6 168	17304	8 561	1,13
26	Bulgaria	7 364	29 090	38 187	38 099	30 219	25030	32 125	4,36
27	Denmark	5 500	16 965	-	20 786	18 946	16723	18 355	3,34
28	Slovakia	5 435	10 422	14 366	11 267	11 991	9979	11 605	2,14
29	Finland	5 375	17 800	14 156	-	15 057	15208	15 555	2,89
30	Kyrgyzstan	5 100	2 739	3 264	3 104	3 278	6145	3 706	0,73
31	Singapore	4 987	-	-	-	5 236	4600	4 918	0,99
32	Norway	4 858	13 499	15 272	-	-	9480	12 750	2,62
33	Croatia	4 290	7 117	7 416	8 008	7 549	5036	7 025	1,64
34	New Zealand	4 271	24 405	24 802	24 315	21 060	18622	22 641	5,30
35	Ireland	4 109	33 460	34 669	35 386	-	-	34 505	8,40
36	Lithuania	3 245	24 030	16 650	15 760	16 195	13411	17 209	5,30
37	Latvia	2 230	17 720	10 179	8 967	9 317	8175	10 872	4,88
38	Slovenia	2 050	-	-	4 504	7 110	3770	5 128	2,50
39	Estonia	1 340	14 900	10 400	9 170	8 421	6439	9 866	7,36
40	Cyprus	803	-	5 993	6 505	5 716	7160	6 344	7,90
Total/Итого/Gesamt:		1 328 150	3 684 362	3 563 923	3 453 399	2 716 598	2 950 979	3 273 852	2,46

* - data of 2009-2010 year for Great Britain

Although many areas of activates are harmonised within EU, functioning of fire brigades still remain a domain of each single member state. Considering also different organisational models of fire & rescue services in Europe (see chapter 1.3), it is not difficult to imagine that principles of fire statistics registration are different in different countries. A following example can be used to illustrate a problem. In some countries all fire incidents are included in statistics, in others some kind of fires have so far not be recorded (e.g. fires of grassland and garbage).

Next to comparison difficulties, problem of different definitions of fire related terms should not be omitted. For example in some countries a „fire death" is defined as a fatality whose death was declared on the scene of a fire only (if causality will die 3 minutes after an ambulance leave the fire scene, this case will not appear in fire statistics). In another country a fire causality who dies because of fire up to 15 days after it occurrence, will be recorded in fire statistics.

Another question when using fire statistics it is credibility and accuracy of records. If sufficient care is not exercised in collecting, analysing and interpretation the data, statistical results might be misleading. Some errors are possible in statistical decisions. Particularly the international statistics is prone to certain errors. Besides, statistical laws are not exact like in case of natural sciences. These laws are true only on average. It should be also remembered that only a person who has an expert knowledge of statistics can handle statistical data efficiently.

If we add problems of representativeness of the sample, incompleteness of data, lack of accuracy in data collection, possible mistakes, we should come to a conclusion that a comparison of fire statistical data over time and across countries should be undertaken with a really great caution. It is also advisable to have in mind a popular and often justified phrase describing the persuasive power of numbers: "There are three kinds of lies: lies, damned lies, and statistics."

1.6 CONCLUSIONS

1. Statistics is indispensable to almost all sciences and is very often used in most of the spheres of human activity.
2. Fire statistics is available, but it is necessary to know which "door to knock".
3. Differences should be consider when benchmarking within and between countries - be sure you compare „apple with apple", not „apple with plum".
4. Statistical methods rightly used are beneficial but if misused these become harmful.
5. To provide good and credible statistical analyse it is necessary to put a lot of effort and be familiar with statistics issue.
6. Use a rule of limited trust, having in mind certain limitations and traps of statistics.

Acknowledgement

The authors would like to express special thanks to Dr. Peter Wagner from the Centre of Fire Statistics of CTIF.

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2 CZECH REPUBLIC STATISTICS OF ACTIVE PROTECTION TO PASSIVE FIRE RESISTANCE

Summary

Fires of structures occur and will occur in the future across all available technical security. It is the accidental incident, the frequency of occurrence is low, but the consequences are usually significant. To reduce the number of fires and accidents is very important task for all the countries. Before we start the prevention steps we need to identity the risks. In different countries we use different methods to identify risks and we also accept risks in a different ways. To identify the local risk it is necessary to look at regional risks, national risks and international risks too. Especially when we are searching for general fire tendency it is necessary to use comprehensive statistics. In this case the statistic data and cooperation with other are very important points how to be successful.

2.1 FIRE RESCUE SERVICE OF CZECH REPUBLIC

Statistics measurement in the Czech Republic are implemented by Fire Rescue Service of CR. FRS CR is one of the basic bodies of the Integrated Rescue System in the Czech Republic. Primary function of the Fire Rescue Service of CR is to protect life, health and property of citizens against fire, and to provide preparation for emergency situations.

2.1.1 History

The first professional fire service on Czech area was established in Prague in 1853 already, but the main responsibility for fire fighting in the second half of the 19th century, even after the Czechoslovak Republic was established and up to the beginning of the 2nd World War, belonged to voluntary fire fighters organisations of cities and municipalities. Public fire units of professional character had existed in certain bigger cities only. Basic reorganisation of fire protection took place after the 2nd World War, namely when the Law No. 35/1953 on State Fire Inspection and Fire Protection came into force. On the basis of the Law, the public and company fire units became executive fire units, and fire protection started to be established on principles of military organised bodies. The new Fire Protection Law in 1958 meant gradual decentralisation of fire protection, and consequent weakening of its level. The sixties are therefore characterised by efforts to establish a new legal frame of fire protection. In last thirty years fire protection has gone through essentials changes. At the beginning of seventies the proportion of technical responses of fire units began to increase, in comparison with fire interventions. And because of their abilities, professional fire units gradually replaced some of other technical services. Therefore, the existing legal provisions and organisation had to be adapted. The process of changes culminated at the beginning of this millennium, when scope of the Ministry of Interior was enlarged in the areas of emergency management, civil emergency planning, population protection, and the Integrated Rescue System. The new legal modifications, which came into force on 1st January 2001, stood for essential change in the position, jurisdiction and organisation of the Fire Rescue Service of CR.

2.1.2 Organization

Fire Rescue Service of CR consists of the General Directorate of Fire Rescue Service of CR (FRS CR), which is a part of the Ministry of Interior, and of 14 Regional Fire Rescue Services, the Emergency Unit of FRS CR, and the Special Secondary School of Fire Protection and High Special School of Fire Protection.

2.1.3 Statistics of Fires in Czech Republic

Statistic data are published every year in Statistical Yearbooks of FRS CR since 1998. The main information are selected from data in statistical monitoring of emergencies, where data are collected, organized, quantified and compared in a structure that was based on the needs of FRS fire units and has undergone long-term development according to FRS needs. Statistical Yearbook, which is prepared by Operational Management Department in cooperation with other specialized departments of Ministry of Interior - General Directorate of FRS CR, offers daily reports on incidents and on fire unit´s activities, fires in CR plus weekly survey of chosen fire cases, consecutive quarterly summary, and fire statistics including an English version. Evaluated and compared data are processed in tables and graphs. The data are organised to 35 parameters: region, sort of event, object type, place of origin, class of material risk, proclaimed degree of alarm, kind of false alarm, equipment type, activity of emergency units, local unit data, type of flammable substances and fire extinguishing mediums, causes of fire, negative effects on the onset and spread of fire, degree of damage of buildings, functionality of the active fire protection, etc. Some significant graphs, numbers of incidents and maps from Statistical Yearbook 2011 are showed in following pages.

Incident type	Number of incidents 2007	2008	2009	2010	2011	Index %
Fires	21,835	20,406	19,681	17,296	20,511	119
Traffic accidents	21,270	20,063	19,004	18,053	17,061	95
Natural disasters	10,044	5,599	5,240	-*)	-*)	-*)
HazMat leakages	6,377	6,242	5,916	5,300	5,285	100
from these oil products	5,235	5,218	4,991	4,407	4,251	96
Technical accidents in total	48,010	42,104	47,412	62,961	50,035	79
from these technical accidents	29	10	21	19	17	89
technical assistances	44,765	38,916	44,187	58,948	45,736	78
technological assistances	1,042	770	761	744	652	88
other assistances	2,174	2,408	2,443	3,250	3,630	112
Radiation incidents	0	0	0	0	1	x
Other emergencies	166	17	10	2	6	300
False alarms	8,148	8,194	8,251	8,037	8,202	102
Total	**115,850**	**102,625**	**105,514**	**111,649**	**101,101**	**91**

Fig. 2.1 Number of particular types of incidents with fire units' interventions in table

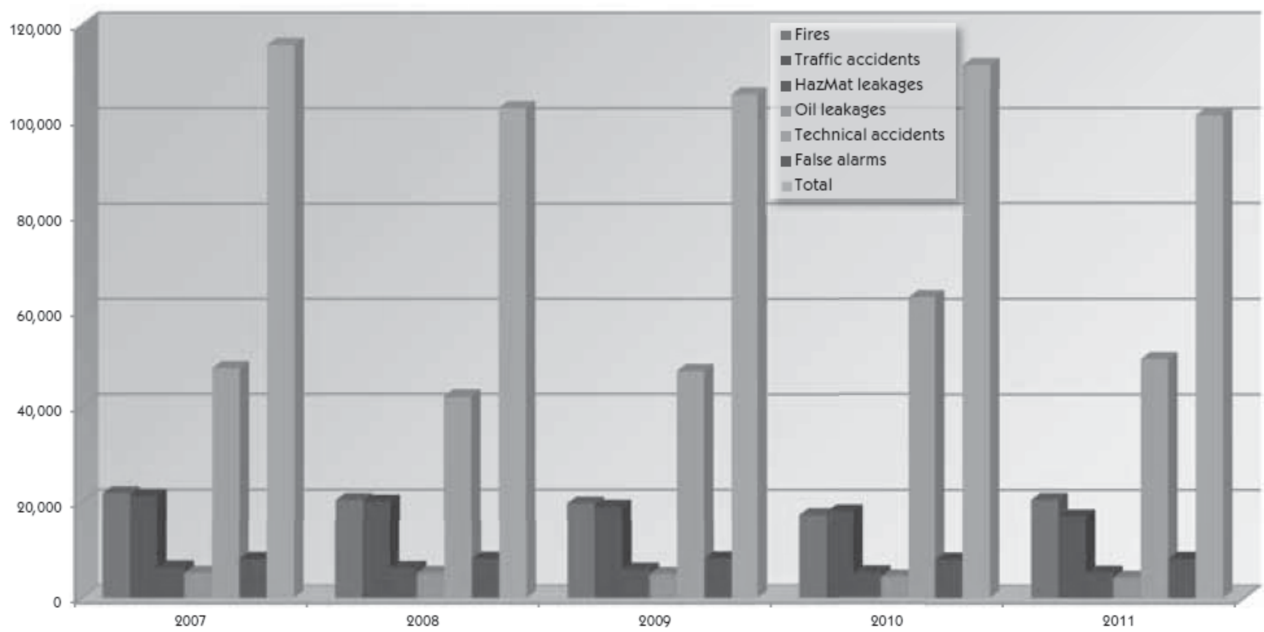

Fig. 2.2 Number of particular types of incidents with fire units' interventions in graph

The following review shows, that in 2011 average of 58 fires with an average damage of 6,140,000 CZK occurred in the Czech Republic. Salvaged values were 3.6 times higher than losses. In 2011, compared to 2010, number of fires increased by 17.8 %, losses increased by 14.6 %. Total of 358 major fires (loss over 1 mil. CZK), i.e. 1.7 % of all fires, caused 69 % of overall damage. Number of casualties dropped by 1.5 %, whereas injuries increased by 8.7 %. Fire fighters rescued 457 persons in fire operations and 6,160 persons were evacuated.

Year	Number of fires	Loss in CZK	Deaths	Injuries
1997	21,540	1,229,951,200	135	1,026
1998	24,041	1,902,566,000	96	1,123
1999	20,857	2,088,610,700	105	934
2000	20,919	1,426,340,200	100	975
1996-2000	**108,896**	**7,992,965,800**	**554**	**5,095**
2001	17,285	2,054,670,000	99	881
2002	19,132	3,731,915,000	109	942
2003	28,937	1,836,614,900	141	1,112
2004	21,191	1,669,305,100	126	918
2005	20,183	1,634,371,000	139	914
2001-2005	**106,728**	**10,926,876,000**	**614**	**4,767**
2006	20,262	1,933,991,700	144	919
2007	22,394	2,158,494,200	130	1,023
2008	20,946	3,277,297,400	142	1,109
2009	20,177	2,169,150,200	117	980
2010	17,937	1,956,159,200	131	1,060
2006-2010	**101,716**	**11,495,092,700**	**664**	**5,091**
2011	21,125	2,241,800,100	129	1,152

Year	Salvaged values (CZK)
1997	6,393,776,000
1998	6,925,493,000
1999	8,907,455,000
2000	6,584,192,000
1996-2000	**37,229,183,000**
2001	6,230,121,000
2002	6,251,751,000
2003	7,646,975,000
2004	6,977,363,000
2005	7,110,116,000
2001-2005	**34,216,326,000**
2006	9,182,541,000
2007	8,974,428,000
2008	14,545,693,000
2009	9,074,906,000
2010	11,115,762,000
2006-2010	**52,893,330,000**
2011	8,078,932,000

Fig. 2.3 Fire-review and values salvaged in fires

Economy branch	Number of fires	Part in %	Index %	Loss in thousands CZK	Part in %	Index %	Deaths	Injuries
agriculture	642	3.04	111	189,844.6	8.47	87	0	36
forestry*	309	1.46	106	11,590.1	0.52	109	1	24
mineral mining	20	0.09	111	27,353.0	1.22	806	0	0
processing industry	569	2.69	104	648,635.7	28.93	119	4	84
electricity, gas, water production/distribution	165	0.78	105	39,003.3	1.74	52	3	7
construction	80	0.38	105	13,665.8	0.61	112	1	6
trade, goods repair	161	0.76	93	329,806.7	14.71	284	3	22
lodging, accommodation	358	1.69	110	130,197.9	5.81	153	10	84
transport	1,988	9.41	98	245,389.4	10.95	99	28	203
post and telecommunication	15	0.07	104	1,473.8	0.07	1126	0	0
banking and insurance	13	0.06	93	1,440.0	0.06	209	0	0
research, company services, real estates	303	1.43	85	52,019.2	2.32	59	3	47
public administration, security	32	0.15	92	1,683.3	0.08	100	0	2
education	45	0.21	94	4,285.0	0.19	58	0	2
health and social activity	48	0.23	102	7,346.9	0.33	270	2	14
other public and personal services	1,890	8.95	108	127,828.6	5.70	112	8	44
households	2,668	12.63	106	408,182.8	18.21	97	66	578
unclassified and other	11,819	55.96	132	2,054.0	0.09	254	0	1
Total	**21,125**	**100.00**	**118**	**2,241,800.1**	**100.00**	**115**	**129**	**1,152**

*) Since 2010 only investigated fires (this does not include grass fires, fires of leaf and needles litter or peat fires without loss, spread, death or injury)

Fig. 2.4 Fires by branches 2002-2012

On this map, an overview of the fires in the Czech Republic for 2002-2012 is presented. Statistical data from previous reports are corrected every year.

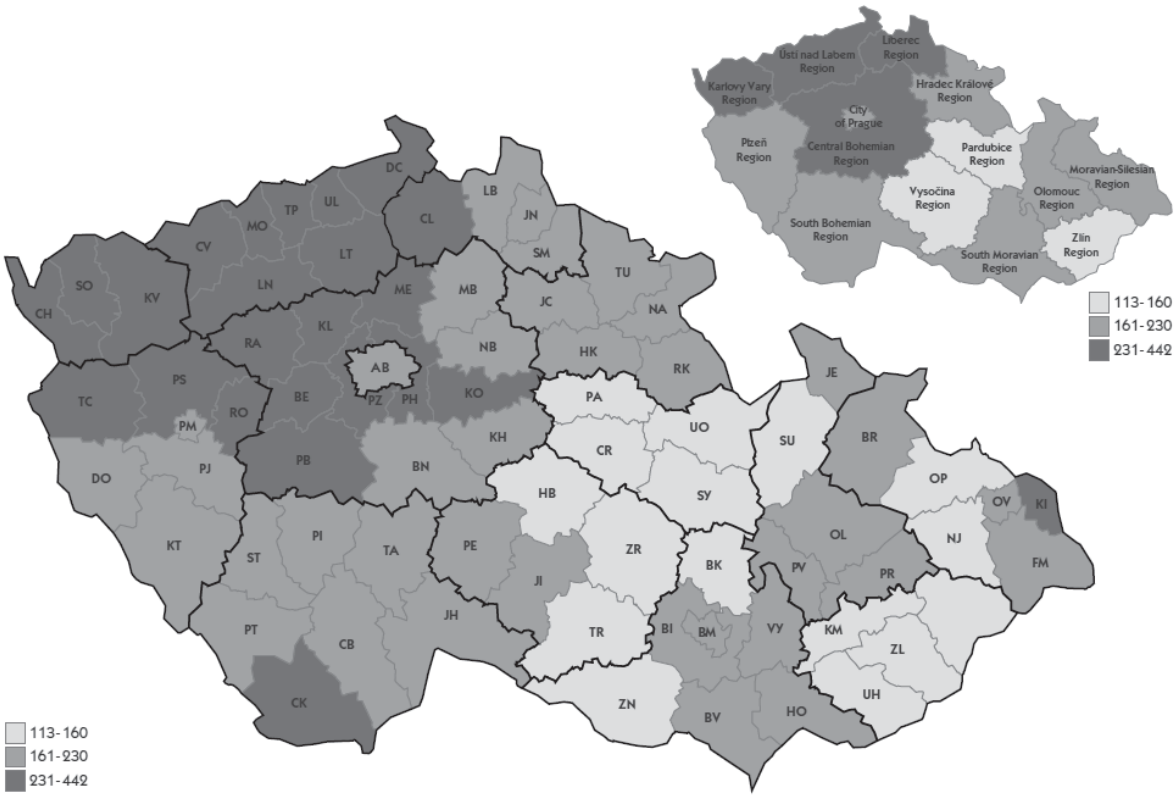

Fig. 2.5 Number of fires in 2002-2011

Free download of Statistical Yearbooks in English is possible on page http://www.hzscr.cz/clanek/statistical-yearbooks.aspx.

In the Statistical Yearbook the main information related to “intervention activities” are regularly mentioned.

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Fires	15,966	18,130	26,648	20,117	19,212	19,189	21,432	20,910	20,283	18,050	21,290
Traffic accidents	18,616	20,207	21,459	21,202	20,753	18,831	20,882	20,426	19,318	18,563	17,853
Natural disasters	,-	12,788	1,136	1,180	1,599	3,175	6,538	2,932	2,835	,-	,-
HazMat leakages	3,625	5,014	5,251	4,757	4,856	5,013	5,534	5,612	5,313	4,763	4,673
Technical accidents	32,518	36,018	32,861	37,807	32,379	37,571	35,905	32,928	35,500	45,598	36,744
Radiation incidents	0	0	0	2	1	10	0	0	0	0	3
Other emergencies	,-	253	157	89	52	702	209	20	14	2	5
False alarms	4,502	5,074	5,494	4,949	4,636	4,620	4,853	5,426	5,334	5,205	5,517
Total	**75,227**	**97,484**	**93,006**	**90,103**	**83,488**	**89,211**	**95,353**	**88,254**	**88,597**	**92,181**	**86,085**

Fig. 2.6 FRS CR interventions by incident type

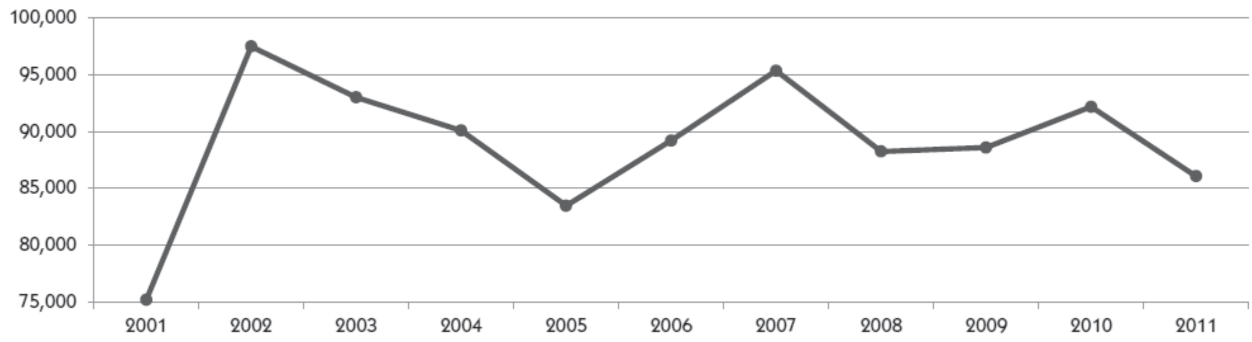

Fig. 2.7 Total number of interventions in graph

2.2 FOREIGN STATISTICAL DATA

2.2.1 World Fire Statistics Centre

The Centre is primarily focused on the collection, analysis and dissemination of internationally comparable fire cost statistics and the main goal of its activities is persuading governments to adopt coherent fire strategies aimed at reducing national fire costs. Between 1975 and 1978, The Geneva Association sponsored research on European fire costs by Sussex University. This led to the publication of a report, *European Fire Costs – The Wasteful Statistical Gap*, which formed the basis of a contribution by Mr Wilmot to a pilot study on fire statistics initiated by a United Nations Working Party in 1981. Subsequently Mr Wilmot, with the support of The Geneva Association, founded the World Fire Statistics Centre to carry forward this work within a more structured organisational framework. The Centre is primarily concerned with the practical problem of reducing fire waste rather than with academic research. The main focus of its work, the collection, analysis and dissemination of internationally comparable fire cost statistics, is thus seen as a means to an end: persuading governments to adopt coherent fire strategies aimed at reducing national fire costs.

Each year the Centre collects and compares fire cost statistics under seven main headings from a steadily increasing number of countries worldwide, mainly from Europe but also including, for example, the USA, Japan and Canada, and more recently The Czech Republic, Slovenia and Singapore.

Each annual report from the Centre to the United Nations forms the basis of a Bulletin sent worldwide to relevant government departments, fire protection associations, fire brigades, insurance companies, fire engineers, the trade press and academic fire experts. These statistics have often proved of use during national reviews of various aspects of fire-related expenditure or organisation.

2.2.2 International Association of Fire and Rescue Service (CTIF)

Centre of Fire Statistic of the CTIF is international information network, which provides comprehensive world fire statistics for eleven years. Data on fire issues contains 85 countries and more than 100 capitals. Free download of Annual Reports is possible on page: http://www.ctif.org/Introduction,25 .

In 2006 fire statistics from Czech Republic is presented for the first time. In table 1, an overview of the fire problem in the world for 1993-2004 is presented. Statistical data from previous reports are corrected every year.

2.3 SUMMARY

Statistics are important because they gather the information about fires, which lead to prevention of fires, to ensure safer fire fighting and for improvement to fire standards and regulations. International cooperation is significant, because it brings a larger number of input data, from which is possible to analyze and using experience and knowledge from other states. All these factors lead to reduce the number of victims, financial looses and damage of estate.

Acknowledgement

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3 USAGE OF STATISTICAL DATA FOR A PROBABILISTIC MODEL FOR FIRE DEPARTMENT RESPONSE

Summary

The paper discusses the possible usage and benefit of statistical data obtained from fire brigade reports and investigations. In order to determine the optimal amount of structural fire protection measures, the system of protective measures should be considered in a holistic way. In case very effective fire brigades or active fire protection measures are present in buildings, the amount of structural fire protection can be reduced as it is very likely the fire will not become as large as if this is not the case. The German National Annex to Eurocode 1 part 1-2 (DIN EN 1991-1-2/NA) contains a safety concept that is able to quantify the benefit of effective fire fighting measures for structural fire protection. The statistical information obtained from fire brigade reports and investigations can be used to improve the underlying model and the resulting predictions. The model considers the different time intervals between the ignition of the fire and the start of fire fighting measures. On this basis the paper describes what kind of information should be included in fire brigade reports and investigations to be of further use.

3.1 INTRODUCTION AND MOTIVATION

The German National Annex to Eurocode 1 part 1-2 (DIN EN 1991-1-2/NA) contains a new safety concept that replaces the informative Annex E of Eurocode 1 part 1-2 (DIN EN 1991-1-2). For more details and background of the safety concept see (Hosser, 2008) and (Klinzmann, Hosser, 2011).

The objective of the semi probabilistic safety concept is to provide design values for heat release rate and fire load as a basis of structural fire safety design calculations. The design values are calculated on a required safety level for a building structure and the reliability of all relevant elements of fire protection.

This includes the available active fire protection measures (e. g. fire fighting measures and sprinklers). The idea behind this concept is that in case effective active fire protection measures are present, the amount of structural fire protection can be reduced.

The calculations that were carried out to validate the safety concept used probabilistic models to assess the reliability of the different fire protection measures. This paper will discuss a more detailed probabilistic model regarding the probability of failure of the fire department to fight the fire successfully. The idea is that statistics of fire fighting measures can be used to improve the provisions of the model and subsequently to adjust the amount of structural fire protection to the necessary amount. Based on the findings suggestions can be given what kind of data and information should be recorded with fire brigade reports to provide the necessary input for the safety concept.

3.2 DEVELOPMENT OF AN IMPROVED PROBABILISTIC MODEL

The original probabilistic model that was developed with the safety concept described above used a rather coarse approach, comparing the estimated size of the fire at the time of the fire brigade intervention with a fire size the fire brigade is assumed to be able to handle. As fire statistics are not collected systematically in Germany, this time span and the estimated values had to be chosen on the basis of reasonable assumptions based on regulations for the planning of emergency response services (EMS) in Germany.

The coarse model could be improved if detailed statistical information from EMS would be available in Germany. In a first step detailed information from fire brigades of different sizes was evaluated in a student research project conducted at TU Braunschweig (Schwanitz, Benedikt, 2009) to improve the original model.

The original model neither includes the time from the fire initiation until detection, nor does it regard the time that the fire brigade crew needs to setup their equipment to start the initial attack. The collected data from the fire brigades can be used to split the time interval "intervention time" from the time of ignition of the fire until the fire brigade intervenes at the scene into various characteristic intervals according to the following chronological order. This is in good accordance with the literature, especially the work from Tomasson et al. (Tomasson, 2008).

a) Detection Time t_{det}
b) Dispatch Time
c) Turnout Time
d) Travel Time
e) Setup Time

The different relevant time intervals and the results from the student project are summarised in the following.

3.2.1 Detection Time

The detection time t_{det} is the time from the ignition of the fire until the first notification of the dispatch centre. The notification can either happen by an automatic detection system connected to the dispatch centre, a signal from a fire alarm box or an emergency call by phone. Usually, an automatic fire detection system with a direct transmission to the dispatch centre detects and reports a fire approximately in 1 to 1.5 minutes after ignition, depending on the intensity of the fire and type of fire load. A significantly longer time with greater variation has to be considered for the detection and alarm by occupants. The time to alarm can vary between less than a minute and hours, depending on the presence or the absence of occupants in the vicinity of the fire origin. For that reason the presence of a fire alarm system will result in a reduction of the overall intervention time of the fire fighters. In the probabilistic analyses, the effect of an automatic fire detection system was investigated for an assumed gain of time of 3, 5 or 7 minutes with a coefficient of variation of 20 %. The probability of failure of the detection system was conservatively assumed to be 0.1 according to a literature review (Joint Comitee on Structural Safety, DD240, 1997).

3.2.2 Dispatch Time

The dispatch time t_{disp} is the time between the first emergency call or the first notification of an automatic fire detection system and the alarm of fire brigade personnel. The German consortium of professional fire fighters (AGBF) suggests a maximum value of 90 seconds for the dispatch time (Arbeitsgemeinschaft der Berufsfeuerwehren, 2004). International literature shows that this time is within the margin of dispatch times in other countries. Gaskin and Yung find the average dispatch times to be within 1.0 and 1.5 minutes (Gaskin, 1993). According to Tomasson et al the dispatch time can be assumed to be log-normally distributed with a mean μ of 58.7 seconds of and a standard deviation σ of 47.8 seconds.

The stochastic model for the dispatch time was chosen to be a normal distribution with a mean of 1 minute and a variation of 20%, based on those findings and accounting for the suggestions of the AGBF. This implies a dispatch time of less than 90 seconds in 99.4% of all emergency calls.

3.2.3 Turnout time

The time between the first alert of the fire brigade personnel and the fire engines leaving the station is called “turnout time” t. Gaskin and Yung (Gaskin, 1993) state an average time between 0.5 and 1.0 minutes for professional fire fighters who work or sleep in the fire station. Tomasson et al use a model based on a log-normal distribution with a mean μ of 88.4 seconds with a standard deviation σ of 41.1 seconds for the turnout time.

These results were compared to the findings of the student research project. In Germany fire brigades, consist either of professional or voluntary fire fighters. For that reason different models have to be found for each type of fire brigade. This is due to the fact, that professional fire fighters are present at the fire station at all times, while voluntary fire fighters have to get to the station first, which significantly delays the turnout time. Based on the collected data, the turnout time for the professional fire fighters can be modelled as a normal distribution with a mean μ of 1.0 minutes and a standard deviation σ of 0.5 minutes, which is in good compliance with the findings for professional fire brigades in the international literature.

The turnout time for voluntary fire brigades was found to be in good accordance to a Gaussian distribution with a mean μ of 3.5 minutes and a standard deviation σ of 1.5 minutes. This accounts for small as well as large voluntary fire brigades.

3.2.4 Travel Time

The travel time t_{trav} is the time the fire engines need to travel from the fire station to the scene of the incident. Gaskin and Yung (Gaskin, 1993) find the travel time to be between 2 and 5 minutes on average, while Tomasson et al (Tomasson, 2008) use a refined model based on findings of Tillander (Tillander, 2000), who found an under proportional relation between travel time and distance for distances less than 4.6 kilometres and thereafter a proportional relation for distances greater than 4.6 km.

An unpublished study of the Bielefeld fire brigade found that the average alarm speeds of fire brigades are between 35 and 45 kilometres per hours. With greater distances, the average speed increases to above 50 km/h, which complies with the findings of Tillander, (Tillander, 2000) and of Tomasson et al., (Tomasson, 2008).

For the probabilistic analyses, the travel time was modelled conservatively to be proportional to the distance and the speeds were chosen to be 45 km/h for professional fire companies and 40 km/h for voluntary fire brigades to account for the different levels of experience of driving in alarm conditions. The mean travel time was calculated to be 1.3 minutes per kilometre (min/km) for professional fire brigades and 1.5 min/km for voluntary fire brigades. The standard deviation was chosen to be 0.5 minutes. This leads to a rather high coefficient of variation which was chosen to account for high traffic volumes during rush hours. Consequently, a detailed evaluation of speeds in relation to the time of the day was omitted in favour of the more general model.

3.2.5 Setup Time

The setup time t_{set} is the time between the arrival at the scene and the start of the initial fire extinguishing actions. This time-span includes the time needed for exploration of the scene and the preparation time of the equipment.

An in-depth analysis of the incident reports of the different fire brigades has shown that the exploration times depend on the size and the complexity of the building. For smaller apartment buildings the exploration times average 2.5 to 3.5 minutes, while for industrial buildings or storage houses 4-6 minutes have to be assumed. For hospitals with automated fire detection systems and staff present and well-trained for emergencies, this time can be reduced to an average of 2 minutes.

The preparation time starts with the exploration time, but is initially limited to the preparation of the equipment for the initial attack. After the completion of the exploration phase, the at-tack is initiated. Multiple tests with members of a voluntary fire brigade during the student research project have shown that the time until the initial attack is carried out highly depends on the location of the fire. For the research project, different locations of a fire were assumed in an apartment house without standpipes. First, a fire a fire was assumed to have occurred in the basement, then on the ground floor and in the 3rd floor of the building. The maximum length of a fire compartment was chosen to be about 40 m in compliance with the German building codes.

For each scenario, three fire locations were tested: a fire near the entrance of the compartment, a fire at about 20 m from the entrance and a fire at the maximum of fire compartment length (40 m). In Tab. 3.1 the results for the time needed by the fire fighters arriving at the entrance of the building with their equipment ready until the first water was at the nozzle at the particular scenario location are shown. The times shown do not include moving in very thick smoke or exposure to extreme heat. Additionally, these times do not incorporate additional time needed for other actions like the rescue of occupants.

Tab. 3.1 Time to initial fire brigade attack in [min:sec]

	Location	Time	Average
Basement	near Entrance	2:02	
	20 m	2:20	
	40 m	2:48	2:23
Ground Floor	near Entrance	1:49	
	20 m	2:03	
	40 m	2:17	2:03
3rd floor	near Entrance	3:22	
	20 m	3:58	
	40 m	4:29	3:56

The results clearly indicate the high influence of the height of the building even for buildings of lower heights. This corresponds to the results of Tomasson et al for high-rise buildings (Tomasson, 2008).

For a further consideration in the probabilistic analyses the setup time was chosen conservatively based on the findings. It was assumed to be distributed according to a Gaussian distribution with a mean of μ=3.5 minutes with a standard deviation of σ=0.5 minutes for an apartment house with up to two floors. Additional two minutes have to be added for apartment houses with three to five floors. The setup time was modelled according to a Gaussian distribution with a mean μ of 5 minutes and a standard deviation σ of 0.5 minutes for all other building types.

3.2.6 Limit State

The approach developed by Hosser et al (Hosser, 2008) and Klinzmann and Hosser (Klinzmann, Hosser, 2011) for the safety concept assumes a radial fire growth which is compared with a maximum fire size ($A_{f,lim}$) that a fire brigade is assumed to be able to extinguish. This approach is based on a similar model used for the German industrial fire code [8]. The limit-state function yields to

$$Z = A_{f,lim} - \pi \cdot (v_f \cdot t_{int})^2 \ , \tag{1}$$

In the formula v_f denotes a constant fire growth speed in m/min and t_{int} is the total intervention time of the fire brigade. The model was tested by Klinzmann and Hosser in (Klinzmann, Hosser, 2011) for various different values for the intervention time and maximum controllable areas. It was found that due to a high uncertainty the intervention time t_{int} has the highest sensitivity on the limit state.

The simple model can be refined by a subdivision of the total fire brigade intervention time into smaller time interval by using the stochastic parameters found in the previous sections. Following this approach, Eq. 2 yields

$$Z = A_{f,lim} - \pi \cdot [v_f \cdot (t_{det} + t_{disp} + t_{to} + t_{trav} + t_{set})]^2 \ . \tag{2}$$

The maximum containable fire area was chosen to be either 200 m² or 400 m² to account for different crew sizes arriving at the scenes. The coefficient of variation was chosen to be constant at 15%.

Tab. 3.2 Stochastic parameters for the fire brigade intervention time

Parameter	Unit	Distribution	Mean μ	Std.Dev. σ
Fire Spread	m/min	Normal	0.4	0.08
Max. Containable Fire Area	m^2	Normal	200/400	30/60
Detection Time				
without detection system	min	Normal	3/5/7	0.6/1/1.4
with detection system	min	Normal	1.25	0.125
Dispatch Time	min	Normal	1	0.2
Turnout Time				
Professional FD	min	Normal	1	0.5
Voluntary FD	min	Normal	3.5	1.5
Travel Time (4km)	min	Normal	6	2
Setup Time	min	Normal	3.5	0.5

Tab. 3.2 summarizes the stochastic parameters of the refined model. The sum of the mean values of the different time intervals leads to an average intervention time of 12 minutes in case of an automatic fire detection system and a city with professional fire fighters up to an average intervention time of 21 minutes for scenarios with manual fire detection and voluntary fire fighters. The incident was assumed to be located 4 kilometres away from the fire station. The calculated times coincide well with the original time spans used in the development of the original safety concept.

3.2.7 Results of the refined model

The probability of failure for the fire department intervention $p_{f,FD}$ can be calculated using first order reliability method (FORM), (Melchers, 2002). FORM also allows the calculation of sensitivity factors (α_i) of the stochastic parameters in the limit state function, denoting the importance of a parameter on the limit state. Fig. 3.3 shows the probability of failure of the fire brigade ($p_{f,FD}$) as a function of time for maximum controllable fire areas A_f of 200 m² and 400 m² with a standard deviation of 30 m² or 60 m²

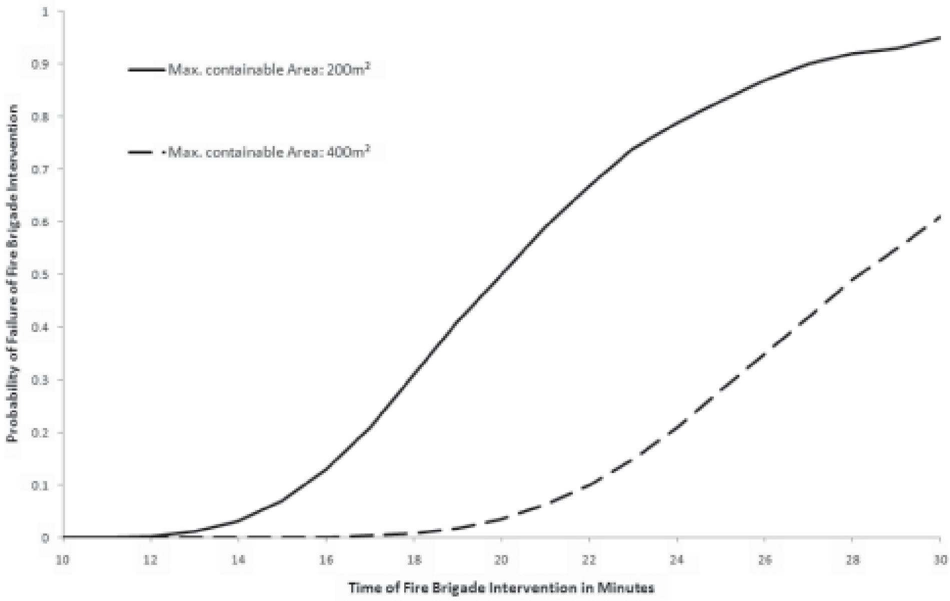

Fig. 3.3Probability of fire brigade failure as a function of time

Comparing the sensitivity factors α_i of the parameters on the limit state for the simple and the refined fire brigade model, it is obvious that the influence of the fire brigade intervention time is reduced due to the more accurate modelling. In the refined model, the fire spread rate and the maximum controllable fire size now dominate the limit state. It could be derived that the turnout time for voluntary fire brigades has a high influence on the success of the fire fighting. Similar results could be found for professional fire fighters, but due to the significantly lower value of the turnout time the effect is not as large. The dispatch time only had a very small contribution to the limit state.

3.3 RECOMMENDATIONS FOR QUESTIONS TO BE INCLUDED IN STANDARDISED NATIONAL FIRE FIGHTERS REPORTS

Fire brigade reports and investigations can be used to improve the prediction of the described model and can be of further use when defining the optimal amount of structural fire protection.

The results of the studies and analyses showed that the improved knowledge about the different time intervals is not as important as the overall intervention time itself. The (estimated) time span from ignition and the arrival at the scene as well as the duration of the exploration of the scene and the start of the fire fighting measures should be recorded. A longer intervention time usually leads to larger fires, depending on the type of burning structure or building so as well the type of building, size of burning compartment and the floor level of the fire compartment should be included in the reports. On the other side of the equation the size of a fire a fire brigade is able to handle is very important. A fire investigation or the fire brigade report should include the information whether the size of the fire increased significantly or spread beyond the compartment or structure of origin after the ignition.

The information could be compiled into tables to provide more advanced input values for the structural fire safety concept included in the German national annex of DIN EN 1991-1-2.

Acknowledgement

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4 FIRE BRIGADE TASKS, REPORTS AND INVESTIGATIONS IN THE POLISH REALITIES. GENERAL DESCRIPTION AND EXEMPLARY REPORT OF INVESTIGATION

Summary

In Poland some detailed information on fire and other events are compiled, collected and processed at four levels of command by the agencies comprising the State Fire Service (SFS): Rescue Firefighting Unit, County (or City) Position of Management, Regional Rescue Coordination Function, and the National Rescue Coordination and Civil Protection Centre. This structure forms the skeleton, which globally creates the National Firefighting and Rescue System (NFRS) to which belong most of the entities performing tasks in a very widely understood „a rescue area". The State Fire Service as the superior coordinating and supervising institution also implements measures to prevent fires and other threats, discussed in detail further below. The typical example of such an activity is an issuance of professional opinions relating to fire protection, on which the formal authorization of building objects is based. The State Fire Service as an institution does not conduct investigations themselves. In the Polish system all the required investigations are leaded by the authorities responsible for public safety as police, prosecutors and courts. All these bodies are authorized to appoint experts, whose task is to give an appropriate feedback. The chapter describes the function of experts and their jobs, and discusses an example of an opinion - a report of the investigation.

4.1 GENERAL DESCRIPTION OF THE SYSTEM

4.1.1 Collecting and processing of information

In Poland some detailed information on fire and other events are compiled, collected and processed at four levels of command by the agencies comprising the State Fire Service (SFS): Rescue Firefighting Unit, County (or City) Position of Management, Regional Rescue Coordination Function, and the National Rescue Coordination and Civil Protection Centre. This structure forms the skeleton, which globally creates the National Firefighting and Rescue System (NFRS) to which belong most of the entities performing tasks in a very widely understood „a rescue area". The State Fire Service as the superior coordinating and supervising institution also implements measures to prevent fires and other threats. The typical example of such an activity is an issuance of professional opinions relating to fire protection, on which the formal authorization of building objects is based.

4.1.2 Tasks and responsibilities of the State Fire Service

The tasks and duties of the State Fire Service are determined by several acts (with the leading position of two of them: on Fire Protection (Law, 1991a) and on the State Fire Service (Law, 1991b)). The main ones resulting from the law are listed below, (Law, 1991b):

- identifying fire hazards and other local hazards,
- organizing and conducting rescue operations during fires, natural disasters or elimination of local threats,
- providing specialist support rescue operations during natural disasters or elimination of the local threats by other emergency services,
- training of staff for the State Fire Service and other units of fire protection and the National Civil Defense,
- supervising the compliance with fire regulations,
- conducting research on fire safety and civil protection,
- collaboration with the Head of the National Criminal Information Centre in the range necessary to carry out its statutory duties,
- interaction with fire brigades and rescue services of other countries and their international organizations on the basis of binding international bilateral agreements,
- implementation of other tasks arising from international agreements on the rules and within the range specified therein.

4.1.3 Statistical data

Statistically in 2010 in Poland nearly 136,000 of fires of different sizes were formally recorded, while in 2011, respectively, nearly 172,000 of events were reported in the SWD-ST system, (http://www.kgpsp.gov.pl). Fires are classified there by size, location and the most likely reason of the occurrence.

In general, the main reasons of a fire classified are the following: defects of electrical and/or heating appliances and chimneys, their improper exploitation, faulty technical equipment, poorly planned technological processes and forces of nature. Frequently the main cause of the fire is reckless, irresponsible and thoughtless, but sometimes also thoughtful human behavior.

Due to the size, the fires are divided into small, medium, large, and very large. The location data specifies a building or the area where a fire occurred.

Statistics of events are run by the State Fire Service. The information collected are related to ongoing activities or emergency firefighting, and except basic data which would allow to classify fire concerns (in the majority) only the tactical aspects that make them not very useful or completely useless for scientific purposes or more sophisticated technical analyses. Data is entered into the nationwide computer system for collecting and processing data in the form of incident reports, prepared by the person heading the rescue operation. The cause of fire given in the report is only supposed, based solely on the observation of the event and is not confirmed by any thorough analysis of facts or evidence. In most cases the real reason is not obvious and its indication requires careful analysis.

4.1.4 Investigations

The State Fire Service, as the institution does not conduct investigations themselves. In the Polish system all the required investigations are leaded by the authorities responsible for public safety as police, prosecutors and courts. Public security authorities have to exclude the criminal activity – both intentional and unintentional. If there is a need to assess the cause of a fire or structural building disaster all these bodies are authorized to appoint experts (individual expert or team of experts), whose task is to give an appropriate feedback. Professional firefighters of the State Fire Service, having an adequate stock of knowledge and experience, are very often appointed as such experts. The rules for appointing experts and issuing opinions are governed by the Code of Criminal Procedure (KPK), (Code, 1997). They're particularly respected when, as the result of incident exist any fatalities or when anyone is suspected of committing a crime. Quite another case when the opinion of experts is necessary, is a suspicion of insurance fraud. In such situations the opinion can also be ordered by insurance companies.

There are people who may not be invoked as an expert, (Regulation, 2005). In criminal cases list of persons who cannot be certified experts include:

- defenders as to the facts, which are learned by giving legal advice or prosecuting the case,
- clergymen, as to the facts, which are learned by confession,
- the person closest to the accused or remaining with him in particularly close personal contact,
- spouses, relatives, in-laws, people who witness the criminal act.

4.1.5 Other tasks

One of the tasks worth mentioning which is carried out by the State Fire Service is awarding licenses of fire protection experts, who lead a key role in construction investment processes. In some cases, wider described in the Polish Construction Law (Law, 1994) a construction project requires some prior arrangements to confirm that it contains technical solutions consistent with the general requirements of fire protection. This concerns first of all objects that are classified as risky to humans, manufacturing-warehouse, closed garages or car parks, tunnels, etc.

After completion, such an object usually requires the administrative decision authorizing its use. The construction law requires the investor should notify the local State Fire Service unit about the completion of construction process and his/her intention to use. The State Fire Service controls the building and verifies its compliance with the construction process.

4.2 EXEMPLARY REPORT OF INVESTIGATION

The structure of a typical report of investigation and its substantive content is mainly dependent on the reason of its development as well as on who is ordering. It's possible, however, to mention a few points that appear in most studies. These are the analysis of the circumstances of the fire, the fire inspection, determination of the location and the most likely reason of the fire. Opinion presented below relates to the fire of two production-storage buildings located within one property.

The report was prepared on behalf of the insurance company and its aim was to determine the likely causes of the fire, determine violations of fire protection having an impact on appearance and increase of the damage and to estimate the quantity of combustible material that was burned during the fire.

The insurance company suspected that the amount of material, which burnt according to the statement of the owner was too high and thus it was an attempt to defraud the financial compensation.
The expert developing this report was an officer of the State Fire Service and the court expert in the field of fire protection.

The report of investigation was based on materials provided by the customer (application for the financial compensation, factory documentation specifying the amount of products stored at the site of the company at the time of fire occurrence), the outcomes of an inspection carried out by an expert and the information obtained during the inspection from the owners and employees. Inspection was carried out four days after the fire.

4.2.1 Analysis of the circumstances of the fire occurrence

The fire was spotted by a driver passing the nearby road. Fire brigade was alarmed about the fire just a few minutes after midnight. The interview with the first commander of the firefighters indicated that at the time when the fire brigade came, a higher building was burning. Firefighters opened the gate and entered the lower house. As there was a high temperature inside, forcing firefighters were forced to withdraw. After some time the fire moved to a lower building. Fire-fighting lasted totally about six hours. The security guard employed in a facility testified that in the initial stage of a fire he spotted some flames in a higher of two buildings just next to the wall adjacent to the lower one.

The owner reported that the higher building was exploited as a grocery store. Inside there were some refrigerators and cooling racks working. In the morning hours the staff brought into the store some poultry meat pieces. The second object was used as a production-warehouse associated with the production and storage of traditional candles. Production in this part of the property had not been carried out for some time, and a week before the fire the store was closed and no one entered it.

4.2.2 Visual inspection of the scene of an incident

Visual inspection of the scene of an incident was made four days after the fire. At the time of inspection the photographic documentation by a digital camera was made.

The pictures taken show, that:

- there were two warehouses located within the property,
- these were the buildings of varying heights,
- the roof structure of the lower building was significantly stronger damaged,
- inside the higher building some burned cooling devices were seen (Fig. 4.1, Fig. 4.2),

Fig. 4.1 Burnt refrigeration appliances and the roof structure

Fig. 4.2 Burnt refrigeration appliances and the roof structure

- on the floor of the lower warehouse some burnt cardboard boxes and destroyed equipment were seen (Fig. 4.3)

Fig. 4.3 The interior of the lower warehouse

4.2.3 Determination of the reason and location of fire

According to information provided by a security guard the first signs of burning were noticed in the upper of the buildings, at the junction with the lower one. In addition, the first head officer of the fire brigade troops said that after the entry into the lower building through the gate the flames were not visible but the high temperature of the air was felt. According to the expert opinion observation indicates that the initiation of combustion had place in the upper house.

As the reason of a fire an expert considered one of the following factors:

a) accidental starting a fire

The term “accidental starting” means a unintentional triggering of a fire resulting from human inattention or error. The most common initiators of such fires include cigarette butts, smoldering matches, improperly performed renovations using torches, grinders, etc. According to a statement of the building owner production process in this part of the property had not been carried out for some time, and a week before the fire the store was closed and no one entered it. This statement eliminates the possibility of accidental triggering of fire inside the building for candles’ production and storage.

The owner of the building reported that some poultry meat was brought into the food warehouse in the day of fire, between 8 a.m. and 10 a.m. hours. This means that between the presence of people inside the store and noticing of fire passed from about 17 to 19 hours. In the opinion of an expert such a period of time was too long to consider the possibility of accidentally leaving the initiator and thus eliminate the accidental initiation as the reason of the fire.

b) setting a fire

Immediately before noticing the fire, the building was closed. Intervening firefighters opened the entrance gate of lower storage. In the rear wall of the higher building there was a barred window that could be used as a possible way to provide a fire starter. On the frame of the window there was no evidence indicating the existence in this area particularly strong thermal damages suggesting the presence of any liquid intensifying the burning process. In addition, the window was located high enough above the ground level of the surrounding area. Any hypothetical offender would have to move a fire starter through the window bars, which must lead to the destruction of the window frame. Based on the deduction, an expert ruled out setting a fire as the reason of the fire.

c) emergency status of wiring or electrical devices

Fig. 4.4 Burned floor and roof structure of the attic

During the inspection of the fire some disproportion in the grocery store thermal damage was observed. The strongest damage in the warehouse was visible next to the wall adjacent to the candle store. Wooden ceiling has totally burned over this area (Fig. 4.4). After the fire, just below this area, one of refrigerating devices was found, that had been moved from its original location (Fig. 4.5).

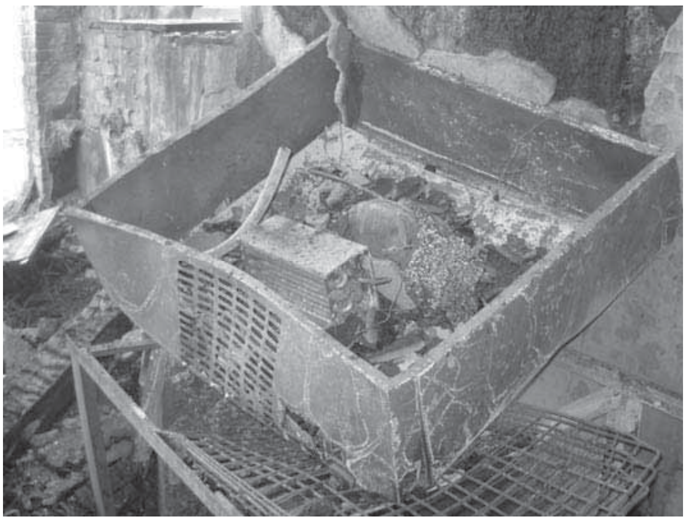

Fig. 4.5 Refrigerating appliance in a place of fire outbreak

The presence of the strongest signs of thermal damage just in the close neighborhood of electrically powered refrigerating device, working before the fire provides a basis for consideration the emergency operation of this unit as the direct cause of the analyzed fire.

4.2.4 Estimation of the quantity of the combustible material burned

The victim provided a list of materials stored in the burned warehouse. The first list presents the results of physical counting carried out about three months before the fire. The second list is a list of the census completed just immediately after the fire. The documentation did not allow the precise assessment of paraffin wax content in the products. Amount of paraffin possible to identify and volume of packages are presented in the Tab. 4.1.

Tab. 4.1 Amount of paraffin accumulated in specific products

Assortment	Quantity [pcs]	Weight [kg]	No. of packages	Volume [m^3]
Cylinder 140/95 candle	1020	1530	68	2,58
Cylinder 60/70 candle	321	57,78	2	0,089
Cylinder 60/90 candle	485	121,45	3	0,122
Twisted candle 23 different types	7788	389,4	26	0,0637
Candle - type 23	12200	610	41	1,55
Decorative sphere	1020	173,4	5	0,194
Big ball of daisies	1030	288,4	10	0,39
Small ball of daisies	2050	287	10	0,39
Lily candle	852	127,8	4	0,16
St. Nicholas candle	710	198,8	7	0,27
Rubella candle	1020	163,2	5	0,19
Table candle 10 pcs	1050	42	105	0,0798
Cone candle 30	34130	2218,45	114	4,32
Small cone candle decorative	1180	212,4	8	0,3
Paraffin wax for production of candles		82850	1381	132,56
Easter cone candle	865	138,4	5	0,18
Hare candle	420	117,6	4	0,16
Scented Candle 2230	1870	1498	62	2,37
Decorative Candle 60/90	458	114,5	3	0,114
Small sphere (ingot)	3810	609,6	25	0,97
Big sphere (ingot)	2520	428,4	13	0,48
Large daisy (ingot)	1600	448	16	0,6
Small daisy (ingot)	850	119	4	0,16
Totally		92743,58		148,2925

In addition, there were some semi-finished products accumulated on the stock, presented in Tab. 4.2.

Statements of Tab. 4.1 were carried out based on the assumption that the density of paraffin is 813 kg/m^3, and candles were packaged in individual containers in the maximum amount provided by the owner.

Statements of Tab. 4.2 were made with the assumption that the paraffin density is 813 kg/m^3, and the calculated volume was only the volume of the raw paraffin itself.

Tab. 4.2 Amount of paraffin accumulated in specific semi-finished products

Assortment	Quantity [pcs]	Weight [kg]	Volume [m^3]
Table candle (ingot)	18250	730	0,9
Twisted candle type 23, (ingot)	23300	1165	1,43
Candle type 30 (ingot)	18900	1228,5	1,5
St. Nicholas candle (ingot)	3200	896	1,1
Lily candle (ingot)	2100	315	0,39
Rubella candle (ingot)	1950	312	0,38
Totally		4646,5	5,7

Summing the quantities given in tables follows to the conclusion that before the fire at least 97,390.08 kg of paraffin was accumulated on the stock, and the size of the products was around 153.99 m^3.
In fact, the volume of products provided by victim would have to be higher, because many of the items on the lists could not be identified (no detailed information as to the quantity of paraffin, wrapping, etc. provided).

Estimation of quantities of materials burned during a fire might be done by determination of the mass burning rate. In order to determine the correct mass burning rate of the substance of the four types of paraffin candles, the sample of 200 g of paraffin wax were taken. The sample was placed in a metal box with a diameter of 8.5 cm. The can was placed on a hot plate of electric stove and heated. After melting of the material the heating process was continued, trying every 5 minutes to ignite the vapors above the liquid surface. The time period from ignition to completely burn of paraffin substances was measured and obtained 2h 8' 34'' = 128.57 min. As the surface of the burning material was equal to:

$$\pi d^2/4 = 3.14 \times 0.085^2/4 = 0.00567 \text{ m}^2,$$

thus, the specific mass burning rate of paraffin was equal to:

$$V_m = m/t \cdot F = 0.2/128.57 \cdot 0.00567 = 0.274 \text{kg/m}^2 \cdot \text{min}$$

The expert pointed out that the value determined above was higher than the real one, or that one observed during the fire, because during the experiment the paraffin was heated up only from below.

Since the fire was noticed until it was put out about six hours passed. This is the maximum time period during which burning of paraffin accumulated in a warehouse could happen. These assumptions determine the maximum (theoretical) amount of wax that could be burned in a fire. These conditions are true for ideal combustion, when burning is not limited by any quenching action carried out or shortage of oxygen provided to the combustion zone. In fact, these conditions do not occur in reality and this means that in fact the amount of wax which could be burned was less than that calculated below. The largest mass of wax - M, which could be burned in the fire can be estimated with the following assumptions:

- melted paraffin substances spilled over and burned on the entire surface of the warehouse (the area occupied by the equipment of warehouse is not included),
- burning is a process continuing evenly from the very initiation of event up to total extinguishing by the fire department (the impact of firefighting to slow the combustion process and the gradual reduction of the surface of the firing is not included).

Using paraffin mass burning rate calculated earlier one gets:

$$M = V_m \cdot t_p \cdot F_p = 0.274 \cdot 360 \cdot 140.1 = 13819.46 \text{ kg}$$

Burnout of such a mass of paraffin means that at the place of fire it should still remain at least 83,570.62 kg of this substance. That amount of wax should fill 102.79 m^3 or spill over the surface of the warehouse on the height of 0.73 m. The value of the mass burning rate of paraffin substance adopted for calculation had not been designated for a real material that occurred in an actual fire. However, as substrates used in the manufacturing process of candles have very similar physic-chemical properties, the value of the relevant mass burning rate of the material contained in the fire should not differ more than 10% from the value determined in experiments. Having regard to the amendment it can be stated that during the analyzed fire could not be burned out more than 15,201.41 kg of paraffin. Considering the above amendment, in the stock should still remain after the fire, at least 82,188.67 kg of paraffin. That amount of paraffin would take 101.09 m^3 of volume or spread over the entire surface of the lower warehouse on 0.72 m of height.
The next photographs, Fig. 4.6 – Fig. 4.7, illustrate the view of the place of fire at the time of inspection.

Fig. 4.6 Wooden transportation pallets

As it was reported by a victim, at the locations shown in the pictures, referred earlier paraffin products were stored. Burning of paraffin should cause severe charring of wooden pallets shown on Fig. 4.6. In the opinion of an expert, after the analysis of the pallets' condition, it was absolutely not possible that the burning of liquid paraffin could take place at the site of pallets.

Fig. 4.7 Equipment and appliances of the warehouse

Fig. 4.8 Beverage storage site after a fire

The victim also reported the destruction of the beverage contained in the grocery store. Calculations of the amounts of beverages specified by the victim showed that, in the warehouse should be stored about 5,158 m^3 of liquid substances, primarily water. According to the expert's opinion, such quantity of water must have had an impact on the development of fire (burning would have been limited). In addition, on the stock should remain at least 2,320 pcs. of glass bottles. Such an amount of bottles is equal to 774.4 kg of glass. Beverage storage sites with bottles found during the inspection are presented in Fig. 4.8 – Fig. 4.9.

Fig. 4.9 Beverage storage site after a fire

In the author's opinion it was absolutely impossible that in the area shown in Fig. 4.9 were stored any liquid beverages.

4.2.5 Fire safety and fire protection assessment of the burnt buildings

From the submitted documents, collected and used to prepare the expert's opinion could be deduced that as a result of fire were damaged two adjacent buildings. The first building was a warehouse with 256 m^2 of floor space and cubature of 1,500 m^3. The second building was a single story building with a floor area of 140.1 m^2, and 770 m^3 of cubature. Between these two objects, there was no fire separation, which means that these buildings were treated as one, singular and not separable fire zone.

The victim reported that none of these buildings did not meet the requirements for the development of fire safety instructions. The obligation of equipping facilities in fire safety instructions is governed by provisions of legal regulation, (Regulation, 2010). Following the rules of the mentioned regulation the fire safety instruction was required for the larger of the two buildings, and because both building constituted one inseparable fire zone - both should be covered by such a document.

Later, in the presented opinion a fire load density analysis (PN-B-02852) could be found, which is a basic parameter characterizing the requirements for the production and storage buildings due to the Polish law.

Fire load density has to be calculated from the formula given below (PN-B-02852):

$$Q_d = \sum_{i=1}^{i=n} \frac{(Q_{ci} \cdot G_i)}{F}$$

where

n – number of different sorts of materials,

Q_d – fire load density; [MJ/m^2],

Q_{ci} – heat of combustion for material „i”; [MJ/kg],

G_i – weight of material „i”; [kg],

F – floor area of the room, fire zone, storage, etc.; [m^2].

Initially established requirements for fire resistance of both buildings limited the maximum acceptable value of fire load density at the level of 500 MJ/m^2 what means, that it was a maximum and limited amount of material that could be stored in these facilities. In the case of paraffin wax having a calorific value of combustion heat equal to 62 MJ/kg, the weight of the stored substance in both buildings could not exceed totally 3194.35 kg, assuming that simultaneously in none of both buildings could not be stored other combustible materials, increasing the fire load density.

Exceeding the permissible value of the fire load density (what means exceeding the allowable weight of combustible materials stored) would increase the possible damage. In such a situation fire produced much greater amount of heat, which of course affected the technical state of the analyzed buildings.

4.2.6 Conclusions from the investigation

The presence of the strongest signs of thermal damage just in the close neighborhood of electrically powered refrigerating device working before the fire, provided a basis for consideration the emergency operation of this unit, as the direct cause of the analyzed fire.

Information provided by the victim did not allow for precise determination of amounts of combustible materials present in both buildings before the fire.

Estimation of the amount of combustible material that should remain in the place of fire was developed by adopting the most favorable assumptions for the victim.

Considering all the collected data it was calculated that on site it should still remain after a fire at least 82,188.67 kg of paraffin. That amount of wax should fill the volume of 101,09 m^3 or spill over the surface of the warehouse on the height of 0.72 m. The view of the place of fire seen in Fig. 4.6 definitely excludes burning of paraffin wax in this area.

Adopting the assumptions which were the most favorable from the victim’s viewpoint, during the fire it could burn out maximum 15,201.41 kg of paraffin wax. This was far too much than formally could be stored inside the building. In this case the limit value was exceeded nearly five times. Exceeding the permissible value of the fire load density (what means exceeding the allowable weight of combustible materials stored) affects the range of the possible damage. In such situation fire produces much greater amount of heat, which of course influenced the technical state of the building after fire.

Besides, calculations of the amounts of beverages specified by the victim showed that, in the warehouse should be stored about 5,158 m^3 of liquid substances, primarily water. According to the expert’s opinion, such quantity of water must have had an impact on the development of fire (burning would have been limited). In addition, on the stock should remain at least 2,320 pcs. of glass bottles. Such an amount of bottles is equal to 774.4 kg of glass. When looking at Fig. 4.9 it makes quite clear that it was absolutely impossible that in the area shown in the picture were stored any liquid beverages.

The detailed analysis of the presented case showed, that the building owner was guilty of two misdemeanors. On one hand he was using the building in an improper way, inconsistent with the basic principles of fire safety, on the other hand - giving overestimated data on stored products - tried to mislead the insurance company in order to obtain higher financial compensation.

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5 RESCUE OPERATIONS IN POLAND - GENERAL DESCRIPTION AND EXAMPLES

Summary

This paper presents the course of fire and rescue action during a fire in a hotel building near Warsaw. A fire occurred in January 2011. The property affected by fire is a four-story building with a meeting room for 50 people, catering facilities on the ground floor, and three floors of hotel rooms above. In the fire-fighting action, which lasted more than 10 hours, were involved 80 fire-fighters, 24 fire vehicles and a total of 11 police officers and emergency workers. The hotel's owner estimated the loss at about 1 million PLN. The value of saved property was estimated as 8 million PLN. There were no any casualties among fire-fighters or other victims.

Due to the significant financial damage and the fact that every fire in such facility carries a serious risk to occupants of the building, the operational services of the State Fire Service (PSP) carried out an analysis of the event. That analysis went beyond the typical report - "the information from the event" drawn up after each action (see attachment). This document is supposed not only to assess the efficiency and quality of operations but is also used as training material in other units of the State Fire Service.

The paper presents an analysis of the course of events and activities carried out based on documentation prepared by officers of the State Fire Service.

5.1 GENERAL BUILDING DESCRIPTION

The considered object is a four-storey, detached building located on the main street in the Warsaw suburb of nearly 38,000 city residents. The building is used as a hotel, the first floor is designed in two dining rooms and kitchen facilities, other stories are part of the hotel with single, double bedrooms, and rooms for 3 persons, with the total of 56 rooms for 105 people. The building was built in the traditional way: brick walls with a timber roof structure covered with tile. The building was constructed on a rectangular plan measuring approximately 48m x 20m.

5.2 REASON OF INITIATION OF FIRE

The fire was spread from the arbour (beer garden), attached to the restaurant on the south side. No definite cause of fire was determined. The possible causes are either intentional or unintentional human activity or the failure of the electrical system.

5.3 DESCRIPTION OF FIRE DISASTER

5.3.1 The observation and notification of the event

The facility was guarded around the clock by the front desk clerk and security company responsible for burglary monitoring. In addition, the building was equipped with fire alarm (smoke detectors, manual fire call) connected to the fire monitoring system which did not work on that day. The passer-by, who noticed the fire in the beer garden adjacent to hotel informed the police at 23:17. It was found that the late noticing of the fire in the building was due to failed panel in the fire system. Due to the late hour, few passers-by were present on the streets that could spot the fire. A Duty police forwarded the information to the on duty unit of fire-fighters, which immediately launched a procedure for alerting and disposal. The first units reached the place from the distance of about 1km at 23:20.

5.3.2 Technical conditions and weather

The hotel had provided a total of eight emergency exits. At the time of the fire, the evacuation was carried out through four permeable marked emergency exits. A fire hydrant was originally located, directly at the hotel, at approximately 20m, on the corner of adjacent streets. As a result of the street renovation works the hydrant was closed, but this fact was not communicated to the local Command of PSP. Also the land development plan was not agreed with PSP administration.

Recent activity control and reconnaissance were conducted in 2006 (before the street renovation). The inspections of hydrants were carried out in the city, however in the areas where they were no renovation and modernization of squares and streets. As a result of checks carried out in June 2008, a letter was sent to the Mayor of the City showing the irregularities and asking for a meeting to discuss in detail the audit results. Such a meeting was held in July 2008 and then in March 2009, the Department of Water and Sewage sent to KP PSP minutes of inspection and maintenance of fire hydrants, with the statement that the inspection, maintenance of fire hydrants, and replacement of damaged with a new is done on a continuous basis.

During the fire water, the supply was carried out by setting down ground water from fire hydrants located within a radius of up to 500m, and using a pump station located at a distance of 1000m (tank) because of the speed of filling. The event took place on a clear night: moderate wind blew from varying directions, the air temperature was about 30 °C.

5.3.3 Fire-fighting course

At the moment of arrival at the scene of the first fire brigades, the fire was covering a part of the roof structure. There were people directly exposed to fire, and standing at the windows on the third and fourth floor. At that moment the fire covered the area of approximately 50 m^2 and the total volume of approximately 150 m^3 of the roof of the building. The spread of the fire posed a direct threat to the lower floor and the rest of the roof. The hotel staffs were not able to determine the exact number of evacuated people. In such situations, the regular procedures include the need to search through all the rooms. The shift commander forwarded the information to the commanding unit (PSK) about the need to evacuate other guests, about rapid spread of the fire in the roof of the building, and asked for disposal of additional forces and resources. In the first phase of the fire there was a very big threat to the lives of people in the hotel rooms because of the large horizontal and vertical smoke evacuation routes in the absence of the warning, caused by the failure of the fire alarm system. Due to the large smoke spread in the building, most of the guests stayed in their rooms. Standing in the window called for help. Using attached and caps ladders, starting from the most vulnerable areas, the threatened people were evacuated. At the same time rescuers equipped with respiratory apparatus were let inside the building to search the premises and to evacuate other guests. Upon arrival at the place of action of the hydraulic lift and of another requested unit, the extinguishing current was given at the burning attic. After arrival of the next unit, the commander of the action instructed to give two currents of water (one at the front of the loft, the other on the burning arbour, adjacent to the exterior walls), see Fig. 5.1. In addition, an extinguishing line was set at the front of the building to carry out activities inside the hotel. Two extinguishing lines were introduced into the building with the intention of reaching out to the burning rooms on the fourth floor of the building. Due to the problem with hydrants nearby transportation of water supplies was required. Next arriving units provided water currents to the top of the building from the south west. Extinction of the roof fire was conducted from outside of the building using lifters. Due to large smoke spread in the building and due to the need for frequent replacement of SCBA cylinders the commander of the action KDR (head of rescue operations) ordered a special car, with a supply of compressed air cylinders, and a device that allows filling the cylinders at the scene. At the time of 0:46 the commander of the action concluded that the fire was localized (is not spreading). At the most critical moment of the action, the fire extinguishing units used eight currents, Fig. 5.2. Once the fire was extinguished most of the units were released to their premises and only two local units were left to control and quench the burnt.

In accordance with the procedures the place of the action was transferred to the owner using written protocol, in which the obligation was imposed to provide adequate security at the scene with particular emphasis put on the following recommendations:

- Conduct around the clock supervision of the burnt.
- Make the dismantling of structures under fire.
- Inform local commander of PSP about any re-ignition.

The Action was completed the next day at 9:39.

5.4 WAY OF INTERVENTION BY FIRE-FIGHTERS

Due to the rapidly growing fire and the threat to the people staying in the hotel, in the first phase of the action a decision was made to evacuate people using ladders, socket bit, and with the use of horizontal and vertical evacuation routes. Then the fire-fighters proceeded to divide the area into sections, to organize water supply, and started the liquidation of fire, see Fig. 5.1.

5.4.1 The use of emergency equipment and extinguishing agents.

For the course of action particularly important was to use appropriately the ladders, mechanical and hydraulic jacks. Using wood saws and demolition equipment the units get access to the rooms to check them out and quench any hotbeds of fire. Also a hole in the roof was made as a belt separating and preventing the spread of fire to another wing of the building. The lifters were used due to the development of fire on the fourth floor and due to the limited access to the corridors. The light poles, supplied with the fire trucks, were used to illuminate the area of the action. Due to the large number of respiratory protective devices used during the action at the scene, a car specially equipped, was used to fill the cylinders with air for rescuers on the scene. In the first stage of the action water in the tanks of vehicles was used but due to the lack of hydrants in the vicinity of the hotel and therefore insufficient supply in the scene, a system of fares and disposals tanks was used to refill water shortages. The water was supplied from a hydrant, located in the local Department of Water and Sewerage about 2 km away from the fire area. To deliver water four cars and a tanker GCBM 25/16 (tractor-trailer with 25m^3 of water) were used.

Rescue cushion was not used because of:

- the lack of the spacing due to the specific design of the building (sheds, outbuildings associated with the building);
- the ladders were used as a method more appropriate for the safety and speed of the evacuees;
- the practice of using rescue cushions shows that there are often minor injuries and even fractures;
- manufacturers of rescue cushions recommend their use in the evacuation of the intervention as the final form of saving human lives.

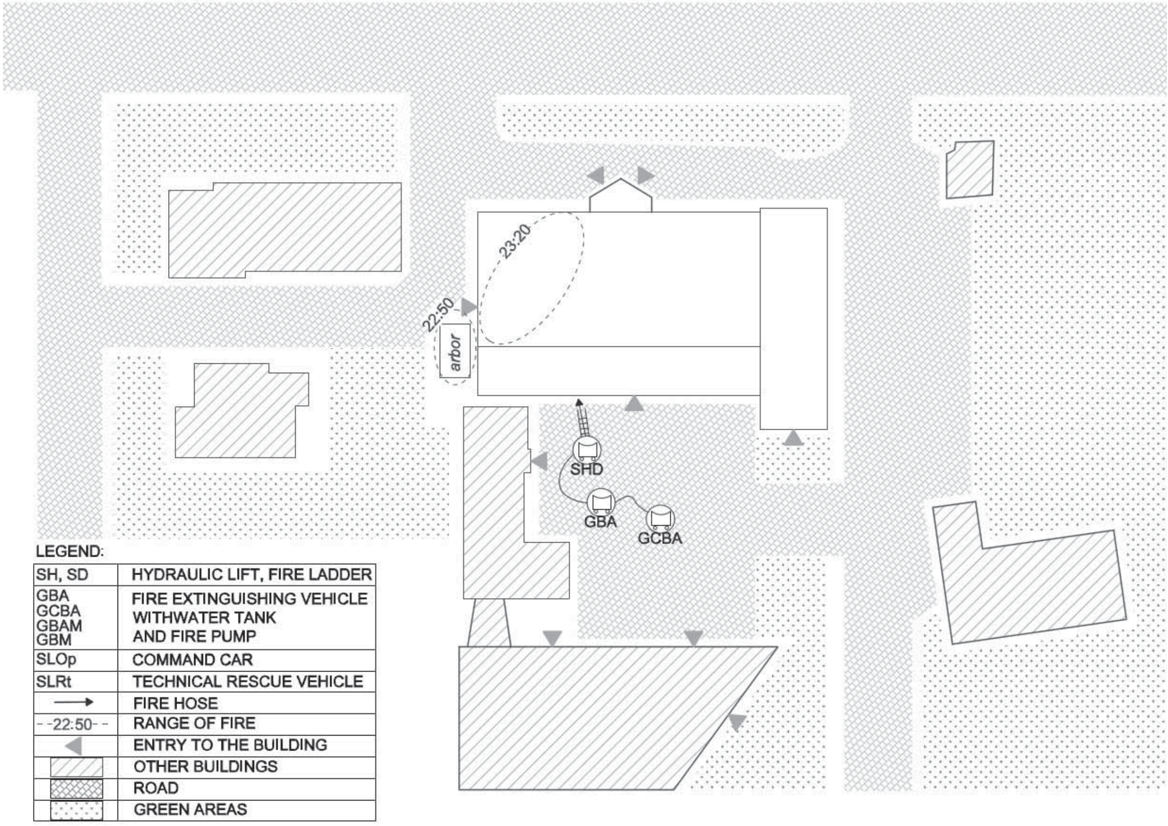

Fig. 5.1 The sketch showing the plan of the first phase of the action

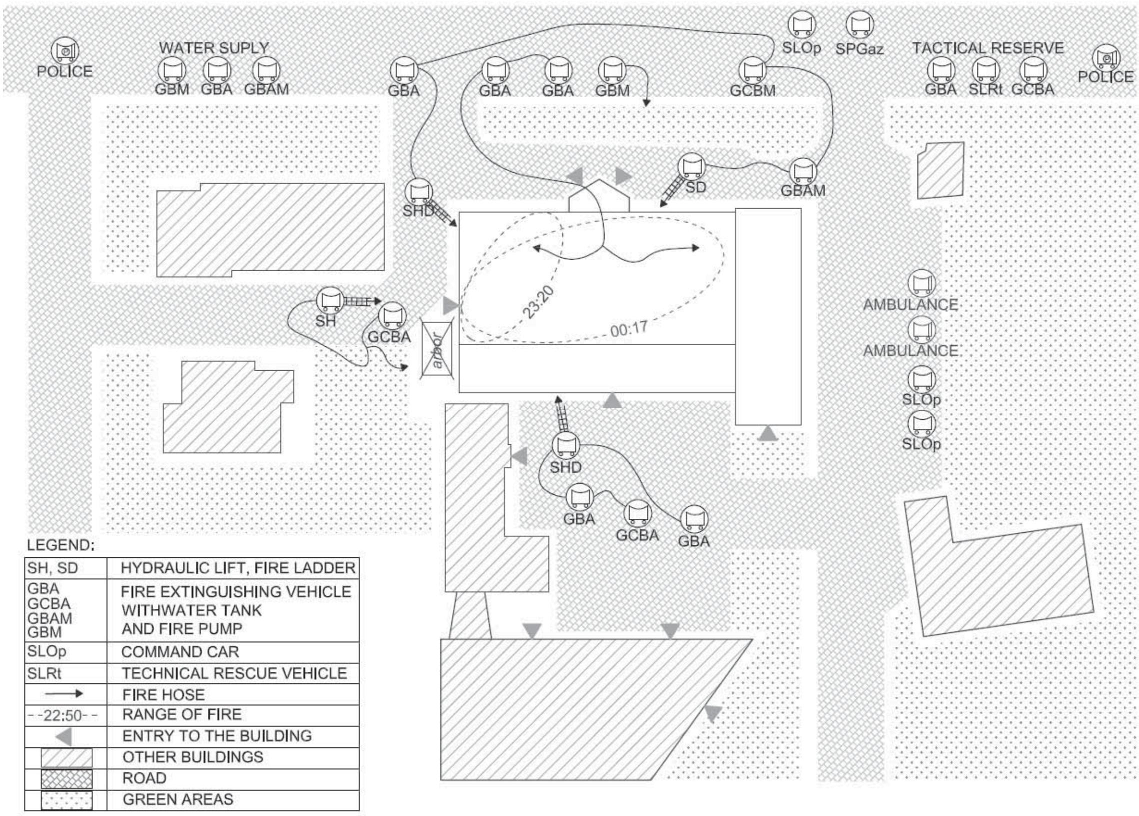

Fig. 5.2 The sketch showing the plan of the second phase of the action

5.4.2 Interaction with other units

In addition to the PSP and Volunteer Fire Brigades (OSP) to the scene of the action came:

- Police (arrived without call) whose activities consisted in securing transport to the fire scene - 2 cruisers (4 people) and commanding the traffic to the scene.
- Ambulance - 2 teams (7 people), which were collateral for the in the event of an accident.

5.5 CONSEQUENCES OF FIRE

The fire was in the arbour (beer garden) adjacent to the building. The arbour was made of timber frame construction with a covering of wooden boards and shingle. Built-up area of the arbore was of about 20 m^2. The building was attached to a wooden beam supporting the roof structure of the arbour which was completely burnt. The wall of the building, along which the fire spread to the attic wasteland, was a brick wall made of 24 cm ceramic brick, Styrofoam with a thickness of 10 cm, on which textured plaster was laid with fiberglass grid. In the initial phase of developing, the fire which originated in the so-called beer garden, spread over the wooden structure of the roof and a wooden floor. Next the fire spread to the wooden construction of the roof, over the facade of the building insulated by polystyrene plates. There was the rapid spread almost all over the wooden roof structure. Eventually, the fire took covered area of 700m^2 (1900m^3).

5.6 CONCLUSIONS

It was found that the walls dividing the rooms were made using lightweight construction method with the wall structure made of fire-resistant drywall on both sides arranged on a steel structure filled with mineral wool with a thickness of 1 cm. It was not confirmed by the documentation. The issue of bringing the full technical efficiency and the missing fire hydrants on water mains were addressed again.

5.7 RECOMMENDATION (changes in fire and safety engineering projects and structural engineering projects)

The legal action will be taken for liquidation of the hydrant.

<u>References</u>

Komenda Wojewódzka Państwowej Straży Pożarnej w Warszawie, Wydział Operacyjny, „Analiza zdarzenia pożar hotelu (...)“, Warszawa, maj 2011.

<u>Attachment</u>

INFORMATION FROM EVENT No: xxxxxxx-xxxx

GEOGRAPHICAL COORDINATES : longitude =xx° xx' xx,xx"E latitude =xx° xx' xx,xx"N

TYPE OF EVENTS : Fire - large

COUNTY : /Xxxx/
ADDRESS : /Xxxx/, ul. /Xxxx/ **PROPERTY :** Hotel /name/
OWNER : /Xxxx/
CLASS OF THE OBJECT : 111. Other public facilities
OWNER CODE : 620. Corporation ownership

NOTE : xx-01-2011 23:17
APPLICATION TO RESCUE ENTITY : xx-01-2011 23:17
ARRIVAL OF THE FIRST RESCUE UNIT : xx-01-2011 23:20
LOCATION : xx-01-2011 00:46
REMOVAL : xx-01-2011 09:39
RETURN OF THE LAST RESCUE UNIT : xx-01-2011 09:46
TOTAL DURATION OF ACTION : 010:29
THE FIRST RESCUE UNIT ARRIVED FROM THE DISTANCE : 1km.
THE EVENT NOTICED BY : employee or resident;
THE EVENT REPORTED : by phone;

PARTICIPATION IN RESCUE ACTIVITIES:

Fire fighting units	vehicles	people	Other services	vehicles	people
SFS	12	29	Ambulance	2	7
VFS w KSRG	8	30	Police	2	4
VFS Others	4	21			

Including SFS special	vehicles	people	operating	vehicles	people
				1	2

EQUIPMENT USED IN RESCUE ACTIVITIES:
Fire Protection Units
- Extinguishing vehicles: medium=11; large=4;
- Special vehicles : SD=1; SH=3; SRT=1; SPGaz=1; SOp=2; Others=1;
- Other units ambulances =2;

SFS units from outside the county = 5 VFS units from outside the county = 12
TYPE OF RESCUE ACTIVITIES: 1. Administration of extinguishing means on the offensive; 2. The administration of extinguishing means in defense; 6. evacuation of people; 10. Securing the scene; 13. Demolition of building structures; 18. Opening of premises; 19. Smoke removal, ventilation;
31. Transportation, water supply for fires;
ACTION EQUIPMENT USED FOR THE ACTION: 2. Pop demolition equipment; 4. Conventional fire pumps; 13. Respiratory protection devices; 17. Portable ladders; 18. Mechanical ladders, lifts ; 19. Mechanical saws for wood cutting; 23. Lighting;
PLACE OF RESCUE OPERATION : 2. Inside the buildings on the ground floor; 3. Inside objects on the floors 1-3; 6. On the roof, attic;
EXTINGUISHING MEDIA USED, WATER SUPPLY :
Xxxx water currents = 8;
Amount of used water = 80 m3;
Amount (in m3) of water used from external hydrants (50);
PROVIDING ASSISTANCE : Evacuated from the danger zone = 15;
SIZE OF EVENTS : area = 700 m2; volume = 1900 m3

PRESUMED CAUSE EVENTS
Undetermined CODE : 37. Undetermined

COMMANDER OF THE ACTION: / listed /

COORDINATION OF THE MEDICAL RESCUE ACTIVITIES:
DESCRIPTIVE DATA TO INFORMATION FROM EVENT:

1) The unit of SFS xxxxxx received telephone notification: first about the damaged of the control panel and next about the fire on the hotel's arbor xxxx.. The units of JRG xxxxxx were disposed to the place of the event. After arriving at the place it was found that burning are the arbor and loft of the hotel. In the rooms there were people directly exposed to fire. Rescuers at the same time attempted to extinguish the fire and started evacuation through the emergency communication waysa nd using ladders attached to the windows of the building. There were 44 guests and 10 members of staff, all of them managed to leave safely the building. During the action the hotel rooms were searched. The scene of action was divided into battle sections to which was coming next units were directed. Extinguishing water currents were used in the internal and external attack and in the defense. Introduction to the action of hydraulic lifts, ladders, and tank trucks had a direct impact on the fast location of the fire. After the location of the phase of quenching and ventilation of rooms began. Several units were set to monitor the conflagration.

2) The units of VFS arrived on the scene: /listed/
3) To the place arrived: /listed/
4) On the scene arrived WSKR task force composed of: /listed/.

After the end of the action the Deputy of JRG passed the responsibility of the burnt to the owner based on the written protocol. In the area of burnt there is investigation conducted by forensic investigator, the prosecutor and the police. During the action, 11 hoses were destroyed (5 hoses W-75, 6 hoses W-52).

INFORMATION REPORTED BY: / listed / DATE xx-01-2011
INTRODUCED TO BASE : / listed / DATE xx-01-2011 06:55

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Laia Haurie

Eduard Caimel

6 COLLABORATION WITH THE FIRE BRIGADES OF CATALONIA TO DEFINE NEW PROTOCOLS TO COLLECT DATA FROM A FIRE

Summary

We present an example of organization and method of operation of the fire brigades in a Spanish region, the autonomous community of Catalonia. First, we briefly describe the current protocols of data collection and their statistical analysis. In particular, we discuss some annual statistics in the city of Barcelona. Then, we present an example of collaboration between the *Technical University of Catalonia* and the fire brigades. We expect it contributs to a better definition of the data collection protocols in case of fire.

6.1 PROTOCOLS AND STATISTICS

6.1.1 Fire Brigade organization in Catalonia

Spain is divided in 17 regions, called "Autonomous Communities". Catalonia is one of them. Catalonia covers an area of 32114 km^2 and has a population of aprox. 7,5 million. The autonomous government of Catalonia (*Generalitat de Catalunya*) has exclusive competence over civil protection (regulation, planning, and coordination), including fire prevention and fire-fighting services. The city of Barcelona, with a surface 100 km^2 and a population of 1.6 million, has its own fire brigades (BombersBCN). They depend on the city council. The *Fire Brigade of Catalonia* (BombersCat) covers the rest of the territory. Whereas in Barcelona the actuations of the fire brigades are of urban type, mainly associated with fires in housing and incidents at the street, the tasks of Catalonian fire brigades are more diverse, including industrial or forest fires. They have developed general plans for civil protection and emergency response plans for particular risks. For example there is *INFOCAT* for forest fires, *PLASEQCAT* for Chemical emergencies or *SISMICAT* for earthquakes.

The protocols of the *Fire Brigades of Barcelona* include the elaboration of technical reports that contain:

- Data of the service: type (fire, rescue,...), call-out time and arrival time, human and material resources
- Characteristics of the service when firefighters arrive and evolution
- Development of the service

- Causes
- Damages and affected persons.

The *Fire Brigade of the Generalitat de Catalunya,* in addition to the current collection of data for statistical purposes, has recently started the development of an incident research system with the objective of creating a database containing information about real fires. This incident research system is called “SIS” (*Sistema d’Investigació de Sinistres*) and is based on *NFPA-901:2006 Standard classifications for incident reporting and fire protection data*. The reports will include detailed data about fire growth and spread:

– Flame development: identification of materials and factors that contributed to flame propagation
– Smoke development: materials involved and avenue of smoke propagation
– Weather information.

The protocol is nearly finished and the computer interface is currently being developed.

6.1.2 The case of the city of Barcelona

Barcelona is a good example of the situations that can happen in a big city, with about 85,000 buildings and 760,000 housing units. We have therefore considered of interest to present in this section some statistical results. These statistics have been performed by the fire brigades from their reports and collected data.

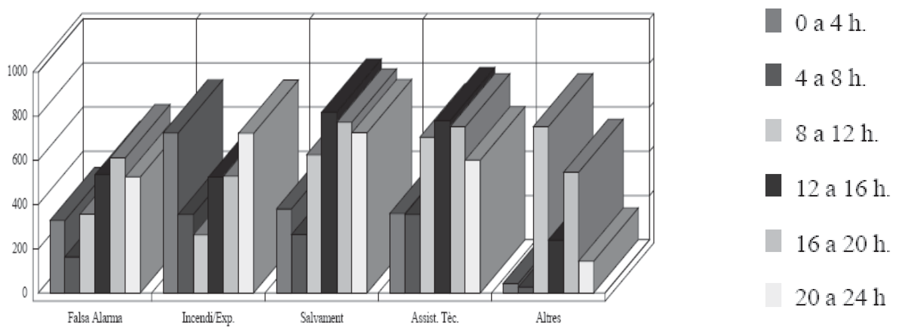

Fig. 6.1 Number of fire brigade interventions in Barcelona, in one year, classified by the time of day and the type of action (false alarm, fire&explosions, rescue, technical assistance and other)

Tab. 6.1 Annual statistics of fires in Barcelona by the 10 city districts

District	inhabitants	km^2	Inhabitants/ km^2	Incidents (%)
Ciutat Vella	107,426	4.4	24,591	9.2
Eixample	266,874	7.5	35,696	17.4
Sants-Montjuïc	182,395	22.9	7,951	13.0
Les Corts	82,952	6.0	13,785	3.9
Sarrià-Sant Gervasi	143,911	20.1	7,162	7.7
Gràcia	123,383	4.2	29,479	6.8
Horta-Guinardó	171,186	11.9	14,329	6.7
Nou Barris	168,181	8.0	20,914	9.0

Sant Andreu	146,528	6.6	22,318	8.3
Sant Martí	228,701	10.5	21,732	18.0
TOTAL	1,621,537	102.2	15,872	100

In Fig. 6.1, the number of fire brigade interventions in Barcelona in one year, are classified by the time of day. It shows that 43.5% of fires happen during the night. Table 6.1 shows the percentage of fires corresponding to the 10 city districts. This is a very illustrative snapshot of the city, because it shows that the number of fires is not always proportional to the number of inhabitants. For example, *Ciutat Vella*, has only 22% more population than *Les Corts*, but it has more than twice the incidents.

Most of the fire brigade actions take place in buildings (43%) or in the road (51%), associated with vehicles or rubbish containers. 6% is related with forest areas, industry, warehouses, or others. In Table 6.2, the percentages of fires for the different type of buildings are presented. It shows that three out of four fires occur in housing. Finally, causes of fire are shown in Table 6.3.

Tab. 6.2 Annual statistics of fires in buildings in Barcelona, classified by the place where they took place

Fires in buildings Place	number	%
dwellings	1,151	75.9
public residences	24	1.6
administrative	51	3.3
hospital and medical	8	0.5
bars, restaurants and meeting points	95	6.3
educational buildings	22	1.4
commercial buildings	118	7.8
garages and parking lots	48	3.2
TOTAL	1,517	100

Tab. 6.3 Annual statistics of fires and explosion in Barcelona, classified by their cause

Fires and explosions Causes	number	%
Undetermined	1,121	35.9
Natural causes	4	0.13
Heating devices	126	4.0
Mechanical energy	75	2.4
Electrical energy	438	14.0
Naked fire	928	29.8
Chemical reactions	6	0.2
Other causes	421	13.5
TOTAL	3,119	100

6.2 THE DEVELOPMENT OF A PROTOCOL FOR FIRE RESEARCH

We can get some useful information about fires and risks from analysing statistical data. However, it is also of great interest to learn to learn from the detailed analysis of particular real fires in order to improve the knowledge of fire propagation. With this aim, a collaboration between the *Fire Brigades of Catalonia* and the *Technical University of Catalonia* was initiated some years ago. The analysis was limited to a few selected cases, for which a specific search for information was done (data about scenario dimensions and characteristics, openings, materials, timing,...). After this detailed information about the scenario was collected, the subsequent analysis, including the performance of numerical simulations, produced successful results.

Figs. 6.2 - 6.4 correspond to the study of a fire occurred in 2011 in a flat of about 80m^2 (Caimel, 2012). The fire started in the living room and spread to several rooms. From the fire-fighters' records it was possible to establish quite accurately the timing of the fire propagation and the main actions that affected its evolution, such as the opening of doors and windows. The study was developed in three main phases: the first was an on-site inspection of housing where the necessary data to simulate the accident was collected. Then, a series of CFD computer simulations were performed, using the software FDS (Fire Dynamics Simulator). Finally, results concerning the evolution of the fire were extracted.

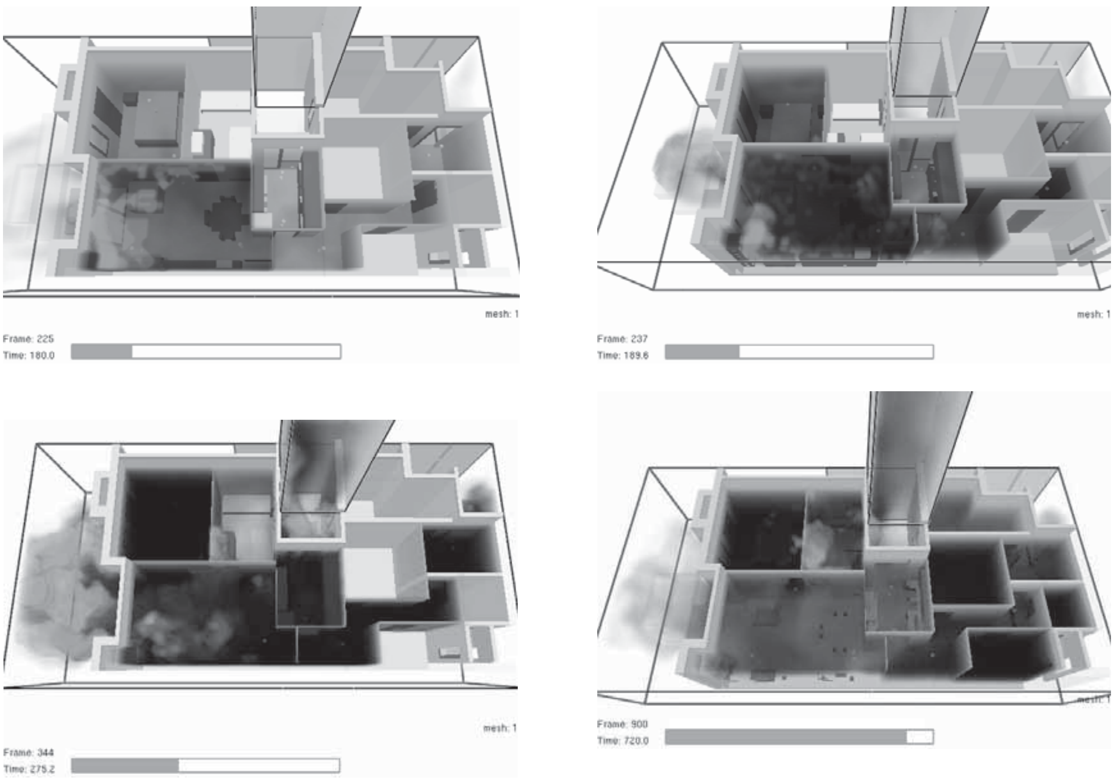

Fig. 6.2 Smoke and flames evolution

Fig. 6.2 show the simulated scenario and the flame and smoke distribution at four different times. This evolution agrees quite well with the real chronology. The comparison between the simulation results and the marks that the fire produced in the façade and the interior of the housing can be observed in Fig. 6.3.

Fig. 6.3 Comparison between simulation results and real fire

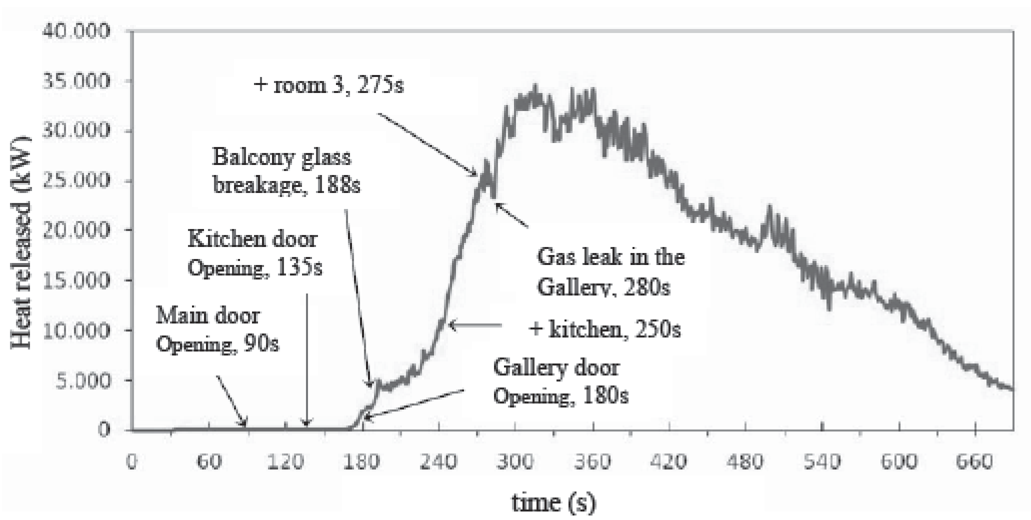

Fig. 6.4 Heat release as a function of time during the fire

Heat release is showed in Fig. 6.4 as a function of time. This evolution, as well as the results for temperatures, seemed to confirm the hypotheses and assumptions made about the real behaviour of the fire. In addition, it was possible to extract a lot of information about the influence of different factors. Similar results were obtained for other real fires that were studied in detail. However, except for this selected cases, the available information about real fires usually include the chronology of their behaviour, but only few details about fire evolution. An interesting goal would be to establish a new protocol of action to collect data in case of fire. In order to create this protocol, close communication between the research groups and the fire brigades would be desirable.

6.3 SUMMARY

The chapter summarises the protocols and statistical analysis performed by the fire brigades in the region of Catalonia (Spain). The collaboration between the University and the fire brigades is briefly described and illustrated by means of one particular example.

Acknowledgements

The authors would like to thank Miquel Rejat and Sebastia Massague from the *Fire Brigades of Generalitat de Catalunya* and Santiago Rovira from the *Fire Brigades of Barcelona*.

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7 SELECTED STATISTICAL DATA RELATED TO FIRE OCCURRENCES IN POLAND IN 2010

Summary

Some statistical trends related to the frequency of fire occurrences and appearing each year in Poland are presented and studied in detail on the base of the annual reports collected by the National Headquarters of the State Fire Service and accessible for publicity in the Internet without any restrictions. The data-set taken only from the one-year observation period, identified with the whole year 2010 time duration, is analysed and elaborated to obtain the illustrative diagrams enclosed to the article; however, all tendencies presented below seem to be typical and repeat each year in similar form under the analogous circumstances. Conclusively, the trends discussed in the article can be predicted to occur also in the future with suitably low uncertainty level.

7.1 DATA SOURCE AND OBJECTIVE OF THEIR ANALYSIS

The classical statistical analysis can be, in general, adopted as a well-justified research methodology, useful for the threats identification as well as for the reliable evaluation of potential risks levels for the case of unexpected event potentiality, danger to some people or some building structures. Such conclusion is highly accurate especially in relation to imminent fire occurrences, when, on the base of the accesible statistical data about the fires previously occurred, the prediction is being made, dealing with the similar fires, developing in the future under analogous circumstances. The most frequently the basic aims of such study are specified as follows:

- to look for the potential trends related to the frequency of the predicted fire events (if any),
- to determine the most hazardous time-periods, extracted from the whole time of the year duration.

Obtained results will be satisfactory, not only in quantitative but also in qualitative sense, only if the data being trusteworthy and homogeneously interpreted are examined and compared one to another. For this reason the best solution in this field is such way of data collecting when the examined data-sets are taken from only one but official source - municipal, regional or even governmental, if possible. In Poland the main data-base in which the basic statistical data are accumulated, related to the fires and also to the other natural calamities, is managed by the National Headquarters of the State Fire Service. Many of those data-files are in public domain and they are easily accesible, without any restrictions. Most of them are simply published in the Internet; however, those are only the numbers presentations, without any specialistic statistic elaboration. In the web-page collection prepared by the State Fire Service we can find mainly the annual reports with particular data given in tables also for each month and for each country province separately. Furthermore, the daily reports with the basic data are each day extra-displayed in the well-visible area of the home-web-page. The detailed structure and hierarchy of the analysed data-sets are shown in the tables presented below (Tab. 7.1 and Tab. 7.2). As we can see, not only the fire statististics but also the numbers of other fatalities occurred in Poland in considered region and in selected year (month) of analysis, connected to the various type of the indigenous hazards, are reported in the presented document.

The second group of cosidered data-sets deals with documentation of the false alarm signals registered each year (each month) by particular fire stations in Poland. All reported signals are divided into three groups:

- the malicious false alarm signals,
- the false alarms provoked in good faith,
- the false alarm signals registered from fire alarm system.

The next information given in the presented reports describes in detail the numbers of the firemen and of the fire appliances, taking part in all types of the firefighting actions as well as of other rescue services occurred each month in particular country districts (provinces). If we want to obtain the reliable evaluation of the real fire hazard level related to the selected country region and adequate for the given time-period chosen from the whole time of considered year duration, then the data giving the numbers of the dead and injured people, being the building occupants and also the firemen rescuing those people and their property, seem to be of the great importance and should not be neglected in the global safety analysis.

In the presented paper only the official data originated from the year 2010 and taken from the whole Poland area are analysed in detail.

Tab. 7.1 Fire types reported in the Polish State Fire Service reports

Fires (the first specification)	Small
	Medium
	Large
	Very large
Fires (the second	In public utility permises
	In flats
	In industrial permises
	In warehouses
	In transport facilities

specification)	In forests
	In cultivated areas
	Others

Tab. 7.2 Other fatalities reported in the considered reports

Indigenous hazard (the first specification)	Small
	Local
	Medium
	Large
	Calamity
Indigenous hazard (the second specification)	Exceptionally strong winds
	Flood water rises
	Exceptional rainfalls
	Exceptional snowfalls
	Chemical
	Ecological
	Radiological
	Medical
	Building
	In municipal (comunal) infrastructure
	In road communication
	In railway communication
	In airplane communication
	In water communication
Indigenous hazard (the thirth specification)	In public utility permises
	In flats
	In industrial permises
	In warehouses
	In transport facilities
	In forests
	In cultivated areas
	Others

7.2 FIRE OCCURRENCES IN POLAND IN RELATION TO THE FIRE SIZE AND FIRE INTENSITY

Let the first step of the analysis made in this paper be the specification of the number of fire occurrences in which the simple division has been made, into the four basic groups related to small, medium, large and very large fires respectively (see Tab. 7.1), according to the size and the intensity of reported fires. Suitable results, obtained for particular months from the data-set covering the whole 2010 year duration, are shown in Fig. 7.1.

It is easy to see that the distinct maximum of the number of the reported fire events can be identified with the time of the early spring (March and April, respectively), especially when small and medium fires are taken into consideration.

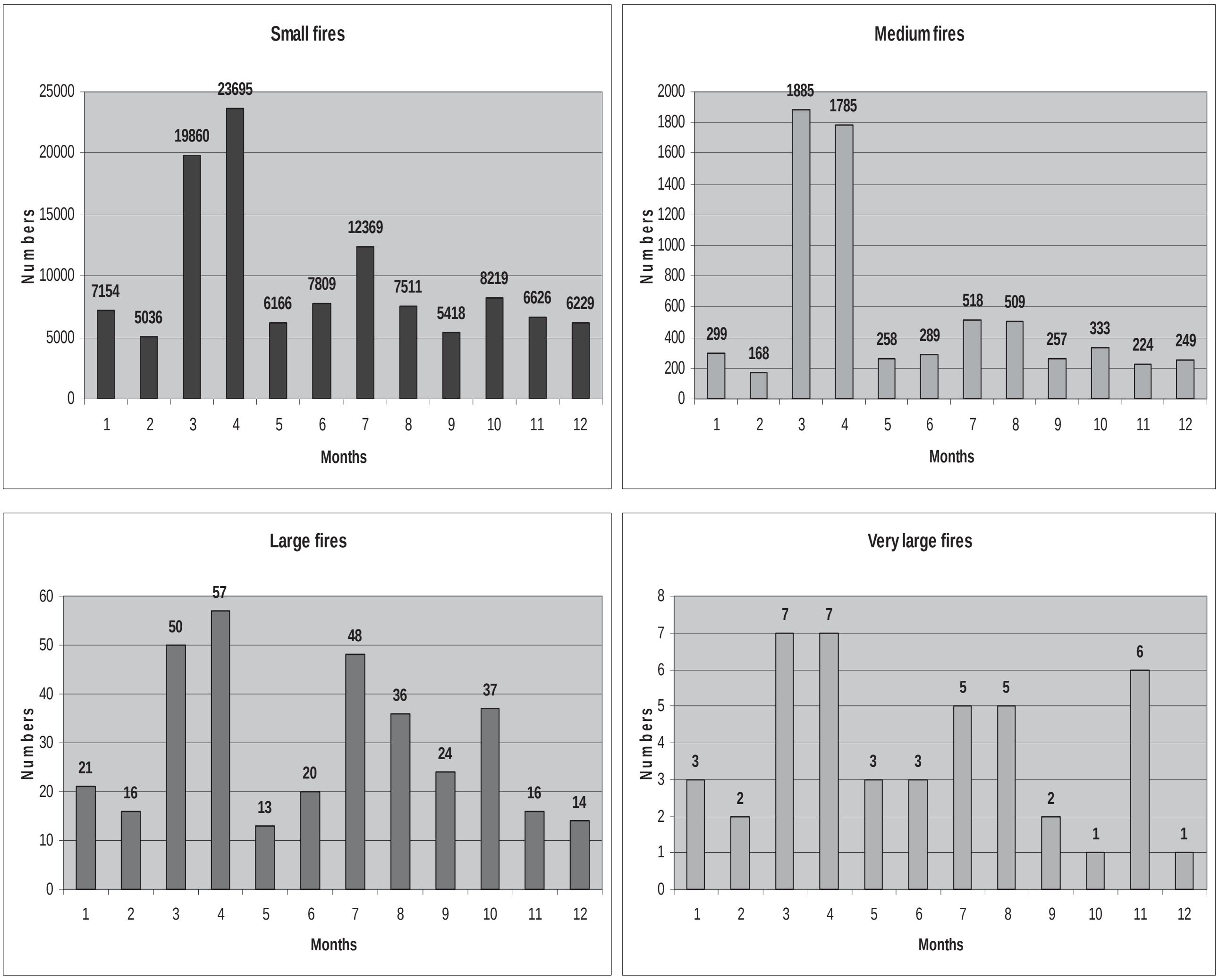
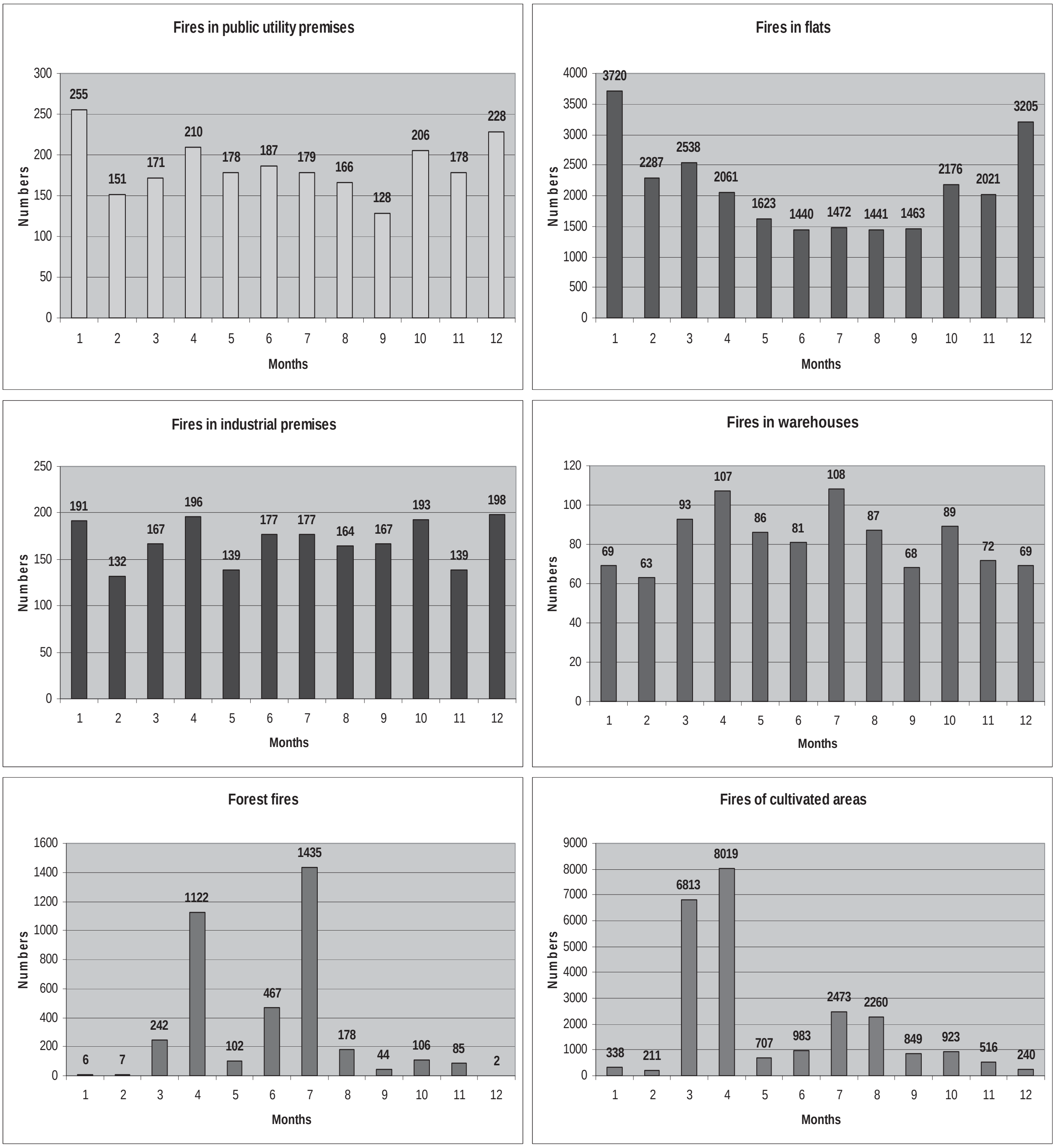


Fig. 7.1 The number of fire occurrences in Poland in 2010 with respect to fire size and fire intensity

7.3 THE SPECIFICATION OF PARTICULAR FIRE EVENTS IN POLAND ACCORDING TO THE FIRE TYPE AND ITS LOCALISATION

The more precise conclusions can be drawn if the particular fire types are examined separately, dependently on their source and their localisation. Let us see Fig. 7.2 in which the numbers of the fire events with respect to the eight basic fire types are presented in detail (see Tab. 7.2).

Moreover, the diagrams presenting the proportional frequency of the occurrence of particular fire types in relation to the number representing all reported fires occurred in 2010 seem to be very impressive and informative. They are shown in Fig. 7.3.



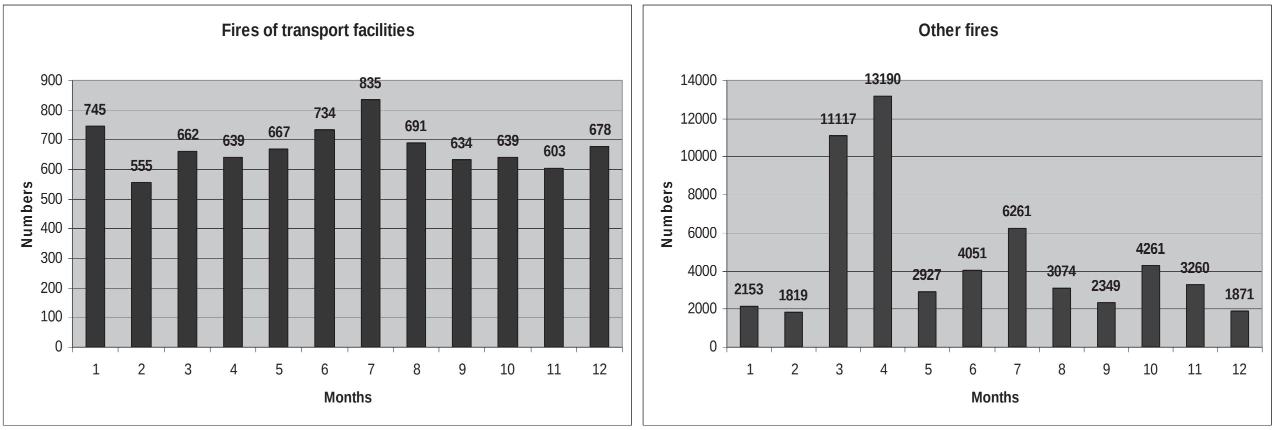


Fig. 7.2 The numbers of particular fire events in Poland in 2010 dependently on the fire type and its localisation

Fig. 7.3 Proportional frequencies of the occurrences of particular fire types in Poland in 2010

7.4 OTHER STATISTICAL DATA-SETS ACCESSIBLE FROM THE CONSIDERED DATA-BASE

The author of the presented paper would like to draw the additional attention of its Readers to the other statistical data-sets being easily accessible from the considered data-base, without any special restrictions. Two of them seem to be very interesting if the reliable safety level for the case of the potential fire occurrence is going to be assessed. The first one deals with the number of dead and injured people under fire conditions, not only the occupants of the building exposed to the fire, but also the firemen taking part in the firefighting action. Detailed data, adequate for the one-year observation period, related to the year 2010 in Poland, are collected in Fig. 7.4. The second data-set allows to study the number of the false-alarms registered in the whole country by the local Fire Service units. All reported alarms are divided in the considered data-base into three groups (see Fig. 7.5) as it has been explained in the previous part of this presentation.

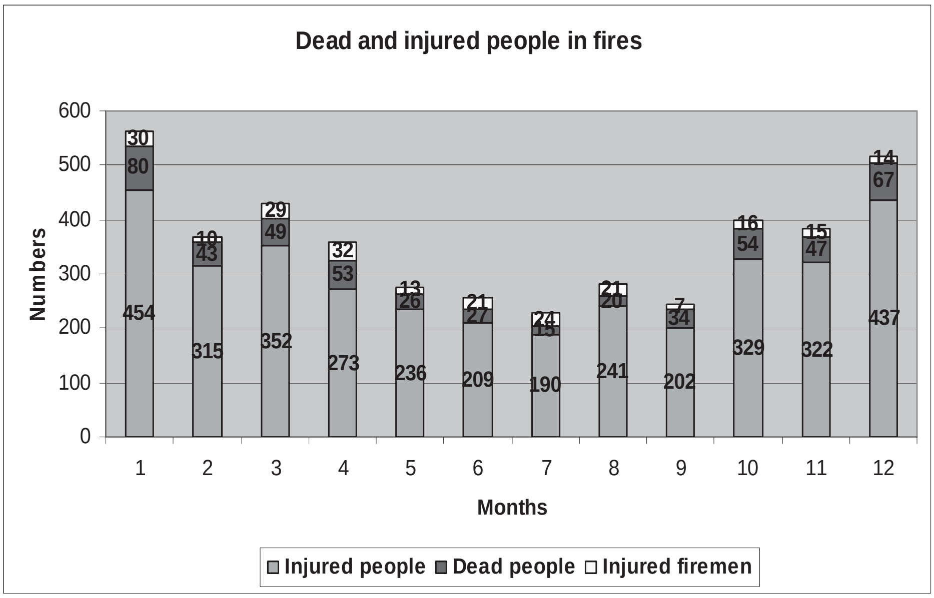


Fig. 7.4 The number of dead and injured people being victims of fires occurred in Poland in 2010

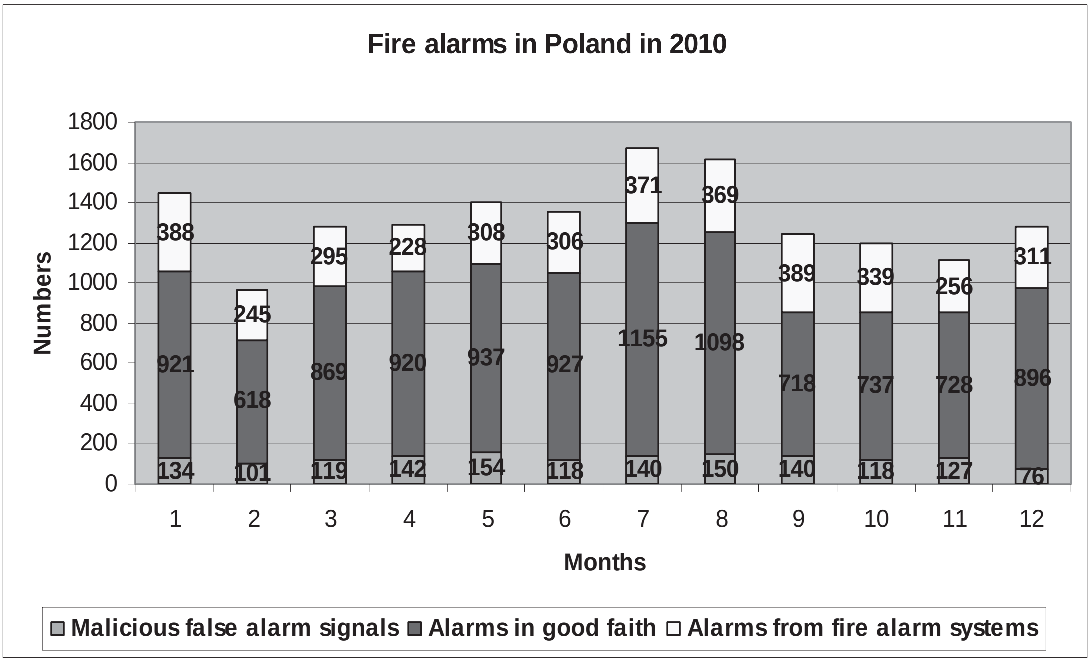


Fig. 7.5 The number of false fire alarms reported in Poland in 2010

7.5 CONCLUDING REMARKS

Careful observation of the data-sets subjectively selected to the analysis in the presented paper allows to specify some interesting trends characterising the frequency of fire occurrences in Poland. If the observation period would be longer than only one-year duration the repeatability of such trends should become easily indicated. This means that all tendencies being statistically justified basing on the analysis of only the data-set limited to those originated from the year 2010 can be reliably extrapolated to the analogous time-periods separated from the other years, previously occurred. Moreover, the prediction of future revealing of similar or even of the same tendencies is not very uncertain. To practically confirm such general statements, quoted above, let us underline the existence of some trends clearly appearing if the diagrams enclosed to this article are studied in detail. Three of them seem to be extremely influential in the expected process of improving and optimizing the global safety level for potential fire conditions. The basic reasons of the fire generation are as follows:

- grasses and waste lands burning out in the beginning of spring – such activity is still widespread in Poland, above all in the country areas, though it is legally prohibited and prosecuted – as a consequence fires of cultivated areas and also even fires of buildings and forests are mostly extinguished in this time (especially from the middle of March to the end of April, each year similarly),
- flat heating up with the additional electric radiators in cold winter – in consequence the number of fires in private dwellings (flats) grows rapidly in time-period specified from each December to the end of March next year,
- very hot and dry climate in summer in Poland and in other European countries localised in close neighbourhood – as a result more and more forest fires, ignited spontaneously, are indicated and suppressed each year, mainly in April and in July.

As far as the safety level related to people is considered, not only to the building occupants remaining in the fire zone but also to the firemen taking part in firefighting action, it is easy to see that the winter months are the most hazardous time-periods in this field. It is not a surprise, because the weather conditions are frequently very poor at that time, people cannot stay outside for a long time because of the low temperature and cold wind, ice and snow disturb to carry out the firefighting actions, slipperiness under foot, short and dark day and frosty air are the main factors resulted in so many injured people. On the other hand, many people die at night at that time in their own dwellings, getting caught unawared by the fire being started and developed there as a consequence of the application of unproffessional heating radiators.

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8 FIRE BRIGADE REPORTS AND INVESTIGATION IN ITALY: PROCEDURES, STATISTICS AND REAL FIRE DESCRIPTION

Summary

The determination of the causes of fire requires extremely complex investigations, because fire tends to destroy or make unrecognizable elements that could be traced back to its origin and development.

Fire Brigade Reports contain the first direct information concerning the description of a fire event. However, they cannot have usually exhaustive information concerning the causes and development of fire events, the damages of constructions and so on.

The paper illustrates the procedures generally applied by the Italian Fire Brigades to describe a fire event in the technical fire brigade reports, with particular reference to those provided by the Fire Investigation Team *(Nucleo Investigativo Antincendio – NIA)*. Some statistical data based on the fire brigade reports are also shown and discussed.

8.1 INTRODUCTION

The Italian National Fire Organization (in italian “Corpo Nazionale dei Vigili del Fuoco - CNVVF”), which is part of the Department of Firefighters, Public Rescue and Civil Defence, depends by the Ministry of the Interiors; it operates all over Italy, except Valle d'Aosta region, Bolzano and Trento provinces, with around 35.000 professional and volunteer units.

The National Fire Organization has the duty of assuring the urgent technical rescue, even in events in which are present non-conventional substances, and perform fire prevention services. In order to protect the personal safety and integrity of goods, it provides technical rescue and assistance, which requires technical skills even for highly specialized equipment and adequate resources, and performs technical studies and experimental tests in the specific field. Included among the technical operations of public assistance of the National Fire Organization are:

- technical rescue during fires, uncontrolled releases of energy, structural collapse, landslide, floods or other public calamities;
- technical work against risks from the use of nuclear substances and the use of chemical, biological and radiological threats.

Fire prevention and protection is the principal public interest function intended to achieve, according to uniform criteria for application in national territory, the safety objectives of human life, personal safety and protection of property and the environment through the promotion, study, preparation and testing of modes of action designed to prevent the occurrence of a fire and the connected consequences. It is expressed in all areas characterized by exposure to the risk of fire and, because of its interdisciplinary importance, including in the areas of safety in the workplace, control of major accident hazards involving dangerous substances, energy, protection from ionizing radiation of construction products (http://www.vigilfuoco.it).

In 2004, the Italian National Fire Organization was endowed with the specialized Fire Investigation Team (NIA - Nucleo Investigativo Antincendio), which depends on the Central Directorate for Fire Prevention and Technical Safety and takes place in the area of the Basic Training School of the Firefighters', Public Rescue and Civil Defence Department (Capannelle, Rome). In the following the main tasks and investigation's procedures of NIA are described.

8.2 RESEARCH AND INVESTIGATION'S PROCEDURE OF THE FIRE INVESTIGATION TEAM

The Fire Investigation Team (NIA) is a specialized team for fire prevention and technical safety.

The NIA cooperates with national and international bodies in the fields of forensic science and scientific-technical investigations and provides to:

- carry out investigative activity in cases of accidents caused by fire and/or explosion, focused on the search of the causes of the accidents;
- make inquiries on accidents on workplaces (Legislative Decree n. 81 April 9th 2008 – Safeguarding of health and safety on workplaces – art 46 Fire Prevention) in which proper measures must be adopted in order to prevent fires and to preserve workers' safety;
- support, as investigative police, the Judiciary and the Provincial Fire Stations in their urgent investigations and technical evaluations and if necessary in judicial attachment of products, materials and everything else useful to establish the causes of the event;
- research and experiment in the field of Fire Investigation;
- rain the fire investigators of the Provincial Fire Stations.

The NIA has a test-laboratory located in the area of the Operational Training School of Montelibretti, where fire simulations on full-scale and fire scenarios are carried out during research and investigation's activities. The parameters checked during full-scale fire experiments are then compared, through numerical model, with the output data of simulations, carried out under the same conditions. The entire process of simulations and the following analysis of the occurred events through mathematical models are performed in cooperation with other offices of the Central Directorate for Fire Prevention and Technical Safety.

NIA has a mobile laboratory, an intervention vehicle specifically equipped with systems for the environmental monitoring operations, for detecting flammable substances, for producing evidence, and for judicial attachment. It allows also producing the documents of the conducted investigation. The technical equipment of mobile laboratory is mainly composed of:

- a set for producing evidence;
- a set for measuring and surveying;
- a tool set, digital camera, video camera, Photo Ionization Detector (PID), multi-gas detector, biological microscope, mobile PC and printer, digital recorder.

The investigation's procedures adopted by NIA can be summarized in four stages (Gamberi), shown in Fig. 8.1:

1) Preliminary survey
2) Preparation
3) Implementation
4) Conclusion.

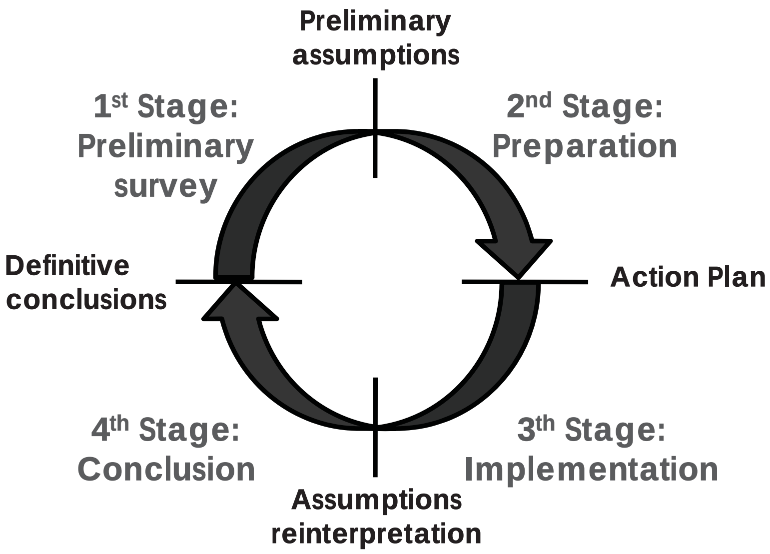


Fig. 8.1 NIA investigation's procedure

In the first stage, at the beginning of the investigation, the investigator doesn't have any information about what happened and how it happened. Therefore, investigator, based on first evidence collection, achieves a preliminary and temporary assumption. In the second stage, the investigator checks the preliminary assumption and defines an action plane. Based on defined action plane, in the third stage, investigator performs tests in situ or/and in laboratory, and suggests an assumption reinterpretation. In the final stage, investigator develops a definitive conclusion.

The investigation on the real case is the basis for improvement of fire prevention regulations.

8.3 INVESTIGATION'S PROCEDURES OF NIA: A REAL INVESTIGATIVE ASSET

In October 2008, a fire in a parking of a residential building involved 39 cars and 17 motorcycles.

Building is 27 m high, 120 m long and has 8-storey above the ground.

The fire caused the rupture of water, gas and electrical systems, therefore building was evacuated.


Fig. 8.2 Building after event

The Investigator, during the first stage of the investigation, based on evidence collected, assumed that fire started from a car, probably due to failure of car's electrical equipment or use of open flames or liquid fuel; moreover, based on the analyses of reports of first rescuers, fire reached the flash-over. The analysis of a video recorded during the event and posted in web, confirmed the assumption about the flash-over and permitted the calculation of fire spread and time in which the flash-over was reached, as following illustrated: fire crossed the space between two columns, distant 4-6 m, in 50 s; therefore fire spread was 8-12 cm/s and the flash-over was reached in 15-22.5 min, being the driveway about 108 m long. Moreover, the analysis of fire's report about a building with the same characteristics easily permitted to express temporary assumptions about the causes of development of fire: flash-over could be reached due to dripping of the polystyrene used for the insulation of the ceiling.

In the second stage, the investigator planned some tests to verify:

- the presence of liquid fuel, as petrol, able to accelerate the development of fire,;
- the presence of solid fuel, able to ignite fire;
- the failure of electric equipment of car from which fire started;
- the assumption about the dripping of polystyrene and its ability to spread the fire to the other vehicle.

In the third stage, the monitoring of presence of liquid fuel, by using P.I.D., was performed along the covered street, intended for the transit of vehicles incoming and outgoing, and near the tanks of cars.

Moreover, two fire reaction test on a sample made of polystyrene with a thin layer of plaster were performed in accordance with "UNI-CNVVF 9174" (Italian radiant panel test), aimed to define the fire spread, the damaged area and the polystyrene's dripping. During the test, the sample is ignited with a pilot flame (about 120 W) in presence of a radiant panel, whose emissivity is about 6.2 W/cm^2 (see Fig. 8.4).

During the first test, the fire spread was measured as a function of the time in which the flame front reaches the vertical targets marked on the sample every 50 mm (see Fig. 8.3).

During the second test, in the ground was placed a portion of a tire of a car in order to verify if the dripping of burning material could be able to ignite it.

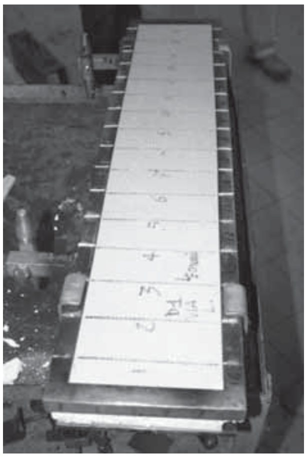


Fig. 8.3 Test sample

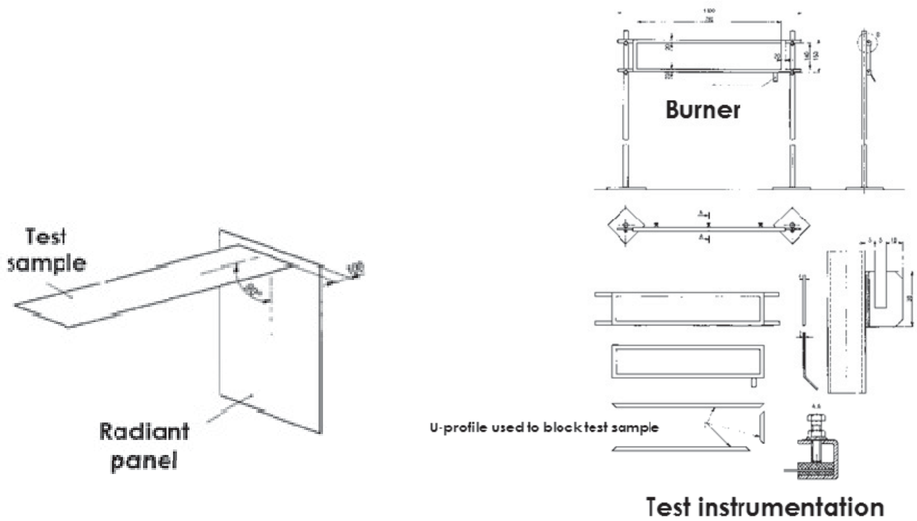


Fig. 8.4 Test instrumentation

Based on test's results, the conclusion of the real investigative asset can be summarized as follow:

- the P.I.D. didn't detect the presence of liquid fuel, even near the tanks, therefore the result isn't reliable because all the fuel is burned;
- the presence of solid fuel wasn't detected;
- the car from which fire started was completely destroyed, therefore it isn't possible to verify the electrical failure;
- the small portion of tested polystyrene was able to ignite a tire of car following the dripping, therefore is reliable that in situ other cars were involved in fire due the dripping of large size of material.

The lesson from this investigative asset is the necessity to protect from the fire the materials used as a coating in buildings. As recommended from EUMEPS (European Manufacturers of Expanded Polystyrene EPS), the protection can be realized with a layer of plaster thickness of 9-10 mm minimum, because it was shown that this is sufficient to reduce the possibility of ignition, provided that the coating layer is mechanically anchored.

8.4 STATISTICS

A useful tool for documentation on the causes of fires in the main economic activities and the effects caused by them is represented by the statistical data. The knowledge of the causes of fires and their effects can identify technical requirements and protection systems (active and/or passive) that are able to implement an effective prevention against the fire risk of any kind of activity.

In 2001, a working group was established with the aim to develop a research entitled “Research on fires” with the aim to define the causes and the effect of events verified in hotel and public entertainment activity (updating to 2001 of a precedent research), in school and shopping centre (in time period 1990-1999), (D’Addato, 2001). The working group analysed civil activities, defined as “activities with a large crowding of people for which fires can be relevant both for scale of event and for relevance of building, which affect operational and technical activities of CNVVF.

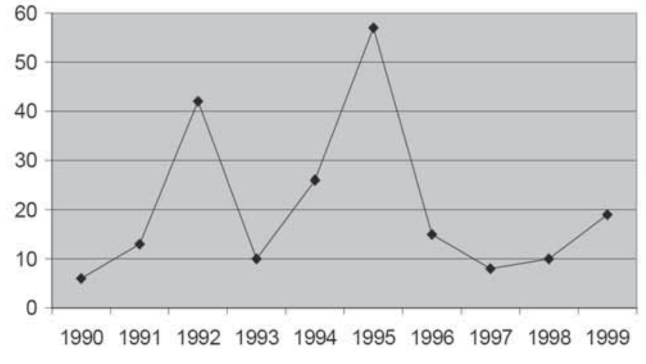
The methodology adopted by the working group can be summarized as follow:

- research and data collection;
- data evaluation;
- conclusions.

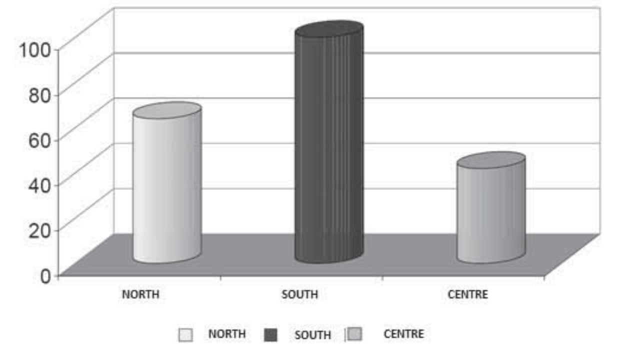
From processed data some tables and graphs were prepared (see Fig. 8.5, Fig. 8.6, Fig. 8.7, Fig. 8.8) according to the criteria of occurrence of the event, illustrated below: causes (intentional, electric, indeterminate, other); geographical distribution (Northern, Central, South Italy and Islands); area of ignition; times of the day.

Based on data shown in Fig. 8.5, Fig. 8.6, Fig. 8.7, Fig. 8.8, the largest number of fires occurred in school, in time period 1990-1999, and very often the fire’s causes are indeterminate or intentional.

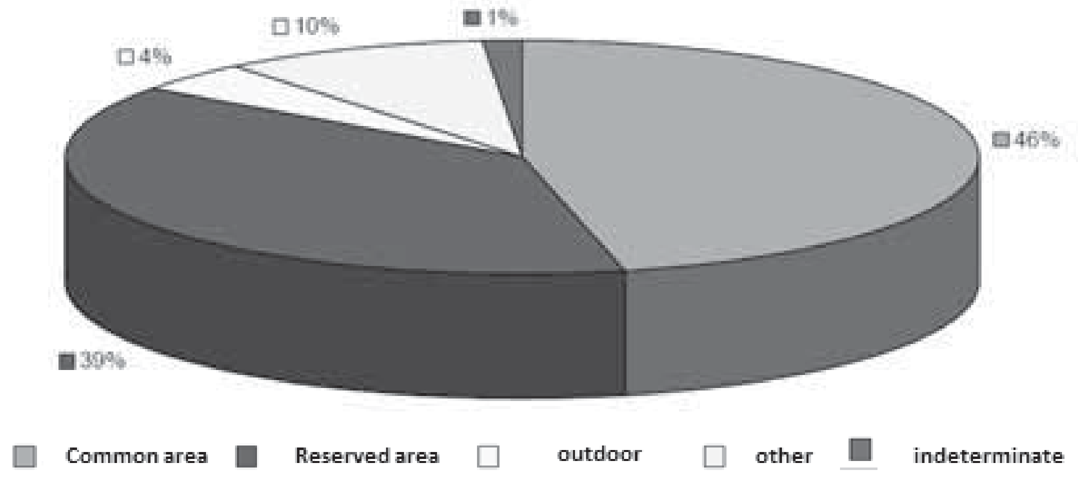
Recently, a research has examined all the reports received by the National Operations Centre of the Ministry of the Interior, relating to fires and explosions occurred in Italy, in the time period between 2007 and 2010 (D’Addato, 2010). For better processing, the data were compared with information reported in national newspapers, whose archives can be easily found online now.



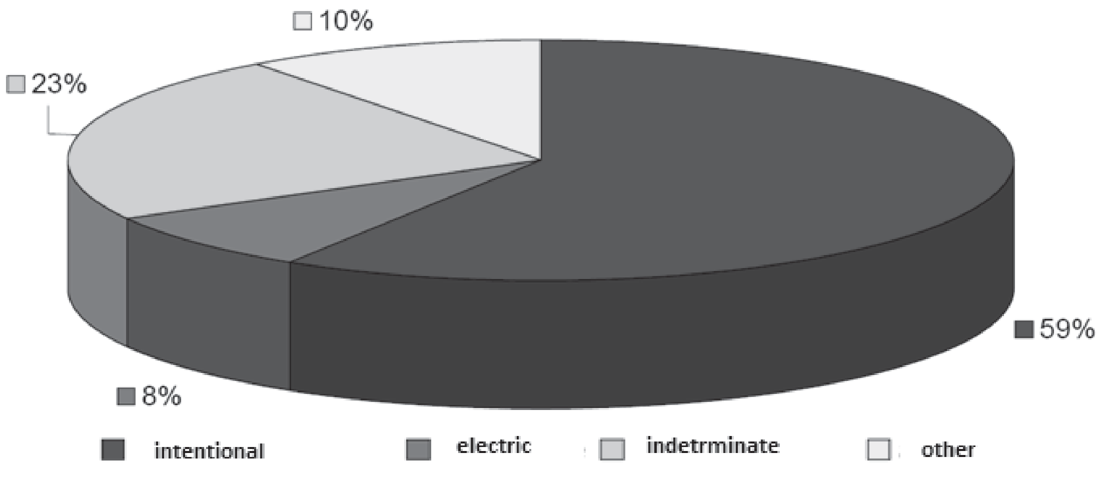
a) Number of fires in time period 1990-1999



b) Geographical distribution

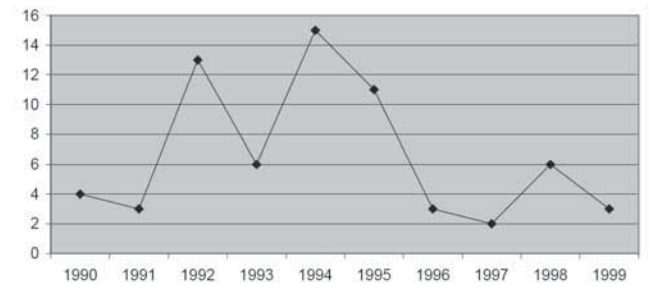


c) Ignition's areas

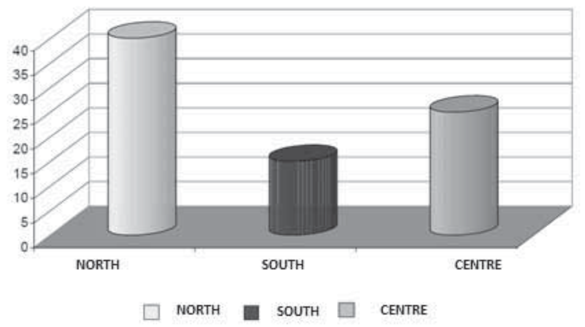


Fire's causes

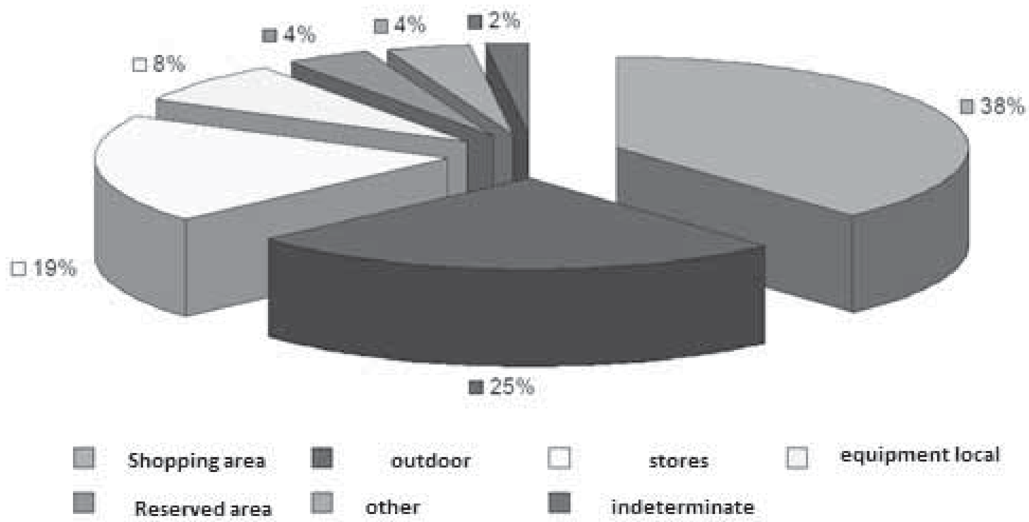
Fig. 8.5 Fires in Schools



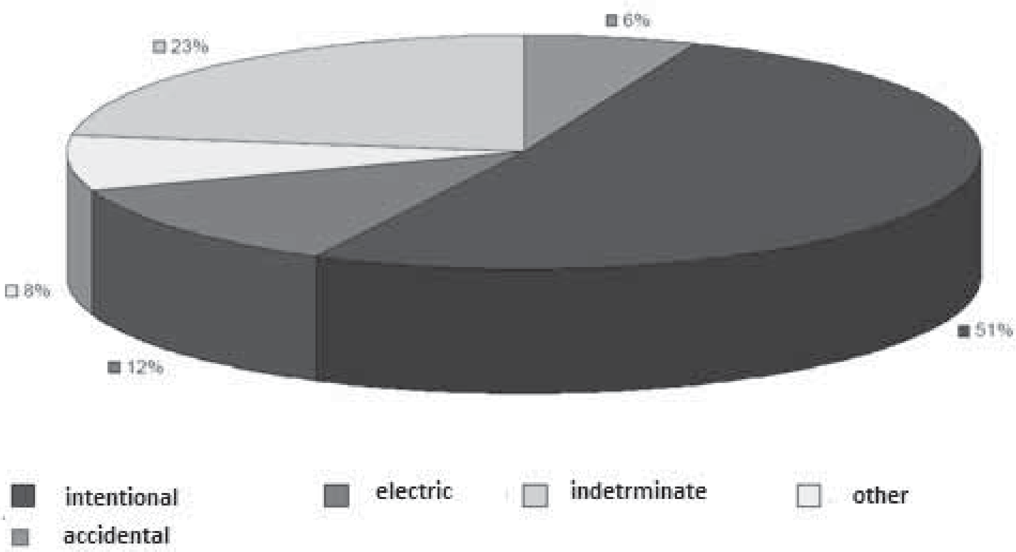
a) Number of fires in time period 1990-1999



b) Geographical distribution

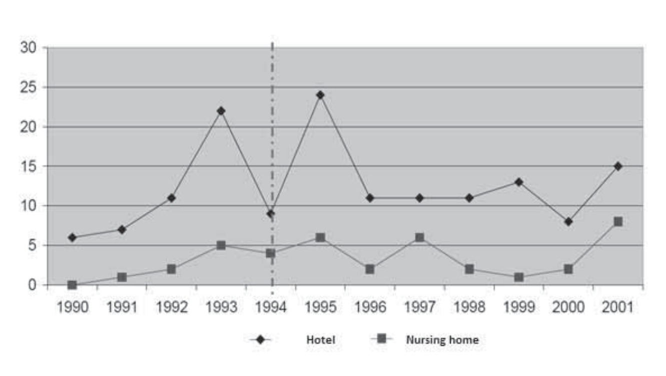


c) Ignition's areas

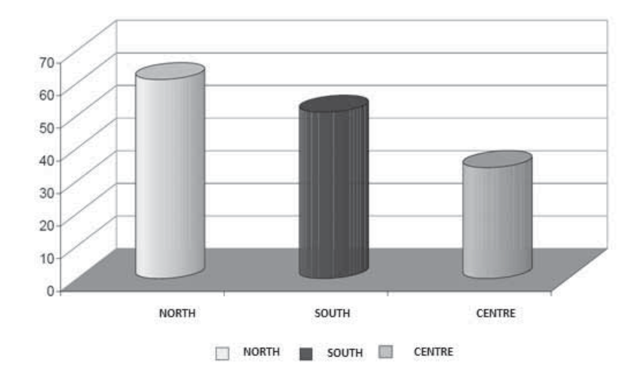


d) Fire's causes

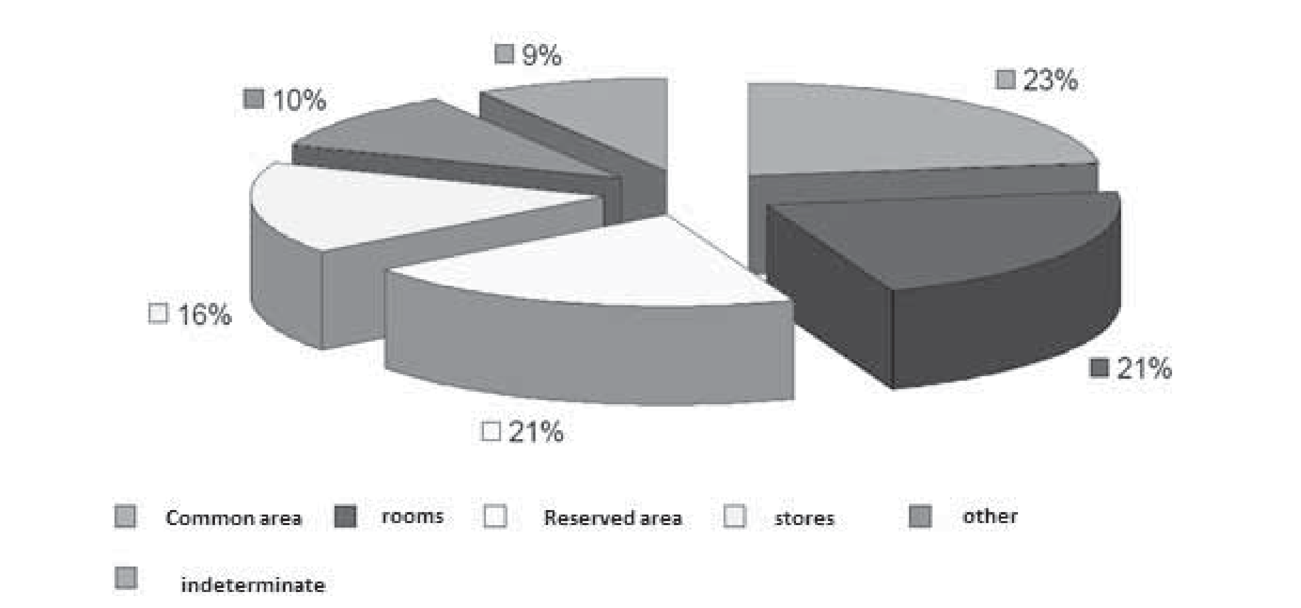
Fig. 8.6 Fires in Shopping centres



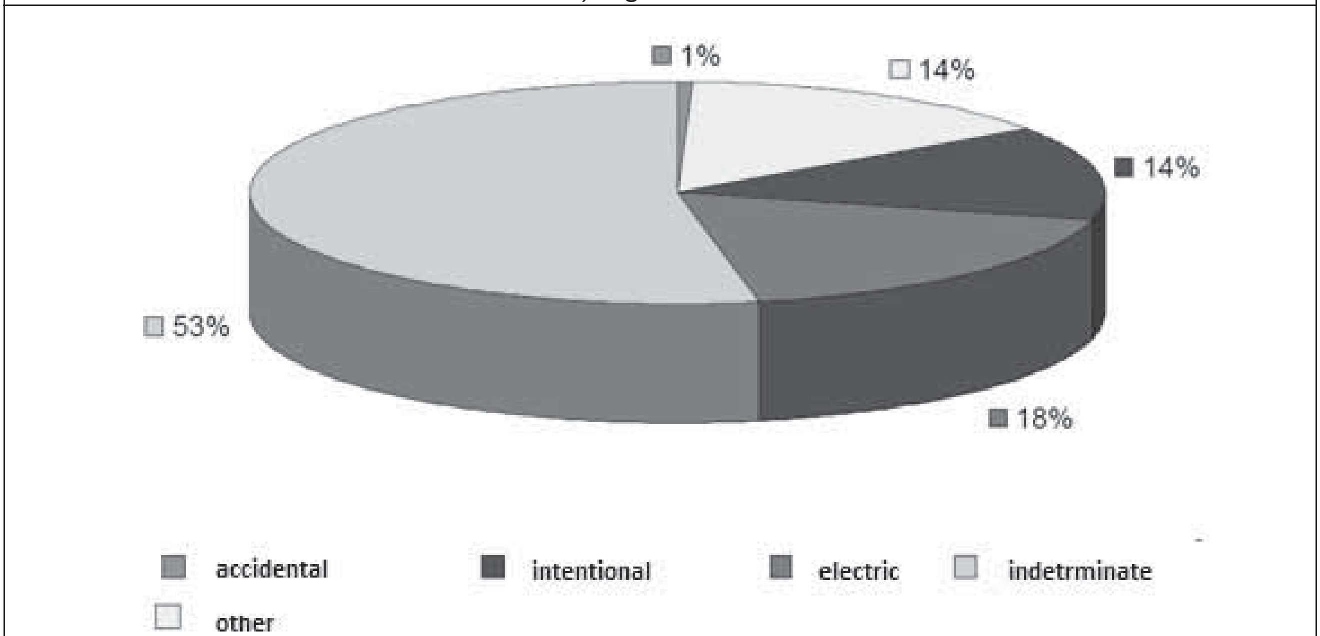
a) Number of fires in time period 1990-2001



b) Geographical distribution

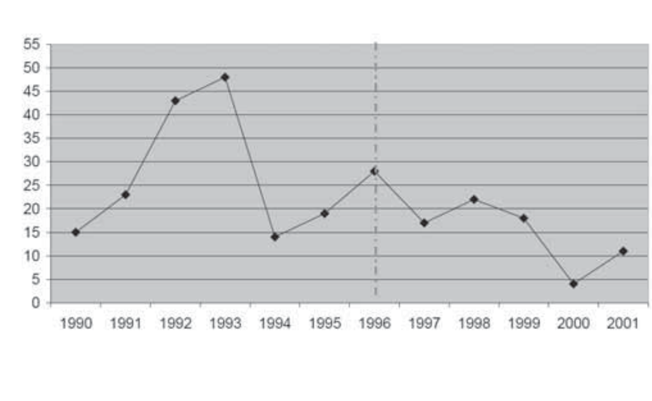


c) Ignition's areas

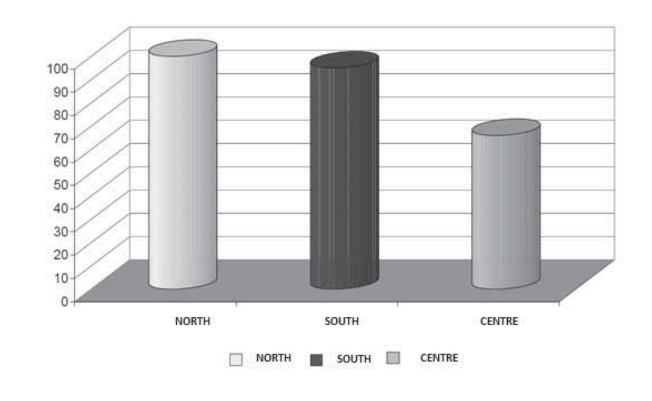


d) Fire's causes

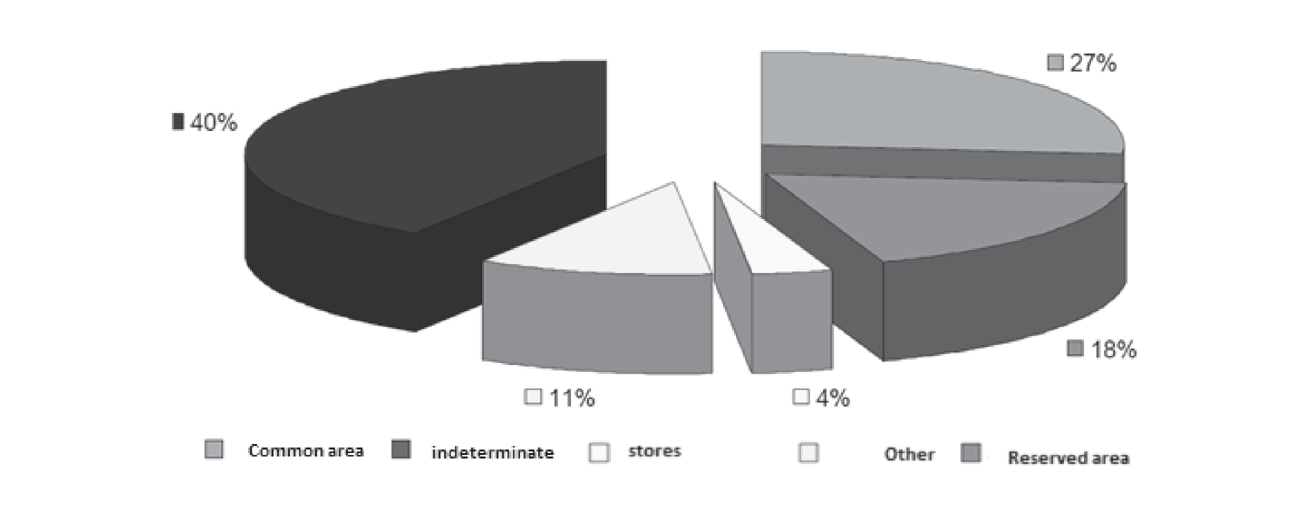
Fig. 8.7 Fires in Hotels



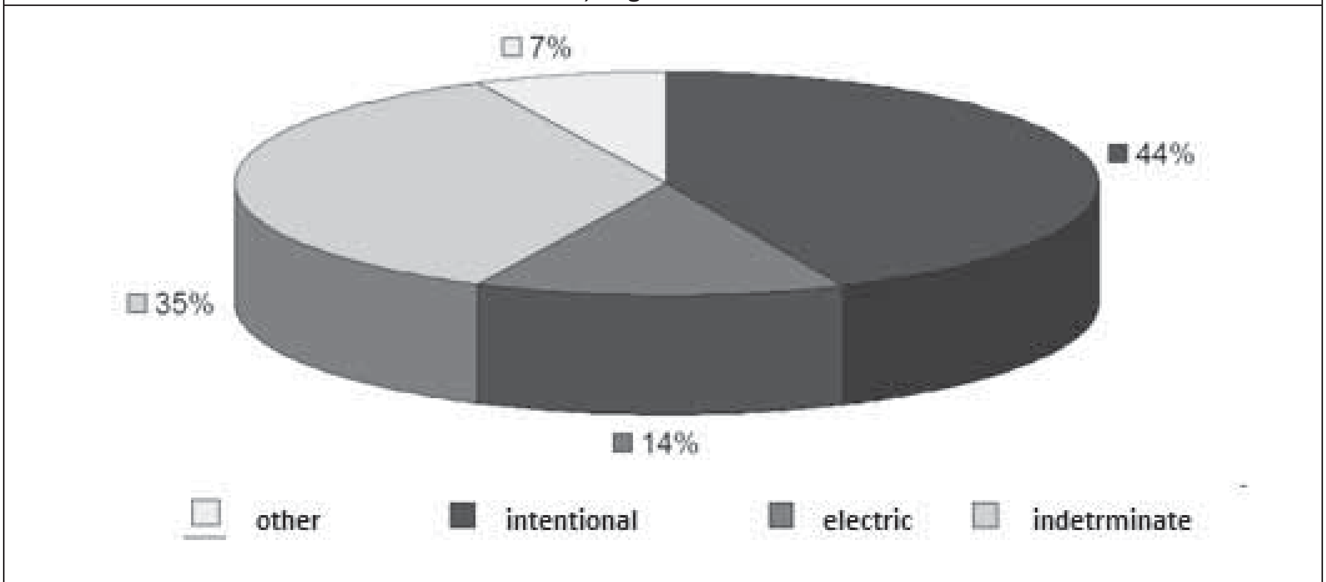
a) Number of fires in time period 1990-2001



b) Geographical distribution



c) Ignition's areas



d) Fire's causes

Fig. 8.8 Fires in Public entertainments

From processed data were obtained informations about the death and injured in the fires and explosions in that time period, from which some tables and graphs were prepared (see Fig. 8.9, Fig. 8.10, Fig. 8.11) according to the criteria of occurrence of the events, illustrated below: distribution by year, month and region; geographical distribution (Northern, Central, South Italy and Islands); type of activities where event was verified (house, businesses activity, stores, industry, etc.).

Based on data shown in Fig. 8.10, the largest number of deaths due to fire occurred in houses in 2007.

It should be noted that in Italy in 2007, based on data available, new fire codes (Decree 16/2/2007, Decree 09/03/2007, Decree 09/05/2007) are published.

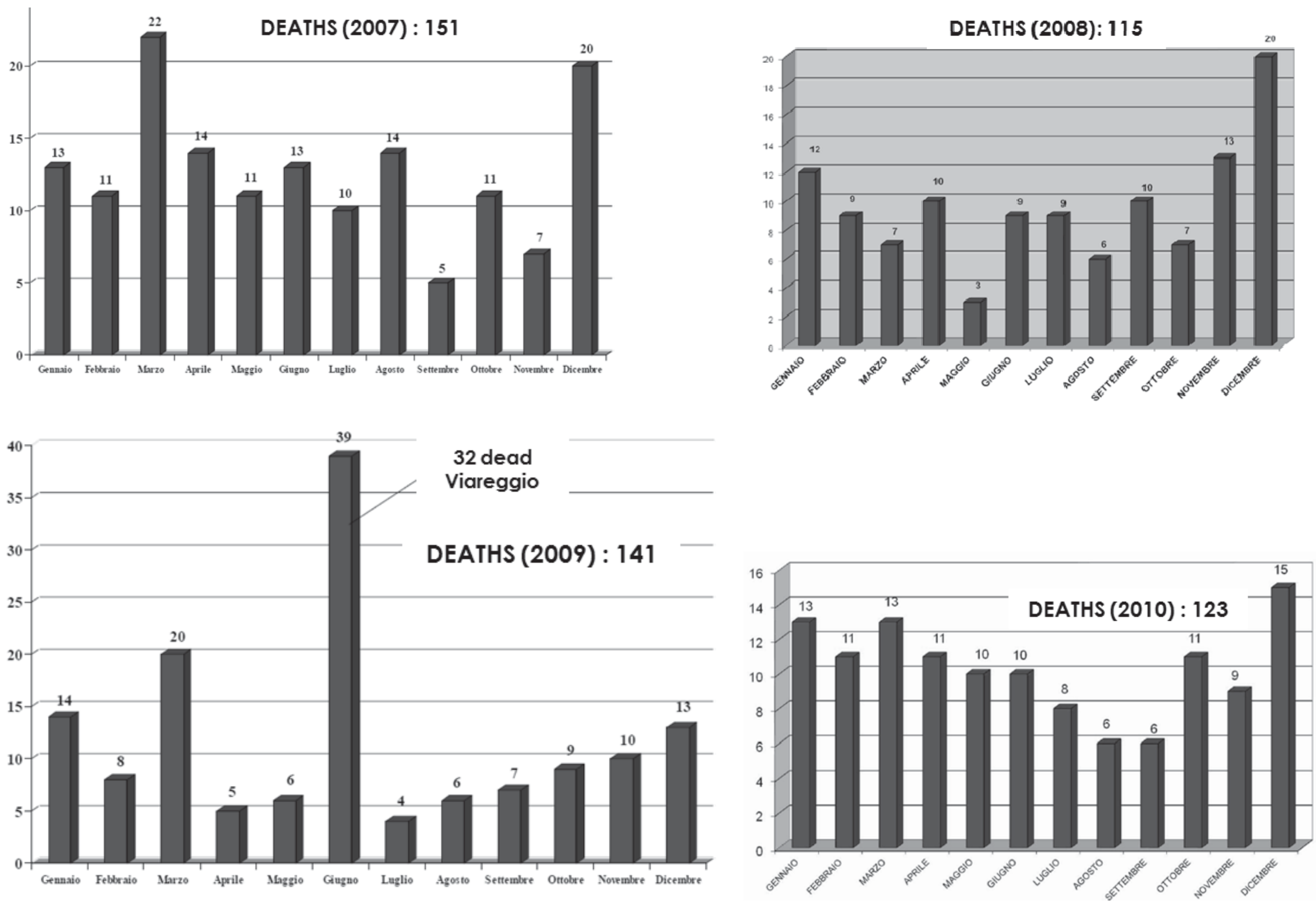


Fig. 8.9 Death's distribution by months

These researches provide useful data not only for accident prevention, but also for the organizational management of the rescue of the National Fire Brigade. Moreover, these data can be used not only to develop new codes but also to establish a methodology with the aim to reduce fire causes and to ensure safety for people and goods.

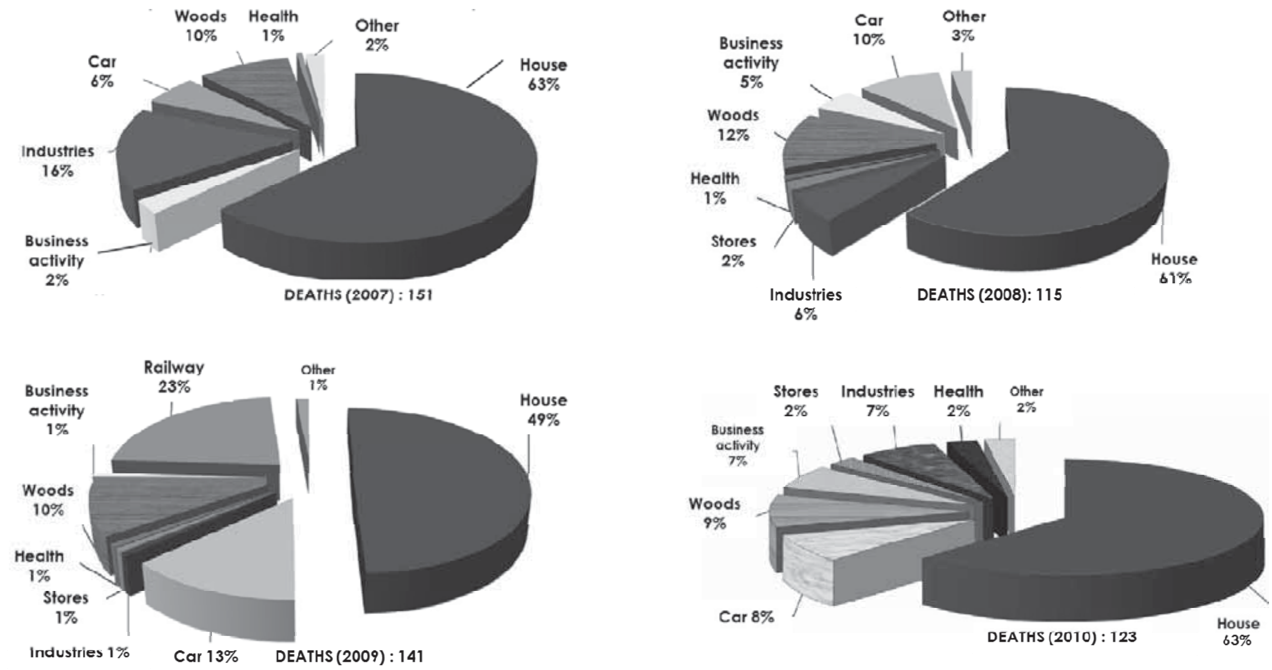


Fig. 8.10 Death's distribution by activities

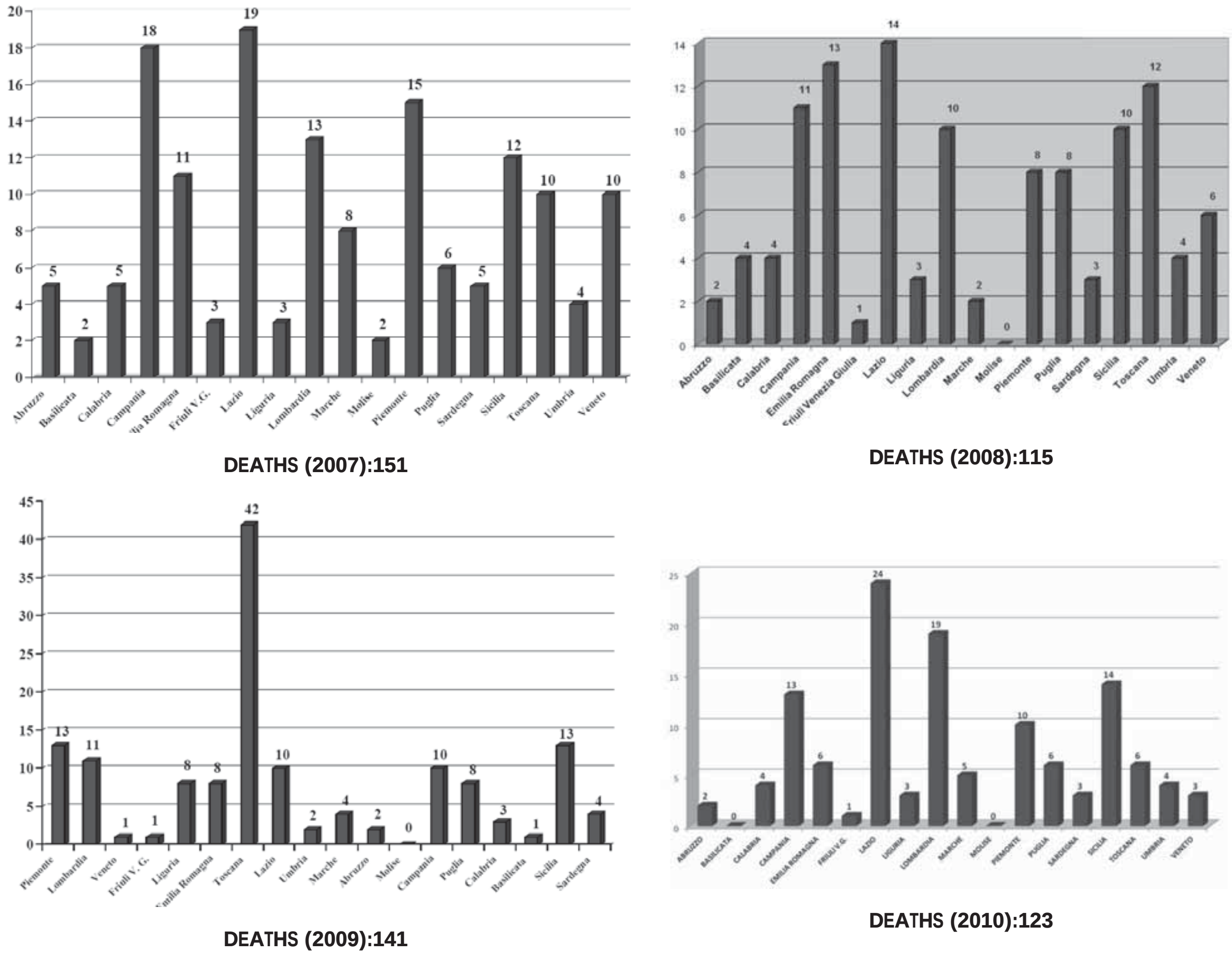


Fig. 8.11 Death's distribution by region

8.5 CONCLUSIONS

The determination of the causes of fire requires extremely complex investigations, because fire tends to destroy or make unrecognizable elements that could be traced back to its origin and development.

The proposed paper illustrates the procedures generally applied by the Italian Fire Brigades in the technical fire brigade reports, which contain the first direct information concerning the description of a fire event. However, they cannot have usually exhaustive informations concerning the causes and development of fire events, the damages of constructions and so on.

The Italian National Fire Organization (in Italian "Corpo Nazionale dei Vigili del Fuoco" - CNVVF), operating all over Italy, has the duty of assuring the urgent technical rescue, even in events in which are present non-conventional substances and perform fire prevention services, in order to protect the personal safety and integrity of goods. Fire prevention and protection is the principal public interest function intended to achieve the safety objectives of human life, personal safety and protection of property and the environment through the promotion, study, preparation and testing modes of action designed to prevent the occurrence of a fire and the connected consequences.

In 2004, the Italian National Fire Organization was endowed with the specialized Fire Investigation Team (NIA - Nucleo Investigativo Antincendio). The main tasks of the Fire Investigation Team are the study, the research and the analysis of fire causes, also as support of the Court, the investigative Police and the Local Fire Stations in the investigative activities in case of accidents caused by fire and/or explosions. Moreover, the NIA provides to develop research and experimental activities in the field of Fire Investigation and to train the fire investigators of the Provincial Fire Stations, cooperating also with national and international bodies in the fields of forensic science and scientific-technical investigations.

In the paper a real investigative asset is also illustrated, explaining the investigative and experimental activities performed by NIA, with the aim to define the causes of ignition and development of a fire in a car park.

A useful tool for documentation on the causes of fires in the main economic activities and the effects caused by them is represented by the statistical data. The knowledge of the causes of fires and their effects can identify technical requirements and protection systems (active and/or passive) that are able to implement an effective prevention against the fire risks in any kind of activity.

Based on a research's results performed in 2001, the largest number of fire occurred in school in time period 1990-1999, and very often the fire's causes are indeterminate or intentional. More recently, a research has examined all the reports received by the National Operations Centre of the Ministry of the Interior, relating to fires and explosions occurred in Italy, in the time period between 2007 and 2010. From processed data the largest number of deaths due to fire is verified in houses in 2007.

It should be noted that in Italy in the same year, based on data available, new fire codes were published.

In conclusion, these researches provide useful data to develop new codes, for accident prevention, for the organizational management of the rescue of the National Fire Brigade and to establish a methodology with the aim to reduce fire causes and to ensure safety for people and goods.

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9 STATISTICAL ANALYSIS OF FIRES IN BUILDINGS IN OPORTO, 1996 - 2006

Summary

This paper intends to present the results of a study carried out with the aim to collect, analyse and process information concerning urban fires occurred in the city of Porto between 1996 and 2006.

The data were collected from the information available in the reports existing in the Oporto's Fire Brigade and were then systematized and organized in order to characterize this type of occurrences.

9.1 INTRODUCTION

Fire safety in buildings is a domain of knowledge that has multidisciplinary characteristics and covering different interventions ranging from the design of the spaces up to their using in suitable safety conditions at every moment, involving fields of knowledge as distinct as fire resistance of building elements, fire reaction of materials, fire detection and extinguishing or the behaviour of people in case of emergency.

Fig. 9.1 Fire in a building in the old part of Oporto city

Another feature associated with fire safety concerns the uncertainty related to various phenomena linked to this matter. For the treatment of this uncertainty it is important to know the history in terms of fires because it is possible to obtain information of significant relevance in several aspects. Therefore, to meet the main lines of the incidence of this type of occurrences with a view to adopting measures to improve the situation, whether in terms of preventive measures, information campaigns and public awareness or even search and introduction of technological innovations to control risks more sever or intervene in more effective way.

In Portugal this information is difficult to obtain because there isn´t any report model that can be filled by the fire brigades for the occurrences of urban fires where it is possible to extract information relevant to the investigation.

The development of a model to deal with the problem of the probability of occurrence of a fire should take place, on first analysis, the proper knowledge and characterization of the occurrences of urban fires registered in Portugal.

9.2 DATA COLLECTION

For occurrences of urban fires was proposed a worksheet to record the information from the reports. This integrated, for each month, the following fields, organized as follows:

a. Temporal characterization of the occurrence:
- Serial number (from the beginning of the month);
- Day of the month;
- Day of the week;
- Time to alert;
- Time to completion of the work;
- Origin of the alert message.

b. Location and characterization of the building:
- Address of the occurrence;
- Quarter;
- Type of occupancy of the building;
- Dimension of the building.

c. Extinguishing of the fire:
- Means of the fire-fighters presented on the site;
- Who did the fire extinguishing;
- Means used in the fire extinguishing.

d. Causes and spreading:
- Cause;
- Object where the fire originated;
- Space or compartment where the fire started;
- Extension of the spread that was reached.

e. Victims and damages:
- Victims resulting from fire;

• Property damage reported.

9.3 RESULTS OBTAINED

The results obtained and the analyses carried out were grouped in the four following areas: fires in buildings, victims of fires in buildings, fires in houses and fire in non-residential buildings.

9.3.1 Fires in buildings

In the period under review to all the buildings were recorded and analysed 4698 occurrences of urban fire based on existing reports.

In this period it was found that 12.9 % of the occurrences were false alarms or unfounded alarms and that these values were not significant variation over the 11 years studied.

It was noted that 62.2 % of the alert messages originated from private calls and 36.38 % were coming from the Central 112.

The existence of a receiver central for alarms from automatic fire detection systems in the Oporto's Professional Fire Brigade allowed studying the set of alarms received and it was found that 91 % of the cases corresponded to false alarms or unfounded. This alerts us to the need to promote proper maintenance and a better knowledge of the systems with a view to their use in an effective way.

For hourly distribution, it was found that the hours of the day with the highest number of cases are related to the preparation of meals (12-13 hours and 20-21 hours). These results are a consequence of high relative weight of cases that originate in the preparation of meals.

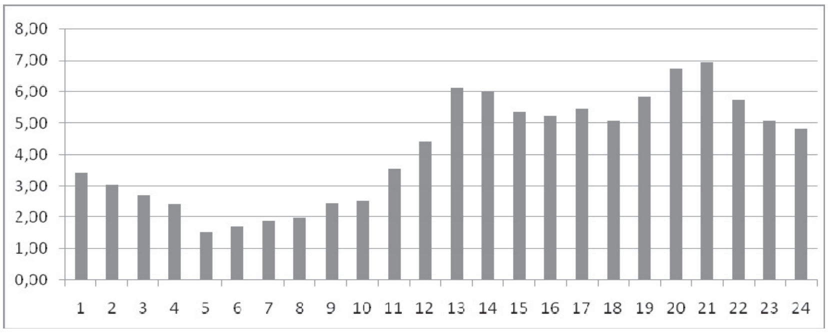

Fig. 9.2 Distribution of fires by time of day, expressed as a percentage

In the distribution by months of the year, it was noted that in the colder months of the year recorded a higher number of occurrences. The months in which there was the highest number of fires are, in descending order of number of occurrences: December, January, November and February.

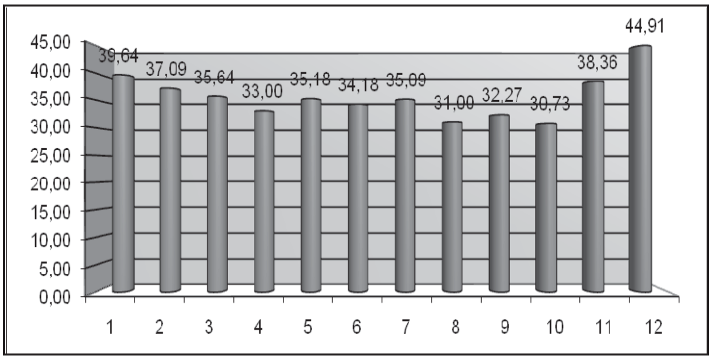

Fig. 9.3 Distribution of fires by month of the year, average values

As for the distribution by type of occupation of buildings, 55.49 % of the fires occurred in residential buildings. The following are the derelict buildings with 16.13 %, hotels and restaurants with 6.77 %, commercial buildings with 5.96 %, administrative 5.26 % and industrial with 3.02%. The hospitals and schools registered a little more than 1 % and the other occupations were below 1%.

In a previous study performed in Oporto for the period 1988-1992 period, were recorded about 63 % of fires in houses, 10 % in industrial buildings, approximately 6% in commercial buildings and 6 % in hotels.

According to these results and its specificities, it is justified the analysis of fires in houses separately from occurrences in other types of occupation.

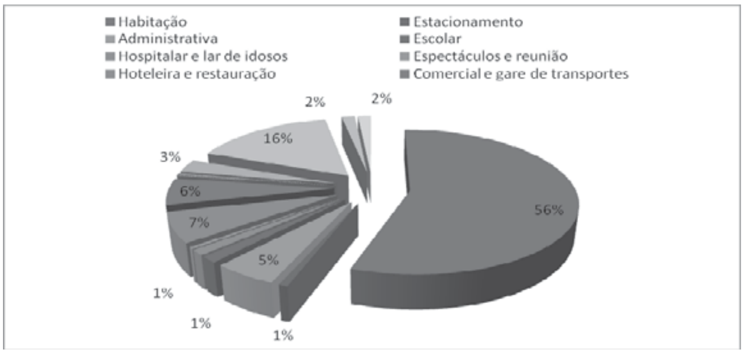

Fig. 9.4 Fires according to the type of occupancy of buildings

With regard to the causes, undetermined or unknown represents 34.14 % of the cases registered at period under analysis. This result is a consequence of the difficulties that the responsible of operations extinguishing face after the fire to determine its cause. Often, in face of a lack of information, the doubts raised and the state of destruction verified, there is no alternative to register the cause as undetermined or unknown.

The causes determined and recorded in the reports noted that the most significant is the carelessness with 24.16 %. This result is the natural reflection of the large number of occurrences related to the preparation of meals and the oblivion cooking left in ovens and other oversights related to candles, heaters, fireplaces and refurbishment works in which refers to the use of naked flame or other sources of heat without the necessary precautions.

Fig. 9.5 Fire in a building under renovation – Rectory of the University of Oporto

Then appears the cause assigned for short circuit with 18.73 % of occurrences. In this figure is included the short circuits and also overheating phenomena linked to the use of electrical installations or overheating of electrical equipment, in particular household appliances.

In 8.94 % of the cases are indicated accidental causes that corresponded to fires with origin in breakdowns or malfunction of electrical or gas powered equipment, fireplaces and other heating appliances, some cases of ignitions in flues of steak houses and even chemical reactions that led to fires.

Regarding the spread in about 13 % of the cases the spread reached was not indicated in the reports of occurrence. From the reports that present this information it can be concluded that the large majority of the fires has no significantly spread. In fact, 75.31 % of fires correspond to situations where the spread was restricted to the origin object or the other in the neighbourhood.

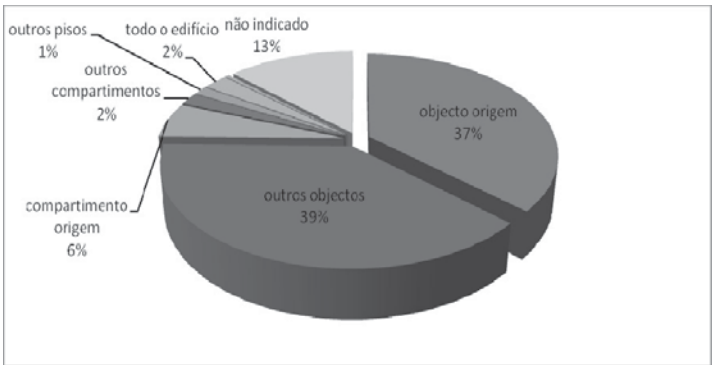

Fig. 9.6 Distribution of fires according to the spread

The spread to any compartment of origin was registered in 5.56 % of the cases and spread outwards from the compartment occurred in 6.26 % of the fires. Of which have spread outward from the compartment of origin, the most significant is that corresponds to spread to the whole building with 2.47%. However, in most of the cases corresponded to derelict buildings.

With regard to distribution according to who did the extinguishment of the fire, it was found that most of the fires, 58.75 %, are extinguished by fire-fighters.

In 18.39 % of the cases there was no human intervention to the extinguishing of the fire. These were cases of false alarms or unfounded and even of fires that have become extinguished without intervention from anyone.

Of the remaining cases, 13.01 % were extinguished by one or more residents of the building, 6.39 % by third parties that might have been: a neighbour, a passer-by or a policeman and 3.45 % were extinguished by one or more employees.

It should also be mentioned that in the analysed period was registered only a fire which was extinguished by an automatic fire extinguishing system.

As regards the extinguishing agent used, it was found that in 17.87 % of the cases were used two or more nozzles, which corresponds approximately to cases in which there has been a significant propagation. In 40.56 % of the cases it was used a nozzle by fire-fighters and in other 41.57 % were used other means of extinguishing. Of these, it was found that the container with water, used by occupants or fire-fighters, is the most frequent, with an approximate percentage of 10 % of the cases. Then, it appears the use of a chemical powder portable fire extinguisher, used in 6.6 % of the total of the occurrences.

In the analysis of the distribution of the number of fires per gross area of several quarters verifies that there is a higher incidence of fires in the older and historic part of the city. If the relationship is made per thousand inhabitants, we note that there is also a higher incidence in the quarters of the city's oldest district. These results confirm, for the case of Oporto, the idea that there are a larger relative number of occurrences in the old areas of our cities, and, therefore, a risk that should not be overlooked.

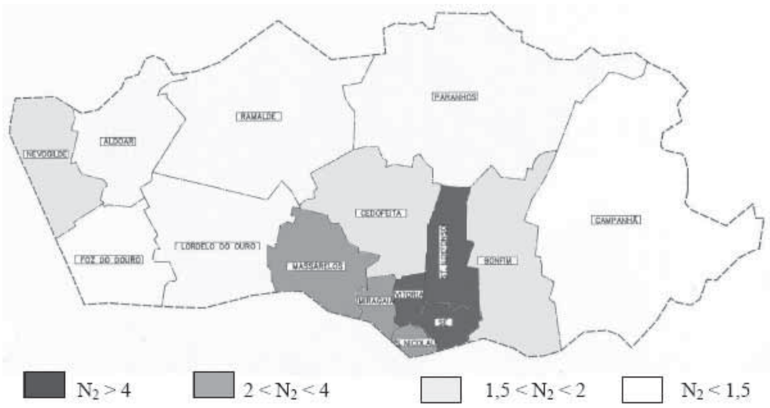

Fig. 9.7 Annual Index of fires by quarter and per thousand inhabitants

9.3.2 Victims of fires in buildings

In the period under review (1996 to 2006) were recorded 16 fatalities in 14 fires and 166 wounded in 128 fires, of which 4 were severe and 162light. In the study carried out previously for the period 1988-1992 it was verified 5 dead, all occupants, and 68 wounded being 7 fire-fighters and 61 occupants of buildings.

It was found that 86% of the fires with fatalities and 73 % fires resulting in injuries happened in houses. It follows the case of derelict buildings in which there have been 14 % of the dead and 9 % of the injured. It is worth highlighting the case of hotels and restaurants that had 6 % of the wounded and the industrial buildings, despite the small number of occurrences, there were 3 % of the wounded.

Of the 16 fatalities 15 were residents and 1 was a fire-fighter who was in a rescue operation of and old lady from a house and when taking her on his back suffered a falling from height.

For the wounded, 56.02 % were residents, 15.66 % employees, 11.45 % neighbours and 10.24 % fire-fighters. It turns out so that the highest incidence of casualties happens in the residents, so in houses.

In terms of hourly distribution, referring to the fatalities, it was found that the highest incidence has been was registered during the early hours, which is precisely the one where there is a smaller number of occurrences.

With regard to the origin and with regard to fatalities the compartment with higher incidence is the bedroom with 36 %, followed by the living room with 7 %. But in relation to the injured the major part of the cases happens in the kitchen.

9.3.3 Fires in residential buildings

It was noted that the largest number of fires and almost all of the fatalities happened in houses and buildings involving mainly elderly people. It is therefore necessary to study preventive measures especially targeted for this type of buildings and for these occupants of higher risk that often are not in possession of all their abilities and they are left alone for large periods of time.

These occurrences took place mainly in poor houses or very old apartments of social housing. In the first case the spread is facilitated by the construction that integrates structures and partitions made with combustible materials, by the high thermal load, by the deterioration of dwellings and by the presence of technical installations in poor working order.

In the case of the apartments of social quarters, there has been a high incidence in households which denote various problems of socio-cultural framework.

It is therefore necessary to intervene in the areas referred to and implements mechanisms to study the sociological dimension of urban fires and duly substantiated conclusions, because the studies carried out in other cities, like London, concluded also by a high incidence in the underprivileged.

The highest percentage of occurrences in houses happened in the kitchen and is related to oversights in the preparation of meals. However, this high number of occurrences is usually in minor damage and low rates of spread.

Most of the cases with fatalities happened in bedrooms and living rooms and especially in the early morning when people are sleeping and therefore limited in its ability to react. The information contained in the reports does not allow significant conclusions to be drawn about the causes but, according to the information collected by those who have acted in these fire places, the clues pointed out oversights with cigarettes or candles and to deficiencies in electrical or heating devices, primarily electric blankets and heating elements. According to the same sources, the leading cause of death is intoxication with the smoke resulting from the combustion of mattress and bedding or upholstered furniture.

9.3.4 Fires in non-residential buildings

Although he found that fires in residential buildings are very important to the results obtained, it was understood that it would be important to characterize also the fires in buildings or establishments with other types of use:

- Derelict buildings, 758 occurrences (16.13 % of the total);
- Hotels and restaurants, 318 occurrences (6.77 % of the total);
- Commercial, 280 occurrences (5.96 % of the total);
- Administrative, 247 occurrences (5.26 % of the total);
- Industrial, 142 occurrences (3.02 % of the total);
- Other, 345 occurrences (7.34 % of the total).

The results show a high number of occurrences in derelict buildings or abandoned, normally occupied or frequented by homeless people who use expedited means for enlightenment and for the preparation of their meals and they are almost always smoking. These issues, together with the fact that it is very old and degraded buildings and to poverty or lack of care of these people, turns out to be translated into a large number of occurrences with high rate of spread. Besides being necessary to solve the problem of these people is also important for this type of buildings is properly closed to prevent the deposition of wastes and debris and the access to its interior.

Fig. 9.8 Fire in a derelict building in the historical area of Oporto

The use-type with the highest number of cases, after housing and derelict buildings, was the restaurants, snack-bars and hotels.

The major part of these occurrences corresponds to restaurants and occurred in the preparation of meals. The main question referred in the reports is the carelessness, followed by accidental cause found to be related with breakdowns in electric fryers or with the accidental ignition of fats deposited in the smoke flues of steakhouses, and in many cases these pipes serve as a vehicle of fire spread to upper floors or adjacent compartments.

9.4 CONCLUSIONS

It is noted in Portugal a lack of systematization of the information about urban and industrial fires that allow the development of studies from the knowledge of this reality, as for example a proper fire risk modelling.

Becomes also necessary develop studies on the consequences of the fires in relation to physical damage, both direct and indirect (question not dealt with in the study due to the lack of this information in the reports). This could be important the contribution of insurers to come up with a model of analysis that compare the risks assumed with predictable costs.

In the face of established results it is necessary to adopt some measures to improve the knowledge of urban fires, reduce the number of occurrences and limit their consequences, including the following:

- Implement a national system of data collection and analysis of urban fires;
- Strengthen the training of the command members and chief of fire fighters regarding the determination of the causes of fire;
- Conduct awareness campaigns to reduce the high number of false alarms and groundless alarms;
- Conduct awareness campaigns for preventive measures to be taken in houses in order to reduce the fire risk, namely: in preparing the meals as a result of deficient electrical installations or resulting from negligence related to heaters, candles and smoking.

- Consolidate studies in the field of sociological dimension of urban fires with a view to identify the main risk groups;
- Strengthen preventive intervention near the neediest families, the elderly and the families that integrate seniors or children of young age;
- Reinforce the awareness measures aimed at food and beverage establishments and hotels in order to ensure the adoption of preventive measures to reduce the number of fires that occur in the preparation of meals.
- Intervene with homeless individuals and communities about the derelict buildings where they are housed in order to reduce the number of occurrences;
- Intervene in historic quarters where there are higher rates in terms of the number of cases and their severity in order to improve the physical conditions of dwellings and their technical installations and to sensitize its residents for the preventive care and prepare them for possible first fire acting.

It is highlighted the importance of having a thorough knowledge of the reality of urban fires in Portugal, which will be possible only if it is implemented a national database and centralized treatment of information. To ensure that this objective is achieved it is necessary that there is a report type that is applied universally by all fire-fighters. In this sense, and as a conclusion of the work, it was proposed a model for the register of occurrences of urban fires, opportunely sent to the National Authority of Civil Defence (ANPC) and expected to constitute the basis of a new report type for use by fire-fighters.

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10 FIRE ACCIDENT AT SHOPPING CENTRE IN ZADAR, CROATIA

Summary

This paper presents the case study of the fire event that took place at a large shopping centre in Zadar, Croatia. The shopping centre was built on area of 3480 m^2, comprising three adjacent buildings. Travelling fire occurred due to a non-existent compartmentation of the buildings. Fire brigade intervention was fast but limited due to the undisturbed horizontal and vertical fire spread. This fire accident demonstrates the importance of having a necessary building compartmentation and the effective sprinkler system in order to extinguish fire at an early stage or to contain it so that the firemen might have a better chance of putting out fire. Fire disaster is presented on the basis of the available fire brigade reports and engineering projects.

10.1 GENERAL BUILDING DESCRIPTION

The shopping centre was located in the industrial part of the city of Zadar, Croatia. Shopping centre was used mainly as a warehouse and a store of home furniture and technical appliances (Čimbur, 2008a). Centre consisted of three sub-buildings: A-C. Building A (720 m^2) was used as an exhibition/administrative area, while buildings B and C (1200 m^2 each + additional 360 m^2 in building C) were primarily used for the storage of goods. Buildings A and B were designed so that they have an additional floor. Additional floor in building A was used as administrative area and in building B as storage area. Layout of the shopping centre is presented in Fig. 10.1.

According to Fire Safety Measures Report[1] of the centre (Čimbur, 2008b), buildings A and B were equipped with sprinkler installations. Building C was built afterwards without having followed the Fire Safety Measures Report and, consequently, no sprinklers were installed in that area. Moreover, building C was constructed without legal permits, therefore being an illegal building. For this analysis, it is important to note that buildings B and C were not designed as separate fire compartments. However, requirement of

[1] Fire Safety Measures Report refers to *Elaborat o zaštiti od požara*, Čimbur 2008b.

the Fire Safety Measures Report was that the separating fire wall should be built between buildings A and B. The estimated fire load for the shopping centre was 500 MJ/m^2.

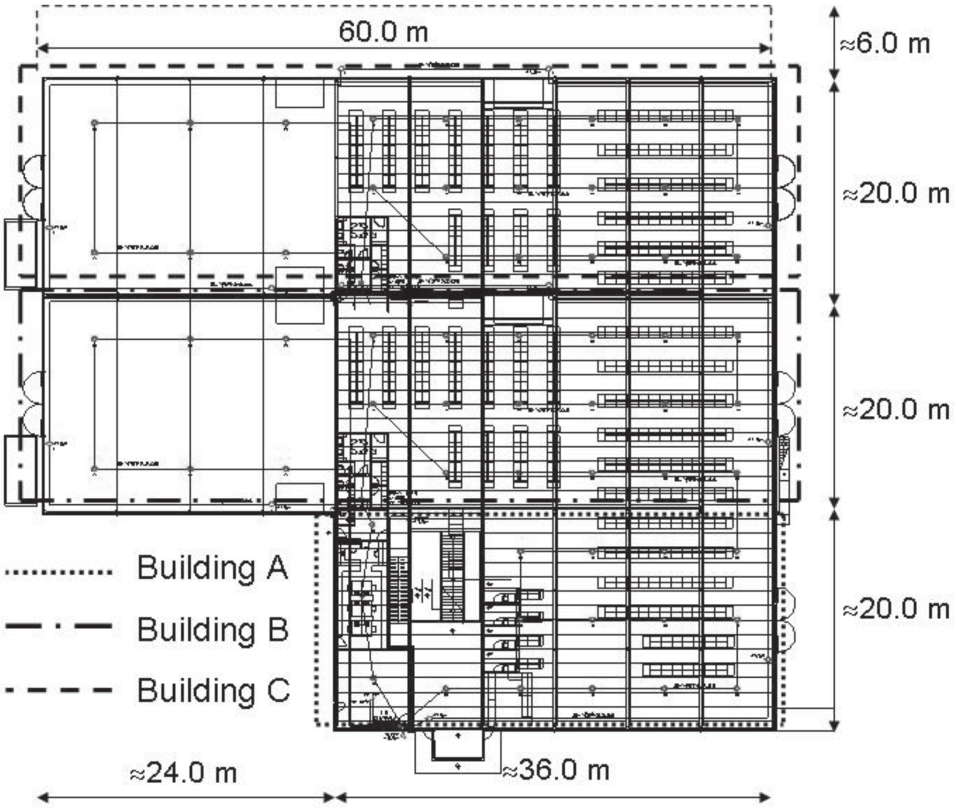

Fig. 10.1 Layout of the shopping centre

Main load bearing structure for each of the buildings was a steel portal frame. The height of the portal frame was approximately 6.0 m at apex with a span of 20.0m. The distance between the plane portal frames was 6.0 m. The portals were also connected with purlins used as a support for the sandwich panels. Columns and beams were made of steel grade S235 (Kovač, 2008). Cross-section of the centre is presented in Fig. 10.2.

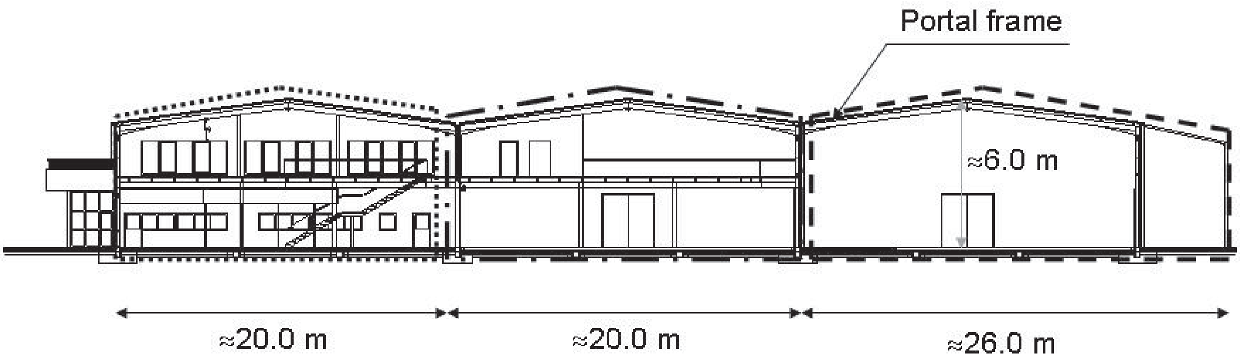

Fig. 10.2 Cross-section of the shopping centre

10.2 REASON OF FIRE STARTING

Suspected cause of the fire was the spark ignition from the malfunctioned electrical installation located at the lower end of building C. However, criminal and court investigation is currently in progress and the official reason of the cause of the fire will be known after the investigation.

10.3 DESCRIPTION OF FIRE DISASTER

Fire accident happened on February 22, 2010. According to the firemen report (Zapisnik, 2010), first report of the fire accident came at 11.43 p.m. The origin of the fire was located at building C. At 11.51 p.m., two fire brigades arrived at the scene. At the time, approximately one half of the building C was under fire. Fig. 10.3 presents the fire event at approximately 1 a.m, February 23rd .

Fig. 10.3 Fire spread from building C to building B (1 a.m.)

Since there were no fire walls between the adjacent buildings, at 0:20 a.m. fire was able to expand freely to building B. Fire spreading to building B was enhanced by ignition of flammable facade panels. Installed sprinkler system in building B was activated, however it was incapacitated since no water was present in the sprinkler installations at the time. The collapse of building C happened at 0:40 a.m., approximately 60 minutes after the fire had started. Collapse of the building B happened at 1:20

a.m., approximately 95 minutes after the fire had started. At that time, fire had already spread to building A, again the sprinkler installations were inactive. Firemen concentrated their efforts on saving the administrative offices. Because of their concentrated efforts, only a partial collapse of the building A occurred. Fire was extinguished after two and a half hours of struggle with fire. Fig. 10.4 presents the fire event at around 1:40 a.m.

Fig. 10.4 Partial collapse of building A (1:40 a.m.)

10.4 WAY OF INTERVENTION BY FIREMEN

Fire was extinguished with the help of two fire brigades, consisting of 15 fire trucks and 28 fire-fighters. Response time of the brigades was approximately 8 minutes; their headquarters was 1 km away from the fire scene. Upon the arrival, the fire-fighters encountered incapacitated fire hydrant system with no water present in it at the time of the fire accident. This event prolonged firefighting because fire trucks had to replenish their water supply away from the fire scene.

10.5 CONSEQUENCES OF FIRE

As a result of the fire accident, buildings A and B were totally damaged, while one half of the building C was saved from destruction. Building surface destroyed by fire was approximately 3480 m^2, with the total damage cost of 3 million Euros. Since one part of the shopping centre was used as a storage area, total damage from the destruction of stored furniture and technical appliances was approximately 1.5 million Euros. Fortunately, no casualties occurred during the fire event. However, the fact that there were no casualties was fortuitous; the fire took place at night and not during working hours when the building premises are occupied by at least 100 people (workers + civilians). It is questionable whether all of the occupants could have been safely evacuated, in case of a fire starting during working hours, since the fire started to spread to adjacent building (B) in less than 35 minutes. This claim is supported by the fact that in less than 95 minutes load bearing capacity of buildings B and C was reached. In that case fire-fighter intervention for extraction of occupants would be rather difficult (Fig. 10.5). It is estimated that the fire temperatures in the buildings were over 1000°C.

Fig. 10.5 Aftermath - building C

10.6 CONCLUSION

As a result of the analysis of the fire accident key conclusions are presented. Building C was constructed without a proper technical plan or feasibility study for the provision of fire. As a consequence, building C was not constructed as a separate fire compartment, thus creating a global compartment with building B (≈2760 m^2). Active fire safety measures were not effective in stopping the fire since there was no water present in the sprinkler system. In addition, fire-fighters were not able to use the fire hydrants because of the above-stated problem. Flammable facade panels enhanced the fire spreading over buildings A and C.

Due to a concentrated fire extinguishing intervention fire brigade was able to save only a part of building A. Although the response time of the fire brigade was low, the intervention was unsuccessful because the buildings B and C were not designed as separate fire compartments.

10.7 RECOMMENDATION

By analysing the fire event, its consequences and the time period in which it took place, the following recommendations for the fire protection of similar building types can be made:

- Storage buildings or warehouses that have a high risk level of fire accident should be built according to Fire Safety Measures Report in full, taking into account the usage of active fire safety measures and compartmentation of the building,
- Adjacent storage buildings should have a separating fire wall in order to prolong the fire spread and to have efficient fire-fighter intervention in stopping the fire spread to adjacent building,
- Active fire safety measures have an important role in the early stages of fire and should be checked on regularly basis for efficiency in order to have fully capable fire safety measures,
- Despite the fast intervention, the efficiency of fire brigades is greatly reduced in saving the storage buildings if the fire spread is not contained by means of sprinklers or compartmentation,
- Owner of the building should ensure permanent control of active and passive fire safety measures in the building and according to regulatory requirements ensure inspectors or a fire brigade that will monitor and control the installed fire safety system.

Acknowledgement

The authors would like to thank the Fire brigade of town Zadar for their help in obtaining the information presented in this paper.

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11 ANALYSIS OF FIRE CASES IN PANEL BUILDINGS IN HUNGARY

Summary

In Hungary ca. 2-3 million people live in large panel buildings. Houses built by industrialized technology raise some problem in Hungary and Eastern-Europe nowadays. The complex refurbishment of panel-houses is continuously a purpose. The refurbishment of block houses means the external thermal insulation of walls, thermal insulation of roof and cellar ceiling, changing of openings (windows, doors), renewal of heating systems and occasional implementation of solar collectors.

During the renewal of a panel building in Miskolc three people died in a fire. The insulation of the facade was made of polystyrene. The fire broke out in a flat on the sixth floor and its spreading was extremely rapid. It reached the tenth floor within a short period of time.

There were some other significant fire cases in medium high-rise houses built by industrialized technology in Hungary, but this incident angled this problem to focus.

The Hungarian fire propagation test for building facades (MSZ 14800-6:2009) is a unique investigation method in Europe. ÉMI Non-profit Llc. runs around 10-16 analysis every year that are concerned with the spreading of fire on building facades by different thermal insulation systems.

11.1 FIRE CASES IN PANEL BUILDING OF HUNGARY

From the 4.000.000 flats in Hungary about 700.000 ones were built with industrial technology and 507.000 homes were built between 1962 and 1992 with panel system.

The 5/1965 BM TOP[1] regulation (which was the first fire safety regulations of medium and high-rise building in Hungary) was revised in 1979 and in 1986.

From fire protection point of view the panel buildings can be divided into two typical groups: the 5-storey and 10 (11)-storey buildings, these latter ones belong to the medium high-rise category. Some large, well-known Hungarian fire cases in panel buildings are as follows:

18. May 1972 Budapest, Csertő u. 12-14. (Fig. 11.1)

- 7 people lost their lives!
- damage to property by fire was estimated at 9 million HUF (cca 32 000 Euro)
- 39 tenant and 2 firemen injured
- The fire directly threatened 40 flats and 150 tenants

[1] BM TOP in Hungarian stands for the Ministry of Interior, National Fire Headquarters

Meter cabinets/shafts with combustible doors, which are suitable for material storage along the middle corridor were not separated at the line of storeys. Problems of fire protection were also the lack of heat and smoke exhausting, central alarm, dividing for appropriate sized smoke reservoirs and fire compartments.

Fig. 11.1 Fire case of Budapest, Csertő u. 12-14. (18.05.1972)

26. February 2007 Debrecen, Fényes udvar 6. (Fig. 11.2)

- the fire hazarded 108 flats in 3 staircases
- the renewal cost was 80 million HUF (cca 281 000 Euro)
- 14 people injured in fire
- The fire directly threatened 44 flats

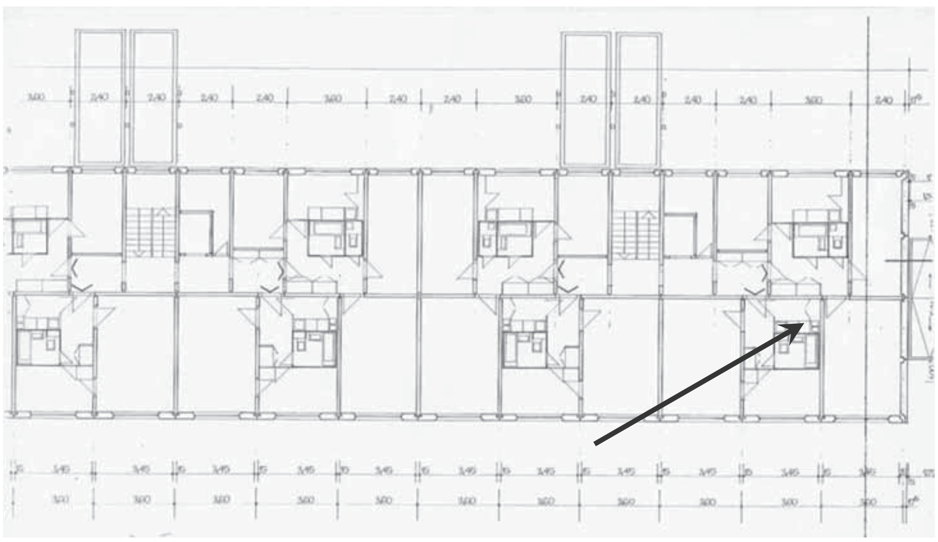


Fig. 11.2 Ground plan of the building, red arrow indicates the kitchen (starting point of the fire)

Fig. 11.3 a) The kitchen was the starting point of fire, b) The kitchen on the next upper storey after the fire case

In the kitchen on the upper next storey where the fire started the shaft and the shaft wall were destroyed, the vent hood made of aluminium melted, the combustible shaft wall burned (Fig. 11.3b).

Fig. 11.4 a) The II. floor kitchen and b) the III. floor kitchen after the fire

The smoke spread over the connecting corridor between staircases at roof level to the adjacent staircases as well.


a) b)

Fig. 11.5 a) The V. floor kitchen and b) the shared air-shaft of kitchen and bathroom looking from the V. floor's kitchen after the fire

7. June 2007 Budapest, Páskom park 35. (Fig. 11.6)

- 1 tenant lost his life!
- 17 people got smoke poisoning
- 30 people were rescued by fire fighters
- Nearly 108 homes have been reviewed


a) b)

Fig. 11.6 The building (Budapest, (Páskom park 35.) after the fire


a) b)

Fig. 11.7 a) The kitchen and b) the entrance door after the fire

The cooker was relocated, exhaust vent and upper kitchen cabinet were over it, the exhaust vent was connected into the central ventilation system (Fig. 11.7a). Fig. 11.7b shows an inadequate fire-resistant door: only the lock remained intact after the fire.

The connecting corridor between staircases on the roof was closed with steel grating. The ventilation design was the same as those in Debrecen Fényes udvar fire.

Other fire cases in panel buildings:

- 30. March 2006 – Budapest XIII., Pannónia u., fire broke out in the garbage container on the ground floor of a ten-storey block of flats
- 26. July 2006 – Miskolc, a flat on the sixth floor of a ten-story panel building burned out completely
- 13. September 2006 – Budapest XI., Menyecske u., fires broke out in a ten-storey panel building (arson)
- 7. February 2007 – Budapest IV., Lebstück Mária u., fire on the first floor of a ten-storey panel building
- 16. February 2007 – Budapest, Csepel, Kossuth Lajos u., fire on the first floor of a four-storey panel building
- 2. May 2007 – Budapest X., housing estate in Harmat u., the accumulated garbage ignited in the basement of a ten-storey panel building
- 23. May 2007 – Debrecen, fire in a ninth-floor flat in a panel building
- 5. January 2009 – Debrecen, István út 45., fire in a ground floor flat

- 5. February 2009, Debrecen, Tócóskert housing estate, fire in the solid waste chute

11.2 FIRE CASE IN A PANEL BUILDING OF MISKOLC, (15. AUGUST 2009)

Fire occurred fatalities on 15. August 2009 in a medium high-rise residential building built with industrial technology (Miskolc, Középszer u. 20.). The fire arose in a sixth floor flat of a ten-storey building. The fire and smoke spread – mostly up – likely through pipe shafts, and the staircase, and along the facades and staircases spread - mostly up – and reached other flats. Due to this fire case the focus during the year 2009 has shifted to polystyrene foam insulation system used on building facades (although here the tragedy was caused mainly by construction issues).

The Fire Service of Miskolc appointed ÉMI Non-profit Llc. as expert institution for the examination of the applied building insulation system. The case is currently going through litigation, so the actual documentation may not be made public. This paper presents the general problem of panel fires, causes, fire investigation, fire spread and the proposed ways of their solution.

a) 

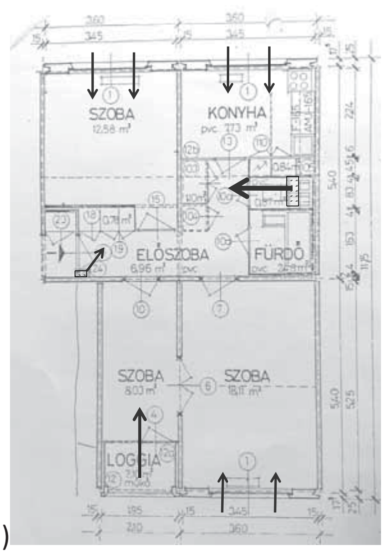
b) 

Fig. 11.8 a) Panel building of Miskolc, Középszer u.20. b) Ground plan of the flat, where the fire started

This residential building (Fig. 11.8a) was built with precast concrete large panel system and has 3 staircases. Fire started in a flat, which had openings on two opposite-facing facade. The flat above it has the same layout. On Fig. 11.8b red arrows indicate the places on the ground plan of the flat, where smoke could spread: pipe shaft, loggia - an open door, which was destroyed in the fire, open windows, rainwater drain pipe next to the entrance door.

a) b)

Fig. 11.9 a) Starting point of the fire b) the toilet after fire

Fig. 11.10 Irregular additional insulation on the side wall of the loggia

More expertise was made on the fire, according to these the followings can be stated as the causes of tragedy:

- due to the warm weather windows were open (tilt position)
- defective formation of reveals at windows
- the insulation material was not correctly fixed (not at edges only in the middle)
- only 2-3 mm plaster was applied instead of the required 5 mm
- the implementation of glass fibre mesh was irregular (insufficient overlap, lack of corner enhancement and glass fibre mesh at tripod connection points)
- irregular additional insulation on the side walls of the loggia

a) b)

Fig. 11.11 a) Fixing points of the insulating material b) formation of reveal at a window

Computer simulations (Csaba Szikra, BUTE, Department of Building Energetics and Service System) were also made, which concluded that the turbulent flow developing at loggia helped the spread of fire into the flats through the open windows. Although the flat facade enhanced the up-rising intensity of the flow, smoke still could get into the flats through the open windows.

11.3 THE LACK OF FIRE PROTECTION IN MEDIUM HIGH-RISE RESIDENTIAL BUILDING BUILT BY INDUSTRIALIZED TECHNOLOGY

In Hungary the fire cases of panel buildings recently came into the focus of interest. Although it didn't change significant the number of fires, some cases were very serious (eg, Debrecen, Budapest).

As result of expertise the lack of fire protections are as follows:

Pipe shafts and ventilation pipes

- The original shafts separation (e.g. backboard in toilet) is painted hardboard (Debrecen, Budapest, Páskom park), which is "easily combustible". This is aesthetically unsatisfactory, so that the occupants replaced.
- The ventilation pipes were made from aluminium, which has good thermal conductivity and low melting point.

Separating, bounding structures of pipe shafts

- Originally the grooved siding or OSB cladding is D-s2, d0

Lack of sectioning of pipe shafts and ventilation

- Between ceiling and ventilation pipes at the level of slab breaking the filling or concreting for barrier against fire spread was omitted (Fig. 11.12).

Ventilation shafts and flues (Fig. 11.13)

- The accumulated fat in ventilation ducts of the kitchens is very difficult to be removed
- The suitability of the slow reaction shut-off mechanism (by fire expandable inset) is questionable, because the heat and fire spread is very fast.
- The correct solution could be the automatic and fast closing of intake (controlled by pneumatic cylinder or fire alarm) and if shaft wall would have adequate fire resistance

Fire protections problems of load bearing structures

- Reinforced concrete structures injured fire damages as spalling and have reduction in strength.
- Rebars, reinforced concrete has thermal expansion problems.

The negligent work at junction by spot welding and concreting on site resulting discontinuities (e.g. smoke spread between two flat), or through the extinguishing water at the drain connection get corrosive substances into the concrete and steel fasteners.

Fig. 11.12 a) Lack of sectioning in a pipe shaft

Fig. 11.13 Ventilation shafts and flues

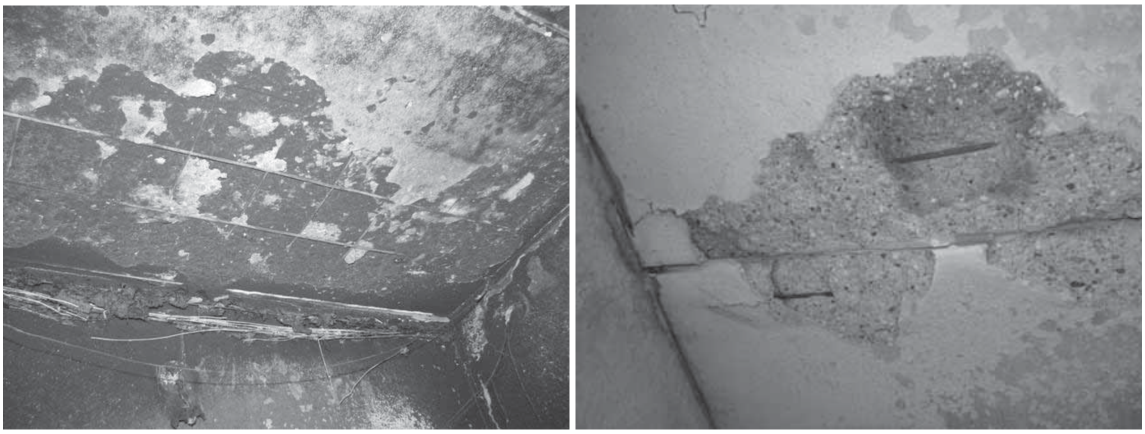


Fig. 11.14 Fire damaged reinforced concrete structure

Entrance doors

- The entrance doors do not have the suitable fire resistance, often occupants have replaced the old doors but not for suitable structure.

Basement level, fire compartment

- Fire barriers, separatings are missing. Combustible materials containing storages are only separated with trusses from the corridors.
- Often there are no separations between corridors and staircases, one or more staircases create together with only one fire compartment (e.g.. Debrecen, Fényes udvar 6., the 4 staircases is a 9.500 m^2 fire compartment).
- At some places security doors was installed at the basement level, but because of the inappropriate fire resistance of staircase wall this can’t be considered as protection against fire spread

Smoke spread through the connecting corridor (passageway) at roof level

- The smoke contacting with the bounding structures cools down and flows down in the adjacent staircases.

Floor penetration without seal (Fig. 11.15)

Fig. 11.15 Floor penetration without seal after fire

Inappropriate heat and smoke extraction (Fig. 11.16)

Fig. 11.16 Staircase after fire

11.4 CONCLUSION

The failures at recent fire incidents in panel houses are nearly identical and not unique. The shortcomings of fire protection in medium high-rise residential buildings are similar throughout the country. The problems of additional thermal insulation at panel building reconstruction contribute to this.

Most of these failures, imperfections are general typical not for the panel building but for the old medium high-rise buildings, where the building services, fire protection and the thermal insulation are also out-of-date. Energy efficiency and fire protection shouldn't be separated. The certification of building materials is not enough if the human factor is inherent in the failures of the implementation. At medium high-rise residential buildings the most common and most dangerous places of vertical fire spread are the pipe shafts. Fires of flats starts mainly in the kitchen, than it gets into the shafts through the ducts, where there are deposited significant amounts of flammable fat and oil residue and dust which feed the fire. The kitchens of the flats one above the other are connected to the same vertical ventilating duct. This circumstance significantly redound the vertical fire spread.

We need to change the approach. The refurbishment of panel buildings must be more general. It should not only deal with heating system, changing of windows and additional thermal insulation, but also fire resistant separation of the flats. We have to determine the lack of fire protection in the panel houses and make suggestions for the theoretical solution. Fire brigade must be more prepared to know more about the fire and smoke spread phenomenon. It would be necessary to prepare a guide about the fire protection specialities of panel buildings.

Acknowledgement

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12 FIRE FIGHTING ON INCLINED COAL HANDLING BRIDGE

Summary

Besides the analysis of fire behaviour, complete description of real fire should include the influence of the active response of fire safety measures. Compilation of the interoperability algorithm overall the fire safety measures is the main objective of this study. This algorithm should include sophisticated cooperation between fire alarm system, fixed extinguishing system, smoke control, evacuation system etc. and fire-fighters intervention.

In 2005 coal handling bridges in Opatovice power station, Czech Republic, were damaged by fire. The coal handling route was completely burned. Effects of the fire limited coal supply for 3 months. Following that fire the new fire protection equipments have been gradually installed in other Czech power plants. In 2007 the installation of a complex fire protection equipment of coal handling route was started in Tušimice power plant. However, after starting the operation it showed that automatic activation of the extinguishing system on the inclined conveyor bridge was threatening the health and life of intervened fire-fighters.

The interoperability algorithm, which enables both an elimination of false alarms or competent control of fire-fighting and automatic extinguishing and cooling of construction in the shortest possible time in difficult conditions of the inclined coal conveyor bridge, is investigated.

Fig. 12.1 The Tušimice power plant

12.1 FIRE IN OPATOVICE POWER PLANT

In September 2005 coal handling bridges in Opatovice power station, Czech Republic, were damaged by fire. About 120 m of steel bridges were affected and coal handling route was completely burned, see Fig. 12.2. Effects of the fire limited coal supply for 3 months. The loss of 3 million Euros was caused by the fire. After investigation several causes of the fire was detected. Lightning was the initial source of fire. Old fire alarm system fell down and the fire was found out after 1 hour. In the meantime coal, belts of coal handling route and cabling were caught by fire.

From the view of fire prevention several failures were investigated. There was only limited fire alarm system which started to signalize the fire. After 2 sec the signalization was cancelled itself by unknown reason. Human operator did not respond to the anomalous alarm. After 30 min shortages on electricity cables were notified by control system, but the human operator did not reply again. After 1 hour a cloud of smoke was noticed and fire-fighters were called. Human mistake was shown as the biggest cause of the disaster.

Fig. 12.2 The Opatovice coal bridge after the fire

12.2 TUŠIMICE POWER PLANT

12.2.1 Fire safety arrangements

Following the fire in Opatovice power plant new fire protection equipments have been gradually installed in other Czech power plants to eliminate influence of human mistake. In 2007 the installation of a complex fire protection equipment of coal handling route was started in Tušimice power plant. Equipment consisted of sensors of temperature above and under belts, coal dust sucking off, alarm system and automatic extinguishing system with sending signals to 3 different surveillance locations.

Automatic extinguishing system was set to start in 5 min after fire alarm. However this time limit was insufficient to complete a fire survey by fire-fighters. In case of automatic extinguishing very dangerous conditions for fire-fighters originated from the water flowing down on inclined coal handling bridge. Moving on inclined greasy floor covered with continuous flush of water (about 6760 l/min) was found as life-threatening. In the first moment there were two solutions. To stop using of automatic start of extinguishing system – the solution could lead to repeating of big fire in Opatovice power plant, or to do not realize fire surveys. The second solution was not acceptable because of high number of false alarms (in last 8 years - 676 false alarms). Extinguishing by false alarm would cause several days of lay-by of power plant and loss of 40.000 Euros per day.

The solution had to be searched. It was found as an interactive algorithm of interoperability, which enables both an elimination of false alarms or competent control of fire-fighting and automatic extinguishing and cooling of construction in the shortest possible time in difficult conditions of the inclined coal conveyor bridge. To find the algorithm, analysis of possible fire scenarios is specified.

12.2.2 Description of inclined coal handling bridge

Coal handling bridge T12 consists of coated steel truss construction inclined in angle of 16°, see Fig. 12.3. Total length of 170m reaches the height of 47 m. The bridge is 7m width and 3,3m high. Steel structure consisted of trusses with upper and lower stiffening trusses is covered by aluminium sheet, window openings are made of reinforced glass. Massive rigid frames are spaced at 3 m. Bottom deck laying under two conveyors with rubber belts is made of reinforced concrete. By the aid of fire protection walls the coal handling bridge is divided into 2 fire compartments of lengths 102 m and 68 m. However because of conveyors going through there are big holes in the fire partitions.

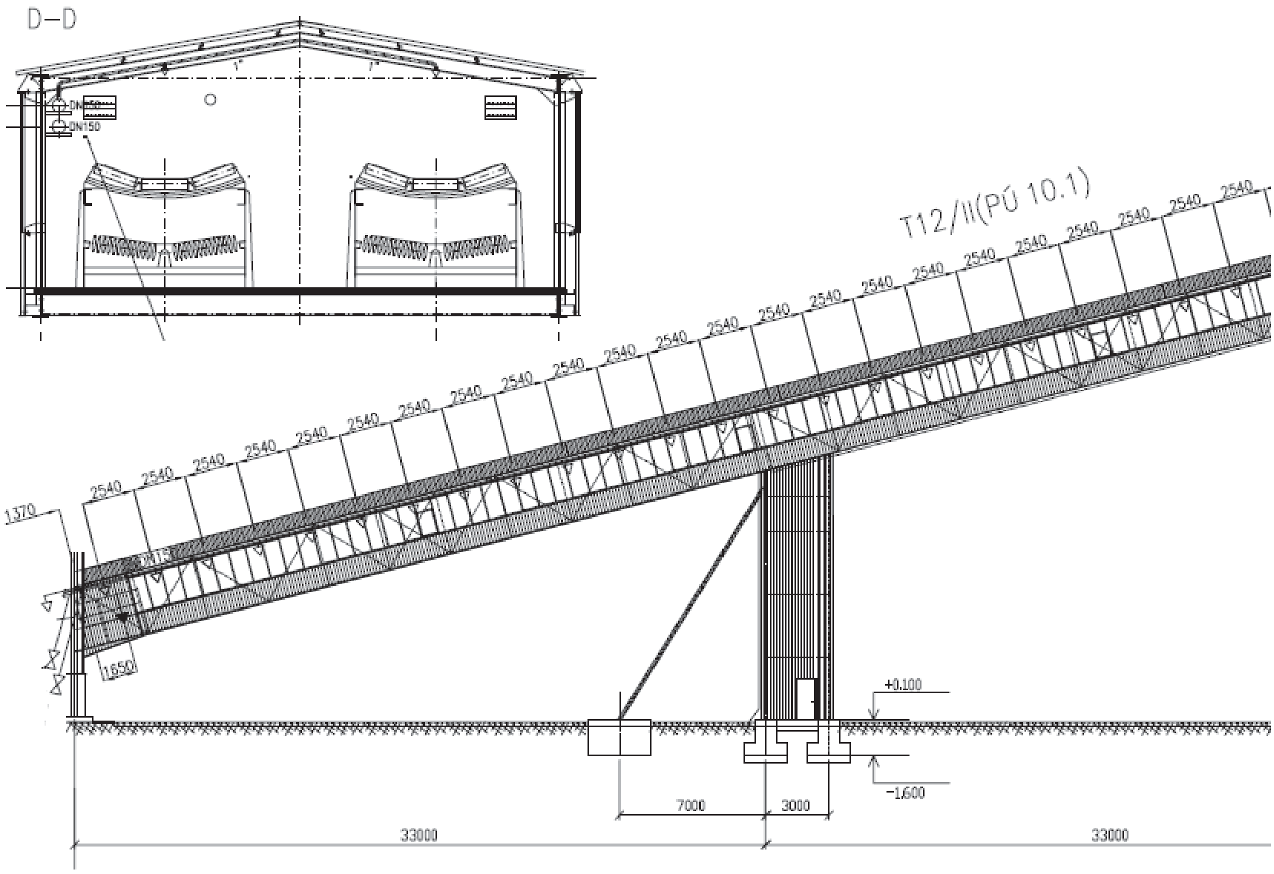

Fig. 12.3 Steel construction of coal handling bridge T12

Inclined bridge is a part of coal handling route used to transport brown coal from surface mine “Doly Nástup Tušimice” to a boilers of power plant Tušimice. Chemical composition of brown coal is $C_{60}H_{60}O_{12}$. Coal is transported on two elastic rubber belts 1,6 m width. Thickness of the belt is 0,013 m. With velocity of the belts of 2 m/s total output of transported coal is 3000 t/hod.

12.3 DESIGN FIRE SCENARIOS

Four main reasons of the fire on the coal handling bridge can be specified:

- seized rollers under the belt causes ignition of the elastic rubber belt (ignition temperature – 460 °C), after burning the coal on the belt can ignite, the belt may sever, and swirling coal dust can explode (scenario A)
- sparkle from the seized roller can initiate ignition of coal dust – thanks to regular cleaning it is not probable
- transport of fire outbreak from outside – burning of coal followed by burning of belt or reversely
- failure of wiring, human mistake, nature element – burning of coal or coal dust, ignition of belt

Last two reasons can be compiled into scenario B.

12.3.1 Scenario A

Burning of the bottom of belt and its subsequent rupture causes whirling of burning materials and the coal dust. This may exceed the limits of coal dust explosion. Early detection of fire from the bottom of the belt is possible only by monitoring the temperature in the area of rollers. Linear heat detectors are installed in the area of conveyors rollers. When the detected temperature is higher than 80 °C, signal is sent to local fire station. However indication of higher temperature does not start any extinguishing sequence. Starting of automatic extinguishing system is not favourable in this case because of a small effect of extinguishing during burning at the bottom side of the belt and conveyors cannot be stopped, because the belt does not ignite during movement. This fire scenario is not further considered because automatic extinguishing does not start.

12.3.2 Scenario B

In this scenario fire detection is possible by monitoring the temperature above the belt. After detection of the temperature higher than 80 °C belts are stopped and fire intervention is started. The fire development can be determined by calculation of the design fire with following conditions:

- the most conservative case is considered (both belts are full of coal)
- a rupture of the belt is not reached
- an explosion of coal dust is not included

12.4 FDS SIMULATION

12.4.1 Description of model

In inclined bridge there is a strong chimney effect, which accelerates the combustion on one side and intensively cools the construction of the bridge on the other side. Cold air is sucked by lower openings and heated by burning of coal on handling bridge. Holes in fire walls allow air flow to upper part of the bridge where the hot air can leave by upper openings. Numerical simulation based on CFD analysis is the most suitable method for solution of this problem. Fire scenario B is studied numerically by FDS 5 (McGrattan, 2010).

One of the FDS model of inclined bridge is shown in Fig. 12.4. The dimension of the computational domain is 165 m by 7 m by 50,5 m. The size of openings for conveyors in the lower, middle and upper fire walls is 2 x 2 m by 1,3 m, middle fire wall is placed in two-thirds of the bridge. In the model there are 6 different materials including steel, concrete, plaster, fire brick, coal and rubber. The detailed properties of these materials are shown in Tab. 12.1. Properties of burning materials come from Catalogue of brown coal 2009-2010 of mining company SD a.s. and Czech standard CSN 73 0804. Surface properties of the obstructions in the FDS model include steel sheets, concrete bottom deck, plaster and fire brick walls, coal layer and rubber belts. Nominal movement of the conveyor belt of 2 m/s is simulated by air flow. Heat release rate, air velocity above the centre of fire, the air temperature below the ceiling and the wall temperature of the structure of the bridge are measured in 10 min (time needed for fire-fighters intervention).

12.4.2 Centre of ignition

During the modeling, it was found that a small fire outbreak did not stop the belt. Because of rapid belt movement the fire does not burn up. Small flaming core is transported across the bridge and dispersed during unloading to next belts. The fact that the fire occurs after stopping the belt, confirmed the long experience of workers at coal handling. In the past workers had following long time work experience - at the time a fire was detected on a belt, the fired coal was quickly transported to the boiler, where it was subsequently burned. In case of larger flaming core, easily repaired local damage of a belt could occur, but there were no further consequences. By this procedure, neither rupture of a belt or fire of the whole bridge did not threaten. Long and good practices of coal handling were changed by requirements of Czech standard CSN 73 0804, requesting to stop belts when temperature increased. In the most probable fire scenarios stopping of belts required by this standard can cause a fire of a bridge and rupture of belts with consequential high economic impact.

Minimum flaming core which causes stopping of belts was found by iteration method. This size depends on parameters of a specific used coal. In this case the minimum flaming core is 40 x 40 x 30 cm. The focus of these dimensions stops the belt after driving of 40m. Flaming core of size 30 x 30 x 30 cm does not stop the belt. It was also found that flaming core starts to burn up on the level of rubber belt. If the flaming core is concentrated in the upper layer of coal, for example, 40 x 40 x 20 cm, bottom layer of coal preclude heating of the belt and prevents burning up a fire.

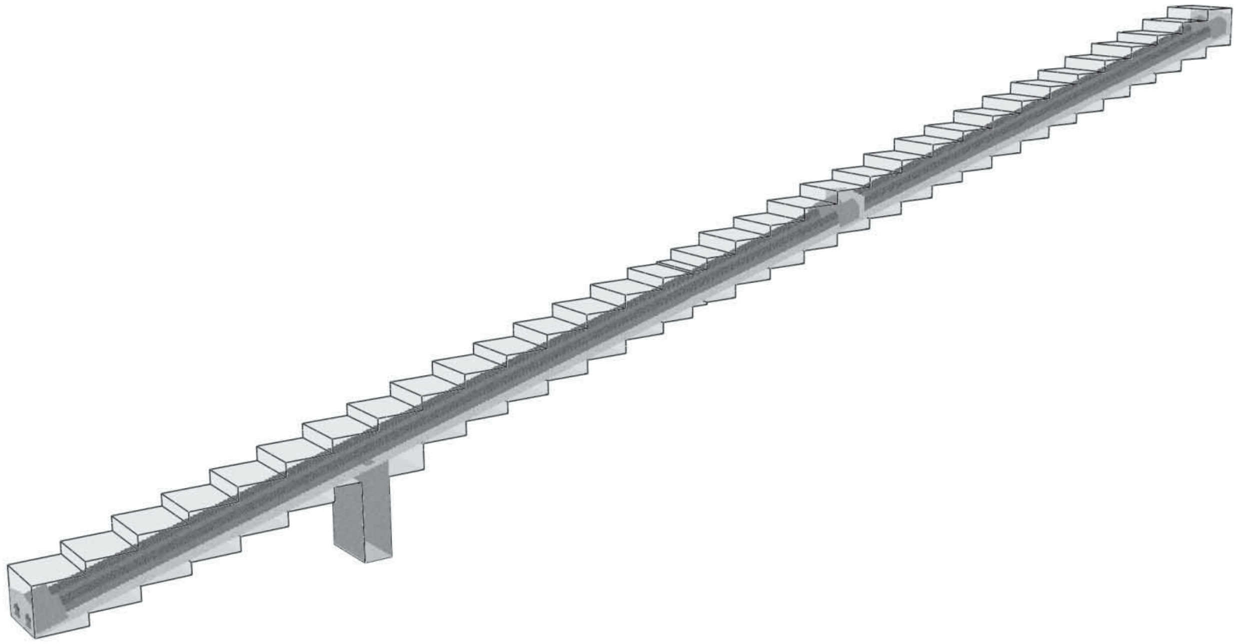

Fig. 12.4 FDS model of inclined coal handling bridge

Tab. 12.1 Properties of materials used in FDS model

	Steel	Concrete	Plaster	Fire brick	Coal	Rubber
Specific heat capacity [kJ/kgK]	0,46	1,04	0,84	0,96	3,1	1,42
Heat conductivity [W/mK]	45,8	1,8	0,48	1,3	0,3	0,16
Density [kg/m^3]	7850	2280	1440	1400	720	1000
Emissivity [-]	0,95	-	-	0,8	0,95	0,94
Heat of combustion [kJ/kg]	-	-	-	-	1,15*10^4	3,5*10^4

12.4.3 Progress in modelling

During the study a number of models were created to find the optimal grid size. A set-up of linked cells of grid allowing solution of specific construction of inclined bridge was formed. Two different approaches were analyzed:

- A model of bridge with inclined construction and ranked grid as stairs (approach A)
  Because of inclined structures this model showed high sensitivity to size of cells of numerical grid. When a grid was rough connection between flammables and holes was interrupted. The solution was to create a heterogeneous grid with variable cell sizes. The ratio of cells in places of structural changes compared to places of continuous construction reached value of 16.

- A model of bridge with horizontal construction and horizontal cells of grid with inclined vector of gravitational forces (approach B)
  From the view of construction this model was stable. However the size of cells of computing grid highly affected the stability of the numerical calculations. To the contrary of approach A, whole grid domain was influenced by sensitivity of the calculation, due to the direction of global vector of the gravity. It was therefore not possible to use the method because high demands on computational power.

The final model of approach A was compiled from a total of 35 computational grids of two sizes of cells. Basic cell size was 6 x 6 x 6 cm, cell size on continuous parts of the bridge was 12 x 24 x 12 cm. The total number of computational grid cells reached 1,8 mil.

Within all calculations an approximation of the total model was used, in which only the one longitudinal half of the bridge was included into the computational domain - the part where the flaming core was. The approximation of the model was based on the verified assumption that the transverse flow vectors are significantly smaller than the longitudinal flow vectors and that the second longitudinal half of the bridge only dilutes gas flow and reduces monitored temperatures. The approximation of the model consisted of 0.9 million computational cells. During modelling it was shown that the half-part model of the bridge was insufficient for detailed study of fire development. By simulation of whole bridge the fire spreads from one belt with origin of fire to the second belt after 6 min.

The size of computational cells is on the edge of acceptability in terms of physical and chemical processes. Computational cell size should be consistent with the Shannon theorem - by dimensions 1 x 1 x 0,6 cm 360 times smaller, or 5760 times smaller than cells, if we assume size of lumps of coal and thickness of rubber belt. The resulting number of cells would reach more than 9 billion cells and in the standard version of FDS it would need order of TB RAM. The model used in this case is therefore a compromise between the physical requirements and available potentialities of computer technology which was searched uneasily.

12.4.4 Fire development

Based on the above findings, a model with flaming core of size 40 x 40 x 30 cm is used. The core is placed at 40m from the beginning of the bridge. After 20s of moving 0,5m above belt the temperature of 80°C is detected and belt is stopped. Diagram of relative air flow shows fast movement of the flaming core inside the bridge, then stopping of the belts is proved, see Fig. 12.5. After stabilization of air flow equilibrium the fire starts to burn up and the flow rate gradually increases. From development of rate of heat release shown at Fig. 12.6, it is obvious that burning the fire up starts after 2 min. The fire spreads upward, in the direction of air flow. Till the 7th min the fire involves only one belt of the bridge. Then it starts to spread to its width - to the second belt, see Fig. 12.7. Because of lack of oxygen in upper part of the bridge flames start to spread in the down direction after 7 min.

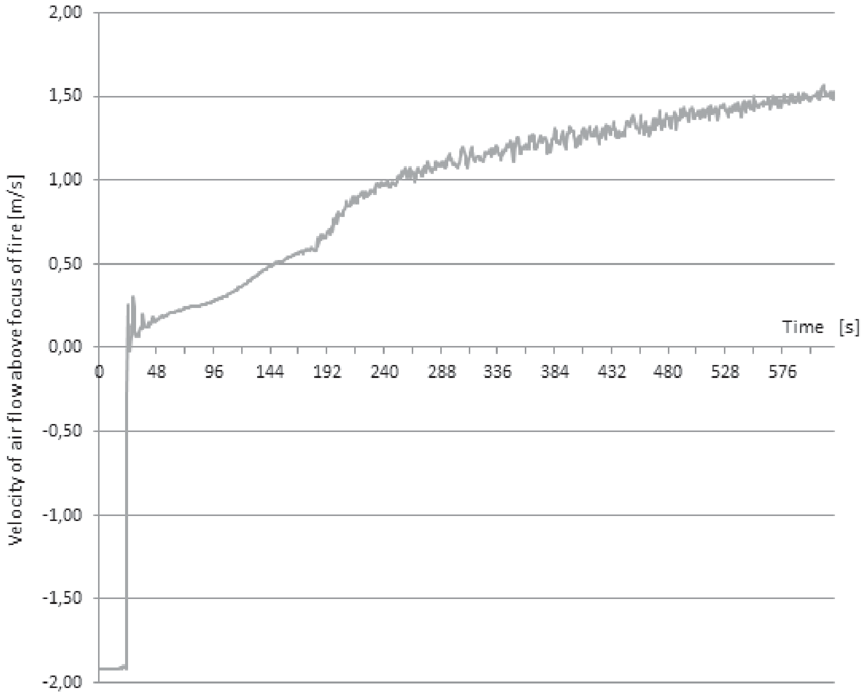

Fig. 12.5 Relative air flow above the fire outbreak, FDS results

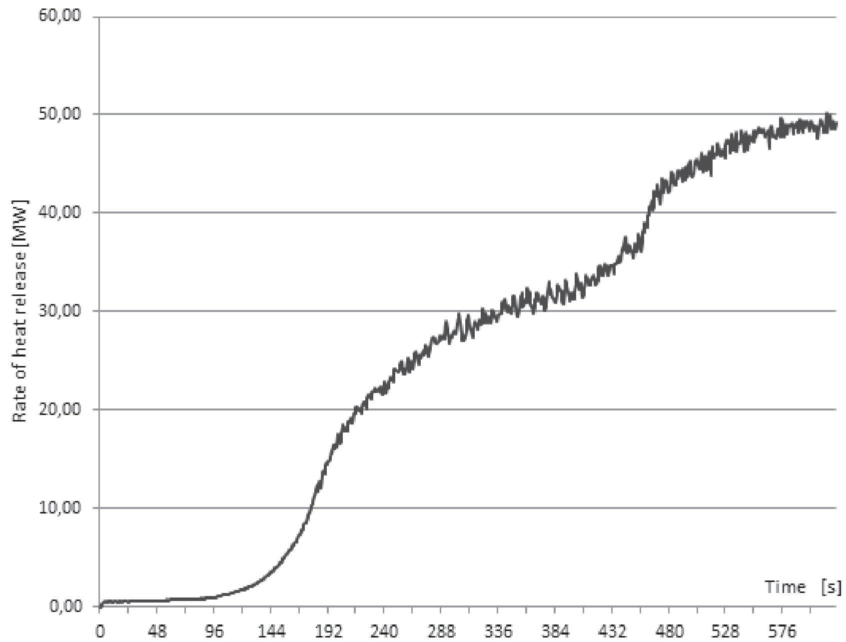

Fig. 12.6 Rate of heat release, FDS results

Fig. 12.7 Development of the fire from FDS calculation

The gas temperature measured below the ceiling, fluctuates significantly. At Fig. 12.8 development of these temperatures in several locations in longitudinal direction of the bridge, below and above the place of ignition are shown (fire outbreak is at position of 40 m). The trend of the transfer of warm air along the air flow direction is evident. The highest temperatures are about 1000 °C.

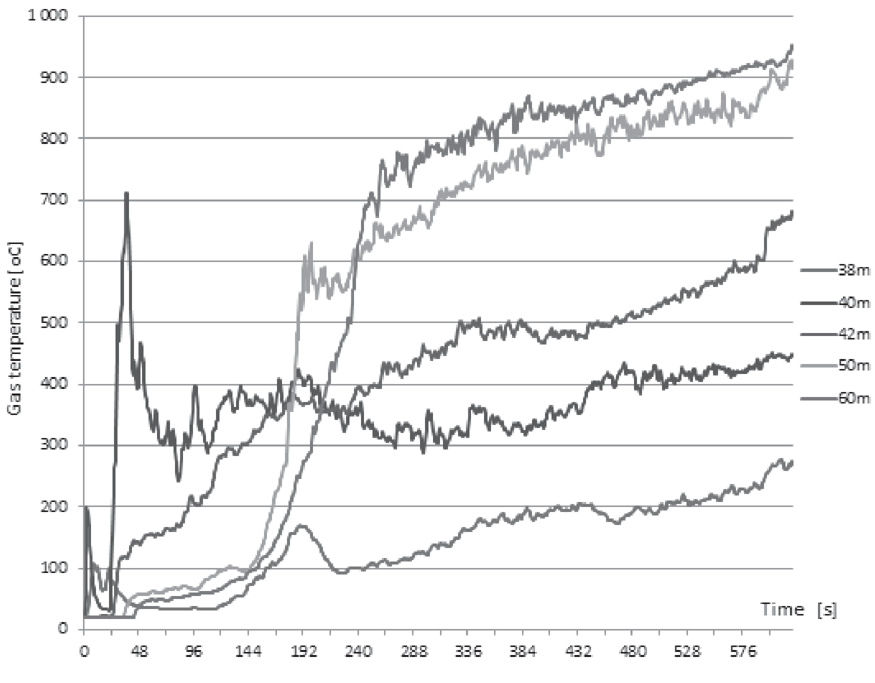

Fig. 12.8 Temperatures of hot gases under the ceiling, FDS results

Maximum temperature of the structure which forms the ceiling reaches more than 800 °C. The most affected part of the bridge is between 40 m and 70 m from the beginning of the bridge. However the highest temperatures occur only at small areas for short intervals of time, see Fig. 12.9. Average temperatures of members of ceiling construction are less than 300 °C.

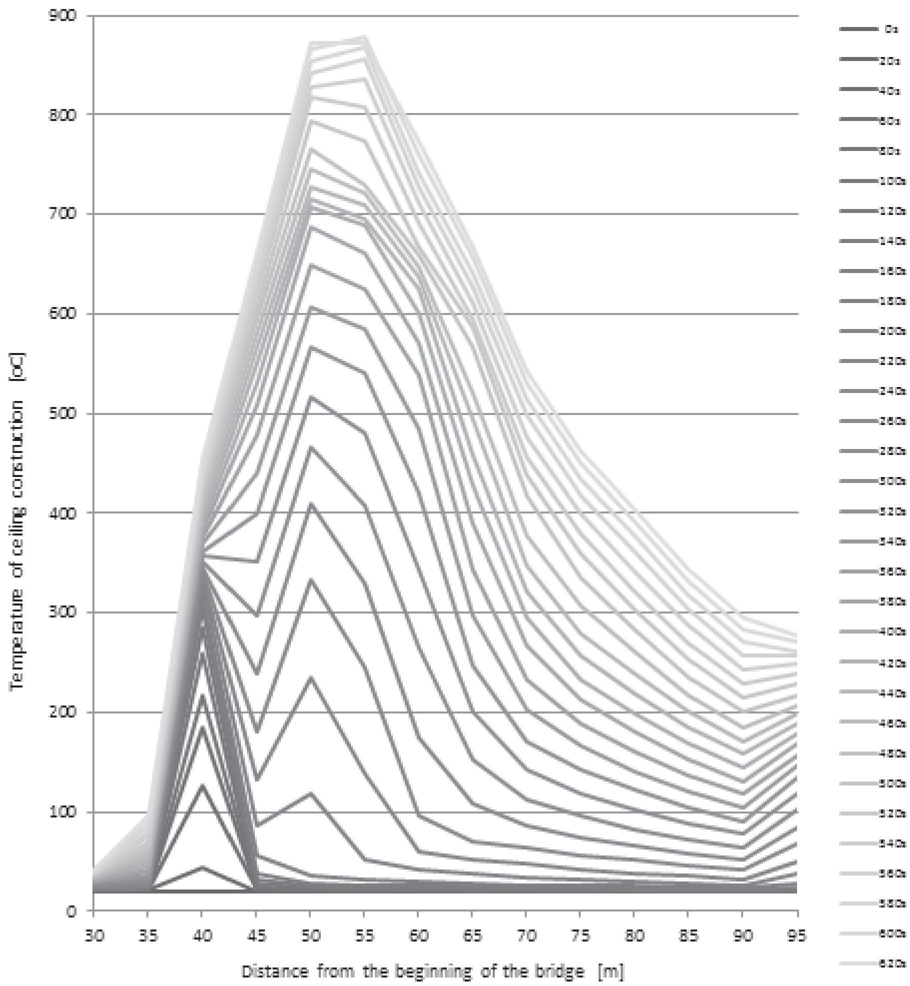

Fig. 12.9 Temperatures of ceiling construction during the fire, FDS results

12.5 RESULTS OF ANALYSIS OF FIRE SCENARIOS

12.5.1 Structural response and its reconstruction

As the temperature at the ceiling above the fire varies in relation to the development of a dynamic, response of steel members will differ in dependence on the temperature reached and on the time of exposition to fire. However some parts as sheathing of walls and roof can be damaged, upper construction of the bridge should survive with only local deformations. After detailed diagnose of level of damage reconstruction of only parts of the structure can be realized. Structures unexposed to the fire which can be affected by the fire through thermal deformation should be also taken into consideration. The major aim of a reconstruction is a minimisation of the reconstruction time. A number of references are available to guide engineers in this process. Above all a structure of inclined coal handling bridge in Opatovice power plant damaged by fire is described in (Wang, 2010).

12.5.2 Interoperability algorithm between fire safety equipment and fire-fighters

The solution of interoperability interactive algorithm is based on an analysis of fire-fighters intervention of fire scenarios. The necessary fire precautions, however, varies according to the fire scenario:

- Detection of elevated temperature in the area of rollers (scenario A) does not start any extinguishing sequence and requires immediate control of coal handling operation by fire-fighters. Until the belts stop, there is sufficient time for the fire survey.
- When a fire on belt is detected (scenario B) automatic extinguishing is started within 2 min from the announcement of a fire to prevent the risk of ignition of a conveyor belt.
- Before the activation of automatic extinguishing the fire-fighters intervention is expected. Within 1 min after fire alarm head of the fire intervention decides on delay of fire-fighting. To carry out a comprehensive survey of the conveyor bridge time of 10 min is required. Therefore, the delay of automatic extinguishing for management of fire intervention is allowed to the head of the intervention by technically interactive form, but no longer than 10 min from the fire alarm announcement.
- In order to prevent the spread of fire and prevent rupture of a conveyor belt, fire-fighting must be started manually immediately after the confirmation of a fire by fire-fighters, at latest 7 min after alarm.
- Elimination of risk of breakage of conveyor belt, which is critical for both fire scenarios, can be ensured by excluding stopping of belts. In practice it is still considered to be the only method to prevent the breakage.
- Delay of automatic extinguishing is made by mechanism of interactive algorithm that allows changing of fire safety operations in accordance with the current development of a fire.
-

Fig. 12.10 shows 3 phases of the interoperability. The phase 1 describes a situation when the fire-fighters intervention is not realised. The phase 2 shows a fire safety process when the intervention is carried out. In case the fire is not confirmed or cancelled during fire-fighters intervention, the process follows algorithm described in phase 3.

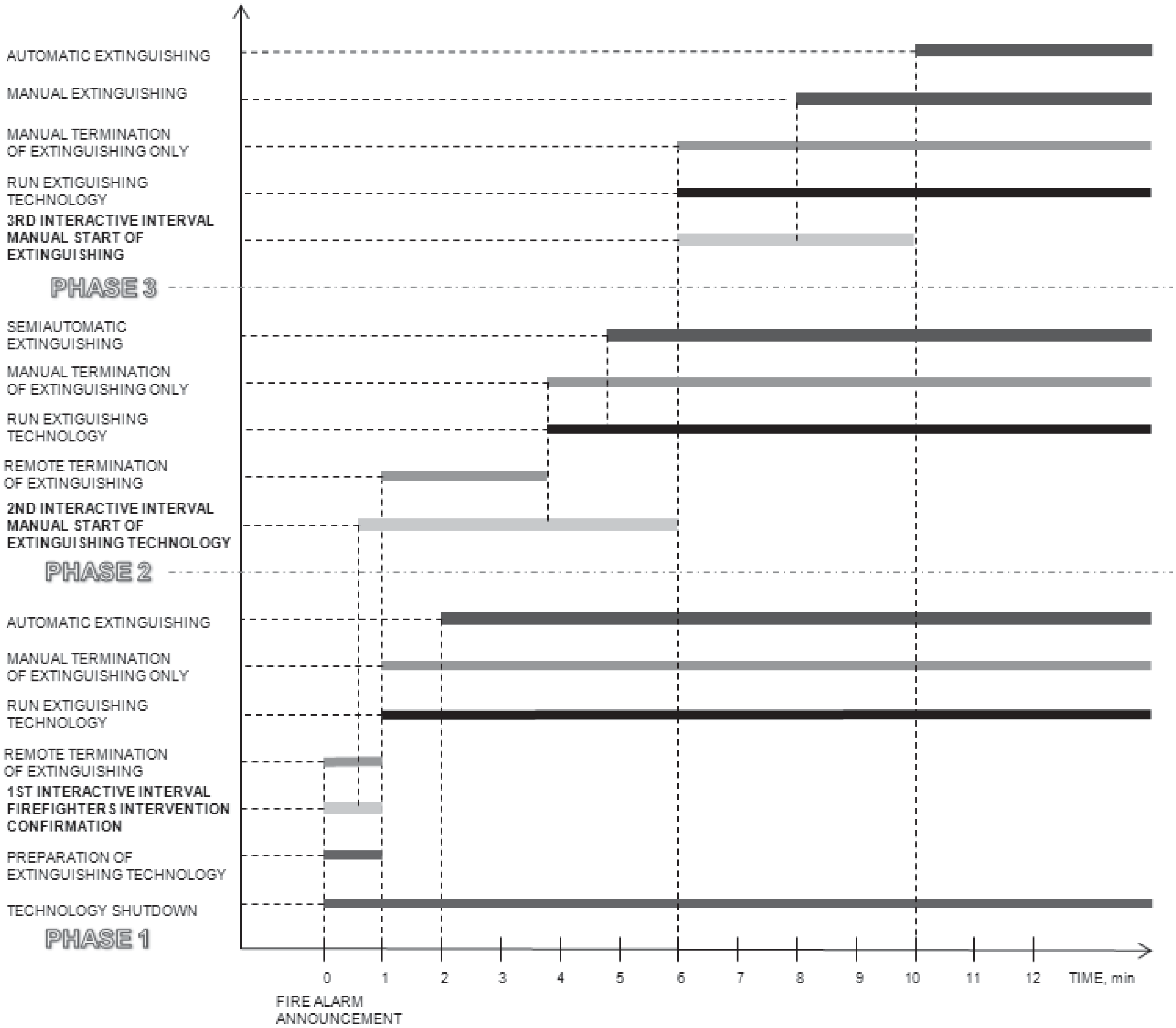

Fig. 12.10 Interoperability interactive algorithm

12.7 SUMMARY

Based on the requirements for the interaction of fire safety equipment and fire-rescue units new interactive algorithm was developed. This algorithm has been successfully operated since 2010 in power plant Tušimice II. Number of tests was performed to confirm its functionality. The algorithm has been further improved and has already been installed on another power plant Tisová.

Analysis of the main design fire scenario in the CFD model shows that the evolution of the fire is based on flammability ratio of coal and rubber conveyer belts. Brown coal burned in the power plant is at low temperatures several-fold less flammable compared to the material of belts. In case the coal is ignited, fire development is very slow and due to the high speed of conveyors transporting the coal it is unlikely probable that the fire occurs on the coal handling bridge. The development of the fire, therefore, depends on the ignition of the conveyor belt, because the fire will spread rapidly at the moment of ignition of a rubber belt. Ignition of rubber belt from coal can occur only in case the flaming core of ignited coal directly touches the belt and at the same time there is enough oxygen for combustion. Given the fact that coal in the lower layer is not ignited and there is not oxygen enough, this layer acts as an insulator. Analysis of all forms of design fire scenarios and CFD models proved that rubber-textile conveyor belts are critical site of fire safety on coal handling bridge. To avoid the risk of fire, regardless its place of origin it is therefore necessary to use a self-extinguishing (fire and flame resistant) conveyor belts.

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13 STUDY OF A FIRE CASE WITHIN A PANEL FLAT

Summary

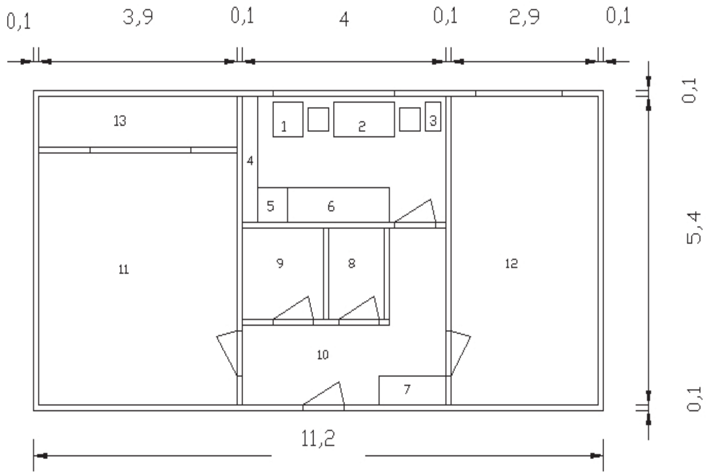
There was a fire within a 10-storey panel flat in Szolnok. This fire case seems worthy to be reviewed. The actions of the fire department and the process of their examinations can be presented very well through this fire (from the setting off of the fire alarm to the spreading of the fire, actions taken during the intervention and during the examination of the fire location). At the beginning stage of fire-generation (free period) no flammable material was left within the area. However, in a few meters distance from the fire flammable materials within the room only suffered minor damage. No reasonable explanation could be given for such an extreme difference in the damage that that flammable materials suffered (when the fire case was examined with the usage of traditional methods). That is the reason why fire-simulation programmes were used to examine the situation. These simulations indicated that the fire's oxygen supply has undergone such changes that the fire could not spread towards the other parts of the room. This question would have been nearly impossible to answer without the help of such simulation programmes.

13.1 GENERAL BUILDING DESCRIPTION

The fire was in a panel structure 10 stories block of flats building. The building was made from pre produced reinforced concrete elements. This building is in Szolnok town. The roads around the building are covered by asphalt by the way the approaching for the fire service is perfectly proved. The fire broken starts on the 9th stories flat. This flat is double room flat.

13.2 REASON OF INITIATION

The most damaged object was the refrigerator. The witnesses said that they were in a room and watched TV. Once time was a power cut so they left the room to saw what caused it. When they left the room they smelt smoke from the kitchen. They saw the fire was behind the refrigerator and when the fire cached the curtain, before the window. From the investigation documents we didn't notice information from the reason of the initiation. The damages of the refrigerator were too serious so the officer couldn't discover the precisely reason.



1. Refrigerator
2. Table with chairs
3. Small refrigerator
4. Cupboard from floor to the ceiling
5. Gas-cooker
6. Cupboard
7. Closet
8. WC
9. Bathroom
10. Vestibule
11. Bigger room
12. Smaller room
13. Loggia

Fig. 13.1 Examples of fire statistics use

13.3 DESCRIPTION OF FIRE DISASTER

The layout of the flat which is above the subject flat is same. The plastic floor finished material was blistered, so it shows the temperature values. The glass in window of the kitchen was cracked. The walls of the corridor were tainted by soot. The internal part of the entrance door of the flat is 50% burned from upper side to bottom. The vestibule and the corridor upper 2/3 part were tainted by soot. There was soot on the door of the bathroom. The upper 2/3 of the door of the bath room was burned. One of the rooms was opened from the corridor. The plastic cover of the electric wire of the lamp was melted. The wall of the corridor which was connect to the kitchen was covered by panelling in 1,2 m high. A wedge form burned sign was seen on the panelling. This wedge form started from the bottom side of the kitchen door. The burning tracks on the panelling starts from the bottom to upper side.

The window and the frame of the window were totally damaged. In the fire just the kitchen burned totally. Away from the kitchen the damages reduce dramatically from above to down. Every combustion-able material what were in the kitchen was totally burned. The panelling on the corridor and closet damage seriously. In the rooms were tainted by soot only. Interesting track was the difference between the kitchen and the corridor. While in the kitchen everything was destroyed in the corridor 2m distance from the kitchen door there weren't burning tracks on the panelling, Fig. 13.4 and Fig. 13.6. The main question was in the investigation: What did it cause these differences. Of course in the most fire cases we can see differences between the hot and cold layer. But in this case the combustion-able materials at the end of the corridor didn't burn, Fig. 13.3 and Fig. 13.6.

The position of the door of the kitchen is clear, according to witnesses and fire-fighters, Fig. 13.7. Charring in deep inside the kitchen door there is just in the upper side. This excludes that the door was closed during the fire. According to the witnesses and the investigation report the flames were behind the refrigerator, that's why we waived the further investigation. We accepted these results.

13.4 WAY OF INTERVENTION BY FIRE-FIGHTERS

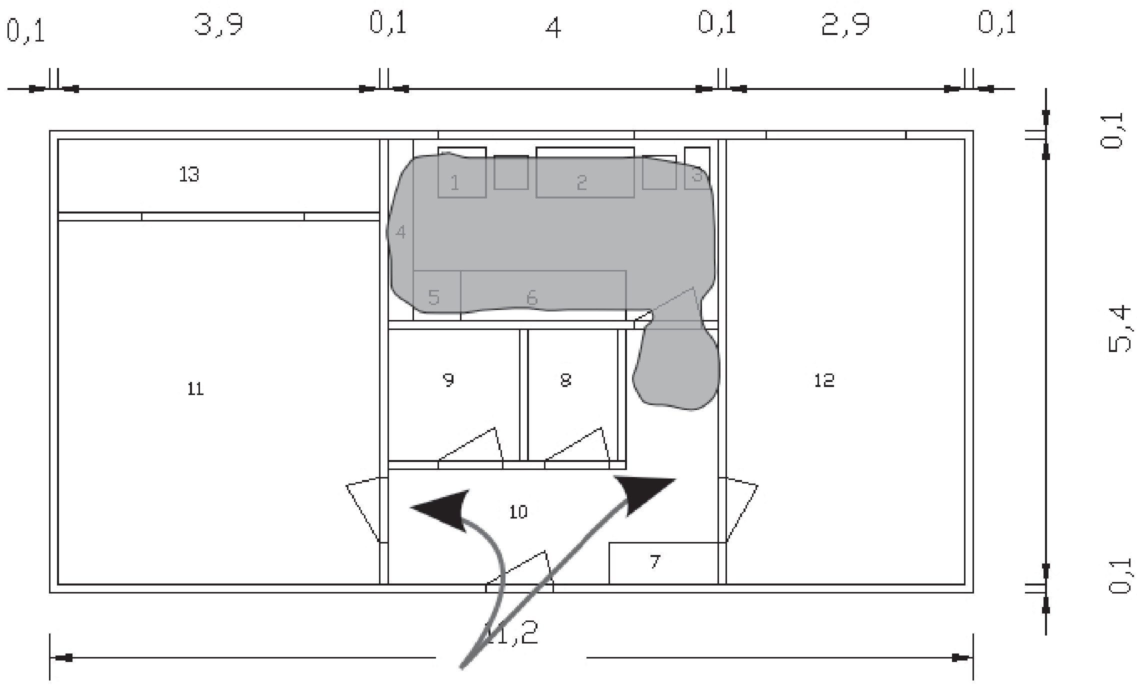


Fig. 13.2 Intervention of fire-fighters

The fire-fighters needed to pull the hose to the 9th floor, because there wasn't stand pipe system in this building. The first fire fighter opened the entrance door and after saw that the flames came to his direction. The fire fighters used one sprinkler during whole fire case, Fig. 13.2.

13.5 CONSEQUENCES OF FIRE

The fire investigation determined that the fire started in the refrigerator in the kitchen, the failure of the refrigerator.

Fig. 13.3 On the right side there is the corridor, on the left side there is the closet, on the front there is the further room

Fig. 13.4 Picture of the corridor from the kitchen door

Fig. 13.5 Picture of the kitchen

Fig. 13.6 Picture of the corridor from the kitchen door

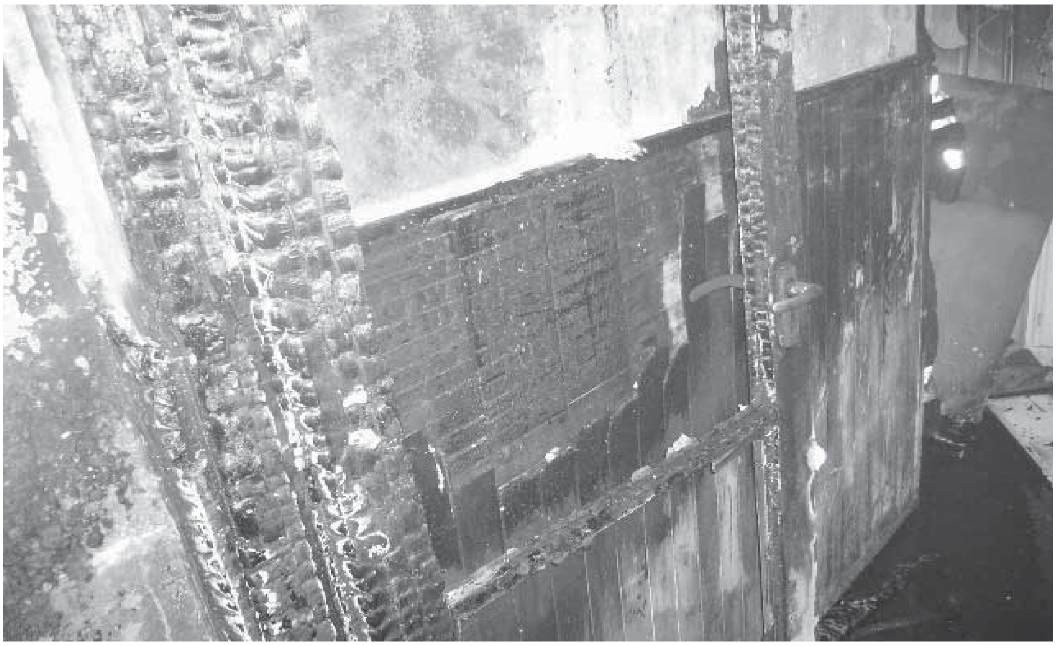


Fig. 13.7 Picture of the kitchen door

13.6 CONCLUSIONS OF THE EVENT

In the FDS more than one source of ignition is usable. It can be determined heat release rate gas flame, and a surface with a temperature value, which causes ignition of different material with heat radiation, thermal conduction, or thermal convection. The fire spread inside the refrigerator could have been too complex, and probably it couldn't give precisely result enough. The VTT in a large scale model analysed refrigerators, (Hietaniemi, Mangs, Hakkarainen). In the Finnish model the size of the refrigerators is 0.59 x 0.60 x 1.85m combo machine. The fire starts at the compressor and after 5 minutes across the back wall spreads on the top. In the end after 11 minutes when the door opens the whole machine was in the flames.

The maximum heat release rate at 12 minutes is 1900 kW. In our case the refrigerator is just a simple, 110 cm tall. That's why we modified the spreading data. The model starts with the whole back wall burning, because of according to the witnesses this was the zero point of the time scale. We correlated everything to this time. We use the same time interval like was in the large scale model. The half top of the refrigerator burns in same time in 35 seconds relative to the back wall. The whole top burns in 96 seconds. The whole object burns in 436 seconds. We decided the heat release rate at the whole back wall is 150 kW, at the half top is 350 kW, at the whole top 600 kW, and at the whole object is 550 kW, so the total heat release rate is 1300 kW. The spread time was set according to the large scale model.

13.6.1 Fire spread

In the model we can look the maximum heat release rate there is in around the 200 second. The kitchen in this time is burning fully, but next 13 minutes pass to the arriving of the fire-fighters. The kitchen windows have already broken in 72 second so the fresh air supply is provided. The question was: Why doesn't spread the fire beyond the kitchen?

In the model there is possibility to analyse the spread of the fire. In the model the zero time point was the observing of the fire, in this time the back wall of the refrigerator was in fully burning. On the 3rd figure would see how spread the fire in different times. The fire started from the refrigerator, ignitions the curtain in the 5-6 seconds, after the burning refrigerator produced heat enough to ignitions the cupboard which is 30 cm from the fire. On the cupboard the fire spreads away parallel with the shorter wall (98.8 seconds), after the cupboard which is front of the refrigerator ignitions too (105 seconds). In this time the hot layer temperature is warm enough to ignition everything in the kitchen. However the fire could have spread away to the corridor in 165 seconds.

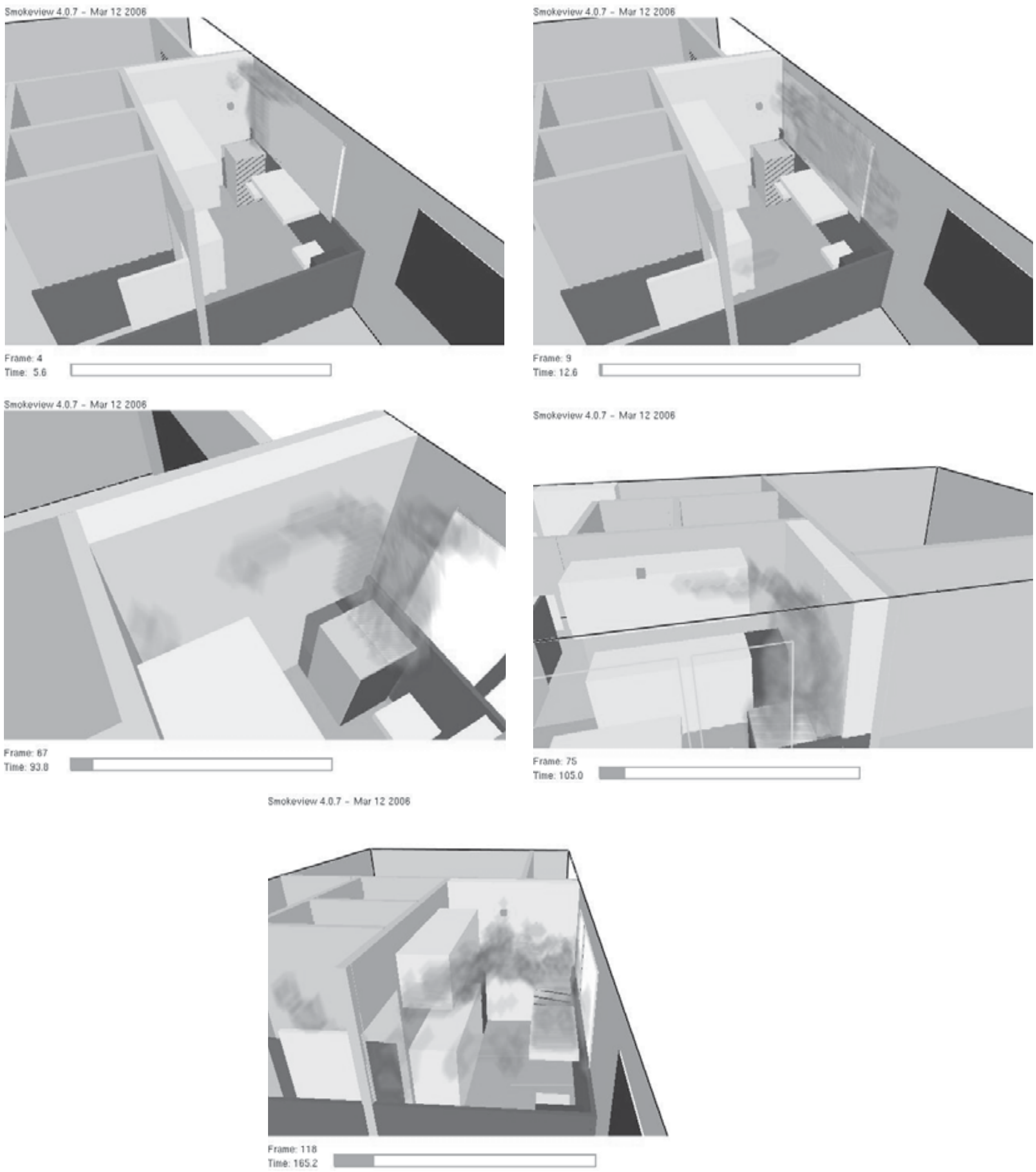


Fig. 13.8 Fire spread

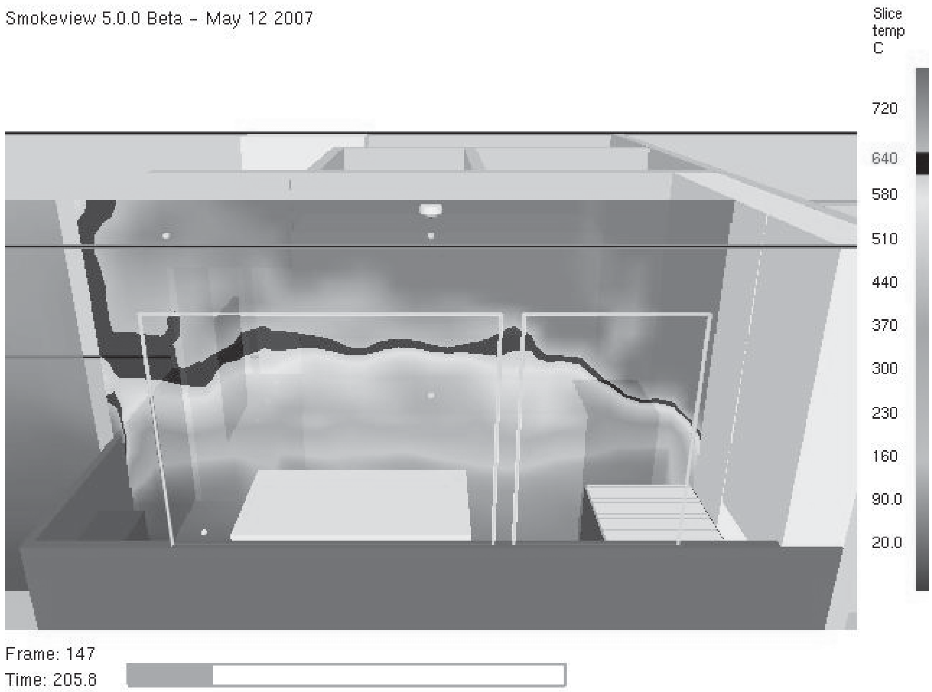


Fig. 13.9 The kitchen

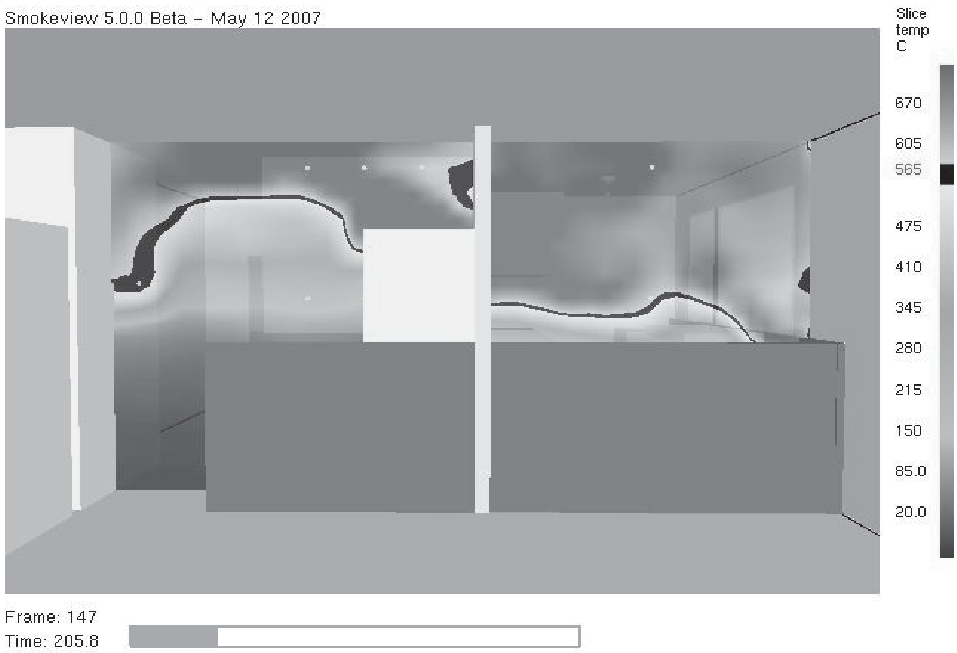


Fig. 13.10 The corridor

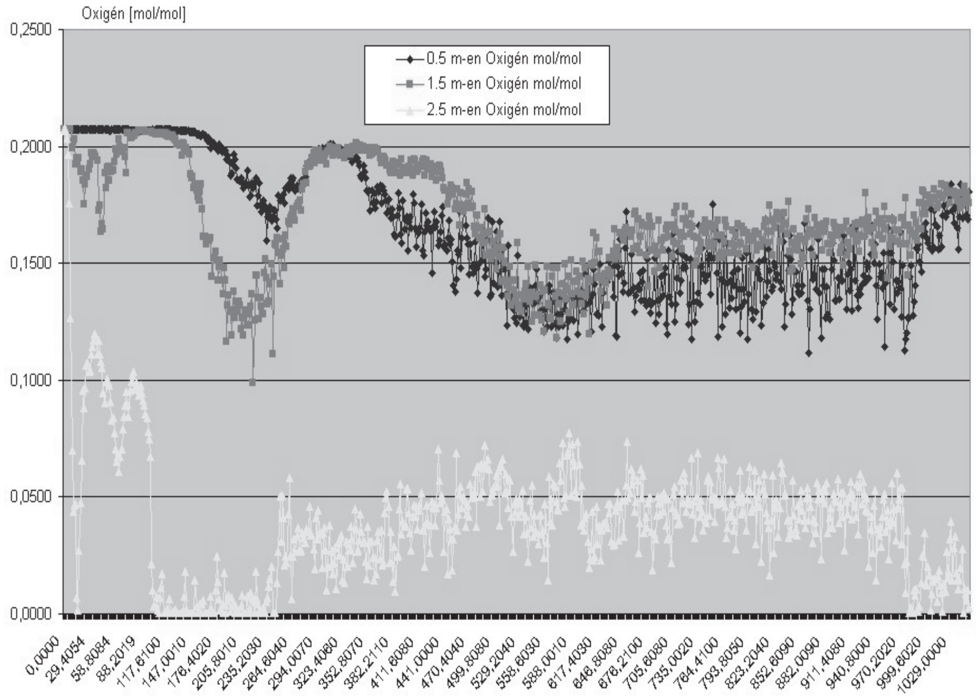


Fig 13.11 The kitchen

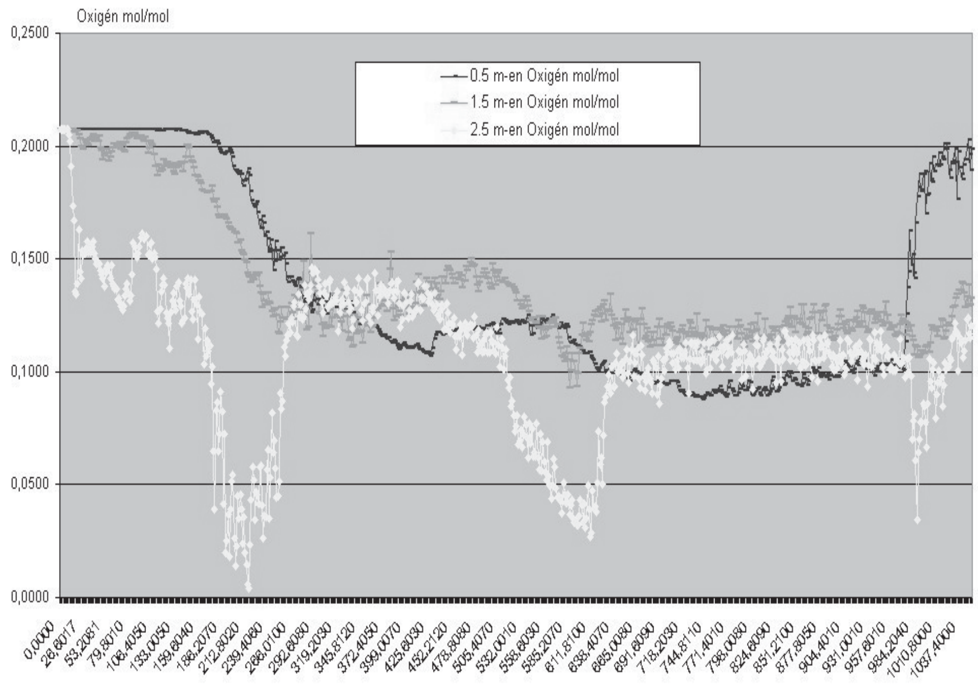


Fig. 13.12 The corridor

The conditionals of fire are the combustion-able material, the oxygen, and the activation energy in same time in same place. In the kitchen the furniture, in the corridor the closet and the panelling were the combustion-able materials. In the kitchen the temperature of the hot layer is 700 Celsius degree, and in the corridor at the upper part of the closet is 580 Celsius degree. So the temperature is high enough to ignition. (Fig 13.9 and Fig. 13.10). The last factor is the oxygen. We can observe well the changing of the oxygen concentration in the kitchen (Fig. 13.11) and in the corridor (Fig. 13.12). In the corridor the concentration of oxygen reduce under 15 % after 200 seconds, and doesn't increase till the opening of the entrance door by fire-fighters (970 second). Although in the kitchen in the whole simulation the oxygen concentration is around 15 % in 0.5m and 1.5m high too. According to the research of Craig Beyler the combustion is impossible under 14% in normal circumstances, (Beyler, 2002).

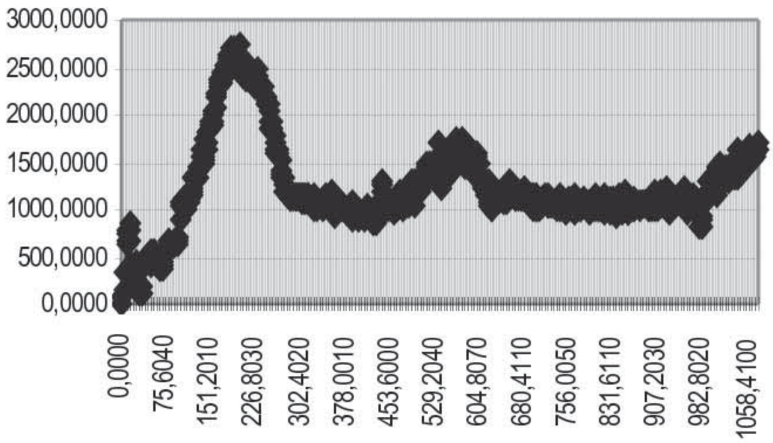


Fig. 13.13 Heat release rate (kW)

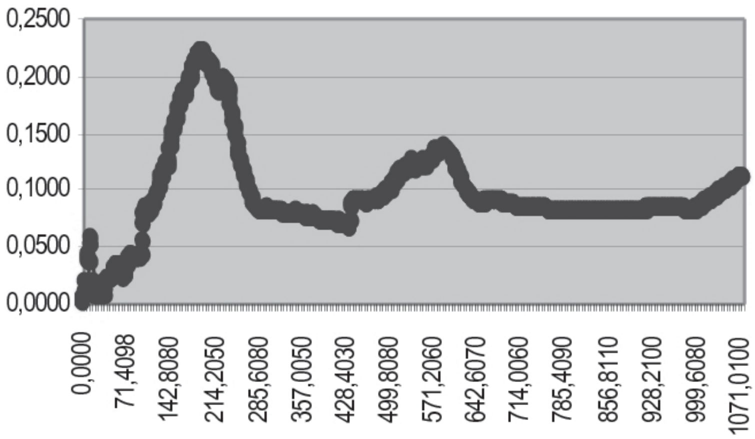


Fig. 13.14 Burning mass rate (kg/s)

After the full-grown fire at 200 seconds the heat release rate reduces, (Fig. 13.13 and Fig. 13.14). According to the results determinable that the temperature was in vain enough in the corridor. The oxygen concentration was too low on account of oxygen absence. That's why the fire couldn't spread to another part of the flat. The most important factor was the closed entrance door and closed windows in the non spread. On account of the low in the corridor and just right oxygen concentration in the kitchen significant combustion was just in kitchen. But in the kitchen the combustion was also controlled by oxygen.

Supposable from the reducing of the heat release rate and burning mass rate that the combustion was smouldering or not too intensive after the oxygen control phase.

We get answer with help of the model from the direction of the fire spread, and that how can fully burn out the kitchen until another part of the flat was intact.

13.7 RECOMMENDATION

The main structures were not damaged during the fire. The heating up of the reinforced concrete slab was observed, which was indicated by plastic floor finish material blistering on the upper flat. The low oxygen concentration provided the fire didn't spread away and that didn't spread in whole flat. The fire fighters intervention was in the 16 minutes, which is enough for the flash-over emergence, according to the statistics and this model. During the flash-over the temperature can be too high and it can cause damages in the main structures. In this fire case the closed entrance door prevented that the fire can spread into the flat. That's why we recommend self closing doors in the high rise block of flats, because this tool is able to reduce the heat effect for main structures indirectly.

Acknowledgement

The authors would like to thanks Dr. Laszlo Beda and the Fire prevention office at Szolnok Fire Department.

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14 INVESTIGATION REPORT ON A WOODEN FURNITURE INDUSTRY FIRE

Summary

A case study of fire investigation of a 'Serious fire' in a wooden furniture industry located in Northern Greece is presented. This work summarized, analyzes and reports detailed fire itself, the suspect experience data through on-site investigation and significant investigation report. This fire investigation provides all evidence, witnesses and suspect statements, as well as conclusions and recommendations offered by the fire investigative team in relation to the fire and potential prosecution.

Areas documented in this work include details about the causes of a fire, detailing the location of fire ignition, fire development, contributions of building construction, fire suppression scenarios; performance of structures exposed to the fire; toxic emissions; human reaction (response) and evacuation; and the extent of life loss, injury and property damage.

Small-and medium-scale tests were performed to simulate fire incident to determine fire initiation and spreading and to evaluate overall toxicity.

14.1 INTRODUCTION

This study present the main features of a fire incident report and the experimental work that was performed in order to investigate a 'Serious fire' happened on 25-09-10 in a wooden furniture industry located in an industrial area in Northern Greece in a small distance from the City of Thessaloniki .

This wooden furniture industry was complied with fire safety measures as predicted by the Greek Government Decision (no 1589/2006) "Industrial Fire protection". (so, it has been supplied with passive protection measures i.e means of escape, emergency lighting and signs , and active measures i.e. fire detection , permanent fire water supply network but with no sprinkler installation). The Timber industry was a 12.500 m2 concrete building. Processed materials were raw wooden materials and final products were furniture and other wooden constructions.

14.2 INCIDENT ANALYSIS

14.2.1 Emergency response

The initial call reporting this incident was at 13.08 hours i.e in the middle of working day. Immediately the fire service was called. 85 employees were working in the industry at that time. Timber complex had a trained and equipped Emergency Response Team (ERT) that included 30 members. On the day of the incident; 15 trained emergency responders were immediately available. They effectively helped building evacuation and tried to extinguish the fire using permanent fire water supply network of industry. Their effort was unsuccessful due to severe fire conditions.

a) b)

Fig. 14.1 Fire incident during post-flashover period a) production area, b) storage area

Firefighters from the surrounding fire stations were at 'emergency alert' providing 27 fire vehicles with 80 fire fighters deployed at the scene of fire. Immediately four (4) firefighters using breathing apparatus invaded into the storage area in the front of the building and rescued two employees that were trapped over there. Simultaneously, fire fighters deployed 2-1/2" (64 mm) handlines around the burning building. All lines were immediately placed into operations.

Fig. 14.2 Fire fighters efforts to tackle the fire

Three hydrants closest to the fire were used, although one of them was not providing water with the appropriate pressure and flow. In an effort to sustain firefighting operations while trying to establish a continuous water supply, tank water from multiple apparatus was transferred to the engines supplying handlines. One aerial ladder truck had been used with effective results in the fire extinguishment efforts. It was used to fight a fire from above and access the upper reaches of a building from the outside.

Fire extinguished after ten (10) hours.

14.3 FIRE INVESTIGATION ANALYSIS

Fire Department administration requested from fire investigation team to undertake a project to investigate the fire incident to determine:

- Causes of the fire;
- The flame spread conditions; and the effectiveness of fire protection measures; possible alternative fire protections measures needed to avoid the disaster.
- The composition of the combustion products;
- The effects of standard and alternative firefighting tactics.

14.3.1 Cause of fire

Fire investigation team after witnesses examination and suspect statements experience data through on-site investigation and significant investigation report concluded:

- That the fire has been caused by sparks during maintenance activities (hot works) in the machinery area.
- No special fire precautions during 'hot works' has been taken as predicted by government decision 7/1996
- Fire almost immediately spread from first to second ignited materials.
- Fire Compartments were inadequate to stop the fire, and fire was no possible to be suppressed by permanent fire fighting hose reels by industrial fire staff.

14.3.2 Fire spread

Factors that were leading to the rapid fire growth and flash over conditions:

- First ignited materials that were 'unprotected' stack 2m x 3m x 2.5m of pine wooden pallets
- Secondary ignited materials that were raw wooden material.
- Dust and wooden shavings have contributed to the fire spread in the whole building.
- Fire was not contained to the room of origin and spread to the whole building

14.3.3 Property loss and property value at risk

- Almost the whole wooden material and electro-mechanical equipment of industry have been destroyed by the fire.
- On the other hand, the reinforced concrete, columns, beams performed very well in such a severe fire due to high fire resistance of reinforced concrete.
- Estimated property loss 1.600.000 euro i.e. loss in property 700,000 euro, loss in contents 900,000 euro. Property value that was saved 1.400.000 euro (estimated cash value of the property including its contents that were at risk from the fire condition).
- Nine (9) workers and one (1) fire fighter have been transferred to the local hospital suffering from scrapes and smoke inhalation.

14.4 RESEARCH WORK

A research project was undertaken to investigate this case where the first material ignited was wood; if that ignition and fire spread could have been prevented or minimized by treating the timber surfaces with suitable flame retardants.

14.4.1 Experimental techniques

The apparatus used was a standard Cone Calorimeter manufactured in accordance to ISO 5660 (1993) and ASTM E1354 (1992). The tests were carried out in accordance with the test procedure of ISO 5660.

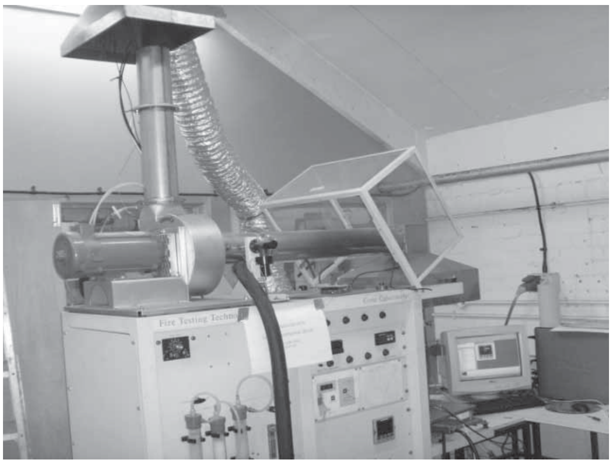


Fig. 14.3 University of Leeds Cone Calorimeter

A 1.56 m3 enclosed fire test facility, 1.4m x 0.92m x 1.22m, was used with separate entrained air inlet at floor level and fire product exit at ceiling level. The enclosure had 25mm thick high temperature insulated walls attached to a steel backing wall that was air sealed. The enclosure ceiling was instrumented with an array of Type K 3mm outer diameter mineral insulated exposed junction thermocouples.

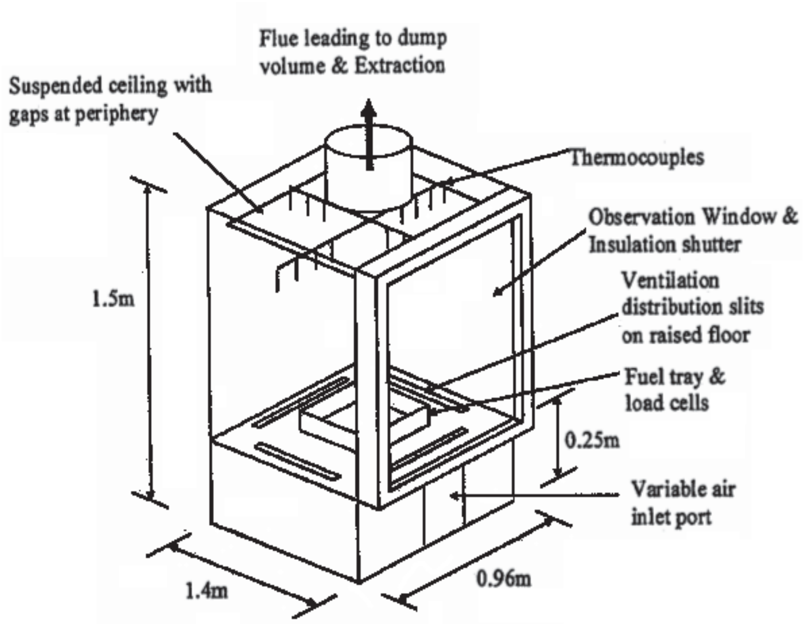


Fig. 14.4 University of Leeds Fire Rig Enclosure

A heated sample line was linked to a TEMET GASMET CR-Series portable FTIR. This has a multi-pass, gold-coated sample cell with a 2m path length and volume of 0.22l. A liquid nitrogen cooled MCT detector was used that scans 10 spectra per second and several scans are used to produce a time-averaged spectrum.

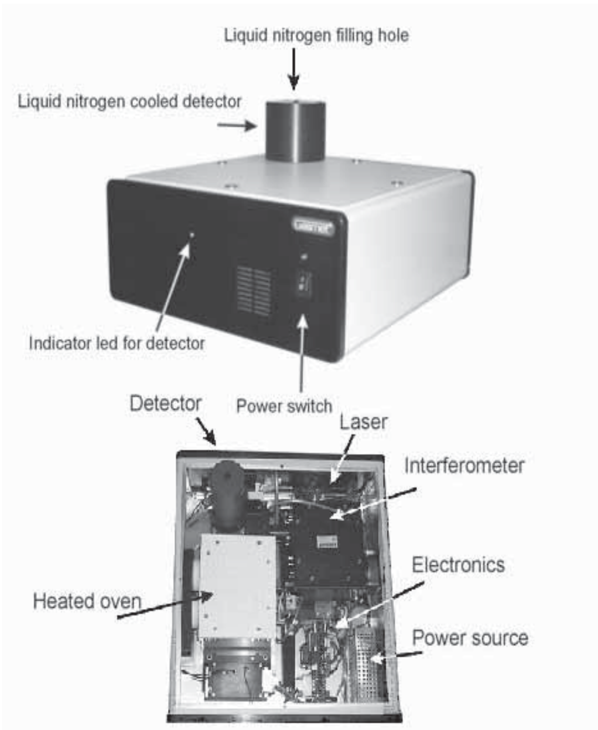


Fig. 14.5 University of Leeds FTIR and its internals

14.4.2 Thermal behaviour of untreated timber

Eight (8) representative species of wood were chosen for experimental investigation (small scale). All untreated samples clearly burned faster and with the highest HRR.

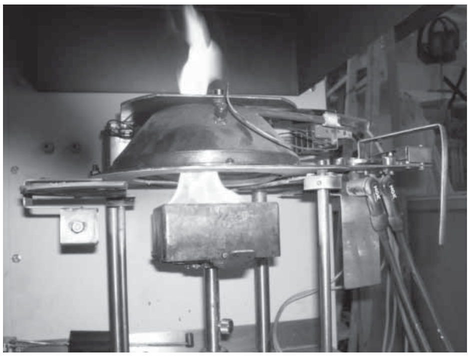


Fig. 14.6 Pine exposed at heat flux 35 kW/m^2

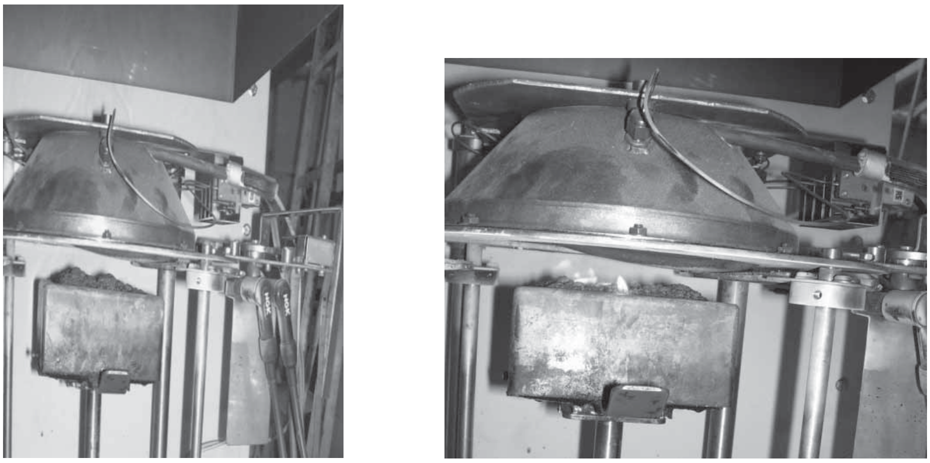
Seven (7) wooden crib fires were investigated using untreated pine wooden cribs or treated at different percentage (%) of the total surface area with a water – based, intumescent, suitable for internal surfaces (medium scale).

One untreated sample was tested using 6g of ethanol as ignition source. The untreated sample clearly burned faster and with the highest HRR.

Fig. 14.7 Untreated pine crib in the test

14.4.3 Thermal behaviour of fully flame retarded timber

The effects of three (3) typical intumescent flame retardants (latest technology) were tested. No ignition' and lower toxic emissions compared to untreated samples were observed at 35 kW/m^2 (small scale).

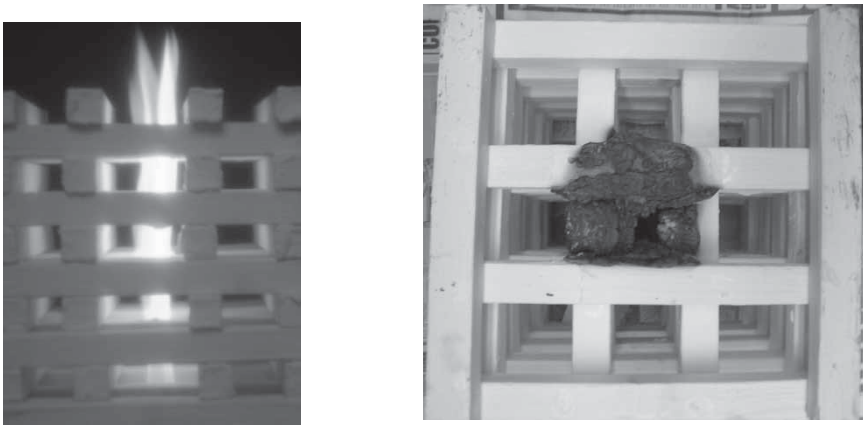


a) b)

Fig. 14.8 Flame retarded pine exposed to heat flux a) 35 kW/m^2, b) 50 kW/m^2

In all fully-treated (100%) cases, there was no ignition, and increasing amounts of ethanol, i.e., 6, 20, and 30g, were used as ignition sources (medium scale).

A “weak” flame initially developed from the burning of ethanol, which “triggered” the in-tumescent flame retardant paint to expand and form “instant firewalls” to contain and finally suppress the developing fire.



a) b)

Fig. 14.9 100% treated pine crib (used 20 g of ethanol as ignition source, a) at 20 sec into the test, b) in the end of experimental process

14.4.4 FTIR toxic gas analysis

The European Community COSHH (Control of Substances Hazardous to Health Regulations) workplace 15 minute maximum allowable toxic concentrations are used to evaluate overall toxicity. For untreated pine, formaldehyde and acrolein were the dominant gases. Benzene was also significant. CO emissions were significant but not very high. Lower toxic concentrations measured for full treatment case where acrolein was the dominant toxic.

The effects of flame retardant treatment on major toxic emissions compared with the bare samples are shown on the following Table. In most fully-treated (100%) cases, even in the half-treated (50%) cases, lower or almost equal to unity emissions were measured compared with the bare samples. This is due to the fact that, in such cases, due to the in-tumescent action, there was either no ignition of the samples (100%-treated cases), or a considerable delay was seen (50%-treated cases). Excessive HCN and N0x occurred in 60% of the untreated cases due to the considerable involvement of the flame retardant paint in flaming combustion, since it contains N in its chemical composition.

Coated emission / Bare emission	100%F.R. 6g ethanol	100%F.R. 20g ethanol	100%F.R. 30g ethanol	50%F.R. 6g ethanol	60% Untreted 6g ethanol	60% Untreted 20g ethanol
'Peak **CO**(ppm) Ratio' ↓	↓↓	↓↓↓↓	↓↓	↓↓	↓	↓
'Peak **HCN**(ppm) Ratio'	↓↓	↓↓	↓	↓	↑↑	↑↑
'Peak **Acrolein**(ppm) Ratio'	↓	↓	↓	↓	≈	≈
'Peak **NH$_3$**(ppm) Ratio'	≈	≈	≈	≈	↑	↑
'Peak **N0x**(ppm) Ratio'	↓	↓	≈	≈	↑↑	↑↑

Each arrow ↓ ↑ indicates decreasing/increaing up to a factor of three. Two arrows together is equivalent to a change by a factor of 3-6.Three arrows together is equivalent to a change by a factor for greater than 6.

Fig. 14.10 Comparative effects of flame retardant treatment on major exhaust emissions

14.5 RECOMMENDATIONS

Performing of more small- and medium – scale experiments, treated with the updated technology of the intumescent paints (different parts of wooden cribs or some other form of samples), and using various ventilation rates to achieve both establishing and documentation of the contribution of intumescent technology in fire suppression, are suggested.

Fire safety management of industry need to be improved following the guidelines below:

- Proper use of fire safety measures from Emergency Response Team. Therefore more fire safety education is needed. Participation in fire fighting exercises in corporation with local fire service is necessary.
- All building employees were required to participate in periodic emergency evacuation drills.

- Check the company's space ; It must be always cleaned from dust and wooden shavings
- Keep out the flammable substances and sparks and take the necessary fire precautions where is required.
- Proper check of fire hydrants used to work properly when is needed.
- A prosecution may be initiated for industry failing to comply with preventive measures during hot works as predicted by government decision 7/1996 .

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ORGANISATION OF NATIONAL FIRE AND RESCUE ARRANGEMENTS IN DIFFERENT EU COUNTRIES

15 INTRODUCTION

In the framework of WP3 – Fire brigade reports and investigations, several questions were prepared to find out how the organisation of national fire and rescue arrangement looks like, how it works and what structure it has in different EU countries. Twelve countries have responded to the call: Croatia, Czech Republic, Finland, Germany, Greece, Hungary, Italy, Poland, Portugal, Romania, Slovenia and Spain.

Questions about integrated rescue system, its history, supporting documents, organisational structure, communication system and its management levels have been made. The aim is to provide information to participants about the practice in other countries. Although EU regulations should make this kind of interaction easier, the national regulations vary a lot and therefore this kind of information is valuable.

All the answers have been collected and put together in this document so that a comparison could be made between them.

The following questions, suggested by Dr. Petra Kallerová, have been sent to the members:

1. Does in your country exist any Integrated Rescue System (IRS)[*)]?
   (Note: [*)] in further text, IRS refers to any kind of cooperation on fire and rescue operations)
2. If yes, since when is the IRS active in your country?
3. Which documents are used in IRS generally? (different kinds of emergency plans, etc.)
4. Which safety and rescue organisations cooperate on the IRS?
5. To which governmental organisation belong individual IRS organisations?
6. Who is the main leader within the IRS?
7. What is the main means of communication between IRS organisations? Is it compatible with other countries from EU?
8. Do the IRS organisations use the Common Emergency Communication Information System (CECIS)?
9. Are there differences in the fire and rescue arrangements between particular regions in your country? (sea side, mountains, etc.)
10. How many alert levels do you have? Describe them briefly.
11. What are the management levels in case of rescue and relief works?
12. Are all of the fire and rescue organisations governed centrally within your country?
13. To which organisation you will call when you dial the European SOS phone number 112?
14. What is the organisational structure of fire brigade?

Responses

The following table shows the colleagues who returned the questionnaire.

Country	Family name	First name	Institution
Croatia	Rukavina	Marija Jelcic	University of Zagreb
	Drakulic	Miodrag	CTP Projekt, Zagreb
	Mercep	Miroslav	Zagreb Fire Fighting Brigade
	Neven	Szabo	DUZS
Czech Rep.	Kallerová	Petra	Czech Technical University in Prague
Finland	Salli	Jukka	Ministry of Interior
Germany	Klinzmann	Christoph	hhpberlin Ingenieure für Brandschutz GmbH, Hamburg
Greece	Pantousa	Daphne	University of Thessaly
Hungary	Hajpál	Mónika	Non-profit Ltd. for Quality Control and Innovation in Building
Italy	Nigro	Emidio	University of Naples
	Cefarelli	Giuseppe	University of Naples
Poland	Łącki	Krzysztof	Warsaw University of Technology
	Kwaśniewski	Lesław	Warsaw University of Technology
	Biskup	Krzysztof	National Headquarters of the State Fire Service, Warsaw
Portugal	Vila Real	Paulo	University of Aveiro
Romania	Golgojan	Ionel-Puiu	Ministry of Interior and Administrative Reform
Slovenia	Hozjan	Tomaž	University of Ljubljana
Spain	Lacasta	Ana Maria	Universitat Politècnica de Catalunya

If there are any mistakes in answers, or changes needed, the writers ask the readers kindly to send comments and corrections to: Kamila Horova [kamila.horova@fsv.cvut.cz].

ORGANISATION OF NATIONAL FIRE AND RESCUE ARRANGEMENTS IN DIFFERENT EU COUNTRIES

16 QUESTIONAIRE

Question 1: Does in your country exist any Integrated Rescue System (IRS)*)?

(Note: *) in further text, IRS refers to any kind of cooperation on fire and rescue operations)

Answers:

CROATIA

Yes.

CZECH REPUBLIC

Yes.

FINLAND

Yes.

GERMANY

Yes.

GREECE

Yes. Only covers Attica i.e. It is the region with the highest fire risk in the whole Greece. Although, there is design / study to cover the entire Greek territory.

HUNGARY

No.

ITALY

Yes. It is called “ProtezioneCivile” (“Civil Protection”.)

POLAND

Yes.

PORTUGAL

Yes

ROMANIA

Yes.

SLOVENIA

Yes, ADMINISTRATION OF THE REPUBLIC OF SLOVENIA FOR CIVIL PROTECTION AND DISASTER RELIEF (ACPDR).

SPAIN

Yes.

Question 2: If yes, since when is the IRS active in your country?

Answers:

CROATIA

In 2005 IRS started to be build into legislation basis of the NATIONAL PROTECTION AND RESCUE DIRECTORATE (Državna uprava za zaštitu i spašavanje – DUZS)

CZECH REPUBLIC

In 1993 IRS started to be build into legislation basis of the Government Resolution CR.

In 2000 IRS came to the anchoring into legislation of Czech Republic.

FINLAND

Since 1975 Finnish legislation has integrated all fire and rescue operations so that rescue operations are based on cooperation between different authorities (rescue services, police, hospital districts, border guard, defence forces etc.) and other actors (third sector). The last legislation the rescue services act is from 2011.

GERMANY

Since the early years of the 20th century, it was reformed after 1990 into a real nationwide IRS.

GREECE

Since 2004.

HUNGARY

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ITALY

In 1982 was founded the Department of Civil Protection directed by the Ministry for Coordination of Civil Protection (Law n.938 del 1982).

Finally, in 1992 (Law no. 225, 1992) was founded the National Service of Civil Protection, with the task of "protecting the integrity of life, property, settlements and the environment from damage or risk of damage from natural disasters, catastrophes and other disasters”.

POLAND

IRS has been activated in 1995. In Poland IRS is named The National Firefighting and Rescue System (KSRG).

PORTUGAL

Since 1988 were produced fire safety regulations. Until 2008 there was scattered legislation in 2008 was almost entirely assembled a new legal regime.

ROMANIA

In 2004 IRS started to be build into legislation basis and came to the anchoring into legislation of Romania (support functions for ministries and other Government Resolutions). For the first time in 2008, regulations were laid down in order to implement the **112** Single European Emergency Call Number, the technical and organizational calls reception and reporting system for fire incidents, accidents, medical emergencies, disasters and other events that require the authorized agencies' immediate response.

<u>SLOVENIA</u>

In the end of 60's of the 20th century (Yugoslavia) in form of civil protection.

After independence (1991) ADMINISTRATION OF THE REPUBLIC OF SLOVENIA FOR CIVIL PROTECTION AND DISASTER RELIEF was formatted.

<u>SPAIN</u>

In 1985 started to be build, with the Law of Civil Protection

Since October 2012 there is a unique emergency phone number (112) for fire brigades, police and health services.

Question 3: Which documents are used in IRS generally? (different kinds of emergency plans, etc.)

Answers:

<u>CROATIA</u>

- Law on Protection and Rescue (N.N. 174/04, 79/07, 38/09, 127/10)
- Law on Fire Fighting (N.N. 106/99, 117/01, 36/02, 96/03, 174/04, 38/09i80/10)
- Law on Fire Protection (N.N. 92/10)
- Protection and Rescue Plan for the teritory of Republic of Croatia (N.N. 96/10)
- Assessment of vulnerability of natural and technical and technological disasters and major accidents in Republic of Croatia (May 2009)
- Regulation of mobilization and activity of protection and rescue forces (NN 40/08 i 44/08)
- Implementing legislation in the area of protection and resue

<u>CZECH REPUBLIC</u>

- Country emergency response plan
- External emergency plan
- Agreement to provide assistance
- Document on joint rescue and relief work
- Alarm plan, ...

<u>FINLAND</u>

- Rescue Service level agreement for every Rescue Region (22)
- Instruction for planning action preparedness
- Ministry degree on Emergency planning for Nuclear and Seveso installations

<u>GERMANY</u>

- Hierarchy for competences during major incidents
- Response plans for major incidents
- Fire and rescue plans of buildings

GREECE

- Fire protection (preventive and suppressive) plan
- Country emergency response plan
- External emergency plan
- Agreement to provide assistance
- Document on joint rescue and relief work

HUNGARY

In the organisation of disaster managment in connection with the intervention of firefigters the following plans available:

- Operation Plan (MT): The Operation Plan is a plan to determine the methods of extinguishing fires, execute technical rescues and to manage disasters.
- Firefighting and Technical Rescue Plan (TMMT): The TMMT helps the firefighting and technical rescue operations, which contains calculations of staff and equipment necessary to execute firefighting and technical rescue interventions, and also contains from the view of fire and rescue operations the most important data of the given establishment or area with drawings and texts.
- Fire alert plan: The fire alert plan is made by the establishment and it is available also there. It contains all measures, which can make the intervention in place succesfull in case of a fire or an explosion on the basis of a pre-organization for the possibble and counted damages.

ITALY

- Municipal civil protection plan
- Country emergency response plan
- External emergency plan
- Agreement to provide assistance
- Document on joint rescue and relief work
- Weather forecast
- Alarm plan, ...

POLAND

Organisation and functioning of IRS (KSRG) is regulated by a Regulation of Minister of Interior on detailed rules of KSRG organisation. Other important documents are rescue plans developed at the level of counties and provinces.

PORTUGAL

Integrated Operations and Protection and Rescue (SIOPS): DL n. º 134/2006, of 25 July

ROMANIA

- National civil protection strategy
- National Strategy on types of risks (floods, landslides, etc.)
- External and internal emergency plan (for SEVESO objectives)
- Document on joint rescue and relief work
- Plans alarm and warning the population,
- Evacuation plans
- Plans alarm and warning the population in armed conflicts
- other

SLOVENIA

Emergency response plan (company, local, regional and national) separately for different threat or disaster (Earthquake, Flood, Forest fire, Nuclear accidents,...), Public warning system and Instruction of citizens.

The emergency response plans are based on:

- risk assessment
- proposals for protection, rescue and relief resulting from the risk assessment,
- available forces and means of protection, rescue and relief

SPAIN

- General plans for civil protection, for example PROCICAT in Catalonia)
- Territorial emergency plans
- Emergency response plans for particular risks. For example:
  - INFOCAT for Forest fires
  - PLASEQCAT for Chemical emergencies
  - SISMICAT for Earthquakes

Question 4: Which safety and rescue organisations cooperate on the IRS?

Answers:

CROATIA

- Basic sectors – Fire brigade of CR, fire protection group of each region, Police, Ambulance
- Other sectors – Army, rescue teams, civil protection, emergency, professional and other services, non-profit organizations, associations of citizens

CZECH REPUBLIC

- Basic sectors – Fire brigade of CR, fire protection group of each region, Police, Ambulance
- Other sectors – Army, rescue teams, civil protection, emergency, professional and other services, non-profit organization, associations of citizens

FINLAND

- Rescue services (including voluntary firebrigades), police, Hospital districts, Border guard, Defence forces etc.
- Third sector actors – Maritime Rescue Associations,

GERMANY

- Cities or counties provide the steering committee for major incidents
- Fire brigades
- Police
- Rescue services (public and private)
- TechnischesHilfswerk (Heavy special technical services)
- Military (only in special cases, must not be brought into service within the country)

GREECE

- Basic sectors – Fire service, General secretariat for civil protection, Police, Ambulance
- Other sectors – Army, rescue teams, voluntary organizations, non-profit organizations.

HUNGARY

Disaster management most often work together with police and ambulance, and furthermore with all other services and organizations, which can be necessary to eliminate damages (army, centre for counter terorism, bomb squad, gas works, ect.)

ITALY

- Basic sectors – Italian Fire Brigades, Army, Order Forces, Forest Service, National Health Service
- Other sectors – Mountain Rescue, Red Cross, Non-profit Organizations

POLAND

The KSRG is created by:

- The State Fire Service – an organiser of KSRG
- Voluntary Fire Services (only those, which meet certain criteria),
- selected hospitals,
- specialists in various fields of rescue (chemistry, construction, radiology etc.).

The KSRG is supported, on a base of civil law agreements, by many public and private entities, among others:

- Police,
- Maritime Search and Rescue (SAR),
- Mine Rescue,
- Ambulance service (including Air Rescue - LPR),
- Border Guard,
- State Inspectorate for Environmental Protection,
- National Atomic Energy Agency,
- Institute of Meteorology and Water Management,
- Non-governmental organizations, such as:
- Voluntary Water Rescue Service,
- Voluntary Mountain Rescue Service (Mountain Rescue),
- Polish Aeroclub,
- Association of Polish Scouting,
- Polish Medical Mission,
- Polish Red Cross,
- etc.

The main idea of founding KSRG was to have a uniform and cohesive system that unites fire protection units, other services, institutions, and entities making it possible to undertake every rescue operation, utilizing their potential (organizational, technical, intellectual, etc.).

PORTUGAL

Firefighters, Republican National Guard, Army and other agents depending on the type and magnitude of emergency.

ROMANIA

- Basic sectors – County Inspectorates for Emergency Situations (with fire and civil protection departments) and the mobile emergency service for resuscitation and extrication (SMURD) of each county, Ambulance.
- Other sectors – Police, Army, Gendarmerie, Voluntaryand privateservicesfor emergency situations, rescue teams, non-profit organization, associations of citizens

SLOVENIA

- Fire brigades
- units and service associations and other non-governmental organizations(Mountain rescue service of Slovenia, Cave rescue service, Underwater rescue service,...)
- companies, institutions and other organizations (Unit to identify dead, Unit for hygienic-epidemiological work, Mobile unit for Meteorology and Hydrology,...)
- Civil protection (First aid units, Unit for the first veterinary assistance, Technical rescue units, ...)
- Police

Slovenian Armed Forces.

SPAIN

- Fire brigades, police and health services.
- Volunteer fire-fighters (mainly related with forest fires).
- Emergencies Military Unit

Question 5: To which governmental organisation belong individual IRS organisations?

Answers:

CROATIA

- Ministry of the Interior: Police
- NATIONAL PROTECTION AND RESCUE DIRECTORATE: National intervention units (Državneintervencijskepostrojbe)
- Ministry of the Interior and NATIONAL PROTECTION AND RESCUE DIRECTORATE and Emergency Management Office: Professional Fire brigade and protection group of each region
- Professional fire brigades (operate within local governments, in the command line are subordinated to DUZS)
- Ministry of Health: Ambulance

CZECH REPUBLIC

- Ministry of the Interior - Fire brigade of CR, Fire protection group of each region, Police
- Ministry of defence – Army
- Ministry of Health – Ambulance

FINLAND

- Ministry of the Interior – Regional rescue departments, Police, Border guard
- Ministry of Social affairs and Health – Emergency medical service
- Ministry of Defence – Defence forces

GERMANY

- The different states implement the laws for fire and rescue services and police, usually via the ministry of interior
- Cities or counties establish fire brigades

GREECE

- Ministry of Public order and citizen protection - Fire service, General secretary of civil protection ,Police.
- Ministry of Health – Ambulance

HUNGARY

In the subserviency of the Ministry of the Interior operating the disaster management and the police.

In the subserviency of the Ministry of Human Resources operating the state ambulance.

ITALY

- Ministry of the Interior – Italian Fire brigade, Armed Forces, Order Forces
- Ministry of Agriculture, Food and Forestry - Forest Service
- Ministry of Health - National Health Service

POLAND

- Ministry of Interior - State Fire Service, Police, Border Guard
- Ministry of Transport, Construction and Maritime Economy - Maritime Search and Rescue (SAR)
- Ministry of Health - hospitals, emergency rescue
- Ministry of Economy - Mine Rescue
- Ministry of Environment - State Inspectorate for Environmental Protection, National Atomic Energy Agency, Institute of Meteorology and Water Management.

PORTUGAL

Ministry of home affairs, ministry of defence and ministry of the environment

ROMANIA

- Ministry of Administration and the Interior - County Inspectorates for Emergency Situations, the mobile emergency service for resuscitation and extrication (SMURD), Police, Gendarmerie;
- Ministry of defense – Army;
- Ministry of Health – Ambulance.

SLOVENIA

- Ministry of defence

SPAIN

- Goverment of the Autonomous Communities (Spain is divided in 17 regions called Autonomous Communities). For example, the Generalitat of Catalonia has exclusive competencies over civil protection (regulation, planning and coordination) including fire prevention and fire-fighting services. For emergencies and civil protection issues which extend beyond Catalonia, the Generalitat shall promote mechanisms for cooperation with other autonomous communities and with the State.
- The Spanish Ministry of the Interior (State level)
- Local governments. For example, the Fire Brigades of Barcelona belongs to the city council.

Question 6: Who is the main leader within the IRS?

Answers:

CROATIA

Two branches of hierarchy exist (civil protection and fire fighting sectors) with chief commanders and Director General of DUZS.

CZECH REPUBLIC

Fire brigade.

FINLAND

Regional rescue Department in fire and rescue operations.

GERMANY

The county or city for the coordination of all rescue operation, assisted by local staff (e.g. Police or fire brigade depending on the incident, Leading emergency doctor for first medical assessment).

GREECE

Fire service.

HUNGARY

Basically the case of intervention determines, which organisation has bigger role.

ITALY

The head of the Department of Civil Protection.

POLAND

The State Fire Service.

PORTUGAL

National Authority for Civil Protection of the Ministry of Home Affairs.

ROMANIA

The National System for Emergency Situations is set up, organized and works in order to prevent and manage the emergencies, and to coordinate the human, material, financial and other measures to restore normality.

The National System is organized by public authorities and consists of a network of organizations skilled in emergency management, based on the levels and areas of expertise, infrastructure and available resources to accomplish the tasks set out in the emergency ordinance.

National System shall be composed of:

a) Emergency committees (ministries level);

b) The General Inspectorate for Emergency Situations (from Ministry of Administration and the Interior);

c) Public service emergency professional community;

d) Emergency operational centres;

e) The master of action.

General Inspectorate for Emergency Situations, as a specialized body under the Ministry of Interior, ensures consistent and permanent coordination of prevention and emergency management.

SLOVENIA

Fire brigade.

SPAIN

In general the main leader is Civil Protection. In some Autonomous Communities the leader are the Fire Brigades.

Question 7: What is the main means of communication between IRS organisations? Is it compatible with other countries from EU?

Answers:

CROATIA

These are VHF communication system, UHF Tetra Motorola, phone, Inmarsat communication system from global satellite network, integrated communication console to connect all of incompatible communication systems (Zetron 50/20 according to FEMA level 4).

Centers for communication and exchange of data are 112 Centers. Police use digital TETRA communication system. Methods of communication with other countries in the event of accidents and disasters are governed by international agreements.

CZECH REPUBLIC

Digital radio communication system TETRAPOL, phone, ... TETRAPOL is system which is compatible only with France and Singapore. TETRAPOL is completely anti-compatible with system Tetra.

FINLAND

Finnish Public Authority Network VIRVE based on TETRA.

GERMANY

Digital BOS network using the TETRA standard is established. Not compatible with TETRAPOL.

GREECE

Tetra, that is normally should be compatible with other countries from EU using the same system.

HUNGARY

The disaster management and th police use TETRA (EDR) digital radio-communication system, which is compatible with other TETRA systems of EU member states.

ITALY

Digital radio communication system, phone.

POLAND

Conventional radio communication systems, regular (fixed) and mobile telephones, internet.

PORTUGAL

Radio. Yes.

ROMANIA

Digital radio communication systems, internet and private networks and phone.

SLOVENIA

A uniform (autonomous) system of radio communications (ZARE) is used in the area of protection, rescue and relief in Slovenia. The Administration of the Republic of Slovenia for Civil Protection and Disaster Relief is in charge of the technical aspect and of ensuring the disturbance-free operation of the system. The system is used by all rescue services in the country. The system's communication centres are located in regional notification centres, where radio traffic is managed and used to connect users to public and functional telecommunications systems. The ZARE system guarantees 95% coverage of the territory by radio signal from a stationary network, and complete territorial coverage by means of mobile repeaters.

SPAIN

There is a computer application that centralizes all the emergency information. Not compatible with other countries.

Question 8: Do the IRS organisations use the Common Emergency Communication Information System (CECIS)?

Answers:

CROATIA

CECIS is used by DUZS continuously. State Center 112 has permanent communication with Monitoring Information Center (MIC) in Brussels.

CZECH REPUBLIC

FINLAND

Yes, in case of large events and in cases where assistance is provided.

GERMANY

No.

GREECE

No.

HUNGARY

The Central Duty Service of disaster management receives, and the International Department of National Directorate General for Disaster Management manages the CECIS messages.

ITALY

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POLAND

Yes. The national point of contact for CECIS is located in the National Headquarters of the State Fire Service.

PORTUGAL

Yes.

ROMANIA

Romania implements the emergency and notification system (CECIS) – a web application that facilitates communication between the states participating in the mechanism. This system provides the ability to send and to receive alert details of assistance required and follows the development of an intervention through an Internet archive.

SLOVENIA

Unknown?

SPAIN

No

Question 9: Are there differences in the fire and rescue arrangements between particular regions in your country? (seaside, mountains, etc.)

Answers:

CROATIA

There are only small differences based on geographic differences. Croatia has a Mediterranean and continental area and structure of protection and rescue system is adjusted accordingly. The organization of the Croatian Mediterranean is more focused on protecting forests from fire and tourists.

CZECH REPUBLIC

Small differences. In the mountains, special groups of rescuers, ...

FINLAND

Yes, differences especially between urban and rural areas. 10 of 22 Rescue Departments are by the sea and in close cooperation with the coast guard. The northern part of Finland is sparsely populated and fjelds (mountains) set challenges to rescue operations.

GERMANY

The organisation can be different in each state and country, depending on the law the state implements. In the IRS countrywide suggestions and guidance is provided. Additional special services in different regions (seaside and mountains)

GREECE

There are significant differences of fire and rescue arrangements (equipment, type of fire vehicles, fire stations) between regions depending on fire risk assessment of each area i.e. related to urban design, type of industrial activity , forest density etc.

HUNGARY

There are little differences in interventions in hills and on plains, furthermore in the Capital and in the countryside.

ITALY

Small differences. In the mountains, special groups of rescuers called Mountain Rescue.

POLAND

Fire and rescue arrangements are the same in all country – fully harmonized system in all country. The only exceptions concern:

- mountain rescue - where a leading role is played byVoluntary Mountain Rescue Service
- main rescue - where a leading role is played by Main Rescue Stations
- offshore sea rescue - where a leading role is played bySAR.

PORTUGAL

There are some peculiarities in the organization in the regions of Madeira and Azores.

ROMANIA

Very small differences (crews and endowment).

SLOVENIA

Small differences in the mountains and seaside (special groups of rescuers).

SPAIN

Some differences in terms of training and equipment, which adapts to the potential risks.

Question 10: How many alert levels do you have? Describe them briefly.

Answers:

CROATIA

The legislation does not prescribe formal alert levels.

CZECH REPUBLIC

- First alert level – announced when extraordinary event place one person or one building at risk without building in which are very difficult conditions for interference, area till 500 m^2 ...
- Second alert level – announced when extraordinary event pace on 100 person, building with difficult conditions for interference, area till 10.000m2, mass transport vehicles ...
- Third alert level – announced when extraordinary event pace more than 100 person, area till 1.000 m^2, ...
- Special alert level – announced when extraordinary event pace more than 1.000 person, area more than 1.000 m^2, ...

FINLAND

- First risk area (rescue unit must be at the destination in 6 mins)
- Second risk area (rescue unit must be at the destination in 10 mins)
- Third risk area (rescue unit must be at the destination in 20 mins)
- Fourth risk area – Area that is not first, second or third risk area
- The whole country territory area is divided into risk classes. Risk classes are based on a risk level Prognosis for risk level in a square 1 km x 1 km.

GERMANY

- No special alert levels standardised in all states and counties. Usually during the alert the type of emergency situation is directly given (e.g. small fire or major incident with high amount of casualties)

GREECE

First level alert- when the fire can be controlled from the nearest fire department / fire station with maximum three (3) fire vehicles .

Second alert level – when to tackle the fire required the whole power of the nearest fire service / fire station.

Partial general alert.- when to tackle the fire required support with fire trucks from other fire departments of the same or neighboring district area.

General alert.- when to tackle the fire required support with fire engines from fire departments from other territories of the same or adjacent regions

HUNGARY

There are five alert level, which can be „seeded" depending on the alert of a special fire vehicle (forest fire, high rise aerial appliance, water carrier, technical rescue, crane, ect.) necessary or not. The Operational Centre of the Disaster Managment Directorate or the fire service commander determines the alert level on the basis of the signal, take into account the type of damage, what is in danger, how many human life is in danger, and the dimensions of the area. These are the main aspects, which determines the following alert level:

Alert level I, where to the intervention not more than 2 squads, which can be half squads, are beeing alerted.

Alert level II, where to the intervention 2,5-3 squads are beeing alerted.

Alert level III, where to the intervention 3,5-4 squads are beeing alerted.

Alert level IV, where to the intervention 4,5-6 squads are beeing alerted.

Alert level V, where to the intervention more than 6 squads are beeing alerted.

Note: one full squad is 1+5 persons, one half squad is 1+3 persons.

ITALY

- Normal (no color): Given the factors monitored by the Civil Protection of the Region there is no evidence of a possible calamity in the area.
- Early warning (yellow): It is possible that a disaster occurs in the region, the consequences of which could affect safety of the population, but the probability of occurrence is still affected by various factors monitored and evolving.
- Alert (orange): Given the factors monitored by the Civil Protection of the region, it is expected in the region (or part of it) a disaster, immediate or conceivable, which could impact safety off the population and / or territory. The Civil Protection of the Region is active in the area with preventive measures.
- Emergency (red): A disaster, with possible consequences for public safety and for the territory, is under development in the region (or part of it) and is constantly monitored by the Civil Protection of the Region, which operates in with measures to protect the population and risk reduction.

- Disasters (black): A hazardous event of exceptional gravity for public safety and for the area, hit the region (or part of it) and is constantly monitored by the Civil Protection of the Region, which operates in the area with actions protection of the population and risk reduction.

POLAND

No special alert system. A content of emergency call (description of emergency situation) determinates mobilized resources (rescuers and equipment).

PORTUGAL

There are four alert levels: blue, yellow, orange and red.

The transition from one level to another, for example from blue to yellow, has the following implications:

- length of readiness
- increasing the number of resources available

ROMANIA

For the General Inspectorate for Emergency Situations, depending on the location, nature, extent and evolution of the event, professional emergency services are organized as follows:

a) First urgency - ensured guard / guard intervention / territorial departments it in the district (objective) affected;

b) Second urgency - provided by CountyInspectorate;

c) Third urgency - provided by two or more adjacent units;

d) Fourth urgency - ensured by operational groups, deployed in order inspector general of the Inspector General, where major interventions and long lasting....

SLOVENIA

Three – yellow, orange and red alert. Criteria for alerts are not unified (we are still working on that) and depends on region and chief of the rescue operation. Criteria also depends on type of the catastrophic event (flood, nuclear disaster, earthquake,...)

SPAIN

It depends on the particular Community and the kind of emergency. Typically there are 4 levels: pre-alert, alert, emergency 1 and emergency 2 according to the degree of risk.

Question 11: What are the management levels in case of rescue and relief works?

Answers:

CROATIA

Tactical: on the place, the chief of the intervention

Operational: distress phone numbers, operation and information centre of IRS of Fire rescue of the region (KOPIS)

Strategic: crisis staff, mayor of community

CZECH REPUBLIC

- Tactical – on the place, the chief of the intervention

- Operational – distress phone numbers, operation and information centre of IRS of Fire rescue of the region (KOPIS)
- Strategic – crisis staff, mayor of community

FINLAND

- Tactical sub. fire officer
- Operational fire officer in Charge
- Regional Fire Chief or regional rescue commander
- Country level General director of Rescue services in the Ministry of the Interior

GERMANY

- Strategic – crisis staff, mayor or other authorized person of county or city
- Tactical – on the scene, the director of intervention
- Medical – Leading emergency doctor

GREECE

- Tactical – on the place of fire incident, the commander of the intervention
- Operational – distress phone numbers, operation and information centre of Fire rescue of the region, the commander of the operational
- Strategic – Crisis management staff, mayor of community

HUNGARY

- Local level – incident or site commander (operational).
- Local level – leader of local defense commission (mayor, political).
- Territorial level – Operative Staff (on the basis of Disaster Management Directorate, operational, executive duties)
- Territorial level – leader of county (capital) defense commission (president of the county (capital) general assembly, decision-making, political)
- National – Centre for Emergency, Situation Analising-Evaluating Centre (on the basis of National Directorate General for Disaster Management and the Ministry of the Interior, operational, executive duties)
- National – Governmental Coordinating Organ (decision making, political)

ITALY

- Strategic – Head of Department of Civil Protection, Crisis staff, Mayor of community
- Tactical – on the place, the chief of the intervention
- Operational …

POLAND

Three levels of management (commanding) in case of rescue activities:

- Intervention
- tactical
- strategic

PORTUGAL

National, Regional and local levels

ROMANIA

Management intervention actions on emergencies ensure the following:

a) First urgency - The head guard subunit intervention for intervention in whose district of county the emergency occurred;

b) Second urgency - the intervention group commander or chief inspector for inspectorates which does not work intervention groups;

c) Third urgency - the chief inspector in whose jurisdiction the event occurred;

d) Fourth urgency - the inspector general of the Inspector General.Actions urgent and complex intervention will be led by commanders of subunits.

In the absence referred to in paragraph commanders, a management intervention action is ensured by legal substitutes to order.

SLOVENIA

The rescue is in accordance with regional emergency response plans but they have to be in accordance with national emergency response plan. Briefly:

- Tactical unit on the place, for most of the catastrophes the action is taken by fire brigade. Chief of the intervention is usually also chief of fire brigade (on the place).
- Operational (communications) – local communications within the unit is via the system ZARE, for any other needs via Regional Emergency Call Centre (for instance to get a new unit on the field)

Strategic – the crisis stab is formatted. If disaster is spread in more municipalities the leader is regional leader of Civil protection. For rescuing in one municipality the leader is local. Regional leaders are professional while local leaders of Civil protection service are not. During the rescue and relief work the leaders cannot be changed.

SPAIN

Rescue and relief works are directly managed from the intervention services of the district.

If the emergency has the category of catastrophe, it is managed at Autonomous Community or State level.

Question 12: Are all of the fire and rescue organisations governed centrally within your country?

Answers:

CROATIA

No, it is organised on the regional level. Only in the case of major disaster when call from NATIONAL PROTECTION AND RESCUE DIRECTORATE professional fire brigade is in the service of government.

Protection and rescue system is decentralized in accordance with the constitution and the law. In the case of more complex events headquarters are formed.

CZECH REPUBLIC

No, ambulance is managed from 14 district headquarters.

FINLAND

No, there are 22 regional rescue departments (municipality organisations), Emergency medical service is governed by 20 hospital districts

GERMANY

No. Rescue operations are governed by the states and cities

GREECE

Yes, using IRS for Attica region and VCF for the whole Greece

HUNGARY

No, voluntary firefighting associations and industrial fire brigades only to some extent belong to the central system of disaster management.

ITALY

No.

POLAND

Characteristics of the State Fire Service:

- leading rescue service
- professional & uniformed
- fully harmonized in all country
- organizer and core element of The National Firefighting and Rescue System
- state but strongly decentralized:
    - supervised by public administration authorities on each level
    - budgets come from public administration authorities on each level
    - appointment of Chief Fire Officers must be agreed with public administration authorities on each level
    - rescue plans are approved by public administration authorities on each level
    - subsidiarity rule is common (also in operational activities).

PORTUGAL

No. There are fire fighters who are driven by municipal councils (these are professional). Most firefighters are volunteers who have their own chain of command but they have to integrate into SIOPS

ROMANIA

Yes, by the General Inspectorate for Emergency Situations.

SLOVENIA

No they are governed on regional level

SPAIN

No, and also depends very much on the particular region.

Question 13: To which organisation you will call when you dial the European SOS phone number 112?

Answers:

CROATIA

NATIONAL PROTECTION AND RESCUE DIRECTORATE (DUZS).

On county levels operate County Centers 112.

CZECH REPUBLIC

Fire brigade.

FINLAND

Emergency Response Centre.Integrated 112-authority. In Finland there is only one emergency number; 112.

GERMANY

Fire brigade.

GREECE

General secretariat for civil protection.

HUNGARY

Police

ITALY

Armade i Carabinieri (that is an Order Force).

POLAND

Dialling the European Emergency Number 112 form a regular (stationary) telephone in most cases (approx. 90%) will contact with The State Fire Service. Dialling from a mobile phone telephone in most cases (approx. 90%) will contact with The Police. A new integrated system of alarm centres has been constructing and has been already acting in a few big cities.

PORTUGAL

For the public security police.

ROMANIA

Ambulance, Police, General Inspectorate for Emergency Situations – fire brigade, Romanian Gendarmerie, the mobile emergency service for resuscitation and extrication (SMURD) - as appropriate.

SLOVENIA

Regional Emergency Call Centre

SPAIN

There is a protocol to derive receiving calls to health, fire or police operator.

Question 14: What is the organisational structure of fire brigade?

Answers:

<u>CROATIA</u>

- Professional Fire Brigades (organized on local community level, in the command line are subordinated to DUZS)
- Volunteer Fire Brigades (organized through Croatian Firefighting Association)
- Professional and Volunteer Fire Brigades in the industry (organized on company level)

<u>CZECH REPUBLIC</u>

- District headquarters of fire brigade
- Territorial departments of fire brigade
- Fire brigade stations

<u>FINLAND</u>

- Regional rescue departments
- Fire brigades

<u>GERMANY</u>

The fire fighters are organized in counties or cities

Professional fire fighters in larger cities
Voluntary fire fighters in smaller cities

Depending on the size of the area, one or more fire stations are established

<u>GREECE</u>

- Headquarters of Fire service
- Territorial command of fire service
- Regional command of fire service
- Fire service stations

<u>HUNGARY</u>

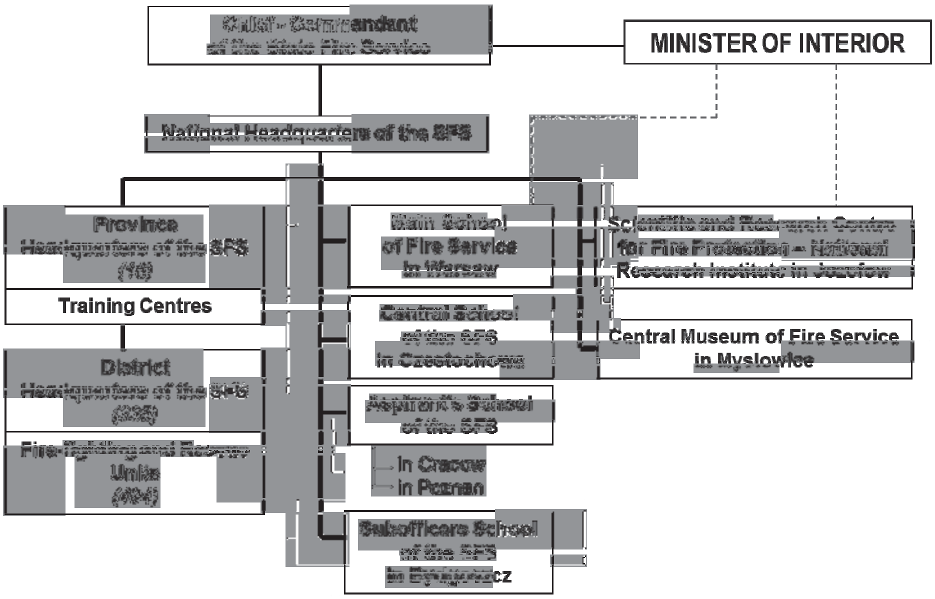
- National level – Ministry of the Interior National Directorate General for Disaster Management
- Territorial level – Directorates of Disaster Management
- Local level – Branch Offices of Disaster Management
  - Professional Fire Brigade HQs
  - Disaster Management Offices
  - Firefighting Posts

<u>ITALY</u>

The Department of Firefighters, Public Rescue and Civil Defence (Dipartimento dei Vigili del Fuoco, del Soccorso Pubblico e della Difesa Civile) is composed by eight central directorates, eighteen regional offices and one hundred provincial commands, with around eight hundred stations throughout the country. National Fire Corps is part of the Department, which depends by the Ministry of the Interiors.

POLAND

Graph 1 - Structure of The State Fire Service (SFS)



PORTUGAL

Has its own chain of command, with one commander and a second commander. To ascend in its hierarchy firefighters must have mandatory training and length of service.

This organization is regulated by law

ROMANIA

General Inspectorate for Emergency Situations – national level

42 County Inspectorates for Emergency Situations

Territorial departments of County Inspectorate for Emergency Situations – fire brigade:

– Detachments (7-8 crews)

– Sections (5-6 crews)

– Stations (3-4 crews)

– Pickets (1-2 crews)

Voluntaries and privates services for emergency situations.

SLOVENIA

District headquarters of fire brigade (National)

Regional departments of fire brigade (17)

Fire brigade stations

SPAIN

It is a territorial structure. Each Autonomous Communities is divided in several Emergency Regions with several fire brigade stations. Each fire brigade station has a fire-fighter in chief who manages the emergency.

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