Study on the regularities and precautions of summer production safety accidents in Jiangsu

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Abstract. In order to study the regularities of summer production safety accidents in Jiangsu and put forward targeted precautions, based on the statistics of summer accident data in Jiangsu from 2016 to 2020, this paper studied the distribution regularities of accident time, accident type and industry fields for ordinary accidents and more major accidents respectively by inductive method. The results showed that more accidents occurred in July in summer; industrial and trade (light industry, machinery, metallurgy, nonferrous metals), construction, agricultural machinery, fishing vessels accidents might occur frequently. This paper put forward precautions for the above industries and hazardous chemicals.

Keywords: Summer accident; Regularity; Precaution; Production safety accident; High temperature season

1 Introduction

Summer in Jiangsu is from June to August, and the main meteorological disasters were lightning, rainstorm and flood in early summer, plum rain and hail in middle summer, and high temperature, drought and typhoon in hot summer. Jiangsu Province is economically developed, densely populated, and has a busy transportation. Meteorological disasters can cause huge economic losses and loss of life and property in Jiangsu Province, but also cause production safety accidents in agriculture, forestry, animal husbandry and fishery, transportation, industry, mining and commerce (hereinafter referred to as 'accident').

Therefore, we focused on finding the regularities and characteristics of summer accidents occurring from 2016-2020 to study the precautions of summer accidents.

2 Data source and statistics

According to the accident database of Jiangsu Province, the accidents from 2016-2020 were analyzed, and studied the distribution regularity of accident time, type and industry fields by inductive method. According to Report on production safety accident and regulations of investigation and treatment (Decree No. 493 of the PRC State Council

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of 2007), the accident is divided into four levels: ordinary, major, serious, and extraordinarily serious accidents. So we studied the regularity of ordinary accidents and more major accidents (major, serious and extraordinarily serious).

3 Regularity analysis of summer accidents

3.1 Overall situation of summer accidents

From 2016 to 2020, there were 32367 accidents and 17959 deaths; the accident rates in spring, summer, autumn and winter decreased in turn; among them, 8709 cases occurred in summer, with 4794 deaths, accounting for 26.9% and 26.7% respectively, ranking the second in the four seasons; the accident rate in summer exceeded 1/4. Among them, 29 more major accidents occurred and with 110 deaths, accounting for 24.4% and 19.0% respectively; not more than 1/4 of all more major accidents.

3.2 Monthly distribution regularity

In summer, the most accidents occurred in July, with a total of 2957 accidents and 1657 deaths, accounting for 34.0% and 34.6% respectively, more than 1/3. Among the 29 more major accidents, 14 accidents occurred in July, with 49 deaths, accounting for 48.3% and 44.5% respectively, far more than 1/3. See Figure 1 for details.

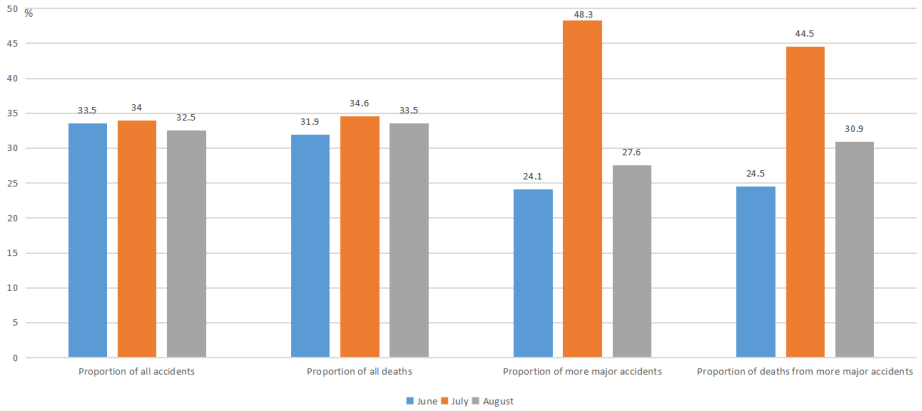

Fig. 1. Monthly distribution of summer accidents in 2016-2020

3.3 Accident type distribution regularity

1)Type of ordinary accident

①There were 21 accident types in whole year, including road transportation, high falling, mechanical injury, object strike and electric shock, etc; there were 18 accident types in summer, including road transportation, high falling, electric shock, mechanical injury, object strike, etc. ②The proportion of electric shock and high falling in summer

in all accident types was significantly higher than that in whole year; the proportion of lifting injury, collapse, poisoning and asphyxiation increased slightly. See Table 1 for details. The accident types or industry fields with less proportion had been omitted. Yellow meant an increase summer, and green meant a decrease in summer, and bold words meant more accident types or industry fields. The following tables were the same as this note.

2)Type of more major accident

①There were 12 accident types in whole year, including road transportation, drowning, explosion, poisoning and asphyxiation, fire, collapse, high falling, other injuries, mechanical injury, boiler explosion, container explosion and electric shock, which decreased in turn; there were 8 accident types in summer, including electric shock, fire, other injuries, explosion, road transportation, drowning, poisoning and asphyxiation, which decreased in turn. ②The proportion of electric shock and fire in summer in all accident types was significantly higher than that in whole year. ③The proportion of road transportation, drowning, poisoning and asphyxiation in summer was lower than that in whole year, but the proportion of deaths in summer was significantly higher than that in whole year. See Table 2 for details.

Table 1. Distribution of main accident types of ordinary accidents in summer 2016-2020

Types of ordinary accidents in whole year	Number of accidents	Proportion of accidents	Deaths	Proportion of deaths	Types of ordinary accidents in summer	Number of accidents	Proportion of accidents	Deaths	Proportion of deaths
Vehicle injury	404	1.3	355	2.0	Vehicle injury	113	1.3	99	2.1
Electric shock	**419**	**1.3**	**422**	**2.4**	**Electric shock**	**249**	**2.9**	**251**	**5.4**
Road transportation	**26341**	**81.7**	**12230**	**70.4**	**Road transportation**	**7047**	**81.2**	**3187**	**68.0**
High falling	**1747**	**5.4**	**1668**	**9.6**	**High falling**	**498**	**5.7**	**482**	**10.3**
Mechanical injury	**1046**	**3.2**	**681**	**3.9**	**Mechanical injury**	**224**	**2.6**	**143**	**3.1**
Other injuries	297	0.9	192	1.1	Other injuries	32	0.4	22	0.5
Lifting injury	335	1.0	333	1.9	Lifting injury	100	1.2	96	2.0
Collapse	231	0.7	235	1.4	Collapse	73	0.8	71	1.5
Object strike	**910**	**2.8**	**767**	4.4	**Object strike**	**200**	**2.3**	**185**	**3.9**
Drowning	172	0.5	188	1.1	Drowning	46	0.5	53	1.1
Poisoning and asphyxiation	113	0.4	141	0.8	Poisoning and asphyxiation	38	0.4	51	1.1

Table 2. Distribution of main accident types of more major accidents in summer 2016-2020

Types of more major accidents in whole year	Number of accidents	Proportion of accidents	Deaths	Proportion of deaths	Types of ordinary accidents in summer	Number of accidents	Proportion of accidents	Deaths	Proportion of deaths
Electric shock	1	0.8	3	0.5	Electric shock	1	3.4	3	2.7
Fire	**8**	**6.7**	**40**	**6.8**	**Fire**	2	6.9	9	8.2
Other injuries	2	1.7	0	0.0	Other injuries	1	3.4	0	0.0
Explosion	**9**	**7.6**	**118**	**20.2**	**Explosion**	**4**	**13.8**	**14**	**12.7**
Collapse	6	5.0	29	5.0	Collapse	1	3.4	5	4.5
Road transportation	**46**	**38.7**	**208**	**35.6**	**Road transportation**	**11**	**37.9**	**44**	**40.0**
Drowning	**32**	**26.9**	**132**	**22.6**	**Drowning**	**7**	**24.1**	**28**	**25.5**
Poisoning and asphyxiation	**9**	**7.6**	**28**	**4.8**	Poisoning and asphyxiation	2	6.9	7	6.4

3.4 Distribution regularity of industry field

1)Industry field of ordinary accident

①Ordinary accidents occurred in agriculture, forestry, animal husbandry and fishery, transportation, industry, mining and commerce, etc; annual and summer accidents were concentrated in road transportation, construction, machinery and other industries. ②The proportion of accidents in construction, agricultural machinery and other industries in summer was significantly higher than that in whole year; the proportion of deaths in the machinery industry was significantly higher than that in whole year. See Table 3 for details.

2)Industry field of more major accident

①The more accidents in whole year were concentrated in 9 industry fields, including fishing vessel, nonferrous metals, light industry, machinery, construction, road and water transportation, chemical industry, etc, which decreased in turn; the more accidents in summer were concentrated in 8 industry fields, including fishing vessels, nonferrous metals, light industry, machinery, road and water transportation, etc, which decreased in turn; no chemical accident occurred in summer. ②The proportion of accidents in fishing vessels, nonferrous metals, light industry, machinery in summer was significantly higher than that in whole year; the proportion of accidents in road transportation in summer was lower than that in whole year, but the proportion of deaths in summer was higher than that in whole year. See Table 4 for details.

Table 3. Distribution of main industry fields of ordinary accidents in summer 2016-2020

Industry fields of ordinary accidents in whole year	Number of accidents	Proportion of accidents	Deaths	Proportion of deaths	Industry fields of ordinary accidents in summer	Number of accidents	Proportion of accidents	Deaths	Proportion of deaths
Agricultural machinery	206	0.6	62	0.4	Agricultural machinery	75	0.9	18	0.4
Fishing vessel	87	0.3	79	0.5	Fishing vessel	13	0.1	12	0.3
Chemical	82	0.3	79	0.5	Chemical	23	0.3	26	0.6
Metallurgical	115	0.4	114	0.7	Metallurgical Industry	25	0.3	24	0.5
Textile	210	0.7	179	1.0	Textile	56	0.6	52	1.1
Machinery	**1016**	**3.2**	**773**	**4.4**	**Machinery**	**240**	**2.8**	**215**	**4.6**
Building Materials	223	0.7	210	1.2	Building Materials	57	0.7	55	1.2
Light industry	255	0.8	207	1.2	Light industry	65	0.7	60	1.3
Construction	**2155**	**6.7**	**2101**	**12.1**	**Construction**	**635**	**7.3**	**622**	**13.3**
Road transportation	**26339**	**81.7**	**12228**	**70.4**	**Road transportation**	**7047**	**81.2**	**3187**	**68.0**
Water transportation	118	0.4	107	0.6	Water transportation	25	0.3	23	0.5
Other industries	**1260**	**3.9**	**1072**	**6.2**	**Other industries**	**370**	**4.3**	**342**	**7.3**
Coal mining	4	0.0	4	0.0					

Table 4. Distribution of main industry fields of more major accidents in summer 2016-2020

Industry fields of more major accidents in whole year	Number of accidents	Proportion of accidents	Deaths	Proportion of deaths	Industry fields of more major accidents in summer	Number of accidents	Proportion of accidents	Deaths	Proportion of deaths
Fishing vessel	**10**	**8.4**	**42**	**7.2**	**Fishing vessel**	**4**	**13.8**	**15**	**13.6**
Nonferrous metal	2	1.7	9	1.5	Nonferrous metal	1	3.4	5	4.5

Industry fields of more major accidents in whole year	Number of accidents	Proportion of accidents	Deaths	Proportion of deaths	Industry fields of more major accidents in summer	Number of accidents	Proportion of accidents	Deaths	Proportion of deaths
Light industry	9	7.6	43	7.4	Light industry	3	10.3	13	11.8
Machinery	5	4.2	19	3.3	**Machinery**	**4**	**13.8**	**12**	**10.9**
Construction	**11**	**9.2**	**49**	**8.4**	Construction	1	3.4	5	4.5
Road transportation	**46**	**38.7**	**210**	**36.0**	**Road transportation**	**11**	**37.9**	**44**	**40**
Water transportation	**21**	**17.6**	**80**	**13.7**	Water transportation	3	10.3	10	9.1
Other industries	10	8.4	36	6.2	Other industries	2	6.9	6	5.5
Chemical	4	3.4	94	16.1					

4 Precautions of summer accidents

According to the regularity analysis and accident risk research, we studied the precautions of the industries with increased possibility of accidents in summer and the key industries in Jiangsu, namely industry and trade (light industry, machinery, metallurgy, nonferrous metals), construction, agricultural machinery, fishing vessels and hazardous chemicals.

4.1 Industry and trade (light industry, machinery, metallurgy, nonferrous metals)

We needed to strengthening the control of special operations such as inflammable and explosive materials, hoisting operation, confined space operation, electrical operation, maintenance operation and work at height[1]; focus on summer special safety training to improve the safety awareness of on-site workers; strengthen safety measures against electric shock, fire, lifting injury, poisoning and suffocation. The main precautions were as follows.

(1) Electric shock accident precautions. Summer was the peak period of electricity consumption, and accidents occurred in summer more than that in other seasons. Therefore, the safety control and education of temporary electrical operation should be strengthened, and it was strictly prohibited to pull and connect power wires without permission.

(2) Fire and explosion accidents precautions. High incidence of fire accidents in summer, so it was necessary to abide by the fire prevention rule, fully equipped fire facilities, and strictly control the fire operation safety; strengthen the management of inflammable and explosive materials storage and use; strengthen metal smelting operation, high-temperature melting operation, explosion-related dust operation and pressure vessel.

(3) Precautions of lifting injury, collapse and high falling accidents caused by extreme weather. Typhoons and thunderstorms had a significant impact on high-altitude operation and hoisting operation, resulting in high falling and lifting injury. In rainy seasons such as thunderstorms and plum rains, collapse accidents were prone to occur in flood season, such as water soaked collapse of factory buildings, materials stacking, warehouses, etc. Therefore, it was necessary to deploy, inspect and implement facilities, equipment and materials for flood control and lightning protection in advance; work could be stopped during extreme weather; after strong winds and thunderstorms, hidden dangers were checked again, and resume production after confirmation that it was normal; after the rainy season, the storage area of materials should be inspected for whether to soak in water.

(4) Precautions of poisoning and asphyxiation. In summer, the volatilization and diffusion of high-temperature toxic gases were accelerated. Poisoning and asphyxiation accidents were prone to occur in poisoning posts and confined space operation. Therefore, it was necessary to strengthen the management of confined space operation, toxic gas monitoring and personal protection.

(5) Precautions of scalding and heat stroke. Multiple types of accidents were other injuries, actually were heatstroke caused death without timely treatment. ①The work and rest time should be reasonably allocated in summer to avoid high temperature period, such as the time period of outdoor inspection; in particular, overtime work should be reduced in summer to prevent fatigue. ②Equipped with necessary heat-proof and cooling supplies. Metallurgical, nonferrous metals and small foundry enterprises with high temperature environment should set up workshops rest rooms[2]. ③Personal protection even if it was very hot. Many accidents occurred when workers gave up wearing safety helmets and belts due to heat during operation, making small accident become fatal accident.

4.2 Construction

At present, most construction companies carried out night operation in hot seasons, so night lighting, fatigue had become new risks in the construction. According to the statistical research of relevant literature[3], accidents had always been frequent in the night operation during high temperature. The main precautions were as follows.

(1) The work and rest time should be reasonably adjusted. It was recommended to adjust the work between 5:00-10:00 and 16:00-20:00.

(2) Strengthen the safety management of night operation in summer. ①Improve lighting facilities. ②Strengthen electricity management and patrol inspection. ③Reflective signs should be set on the work site, and workers should wear reflective clothes. ④One person was not allowed to work alone at night.

(3) Strengthen the safety management of daytime in summer. ①In summer, the daytime was hot, and the work sites were mostly open-air with less shelter; metal equipment surfaces, countertop and hand-held tools were overheated due to direct sunlight. So safety helmet and belt, protective gloves should still be worn, once the protective

equipment were missing, minor accidents such as scratches, collisions, burns and respiratory discomfort were likely to cause large accidents. ②The hot weather would lead to irritated for illegal operation, which would lead to more accidents. Therefore, illegal operations should be strictly investigated and severely punished.

(4) Strengthen the safety and emergency management of adverse weather. Typhoon and thunderstorm had the greatest impact on construction; work sites were usually open-air operation, special operation such as high-altitude operation, hoisting operation, fire operation and earth breaking operation were greatly affected by adverse weather such as wind, rain, thunder and lightning, and were prone to high falling, lifting injury, electric shock and collapse accidents. Therefore, it was particularly important to flood control, wind, thunder and hail prevention, inspection and recovery before and after weather changes.

4.3 Agricultural machinery

The busy farming season during the high temperature in summer was the high incidence period of agricultural machinery accidents. According to the relevant literature and survey data[4], the accident of agricultural equipment concentrated in tractors and combine harvesters; most of the direct causes of the accidents were licenseless driving tractors, operating errors, weak safety awareness of operators, untrained induction, illegal operation, improper handling in emergencies, etc. Therefore, the precautions of agricultural machinery accidents were as follows.

(1) Enhance the law-abiding and safety awareness of agricultural machinery operators, and strictly investigate and punish illegal operations.

(2) To guide the safety use and maintenance of agricultural machinery habits of operators, be able to check circuits, belts, fuel pipe joints, tank water level, tire pressure, etc.

(3) Administrative supervision departments often went to the site to investigate potential hazards and illegal behavior of agricultural machinery and equipment such as tractors and harvesters, and assign professionals to manage and maintain machines and tools.

4.4 Fishing vessels

Typhoon in summer had a great influence on fishing vessels. Fishing vessels were basically prohibited from leaving the sea in typhoon season. So the ordinary accidents of fishing vessels in summer were lower than those in other seasons, but once an accident occurred, it will be more serious. Therefore, the more major accidents of fishing vessels were more frequent in summer and significantly higher than those in other seasons.

Strong winds and waves in summer caused ships to sink or buckle due to collision and center of gravity deviation when berthing and driving. Therefore, strengthen the monitoring and early warning of marine weather; it was forbidden to sail during typhoon and storm wave; all fishing boats could enter the harbor for shelter in case of wind and waves. Strengthening fishery emergency search and rescue capability was a

normalization research to prevent fishing vessels accidents and accident expansion in summer.

4.5 Hazardous chemicals

There were many enterprises producing and using hazardous chemicals in Jiangsu. In summer, there was a high temperature and high humidity working environment. The process of hazardous chemicals production was mostly high temperature and pressure, so the main risk sources of hazardous chemicals enterprises were high humidity and temperature environment[5]. Therefore, we needed to pay attention to the following three areas.

(1) Production: ① Strengthen ventilation in flammable, explosive and toxic places to prevent fire, explosion and poisoning accidents. ② Strict regulations for filling hazardous chemicals, such as space, etc. ③ When the temperature exceeded the spontaneous combustion point temperature of flammable and explosive dangerous chemicals, the work could be stopped.

(2) Storage: ① For hazardous chemicals warehouse in flood control areas and production and storage areas prone to accumulated water, pumping and drainage facilities and various flood response measures should be provided. ②Strengthen the waterproof and moisture-proof measures of hazardous chemicals warehouse, such as hazardous chemicals that react with water and moisture. ③Strictly abide by the storage rule of hazardous chemicals and control the storage temperature of hazardous chemicals. For example, water-burned substances (high magnesium alloy) could not be stored in the open air or in places where it was humid and easy to accumulate water; non-tank liquids with flash point below 45 ℃ and flammable and explosive materials exposed to sunlight should not be stored in the open air. ④Strengthening ventilation, lightning protection and anti-static measures for hazardous chemicals warehouses.

(3) Transportation: According to the characteristics of hazardous chemicals, the transportation management department of hazardous chemicals should reasonably stipulate the embargo time to avoid high temperature periods; strengthen the monitoring of major hazard source transportation, to prevent fire, explosion, leakage accidents.

5 Conclusion

The research on the regularities of production safety accidents in summer and targeted precautions according to the regularities could effectively promote the safe production in summer. According to the regularity analysis, the conclusions were as follows : ① In summer, more accidents occurred in July; more major accidents were most likely in July. ② The ordinary accidents of electric shock and high falling would occur more frequently in summer; ordinary accidents of lifting injury, collapse, poisoning and asphyxiation might occur frequently. In summer, more major accidents of electric shock and fire would be significantly more frequent. More major accidents of road transpor-

tation, drowning, poisoning and asphyxiation might be low, but once occurred, the severity was higher. ③ In summer, ordinary accidents in construction, agricultural machinery, machinery and other industries might occur frequently; however, more major accidents might occur in fishing vessels, nonferrous metals, light industry, machinery industry frequently[6].

According to the above inference, it was suggested that the precautions of summer accidents in Jiangsu Province should focus on July, especially the more major accidents. The main industry fields were construction, agricultural machinery, machinery, especially fishing vessels, nonferrous metals, light industry, machinery which were prone to more major accidents. The main accident types were electric shock, high falling, lifting injury, collapse, poisoning and asphyxiation, especially the electric shock and fire which were prone to more major accidents.

Precautions in various industries had the characteristics of various industries, but in summer, there were four points for specific general precautions. ①Research and analysis the causes and regularities of accidents in various industries, and deploy adverse weather response measures. ②Reasonably adjust the operation time; try to shorten the working time of each shift and avoid fatigue work in high temperature weather. ③ Personal protection should be still required in hot weather. ④Strengthening the emergency response ability in summer, such as the emergency treatment of accidents caused by adverse weather, first aid for heatstroke and scalding, etc.

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