ISSN 2409-4951(Online)
ISSN 2310-1008 (Print)

Ukrainian Journal of Food Science

Volume 3, Issue 2
2015

Kyiv 2015

Contents

Cause of the fire at the food industry enterprises

**Olga Slobodyan, Vira Zaets,
Larysa Neshchadym, Svitlana Avdienko**

National University of Food Technologies, Kyiv, Ukraine

Keywords:

Fire
Burning
Combustion
Explosion
Hazard.

Article history:

Received 07.09.2015
Received in revised form 21.12.2015
Accepted 24.12.2015

Corresponding author:

Svitlana Avdienko
E-mail:
Sv_avdienko@mail.ru

Abstract

Introduction. Research the causes of fires at the food industry enterprises of Ukraine will allow develop effective measures to reduce the likelihood of their occurrence.

Material and methods. We used theoretical methods of research in the above privacy of data analysis of scientific literature on the subject , methods of synthesis , comparison and generalization of data relating the factors that contribute to the raising of fire risk on industrial objects of Ukraine.

Results and discussions. Analysis of fires in different areas of the food industry indicates that most likely their causes are violation of rules for the arrangement and maintenance of electrical installations, careless handling of fire, violation of process regimes (especially during baking, roasting, drying or other processing method), fault or outdated equipment, poor treatment with flammable liquids, violation of terms cleaning of combustible dust. These factors are compounded by the fact that these companies saved, transported or used a substance which under certain conditions can burn or explode, e.g. alcohol, ether, essences, organic acids, gasoline, acetone, hydrogen, etc.; the dust of many food products (flour, sugar, tobacco, tea, starch, cocoa, powdered milk and other); ammonia which used as refrigerant. Also, the food industry uses a large amount of combustible materials and packaging, which increases the fire risk of object.

According to these causes of fire reasonable measures to avoid: compliance the general requirements of fire safety, prevention of combustible environment and the occurrence of ignition sources in it, enhancing monitoring of process equipment and control devices.

Conclusions. The research results can be used in the development and improvement of effective measures to ensure fire safety at the food industry enterprises.

Introduction

Fires are a serious problem for many industrial enterprises, resulting in increased economic, environmental and social damages. Human casualties are the most important of them.

Every year over 6,000,000 fires take place on Earth, including about 60,000 fires in Ukraine.

The fire risks on industrial enterprises of Ukraine increase considerably due to such factors as increased power supply, increased density of transport communications, heightened temperature and pressure in the process equipment, using of new polymers with higher flammable properties. While the modern production processes attain lowered probability of fire, they at the same time get more serious aftermaths and greater damaged areas in case of fire. Statistics show that a fire reaches the maximum tolerable level of hazard within 5-10 minutes. The loss of the metal building structure bearing capacity is reached within another 10-15 minutes. Whereas the effective actions of fire brigade start only within 20-25 minutes after the fire start.

Increased concentration of combustible substances and material assets per unit area of the buildings leads to increasing level of fire hazard.

The main causes of fire are:

- Malfunction of the production equipment — 0.3%;
- Arson — 1.6%;
- Violation of rules for the arrangement and maintenance of ovens — 7.3%;
- Violation of rules for the arrangement and maintenance of electrical installations — 19.7%;
- Careless handling of fire — 59.8%;
- Other reasons — 11.3% [1].

Material and methods

During the investigation of the causes of fires at the food industry enterprises we used theoretical methods of research in the above privacy of data analysis of scientific literature on the subject , methods of synthesis , comparison and generalization of data relating the factors that contribute to the raising of fire risk on industrial objects of Ukraine.

The research was conducted by analyzing explosive and flammable substances and materials, factors available in the baking, confectionery, fermentation, sugar, alcohol, alcoholic beverages, oil extraction, and others food enterprises of Ukraine, that can cause fire and explosions, according to scientific papers in the field of fire safety.

Results and discussions

Combustion is a physical-chemical process of quick interaction between combustion agent and an oxidant accompanied by the production of heat and light. Oxidants may include not only oxygen and air, but also chlorine, fluorine, sulfur, nitric acid and other substances. Start of the combustion process requires three factors: the combustible substance, oxidant and the ignition source. The combustible substance and oxidant create the combustible system (material, mixture, construction). The ignition source starts the combustion process, which does not stop even after ignition source is removed.

Combustion is divided into several types, including blaze, ignition, flame and spontaneous combustion.

Spontaneous combustion is a condition that leads to a rapid temperature rising followed by combustion of a substance without source of ignition. Spontaneous combustion can be thermal, microbiological or chemical. Timber and woodwork, vegetable oil are exposed to thermal spontaneous combustion. Microbiological spontaneous combustion occurs during storage of grain, hay, peat and other vegetable materials [2]. Chemical spontaneous combustion occurs because of chemical interaction of substances as well as due to air and water influence on them. The chemical spontaneous combustion is typical for vegetable oils and animal fats. The ability of oil or fat to combust spontaneously characterized by iodine number. The higher the number is, the more these substances are prone to combust. For example, flaxseed oil has the iodine number of 175-205 and the spontaneous combustion temperature of 343°C, and hemp oil has the iodine number 150-172 and the spontaneous combustion temperature of 410°C. Spontaneous combustion greatly increases the fire hazard if the store rules of sunflower cake, oilcloth, etc. are violated.

Liquids prone to fire are divided into two categories: highly flammable and combustible. In manufacturing environments these liquids can form a steam-air mixture, but it will not ignite if the vapor concentration is too low or too high [3]. There are a lower and an upper flammability temperature. It is the lowest and the highest temperature of combustible liquid that can cause fire from the source of ignition.

Baking industry, confectioneries, pasta industry, fermentation plants and sugar refineries have many fire-hazardous and dangerously explosive places and operations, allocated all over the production chain – beginning from the feedstock storehouses and ending with the finished products warehouses. This is due to the fact that most raw materials, substances and materials utilized in manufacturing of semi-finished or finished products are solid or liquid combustible substances. Substantial part of these substances is also highly explosive.

Such enterprises of food industry as distillery, alcoholic beverage industry, perfumery, fat-and-oil industry utilize and produce fire-hazardous and dangerously explosive substances, e.g. alcohol, ether, essences, organic acids, oils, fats, benzine, acetone, hydrogen, etc.

Table 1

List some of the highly flammable and combustible liquids, gases and their fire-hazardous properties

Liquid	Limit of inflammability				Spontaneous combustion temperature, °C
	Lower		Upper		
	t, °C	Concentration, %	t, °C	Concentration, %	
Ammonia	-	17	-	27	700
Acetone	-10	2,91	-6	13	465
Acetylene	-	2,5	-	82	335
Dichloroethane	8	6,2	31	16	525
Acetic acid	35	3,3	76	22	454
Methanol	7	6,7	39	38,5	464
Ethanol	11	3,61	41	19	404
Hydrocarbon oxide	-	12,5	-	80	610
Toluene	0	1,95	30	7	536
Gasoline	-28	1,9	-9	5,1	260

The dust of many substances also has fire-hazardous and dangerously explosive properties [4,5,6]. Release of the combustible and explosive dust takes place during production of sugar, tobacco, tea, starch, flour, beverages, meat processing, backing.

Table 2

List explosive and fire-hazardous properties of dust

Substance	Minimal concentration for explosion, g/m^3	Spontaneous combustion temperature, °C	Substance	Minimal concentration for explosion, g/m^3	Flash point, °C
Class I (highly explosive)					
Glucose crystal	15,0	250	Dust: fodder	10	-
Forage maize	12,6	-	sugar	8,9	525
Dried milk: whole	7,6	875	sunflower meal	7,6	525
non-fat	8,9	825			
Meal: blood	7,6	-			
meat-and-bone	10,1	-			
Class II (explosive)					
Sunflower cake	22,7	825	Dust:		
Beet pulp	27,7	750	grain screenings	25,5	-
Cocoa powder	45,7	420	flour	17,6	800
Starch: potato	40,3	-	wheat grey	40	-
corn	50	625	coal	32,8	-
Meal: wheat	20	395	Pectin: beet	60	-
barley	32,8	750	apple	27,5	-
Wheat bran	22,7	-	Ground wheat	45,4	-
Class III (highly fire-hazardous)					
Dust: tobacco	68	205			
grain elevator	227	250			
Class IV (fire-hazardous)					
Timber dust	above 65	275			

Many food enterprises are equipped with refrigerators.

Ammonia — the most commonly used refrigerant — is an explosive and toxic gas. Thus, for the most of food industry enterprises the areas with high risk of fire includes ammoniac compressor station and refrigerator compartment with direct cooling [7,8].

Large amounts of combustible containers are utilized and manufactured at the food industry facilities: wood, plywood and cardboard boxes; cloth and paper bags; paper packets; labels, polyethylene and cellophane packaging, etc. The presence of combustible containers increases the fire risk at the enterprise.

Storage facilities and stockrooms to store grain, flour, cereals, vegetables, fruits, tobacco, etc. require disinfestation to combat pests. If carbon bisulfide, dichloroethane or sulfur is used for disinfestation, the fire hazard and explosion threat increase.

Heating, drying, roasting, boiling and baking at the food industry facility requires utilization of ovens working on solid, liquid and gaseous fuel.

The fire threat appears because of violation of technological requirements and fire safety requirements.

At such enterprises of food industry as distillery, alcoholic beverage facilities, fat-and-oil facilities, oil-extraction plants alcohol and fuel — which are highly flammable liquids — can form combustible mixtures with air in case of the equipment and pipeline seal failure due to violation of working and repair instructions. Flammable and combustible liquids leaks because of loose flange connection of pipelines, leaky sealing rings of pumps and shutoff valves, the alcohol in refrigerators is cooled insufficiently.

Leaky manufacturing equipment and communication fixtures cause high leakage of the benzene vapor or other solvents at oil-extraction plants. The highest leakage of explosive substances occurs due to technological requirements violation leading to an accident. The highly explosive mixture of benzene vapor and air occurs due to level drop in the bunker of meal (sunflower, etc.) processing.

There are different cases of the explosive and flammable substances combustion. The most frequent causes of ignition are spark formation of mechanical origin due to collision of the metal parts (ventilator, etc.); metal objects getting into granulators and other processing equipment; a tool falling onto metal surface or concrete floor; open fire of processing equipment, incineration sites, electric welding, matches and unquenched cigarette [9]; heat development of the electric current, short circuit arc or spark; static and atmosphere discharges [10]; ball bearings overheating due to lubricant misapplication, malfunction, wear or clogging.

Main reasons of fire in food industry may be divided into disciplinary reasons, processing reasons, reasons caused by electricity, reasons caused by lack of the inspection or its tardiness.

Disciplinary reasons includes violation of requirements for design of industrial and auxiliary buildings and facilities [11], for the building materials and constructions [12-16], for the facilities planning, for the processing equipment placement; departure from the operation and maintenance rules of the equipment, power consumers and power supply networks; violation of job instruction for fire safety; violation of the safety regulations during fire works; casual handling of open fire sources, smoking at the workshops and storehouses; mishandling of high combustible fluids; incorrect storing of oiled materials and cotton working clothes; violation of the combustible dust cleaning rules and terms [17].

Processing reasons of fire includes work on faulty processing equipment or with the workflow routine violation, especially during baking, roasting, drying or other processing method; use of combustible substances that do not conform to specification of processing stoves, violation of the stove lighting mode, of operation mode, of cutoff mode; incorrect filling of vessels and utility lines with high combustible liquids and gases, use of tools that produce sparks when hitting the solid surface.

Table 3

List of indicators for fire explosion hazard substances and materials

№	Indicators	Using indicators of fire explosion hazard			
		Gas	Liquids	Solid materials	Dust
1	Group of combustibility	+	+	+	+
2	Temperature of flash	-	+	+	-
3	Temperature of flashing	-	+	+	+
4	Temperature of self-ignition	+	+	+	+
5	Concentration limits of spreading fire (flashing)	+	+	-	+
6	Temperature limits of spreading fire (flashing)	+	+	-	-
7	Temperature of self-heating	-	-	+	+
8	Smoldering temperature	-	-	+	+
9	Conditions of the thermal self-ignition	-	-	+	+
10	Minimal energy of flashing	+	+	-	+
11	Index of oxygen	-	-	+	-
12	Ability to explode and burn during interaction with water, air oxygen and other substances	+	+	+	+
13	Normal speed of fire spreading	+	+	-	-
14	Speed of burn up	-	+	-	-
15	Rate of smoke production	-	-	+	-
16	Index of fire spreading	-	-	+	-
17	Toxicity indicators of combustion products	-	-	+	-
18	The minimum explosive level of oxygen	+	+	-	+
19	Minimal retarding concentration of retarder	+	+	-	+
20	Maximum explosion pressure	+	+	-	+
21	Rate of pressure rising during the explosion	+	+	-	+

Note. «+» means applicable, «-» - means non applicable indicator

Reasons of fire related to electricity includes use of electrical equipment that do not correspond to fire and explosion hazard category of the production; overload of the processing transport mains operated from electric drive, overload of other electric equipment and networks; poor electric contact at a wiring point; insulation failure, other faults and damages to power supply consumers or networks; lack of safety devices from the static electricity on the processing equipment and workers, lack or crippling of the lightning rods and protective devices from the secondary effects of atmospheric electric linear discharges[18].

The main drawbacks of control measures leading to fire are lack or tardiness of technical inspection, lack of routine preventive repairs of the processing equipment, automation, control instrumentation and safety devices; insufficient control for temperature

conditions of the processing equipment that use open fire or of the equipment acting through the operating temperature rise (compressors).

Fire safety measures are very diverse but according to its target purpose they can be divided into four groups:

1. Measures in production process, providing fire safety during work of processing system and during storage of end products. Such measures are executed during design process, when in view of the fire safety the most safety temperatures and pressures, reliable control and preventive equipment are chosen and special rules of fire safety, rules of joint storage of materials and substances are set.
2. Construction measures aimed to eliminate the causes of fire breakout and creation of stable protective structure and building as the whole during the fire and limitation of fire spreading and explosion. Such measures are executed during design and construction process; they are connected with choosing buildings according to their level of fire resistance and number of floors according to the fire hazard of production process, choose of heater system, ventilation, construction of fire barriers.
3. Administrative and fire safety mass agitation measures, providing organization of object fire protection in whole and training of all staff measures for preventing fire and use of fire equipment, are executed during the process of exploitation.
4. Measures ensuring conditions and means of fast and successful fire suppression performed during construction and operation; they provide the choose of most effective ways and means of fighting fire, the units for fire water supply, fire alarm, creation of storage with means for fighting fire.

The studies are important to food companies not only in Ukraine but also the world.

Conclusions

The most important task of all fire safety systems is to protect people from the hazards that accompany combustion, and to rescue people in case of fire.

The essential task in the operation process of any facility is to ensure the full evacuation of all personnel in case of fire emergency before reaching the critical values of fire hazard [19].

It is strictly prohibited:

- To set up thresholds, turnstiles, sliding or roll shutter doors, etc. on the escape routes;
- To make clutter on the escape routes with furniture, equipment, materials or finished products even if they do not decrease the regulatory width of the passage ;
- To block, weld up, lock with a padlock the outward facility escape doors ;
- To use combustible materials in facings of walls, ceilings and stairs of the escape routes.

Finally, the one responsible for fire safety should always proceed from the fact that to prevent fire is always better than to fight its aftermath, especially when a human life is at stake.

References

1. Slobodyan O., Zaets V., Neshchadim L. (2013), Warning of origin of fire is on the enterprises of food industry, *The second north and east European congress on food,* pp. 133.

2. Sokolov D.N., Vohman L.P., Zuikov V.A. (2012), Mykrobyolohycheskoe samovozghoranye, *Pozharnaya bezopasnost,* 1, pp. 35-48.
3. Shebeko A,Yu., Shebeko Yu.N., Zuban A.V., Golov N.V. (2015), An investigation an ignition of flammable gaseous mixtures with mechanical sparks, *Fire Safety Journal,* 78, pp. 122-129.
4. Stepanets I.F., Slobodyan O.P, Matiyashchuk O.V. (2011), Zapobihannia vynyknenniu vybukhiv na pidpryiemstvakh tsukrovoi haluzi, *Tsukor Ukrainy, 4(64),* pp. 23-26.
5. Gusyatinska N.A., Stepanets I.F., Slobodyan O.P., Avdienko S.O., Matiyashchuk O.V. (2015), Zapobihannia vynyknennia nadzvychainykh sytuatsii na pidpryiemstvakh tsukrovoi haluzi, *Tsukor Ukrainy, 8,* pp. 35-37.
6. Stepanets I.F., Slobodyan O.P, Matiyashchuk O.V. (2008), Prohnozuvannia rozvytku ta metody otsinky naslidkiv avarii vybukhonebezpechnykh obiektiv na pidpryiemstvakh khlibopekarnoi haluzi, *Kharchova promyslovis, 6,* pp. 128-130.
7. Slobodyan O., Zaets V., Neshchadim L., Avdienko S. (2012), Pidvyshchennia roboty pidpryiemstv miaso-molochnoi promyslovosti, *Zbornik vedeckych a odbornych prac medzinarodneho vedeckeho seminara «Riadenie bezpecnosti zlozitych systemov 2012», Liptovsky Mikulas,* pp.336-339.
8. Ryabokon N., Avdienko S., Slobodyan O., Zaets V. (2013), Predotvrashchenye voznyknovenyia chrezvыchainыkh sytuatsyi pry proyzvodstve molochnыkh produktov, *Zbornik vedeckych a odbornych prac medzinarodneho vedeckeho seminara «Riadenie bezpecnosti zlozitych systemov 2013», Liptovsky Mikulas,* pp. 367-373.
9. Klimkin V.I., Hasanov I.R., Smirnov N.V., Konstantinova N.I., Molgadskiy O.I. (2012), Pozharoopasnost syharet, *Pozharnaya bezopasnost, 3,* pp. 66-70.
10. Marek B., Wiechula (2013), The incendivity hazards of electrostatic discharges from charged, non-conductive, *Fire Safety Journal,* 60, pp.46-55.
11. Shariff A.M.,Wahab N.A. (2013), Inherent fire consequence estimation tool (IFCET) for preliminary design of process plant, *Fire Safety Journal,* 59, pp.47-54.
12. Bajc U., Saje M., Planine I., Bratina S. (2015), Semi-analytical buckling analysis of reinforced concrete columns exposed to fire, *Fire Safety Journal,* 71, pp. 110-122.
13. 13.Eamon Ch., Jensen E. (2014), Reliability analysis of reinforced conerete columns exposed to fire, *Fire Safety Journal,* 62, Part C*,* pp. 221-229.
14. Russa S., Sciarretta F. (2013), Masonry exposed to high temperatures: mechanical behavior and properties, *Fire Safety Journal,* 55*,* pp. 69-86.
15. Huang Zh. (2010), The behaviour of reinforeed slabs in fire, *Fire Safety Journal,* 45(85), pp. 271-282.
16. Arioz O. (2007), Effects of elevated temperatures on properties of concrete, *Fire Safety Journal,* 42(8), pp. 516-522.
17. Piccinini N. (2008), Dust explosion in a wool factory, *Fire Safety Journal,* 43(3), pp. 189-204.
18. Troshyna S. (2016), Zapobihannia vynyknenniu pozhezh cherez porushennia pravyl montazhu ta ekspluatatsii elektrooobladnannia na vyrobnytstvi, *Okhorona pratsi ta pozhezhna bezpeka,* 1, pp. 33-38.
19. Bhushan A., Sarola N.L. (2013), Modeling of building evacuation using ladders, *Fire Safety Journal,* 55*,* pp. 126-138
20. Troshyna S. (2014), Pozhezhna bezpeka evakuatsiinykh shliakhiv ta vykhodiv, *Okhorona pratsi ta pozhezhna bezpeka,* 5, pp. 12-16.