TABLE 5

Temperature Range of Flammability and Flash Points of Typical Combustible Liquids

Name	Formula	Boiling point (° C.)	Flash point ° F.	Flash point ° C.	Temperature range of flammability: Lower ° F.	Lower ° C.	Upper ° F.	Upper ° C.
Acetic acid	$C_2H_4O_2$	118.1	104	40	99	37.3	136	57.0
Acetone	C_3H_6O	56.5	0	−18	−4	−20.0	41	5.0
Acrylonitrile	C_3H_3N	76.0	23	−5	21	−6.2	85	29.4
Allyl alcohol	C_3H_6O	96.6	72	22	66	19.0	138	58.8
Amyl chloride	$C_5H_{11}Cl$	106.6	73	55	42	5.5	104	40.0
Butyl iodide	C_4H_9I	129.6	—	—	92	33.5	126	52.0
Chlorobutene	C_4H_7Cl	67.0	0	−18	−9	−23.0	40	4.5
Crotonaldehyde	C_4H_6O	104.0	55	13	47	8.5	113	45.0
Dioxane	$C_4H_8O_2$	101.0	54	12	47	8.5	137	58.5
Ethylene dichloride	$C_2H_4Cl_2$	84.0	56	13	52	11.0	93	34.0
Furfural	$C_5H_4O_2$	161.0	140	60	133	56.0	237	114.0
Methyl alcohol	CH_4O	66.0	54	12	46	8.0	99	37.0
Methyl Cellosolve	$C_3H_8O_2$	124.5	105	41	93	34.0	176	80.0
Methyl butyl ketone	$C_6H_{12}O$	127.0	95	35	72	22.5	139	59.5
Naphtha		Variable	101	38	98	37.0	163	72.5
Propylene dichloride	$C_3H_6Cl_2$	96.8	61	16	52	11.0	97	36.0
Propylene glycol	$C_3H_8O_2$	188.0	207	97	205	96.0	266	130.0

clusion. In some cases the difference amounts to 15 to 20° F., and in others is somewhat less. The practical significance of these results is that the flash point does not give the absolute minimum temperature at which flammable mixtures may be produced. To be sure that the liquid will not create flammable atmospheres in contact with air, a temperature varying from 5 to 20° F. below the flash point must not be exceeded.

V. Methods of Minimizing Explosions

A. CONTROL OF THE OXYGEN CONTENT OF THE ATMOSPHERE

The fact that a combustible gas, vapor, or mist will not burn or explode when the oxygen content of the atmosphere is reduced below a certain definite value, varying with the combustible material under consideration, enables one to definitely control and in many cases actually eliminate explosion hazards.

The oxygen present in an explosive atmosphere may be reduced by direct absorption, using special reagents and catalysts, or by dilution with inert gases such as nitrogen, carbon dioxide, or combinations of these inerts, as represented by flue gas or exhaust gas from internal-combustion engines. Automobile exhaust gas and flue gases, made by burning fuel gas or fuel oil with the proper pro-

TABLE 6

Oxygen Values below Which Flames of Combustible Gases and Vapors are Extinguished

Name	Formula	Oxygen percentage below which no mixture is flammable: Nitrogen as diluent in air	Ref. no.	Carbon dioxide as diluent in air	Ref. no.
Methane	CH_4	12.1	108	14.6	108
Ethane	C_2H_6	11.0	109	13.4	109
Propane	C_3H_8	11.4	55	14.3	55
Butanen	C_4H_{10}	12.1	55	14.5	55
Isobutane	C_4H_{10}	12.0	8	14.8	8
Pentane	C_5H_{12}	12.1	110	14.4	110
Isopentane	C_5H_{12}	12.1	30	14.6	30
Hexane	C_6H_{14}	11.9	110	14.5	110
2,2-Dimethylbutane	C_6H_{14}	12.1	30	14.7	30
Heptane	C_7H_{16}	11.6	30	14.2	30
Natural gas		12.0	111	14.4	111
Gasoline		11.6	112	14.4	112
Ethylene	C_2H_4	10.0	71	11.7	71
Propylene	C_3H_6	11.5	13	14.1	13
Butene-1	C_4H_8	11.4	30	13.9	30
Butene-2	C_4H_8	11.7	30	14.0	30
Isobutylene	C_4H_8	12.1	30	14.8	30
2-Methylbutene-1	C_5H_{10}	11.4	30	13.9	30
1,3-Butadiene	C_4H_6	10.4	111	13.1	111
Benzene	C_6H_6	11.2	113	13.9	113
Cyclopropane	C_3H_6	11.7	19	13.9	19
Methyl alcohol	CH_4O	9.7	30	11.9	30
Ethyl alcohol	C_2H_6O	10.6	30	13.0	30
Dimethyl ether	C_2H_6O	10.3	30	13.1	30
Diethyl ether	$C_4H_{10}O$	10.3	30	13.2	30
Acetone	C_3H_6O	11.6	30	14.3	30
Methylisobutyl ketone	$C_6H_{12}O$	11.4	30	—	
Methyl formate	$C_2H_4O_2$	10.1	30	12.5	30
Ethyl formate	$C_3H_6O_2$	10.4	30	12.8	30
Methyl acetate	$C_3H_6O_2$	10.9	30	13.6	30
Isobutyl formate	$C_5H_{10}O_2$	12.4	30	14.8	30
Methylamine	CH_5N	10.7	30	—	
Allyl chloride	C_3H_5Cl	12.6	30	15.1	30
Hydrogen	H_2	5.0	114	5.9	114
Carbon disulfide	CS_2	5.4	30	7.6	30
Carbon monoxide	CO	5.6	114	5.9	114

[8] H. F. Coward and F. J. Hartwell, *J. Chem. Soc.*, **129**, 1522 (1926).
[13] G. W. Jones and R. E. Kennedy, *U. S. Bur. Mines Rept. Invest.* No. **3172**, 1932.
[19] G. W. Jones and R. E. Kennedy, *Ind. Eng. Chem.*, **27**, 1344 (1935).
[30] G. W. Jones and R. E. Kennedy, *U. S. Bur. Mines Rept. Invest.* No. **3691**, 1943.
[55] G. W. Jones and W. R. Gilliland, *U. S. Bur. Mines Rept. Invest.* No. **3871**, 1946.
[71] G. W. Jones, *U. S. Bur. Mines Rept. Invest.* No. **3787**, 1944.
[108] G. W. Jones and G. St. J. Perrott, *Ind. Eng. Chem.*, **19**, 985 (1927).