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FIRE HAZARD CLASSIFICATION OF CHEMICAL VAPORS RELATIVE TO EXPLO--ETC(U)
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FIRE HAZARD CLASSIFICATION OF CHEMICAL VAPORS RELATIVE TO EXPLOSION-PROOF ELECTRICAL EQUIPMENT.

Report II.

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9 Progress rept.

12 32 p.

A Progress Report prepared by the
Electrical Hazards Panel
of the
Committee on Hazardous Materials
Division of Chemistry & Chemical Technology
National Research Council
Approved by the Committee December, 1970
Prepared under Contract No. ~~Tgc-~~15559-A
~~DOT-0035-Task No. 13~~
TCG

for the U.S. Coast Guard

10 Donald L. Katz
H. W. Carhart

H. Carhart
Panel Chairman

D. L. Katz
Committee Chairman

Washington, D.C.
October 7, 1971

NOTICE

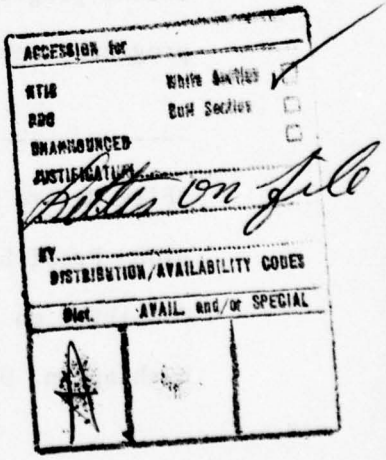
The scientific study described by this report is part of a program undertaken under the aegis of the National Academy of Sciences - National Research Council with the express approval of the Governing Board of the NRC. Such approval indicated that the Board considered that the problem is of national significance; that elucidation and/or solution of the problem required scientific or technical competence and that the resources of the NRC were particularly suitable to the conduct of the project. The institutional responsibilities of the NRC were then discharged in the following manner:

The members of the study panel were selected for their individual scholarly competence and judgement with due consideration for the balance and breadth of disciplines. Responsibility for all aspects of this report rests with the study panel and parent committee to whom we express our sincere appreciation.

Although the reports of our committees are not submitted for approval to the Academy membership nor to the Council, each report is reviewed by a second group of scientists according to procedures established and monitored by the Academy's Report Review Committee. Such reviews are intended to determine, inter alia, whether the major questions and relevant points of view have been addressed and whether the reported findings, conclusions and recommendations arose from the available data and information. Distribution of the report is permitted only after satisfactory completion of this review process.

ABSTRACT

At the request of the U.S. Coast Guard, a detailed study has been made by the Electrical Hazards Panel of the Committee on Hazardous Materials to determine the feasibility of Classifying some 200 chemicals of commerce according to the classifications given in the National Electric Code, NEC 500, by using a scheme based entirely on available physical and flammability properties only. This is the second progress report submitted by the Committee to the U.S. Coast Guard.



FIRE HAZARD CLASSIFICATION OF CHEMICAL VAPORS RELATIVE TO EXPLOSION-PROOF ELECTRICAL EQUIPMENT - REPORT II.

FOREWORD

A request has been made by the U.S. Coast Guard to the National Research Council Committee on Hazardous Materials to consider the classification, based on the National Fire Protection Association National Electric Code (NEC 500),[1] of over 200 chemicals which are being, or are proposed to be, transported by water. It was further requested that serious consideration be given to possible classification based on known, or easily obtained, physical, chemical or flammability properties of the chemicals rather than on the traditional, very cumbersome and costly requirement of actually testing exhaustively a new piece of electrical gear in the vapors of the given chemical or substance to determine whether such gear would be safe in such an environment or not.

In partial compliance with the Coast Guard request, Professor Donald L. Katz, Chairman of the NRC Committee, appointed a Panel on Electrical Hazards to study the matter. This is the second progress report* by the Panel and as such constitutes a progress report to the parent Committee.

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*Fire Hazard Classification of Chemical Vapors Relative to Explosion - Proof Electrical Equipment, Electrical Hazards Panel of the Committee on Hazardous Materials, National Research Council, Washington, D.C., February 10, 1970.

The Panel on Electrical Hazards consists of:

H. W. Carhart, Chairman	Naval Research Laboratory
G. H. Damon	Bureau of Mines
H. C. Hoy	Oak Ridge National Laboratories
J. T. Leonard	Naval Research Laboratory
E. C. Magison	Professional Engineer, Abington, Pennsylvania
A. H. McKinney	E. I. duPont de Nemours & Co., Inc.
F. A. Van Atta	Department of Labor
Fred Alroth	Underwriters' Laboratories
W. C. Westerberg	Underwriters' Laboratories (Ret.)
Peter Schramm	Underwriters' Laboratories
H. H. Fawcett	Technical Secretary, NRC Committee on Hazardous Materials

INTRODUCTION

There are three common ways of enhancing protection from fire or explosion in the use of electrical equipment in areas where the concentration of vapors of combustible materials may exceed the lower flammability limit. These are: (a) use of explosion-proof equipment: (b) use of intrinsically safe equipment, and (c) pressurizing or purging.

The concept of protection by explosion-proof equipment is based on the assumption that the vapors can penetrate the housing of the equipment and be ignited therein, but, the design and construction of the equipment must be such that any ensuing fire or explosion will be contained within the housing and not propagate out into the area surrounding the piece of equipment. Devices that use a considerable amount of power, such as motors, pumps, lights, switches, conduits, etc., usually use this means of protection. Because of the magnitude of power used, such equipment might easily release sufficient energy internally in the form of a spark, arc, or heat, under either operating or failure conditions, to ignite any flammable vapors that might have penetrated the housing of the equipment.

Intrinsically safe equipment, consisting of such items as meters, gauges, controllers, instruments, etc., usually have much lower power requirements. The concept of protection here is to design the equipment such that even under failure conditions of very low probability any possible release of energy (e.g., spark or arc) will be so small that under no conditions will it ignite

the combustible vapor present (i.e., the energy released is less than the minimum ignition energy for the particular combustible). Hence, no fire can ensue.

The concept of protection by pressurizing or purging is to place the piece of electrical equipment inside a container which is either pressurized or purged continuously with clean air or inert gas so that there is no possibliity of flammable vapors from the surrounding area ever reaching a potential source of ignition within the electrical equipment itself.

The studies made by the Panel to date have purposely been restricted to consideration of explosion-proof equipment only.

PROPOSED CLASSIFICATIONS

Chemicals vary markedly in their physical, chemical and flammability characteristics. Some are much more hazardous than others and a given piece of electrical explosion-proof equipment may be safe in one environment, but not in another. Differences in ease of ignition, heat and pressure release, diffusivity, quenching distances, flame velocities, reactivity, etc., account for the differences. In recognition of this, chemical vapors are classified into four Groups in NEC 500, as shown in Table 1, with Group A having the most severe requirements for explosion-proof equipment.

The Panel has been unable to arrive at an unequivocal scheme for classifying chemicals relative to explosion-proof electrical equipment by the NEC 500 system based only on flammability and other properties to be found in the literature. However, tentative classifications, based on the best collective judgments of the Panel and others knowledgeable in the field, have been made and such classifications are given in Table 1 for the list of chemicals supplied to us by the Coast Guard. It must be emphasized that these classifications are based on the NEC 500 scheme since the Panel was specifically enjoined not to invent a new system. As previously noted, the Panel feels that the present system does have drawbacks and contains certain inconsistencies.

It must also be emphasized that the classifications given are based on the expected flammability behavior as anticipated by the Panel from only the chemical structure and combustion properties of the compound, and completely disregard the volatility of

the material. Obviously, other things being equal, a material with a very high flash point will be safer to transport and handle than one which evolves flammable vapors at room temperature. But, since the effect of the flash point on safety, and the possibility of generation and behavior of mists and foams have not been resolved, for the present the Panel had to disregard these important points and thus proceeded to classify compounds only on the basis of their chemical structure and combustion properties.

In Table 1 an underline (e.g., 0) means the compound is already thus classified in the NEC 500. An asterisk (e.g., C*) means there was a difference of opinion among the panelists and the classification given is the higher (more severe) one. A double asterisk (e.g., C**) means that the spontaneous ignition temperature (SIT) was not available and that if the SIT of the compound is between 180°C and 280°C a classification of C will apply. If the SIT is above 280°C a D classification will apply. If the SIT is below 180°C, the compound will remain unclassified. If no modifying mark appears, it means that there was general agreement on the given classification. A few compounds have not been classified, for one of three reasons: (a) the Panel did not feel competent to do so due to lack of knowledge about expected behavior (e.g., aluminum triethyl, phosphorus, etc.), (b) different batches of the material might be expected to have inconsistent properties (e.g., asphalt), and (c) a structural formula could not be assigned to the name given (e.g., butyl formal).

There are a number of compounds the Panel has classified as C

based on the fact that their SIT's are below 280°C, whereas their other flammability properties might more logically classify them as D. This was done in order to stay within the rationale used in Underwriters' Laboratories Bulletin of Research No. 58 for classification by NEC 500 in which an SIT of 280°C was used as the lowest value for a D classification. Such compounds are listed in Table 2. The apparent anomaly of classifying a substance such as n-hexane (in Table 1) in a different category than gasoline points out again the bases for the present classification system need reconsideration. Petroleum ether was classified C** because different batches of it would have different SIT's some of which could be below 280°C.

The Panel recommends that the Committee on Hazardous Materials forward the classifications given in Table I to the Coast Guard with the explanation that such classifications are based on the Panel's best judgment only and should be considered as subject to change as new knowledge is gained.

ADDITIONAL WORK ON FLAMMABILITY

Recently the Underwriters Laboratories extensively studied pertinent flammability properties of 15 compounds for purposes of classification by the NEC 500 system. The results are given in their Bulletin of Research No. 58 (no date) and their recommendations have now been accepted into NEC 500 by the NFPA. This information was used extensively by the Panel. The UL work established certain criteria for classifications based on their results on maximum safe slit widths, and pressure rises (quiescent

and turbulent), using equipment specifically designed for this study. SIT values from the literature were also used as criteria for classification.

In many of the classifications given in Table 1, the Panel feels they may have overclassified a given compound due to insufficient knowledge of its properties, or because NEC 500 did not have compounds that could serve as baselines for the application of analogy or homology. The Panel felt that if the UL type information could be obtained on more compounds, not only could these individual compounds then be classified by the NEC 500 system but they could also serve as excellent baselines on which to classify other related compounds with more confidence. Therefore, the Panel identified 31 substances (again based only on chemical structure) that they felt would be most fruitful as potential candidates for testing by the UL type apparatus. These are given in Table 3. Also given in Table 3, however, are the flash points of the materials in question. It is seen at a glance that many of these are much higher than room temperature and hence it is considered that any further study of them be deferred, at least until the flash point and related issues are settled. Also, experimentally it would be much more difficult to run the tests because the whole apparatus would have to be heated to temperatures much higher than the flash point in order to achieve the most hazardous fuel vapor/air mixtures.

Since the UL has successfully studied styrene (as shown in Bulletin of Research No. 58), and styrene has a flash point of

90°F, perhaps the upper limit for flash point might be arbitrarily set at 110° for the present study. This eliminates 12 compounds (the flash point for sulfolane is not known, but would be expected to be higher). The remaining compounds are listed in Table 4.

RECOMMENDATION OF THE ELECTRICAL HAZARDS PANEL

The Panel recommends that the Committee on Hazardous Materials, with U.S. Coast Guard approval, undertake by contract a study of the 19 compounds listed in Table 4 to determine their maximum safe gaps and explosion pressures by the Westerberg Explosion Test Vessel, and procedure as described in UL Bulletin of Research No. 58, pages 17-27, in order that these 19 compounds may be classified by the NEC 500 system, and serve as baselines for judgment classification of other related compounds with greater confidence. It is recommended that flash points (c.c.), ignition temperatures and flammable limits be determined for the compounds listed in Table 6 as specified, since these are not presently available and are also needed for assistance in classification. In addition, it is recommended that minimum ignition energies be determined for the 19 compounds listed on Table 4 for future guidance in evaluation with respect to intrinsic safety.

DETERMINATION OF ADDITIONAL SIT'S

SIT's for many of the compounds in Table 1 were not available to the Panel. Because of this, the Panel classified many compounds as C (shown in Table 1 as C**) when, if the SIT of such compounds were above 280°C they would be classified as D. It would be highly

desirable to obtain the SIT values for those compounds in Table 1 for which none were available. Since normally the determination of SIT values is not too difficult, the Panel feels that perhaps these could be obtained by the students at the U. S. Coast Guard Academy, if possible from the manufacturers, or, otherwise, experimentally. The compounds lacking SIT's are listed in Table 5.

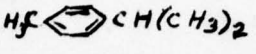
The Panel recommends that the Committee on Hazardous Materials explore the possibliity of obtaining SIT's for as many as possible (and feasible) of those compounds listed in Table 5, particularly those classified C**, through the U.S. Coast Guard Academy, directly from manufacturers, or from other sources. These SIT's should preferable be obtained by the ASTM Method.

TABLE I

NAME	FORMULA		
1. Acetaldehyde	CH_3CHO	C	
2. Acetic Acid (Glacial)	CH_3COOH	C*	
3. Acetic Anhydride	$(CH_3CO)_2O$	C*	
4. Acetone	CH_3COCH_3	D	
5. Acetone Cyanohydrin	$(CH_3)_2COHCN$	C*	
6. Acetonitrile	CH_3CN	D	
7. Acrolein (Inhibited)	$CH_2:CHCHO$	B	
8. Acrylic Acid	$CH_2:CHCOOH$	C*	
9. Acrylonitrile	$CH_2:CHCN$	D	
10. Allyl Alcohol	$CH_2:CHCH_2OH$	C	
11. Allyl Chloride	$CH_2:CHCH_2Cl$	D	
12. Aluminum Triethyl	$Al(C_2H_5)_3$	-	
13. N-Aminoethyl Ethanolamine	$H_2NC_2H_4NHC_2H_4OH$	C	
14. Ammonia, Anhydrous	NH_3	D	
15. iso-Amyl Acetate	$CH_3COOC_5H_{11}$	D	
16. n-Amyl Alcohol	$C_5H_{11}OH$	D	

NAME	FORMULA		
17. Aniline	$C_6H_5NH_2$	D	
18. Asphalt (typical)	--	--	
19. Benzene	C_6H_6	D	
20. Butadiene (Inhibited)	$CH_2:CHCH:CH_2$	B(D)	
21. Butane (Commercial)	C_4H_{10}	D	
22. n-Butyl Acetate (see 107)	$CH_3COO(CH_2)_3CH_3$	D	
23. sec-Butyl Acetate	$CH_3COOCH(CH_3)C_2H_5$	C**	
24. Butyl Acrylate	$CH_2:CHCOOC_4H_9$	C*	
25. iso-Butyl Alcohol (see 108)	$(CH_3)_2CHCH_2OH$	D	
26. n-Butyl Alcohol	$CH_3(CH_2)_3OH$	D	
27. sec-Butyl Alcohol	$CH_3CHOHCH_2CH_3$	D	
28. tert-Butyl Alcohol	$(CH_3)_3COH$	D	
29. Butyl Benzyl Phthalate	$C_4H_9OCOC_6H_4COOCH_2C_6H_5$	C**	
30. 1,3-Butylene Glycol	$CH_2OHCH_2CHOHCH_3$	D	
31. n-Butyl Formal	--	-	
32. n-Butyraldehyde	$CH_3(CH_2)_2CHO$	C	

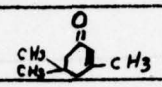
NAME	FORMULA		
33. n-Butyric Acid	$CH_3(CH_2)_2COOH$	C*	
34. Camphor Oil (Light)	--	-	
35. Caprolactone	$C_6H_{10}O_2$	-	
36. Carbon Disulfide	CS_2	None	
37. Casinghead (Natural) Gasoline	--	-	
38. Chlorobenzene	C_6H_5Cl	D	
39. Chloroform	$CHCl_3$	D	
40. Chlorohydrins (Crude)	--	-	
41. Coal Tar Oil	--	-	
42. Creosote (Coal Tar)	--	-	
43. Cresols (Mixed Isomers)	$CH_3C_6H_4OH$	D	
44. Crotonaldehyde	$CH_3CH:CHCHO$	B*	
45. Crude Oil (Petroleum)	--	C**	
46. Cumene	$C_6H_5CH(CH_3)_2$	D	
47. Cyclohexane		C	
48. Cyclohexanol		D	
49. Cyclohexanone		D	

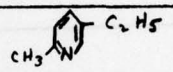
NAME	FORMULA		
50. p-Cymene		D	
51. n-Decyl Alcohol	$CH_3(CH_2)_9OH$	D	
52. o-Dibutyl Phthalate	$C_6H_4(COOC_4H_9)_2$	D	
53. O-Dichlorobenzene		D	
54. Dichloroethyl Ether	$ClC_2H_4OC_2H_4Cl$	C*	
55. 1,2-Dichloropropane	$CH_2ClCHClCH_3$	D	
56. Dichloropropene	$C_3H_4Cl_2$	C**	
57. Dicyclopentadiene		-	
58. Diethanolamine	$NH(CH_2CH_2OH)_2$	C*	
59. Diethylamine	$NH(C_2H_5)_2$	C*	
60. Diethylbenzene	$C_6H_4(C_2H_5)_2$	D	
61. Diethylene Glycol	$HO(C_2H_4O)_2H$	C	
62. Diethylene Glycol Monoethyl Ether	$C_2H_5O(C_2H_4O)_2H$	C	
63. Diethylene Glycol Monomethyl Ether	$CH_3O(C_2H_4O)_2H$	C	
64. Diisobutyl Carbinol	$[(CH_3)_2CHCH_2]_2$ CHOH	C**	
65. Diisobutylene	C_8H_{16}	C*	

NAME		FORMULA		
66.	Diisobutyl Ketone	$[(CH_3)_2CHCH_2]_2CO$	C**	
67.	Dimethylamine	$NH(CH_3)_2$	C*	
68.	Dipentene	$C_{10}H_{14}$	C	
69.	Dipropylene Glycol	$HO(C_3H_6O)_2H$	C	
70.	Dodecyl Benzene (Commercial)	$C_6H_5C_{12}H_{25}$	C**	
71.	Epichlorohydrin	$CH_2\text{-}CHCH_2Cl$	-	
72.	Ethoxy Triglycol	$C_2H_5O(C_2H_4O)_3H$	C	
73.	Ethyl Acetate	$CH_3COOC_2H_5$	D	
74.	Ethyl Acrylate (Inhibited)	$CH_2:CHCOOC_2H_5$	C*	
75.	Ethyl Alcohol	C_2H_5OH	D	
76.	Ethyl Benzene	$C_6H_5C_2H_5$	D	
77.	Ethyl Chloride	C_2H_5Cl	D	
78.	Ethylene	$CH_2:CH_2$	C	
79.	Ethylene Cyanohydrin	$HOCH_2CH_2CN$	C**	
80.	Ethylene Diamine	$NH_2CH_2CH_2NH_2$	C*	
81.	Ethylene Dibromide	$BrCH_2CH_2Br$	Non-flammable	

NAME	FORMULA		
82. Ethylene Dichloride	$ClCH_2CH_2Cl$	D	
83. Ethylene Glycol	$HOCH_2CH_2OH$	D	
84. Ethylene Glycol Monobutyl Ether	$C_4H_9OC_2H_4OH$	C	
85. Ethylene Glycol Monoethyl Ether	$C_2H_5OC_2H_4OH$	C	
86. Ethylene Glycol Monoethyl Ether Acetate	$CH_3COOC_2H_4OC_2H_5$	C*	
87. Ethylene Glycol Monomethyl Ether	$CH_3OC_2H_4OH$	C*	
88. Ethylene Oxide		B(C)	
89. Ethylenimine		B*	
90. Ethyl Ether	$(C_2H_5)_2O$	C	
91. 2-Ethyl Hexanol	$CH_3(CH_2)_3CH(C_2H_5)CH_2OH$	C**	
92. 2-Ethylhexyl Acrylate	$CH_2:CHCOOCH_2CH(C_2H_5)(CH_2)_3CH_3$	C**	
93. 2-Ethyl-3-Propyl Acrolein	$CH_3(CH_2)_2CH:C(C_2H_5)CHO$	C	
94. Formaldehyde Soln. (37-50%)	$HCHO$ $(+H_2O)$	-	
95. Formic Acid	$HCOOH$	C*	
96. Furfural		B*	
97. Furfuryl Alcohol		B*	

NAME	FORMULA		
98. Gasoline (Commercial)	-	D	
99. Glycerine	$CH_2OHCHOHCH_2OH$	D	
100. Glycol Diacetate	$CH_3COOC_2H_4OCOCH_3$	C**	
101. Glyoxal (40% aq.)	$CHOCHO$ $(+H_2O)$	-	
102. n-Heptane	$CH_3(CH_2)_5CH_3$	C	
103. Heptene (Mixed)	C_7H_{14}	C	
104. Hexamethylene Diamine Solutions	$NH_2(CH_2)_6NH_2$	-	
105. n-Hexane	$CH_3(CH_2)_4CH_3$	C	
106. Hexylene glycol	$C_6H_{12}(OH)_2$	C**	
107. Isobutyl Acetate	$CH_3COOCH_2CH(CH_3)_2$	D	
108. Isobutyl Alcohol (see 25)	$(CH_3)_2CHCH_2OH$	see no. 25	
109. Isobutyl Formal	--	-	
110. Isobutyraldehyde	$(CH_3)_2CHCHO$	C	
111. Isodecaldehyde	$C_9H_{19}CHO$	C	
112. Isodecanol (Mixed)	$C_{10}H_{21}OH$	D	
113. Isooctanol	$C_8H_{17}OH$	C**	

NAME	FORMULA		
114. Isooctyl Aldehyde	$C_7H_{15}CHO$	C	
115. Isophorone		D	
116. Isoprene	$CH_2:C(CH_3)CH:CH_2$	C	
117. Isopropyl Acetate	$CH_3(COOCH(CH_3)_2$	D	
118. Isopropyl Alcohol	$(CH_3)_2CHOH$	D	
119. Isopropyl Ether	$[(CH_3)_2CH]_2O$	C	
120. Jet Fuel, JP-3	--	C**	
121. Jet Fuel, JP-4	--	C	
122. Jet Fuel, JP-5	--	C	
123. Kerosene	--	C	
124. Mesityl Oxide	$(CH_3)_2C:CHCOCH_3$	C*	
125. Methane	CH_4	D	
126. Methoxy Triglycol	$CH_3O(C_2H_4O)_3H$	C*	
127. Methyl Acetate	CH_3COOCH_3	D	
128. Methyl Acrylate	$CH_2:CHCOOCH_3$	C*	
129. Methyl Alcohol	CH_3OH	D	

NAME	FORMULA		
130. Methylamyl Acetate	$CH_3COOCH(CH_3)CH_2CH(CH_3)_2$	C**	
131. Methylamyl Alcohol	$(CH_3)_2CHCH_2CHOHCH_3$	C**	
132. Methyl Bromide	CH_3Br	D	
133. Methyl Butyraldehyde	$CH_3CH_2CH(CH_3)CHO$	C	
134. Methyl Chloride	CH_3Cl	D	
135. 2-Methyl-5-Ethyl Pyridine		C*	
136. Methylene Chloride	CH_2Cl_2	D	
137. Methyl Ethyl Ketone	$CH_3COC_2H_5$	D	
138. Methyl Formal	--	-	
139. Methyl Isobutyl Ketone	$CH_3COCH_2CH(CH_3)_2$	D	
140. Methyl Methacrylate (Monomer (Inhibited)	$CH_2:C(CH_3)COOCH_3$	C*	
141. Mineral Spirits (No. 10)	--	C**	
142. Monoethanolamine	$NH_2CH_2CH_2OH$	C*	
143. Monoisopropanolamine	$CH_3CHOHCH_2NH_2$	C*	
144. Monomethyl Hydrazine	CH_3NHNH_2	C	
145. Morpholine		-	

NAME	FORMULA		
146. Naphthalene, Molten		D	
147. 2-Nitropropane	$(CH_3)_2CHNO_2$	-	
148. Nonane	C_9H_{20}	C	
149. Nonene	C_9H_{18}	C**	
150. Nonyl Phenol	$C_9H_{19}C_6H_4OH$ -	C**	
151. iso-Pentane	$(CH_3)_2CHCH_2CH_3$	D	
152. n-Pentane	$CH_3(CH_2)_3CH_3$	C	
153. Perchloroethylene (Tetrachloroethylene)	$CCl_2:CCl_2$	non-flammable	
154. Petroleum Ether	--	C**	
155. Phenol	C_6H_5OH	D	
156. Phosphorus (Elemental)	P	-	
157. Propane (Commercial	$CH_3CH_2CH_3$	D	
158. Propiolactone	$CH_2CH_2C(=O)O$	-	
159. Propionaldehyde	CH_3CH_2CHO	C	
160. Propionic Acid	CH_3CH_2COOH	C*	
161. Propionic Anhydride	$(CH_3CH_2CO)_2O$	C*	

NAME	FORMULA		
162. n-Propyl Acetate	$CH_3COO(CH_2)_2CH_3$	D	
163. iso-Propyl Alcohol	$(CH_3)_2CHOH$	See # 118	
164. n-Propyl Alcohol	$CH_3CH_2CH_2OH$	D	
165. Propyl Formal	--	-	
166. Propylene	$CH_3CH:CH_2$	D	
167. Propylene Glycol	$CH_3CHOHCH_2OH$	D	
168. Propylene Oxide		B(C)	
169. Pyridine		C*	
170. Styrene (Monomer)	$C_6H_5CH=CH_2$	D	
171. Sulfolane		-	
172. Sulfur (Molten)	S	-	
173. Tetraethylene Glycol	$HO(C_2H_4O)_4H$	C	
174. Tetraethyl Lead and Tetraethyl Lead Mixtures	$(C_2H_5)_4Pb$	-	
175. Tetrahydrofuran		C	
176. Tetrahydronaphthalene		D	
177. Tetrapropylene	$C_{12}H_{24}$	C**	

NAME	FORMULA		
178. Toluene	$C_6H_5CH_3$	D	
179. Trichlorobenzene	$C_6H_3Cl_3$	C**	
180. 1,1,1-Trichloroethane (Methyl Chloroform)	CH_3CCl_3	C**	
181. Trichloroethylene	$CHCl:CCl_2$	D	
182. Tridecanol	$C_{12}H_{25}CH_2OH$	C**	
183. Triethanolamine	$N(C_2H_5OH)_3$	C*	
184. Triethyl Benzene	$C_6H_3(C_2H_5)_3$	C**	
185. Triethylene Glycol	$HO(C_2H_4O)_3H$	C	
186. Triethylene Tetramine	$NH_2(C_2H_4NH)_3H$	C*	
187. Tripropylene	C_9H_{18}	C**	
188. Turpentine	$C_{10}H_{16}$	C	
189. Valeraldehyde	C_4H_9CHO	C	
190. Vinyl Acetate	$CH_3COOCH=CH_2$	D	
191. Vinyl Chloride	$CH_2:CHCl$	D	
192. Vinylidene Chloride (Inhibited)	$CH_2:CCl_2$	D	
193. Vinyl Toluene (Meta & Para mixed)	$CH_3C_6H_4CH:CH_2$	C**	

NAME	FORMULA		
194. Xylene	$C_6H_4(CH_3)_2$	D	
195. o-Xylene		D	
196. p-Xylene		D	
197. UDMH	$NH_2N(CH_3)_2$	C	
198. Acetylene	HC=CH	A	
199. Hydrogen	H_2	B	
200. Hydrogen sulfide	H_2S	B(C)	

TABLE 2

Compounds classified C based only on SIT's below 280°C.

Cyclohexane
n-Heptane
Heptene (mixed)
n-Hexane
Jet Fuel, JP-4
Jet Fuel, JP-5
Kerosene
Nonane
n-Pentane

TABLE 3 - THE THIRTY-ONE CANDIDATES

	Flash Point (°F)
ALDEHYDES (4)	
Acrolein	-15
n-Butraldehyde	20
Crotonaldehyde	55
Furfural	140
ALCOHOLS (3)	
Allyl Alcohol	70
Furfuryl alcohol	167
sec-Butyl alcohol	75
ACIDS ANHYDRIDES(3)	
Acetic acid	109
Acrylic acid	130
Acetic anhydride	129
OLEFINS (1)	
Diisobutylene	-
ETHERS (6)	
Dichloroethyl ether	131
Diethylene glycol monoethyl ether	201
Ethylene glycol monoethyl ether	202
Isopropyl ether	-18
Tetrahydrofuran	6
Morpholine	100
GLYCOLS (1)	
Ethylene glycol	232
NITROGEN COMPOUNDS (5)	
Diethylamine	<0
Monoethanolamine	185
Ethylene diamine	110
Ethylenimine	12
Pyridine	68
ESTERS (2)	
Ethyl Acrylate	60
Propiolactone (B)	165
KETONES (1)	
Mesityl oxide	87
OTHERS (5)	
Acetone cyanohydrin	165
Epichlorohydrin	105
Hydrogen sulfide	gas
2-Nitropropane	103
Sulfolane	-

TABLE 4 - NINETEEN SUBSTANCES RECOMMENDED FOR TESTING:

Aldehydes

Acrolein
n-Butyraldehyde
Crotonaldehyde

Alcohols

Allyl Alcohol
sec-Butyl alcohol

Acids

Acetic acid

Olefins

Diisobutylene

Ethers

Isopropyl ether
Tetrahydrofuran
Morpholine

Nitrogen Compounds

Diethylamine
Ethylene diamine
Ethylenimine
Pyridine
2-Nitropropane

Esters

Ethyl acrylate

Ketones

Mesityl oxide

Others

Epichlorohydrin
Hydrogen sulfide

TABLE 5 - COMPOUNDS FOR WHICH SIT's WERE UNAVAILABLE TO THE PANEL

Acrylic acid

Aluminum triethyl

sec-Butyl acetate (C**)

Butyl acrylate

Butyl benzyl phthalate (C**)

n-Butyl formal

Camphor Oil (light)

Caprolactone

Casinghead (Natural) gasoline

Chloroform

Chlorohydrins (crude)

Coal tar oil

Creosote (coal tar)

Crude oil (Petroleum)(C**)

Dichloropropene (C**)

Dicyclopentadiene

Diethylene glycol monoethyl ether

Diethylene glycol monomethyl ether

Diisobutyl carbinol (C**)

Diisobutylene

Diisobutyl ketone (C**)

Dipropylene glycol

Dodecyl benzene (commercial)(C**)

Epichlorohydrin

Ethoxy triglycol

Ethyl acrylate (inhibited)

Ethylene cyanohydrin (C**)

2-Ethyl hexanol (C**)

2-Ethyl hexyl acrylate (C**)

2-Ethyl-3-propyl acrolein

Glycol diacetate (C**)

Glyoxal (40% aq.)

Hexamethylene diamine solutions

Hexylene glycol (C**)

Isobutyl formal

Isodecaldehyde

Isooctanol (C**)

Isooctyl aldehyde

Jet Fuel, JP-3 (C**)

Methoxy triglycol

Methyl acrylate

Methyl amyl acetate (C**)

Methyl amyl alcohol (C**)

Methyl butyraldehyde

2-Methyl-5-ethyl pyridine

Methyl formal

Mineral spirits (no.10) (C**)

Monoethanolamine

Monoisopropanolamine

Monomethyl hydrazine

Nonene (C**)

Nonyl phenol (C**)

Table 5, continued

Propiolactone (B)

Propionic anhydride

Propyl formal

Sulfolane

Tetraethylene glycol

Tetraethyl lead and tetraethyl lead mixture

Tetrapropylene (C**)

Trichlorobenzene (C**)

1, 1, 1-Trichloroethane (methyl chloroform) (C**)

Tridecanol (C**)

Triethanolamine

1, 2, 4-Triethyl benzene (C**)

Tripropylene (C**)

Valeraldehyde

Vinyl toluene (meta and para mixed) (C**)

Xylene

TABLE 6 - Determine Items Which are Marked with X

Compound	Flash Point c.c.	Ignition Temp. ASTM	Flammable Limits
sec-Butyl alcohol			X-(question if V.P. is adequate)
Acetic acid (glacial)		(Upper only)	X(Question if V.P. is adequate for upper limit)
Diisobutylene	X	X	X
Morpholine	X		X
Diethylamine	X		
Ethylene diamine(anhydrous)	x		x
2-nitropropane	X		X (Upper only)
Ethylacrylate (inhibited)	X	X	X (Upper only)
Mesityl oxide			X
Epichlorohydrin	X	X	X
Acrolein (inhibited)	X	X	X