Journal of the University of Chemical Technology and Metallurgy, 46, 4, 2011, 433-436

THE PROBLEM OF SECURITY FOR THE DISCONNECTING OF CARS WITH FLAMMABLE LIQUIDS FROM SORTING HUMPS

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Received 13 July 2011
Accepted 28 October 2011

ABSTRACT

The evaluation of the risk of flammable liquids during an emergency by an integrated index is discussed. Relevant proposals on the possibility of downloading of some flammable liquids, with a stamp "Not down from the hump" from sorting humps are made.

Keywords: sorting humps, flammable liquids, railway transportation, car, disconnecting of cars, fire danger, emergency, toxicity, comprehensive indicator.

INTRODUCTION

Currently, the share of dangerous goods is more than 25 % of the total turnover of outbound cargoes. In the carriage of many dangerous goods, including flammable liquids (FL), a stamp "Not down from the hump" on shipping documents is put [1-3]. This leads to the need to perform additional volume of shunting works at the sorting stations (yards), but also reduces the efficiency of sorting humps, increases the downloading time at the station, slows delivery time of goods. Accumulation of cars with dangerous goods also increases fire hazard at the station. In this regard, the railways have repeatedly appealed to the JSC "National Company "Kazakhstan temir zholy" to lift the ban on the disconnecting of cars with certain types of goods from humps.

However, the criteria for dangerous goods, with which cars with cargo can not be downloaded from sorting hump, are absent, and the problem is still not solved.

EXPERIMENTAL

We carried out theoretical studies of the danger from flammable liquids. For this purpose, were calculated the areas of the spill, the rate of evaporation, the radii of explosive and toxic zones formed, the values of the complex index of risk of most known flammable liquids. Table 1 shows the areas of the spill, the evaporation rate and mass of the vapor entering the air for 1 hour from an estimated area of the spill of some flammable liquids [4].

The main types of hazardous flammable liquids have the ability to create over their surfaces concentrations of flammable or explosive vapors. Some flammable liquids are toxic. Leaks from them contaminate large areas of land surface and water reservoirs.

Table 1 shows that the spill area of one ton of a highly flammable liquid depends on its density, ranging from 15.87 to 32.28 m^2.

The rate of evaporation of the liquids under consideration, calculated by the formula

$$W_{ev} = \frac{10^{-6}\eta}{M \cdot P_v}$$

has a value from 0.014 to 0.14 kg m^{-2} min^{-1}.

In the formula: η - a coefficient that depends on the speed of the air flow and temperature, M - molecular mass of flammable liquid, kg mol^{-1}; P_v - vapor pressure, kPa. Within one hour at 20°C in the air flow up to 214 kg of vapor that mixes with it and creates an

Table 1. Areas of spill, evaporation rate and mass of the vapor entering the air for 1 hour from an estimated area of the spill of some flammable liquids.

Name of substance	Rate of evaporation, kg m^{-2} min^{-1}, at wind speed 0,2 m s^{-1}	Area of the spill, 1ton FL, m^2	Mass of vapor emitted in the air for 1 hour from 1 ton spill area, kg
Acetaldehyde **	0,140	25,53	214,01
Isopentane *	0,137	32,28	264,67
Diethyl ether **	0,106	28,03	178,22
Isoprene *	0,105	29,37	185,53
Pentane *	0,101	32,19	194,75
Ethyl mercaptan	0,098	24,00	139,52
Propylene oxide	0,094	23,28	131,48
Piperylene (pentadiene)*	0,077	29,24	134,74
Carbon bisulfide *	0,073	15,87	69,18
Acrolein	0,059	23,78	84,08
Petrol AI-93 (winter)	0,052	27,00	86,15
Gasoline A-72 (winter)	0,049	27,00	80,45
Petrol AI-93 (summer)	0,049	27,00	80,55
Diethylamine	0,045	28,17	75,84
Methyl	0,042	21,44	53,40
Acetone	0,039	25,29	59,57
Gasoline Aviation. B-70	0,023	27,00	38,13
Methyl acrylate	0,022	20,99	27,18
Acrylonitrile	0,019	24,81	28,68
Methanol **	0,015	25,42	23,13
Acetonitrile	0,014	25,55	20,92
Note: Loads in bold (eg, acetonitrile), according to [5], belong to the category of special hazardous cargo. * Can not be downloaded from the humps in tanks. ** Can not be downloaded from hills in tanks and boxcars.			

explosive and poisonous cloud. For some liquids the explosive radius of the FL zone exceeds the radius of the toxic zone, (Fig. 1), for others – the toxic zone is wider [6, 7].

Therefore, to assess the danger of flammable liquids in an emergency situation on only one indicator (fire hazard or toxicity) is not possible, as some have FL prevailing fire danger, while others - toxicity [6, 7].

To assess the risk of flammable liquids in an emergency situation a complex indicator that takes into account the fire risk, toxicity, and the rate of evaporation of the liquid can be used.

$$K_{IND} = \left(K_D^F + K^T\right) \cdot W_{EV} \qquad (1)$$

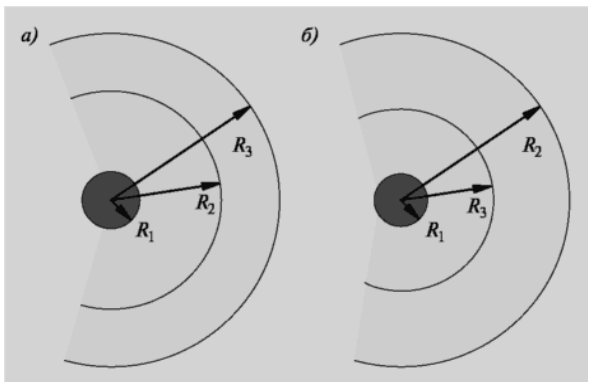

Fig. 1. Radii of explosive and toxic vapor-zones: *a* — methanol; *b* — diethyl ether; R_1 — radius of the spilled flammable liquids; R_2 — radius of the explosive area; R_3 — radius of the toxic zone.

where K_{IND} - comprehensive indicator of danger FL;

$K_D^F = \frac{C_V}{LCLFP}$ - indicator of fire danger,

C_V - saturated vapor concentration, g m^{-3};

$LCLFP$ - lower concentration limit of flame propagation, g m^{-3};

$K^T = \frac{C_V}{MAC \cdot 500}$ - toxicity,

MAC - maximum allowable concentration of vapors, g m^{-3};

W_{EV} - evaporation rate, kg m^{-2} s^{-1}.

RESULTS AND DISCUSSION

The results of the calculations of toxicity, fire hazard, the complex refractive index for flammable liquids at 20°C are given in Table 2.

In Table 2 the largest indices of the hazardous liquids are for acetaldehyde, acrolein, acrylonitrile, carbon disulfide, isopentane, having values of 20 and higher.

The complex index and its components depend on environmental temperature.

At temperature 0°C and below, the complex indices of diethyl ether, piperylene and methanol, having on the shipping documents a stamp “Not down from hump”, is lower than the index for gasoline, admitted for downloading from sorting humps. For example, the

Table 2. Calculated toxicity, fire hazard, and complex refractive index for flammable liquids.

Name of flammable liquids	$K_D^F \cdot W_{EV}$	$K^T \cdot W_{EV}$	K_{IND}
Acrolein	145,13	0,78	145,91
Acetaldehyde **	101,25	3,37	104,62
Acrylonitrile	21,13	0,08	21,21
Carbon bisulfide *	18,00	2,84	20,84
Isopentane *	12,40	7,60	20,00
Isoprene *	8,94	3,71	12,66
Ethyl mercaptan	9,77	2,03	11,79
Pentane *	6,76	3,83	10,58
Acetonitrile	9,33	0,04	9,36
Diethyl ether **	1,26	3,61	4,87
Piperylene (pentadiene)*	1,90	2,24	4,14
Propylene oxide	1,10	2,02	3,12
Diethylamine	2,24	0,62	2,86
Petrol AI-93 (winter)	1,05	1,20	2,25
Petrol AI-93 (summer)	0,93	1,07	2,00
Gasoline A-72 (winter)	0,92	1,06	1,98
Methanol **	1,02	0,03	1,05
Methyl acrylate	0,85	0,10	0,95
Methyl	0,58	0,30	0,88
Acetone	0,23	0,35	0,58
Gasoline Aviation. B-70	0,21	0,27	0,48
Note: *, **, bold type - see. Table 1.			

complex index of diethyl ether at 0°C is 1.39, for piperylene 1.3, which is lower than that of gasoline (2.0 – 2.1), admitted for downloading from sorting humps for all ambient temperatures, i.e. they are less dangerous in case of emergency at lower temperatures than gasoline.

CONCLUSIONS

The standard for gasoline, which has no ban for downloading at all temperatures of transportation is adopted. Then, comparing the risk of flammable liquids in an emergency with gasoline, we can propose:

• the downloading from sorting humps of cars with flammable liquids should, take into account the ambient temperature. At an ambient temperature of 0°C and below, for highly flammable liquids having a comprehensive index as that of gasoline or less, the ban on the downloading from sorting humps can be lifted;

• in the most dangerous flammable liquids - acetaldehyde, isopentane, carbon disulphide and isoprene - at temperatures 0°C and below the stamp: "From hump move down gently" should be used.

The proposed index objectively evaluates the danger of flammable liquids in an emergency, since it takes into account the fire, toxic hazard and the rate of evaporation. The most dangerous flammable liquids are liquids having higher value of the complex refractive index - acetaldehyde, acrolein, carbon disulfide and others.

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