

VII. RESEARCH NEEDS

Research focused on the prevention of adverse health effects in workers who manufacture, handle, or use NG or EGDN is needed in several areas. For workers who handle NG or EGDN directly, skin absorption appears to be the major route of exposure. Thus, investigators should develop processes that will minimize or prevent skin contact with these compounds.

NG and EGDN penetrate gloves made of neoprene, rubber, leather, or cotton that are currently worn by exposed workers. Research should be conducted to identify a material suitable for use in work clothing and gloves through which these nitroesters will not penetrate. As an interim measure, a safe compound that changes color when it comes in contact with NG or EGDN should be identified. If used on gloves and clothing, workers would be warned by the change in color that their clothing had become contaminated with nitroesters.

Compounds should be identified that will remove NG and EGDN from the skin and from surfaces in work areas more effectively than do soap and water.

Further research is needed to identify a "no effect" level for exposure to NG or EGDN in the workplace, and appropriate indices of both exposure and effect should be developed that can be used to determine whether workers are overexposed to these substances. Exposure by inhalation can be estimated from concentrations of these airborne compounds, but no method is currently available to assess the extent of exposure through the skin. Such estimates might be based on measurements of concentrations of NG or EGDN removed from the skin on swabs or in cotton

gloves, glove liners, or socks. An index of exposure by both inhalation and skin absorption could be obtained by measuring concentrations of NG and EGDN in the blood or possibly the urine of exposed workers. An index of effect might be constructed of information on symptoms, blood pressure estimations, and such measurements as fingertip volume by plethysmography. New techniques, such as echocardiography, may provide information on the effects of NG or EGDN on cardiac function.

Angina pectoris, caused by an insufficient supply of oxygen to the heart, is usually associated with sclerosis of the coronary arteries. However, it does not appear that atherosclerosis is more extensive in workers exposed to NG or EGDN than in the general population. It has been suggested that spasms of the coronary arteries may lead to angina or sudden death in exposed workers, particularly during brief periods of withdrawal from exposure, such as on weekends. The mechanism of causation of these spasms and the possibility that other factors may be associated with angina and sudden death in exposed workers, should be explored. Detailed epidemiologic studies are needed to determine the extent of the risk of developing heart disease in former workers who are no longer exposed to NG or EGDN and to identify factors, such as duration of exposure, that may be associated with this increased risk.

Reports, primarily from the turn of the century, suggest that exposure to NG alone or, especially, with alcohol can cause psychologic effects. More recent reports suggest that workers who absorb NG or EGDN through the skin can develop numbness in their fingers. Further studies are needed to determine whether these nitroesters act directly on the central or peripheral nervous systems or whether the reported effects are

secondary to the effects of these compounds on the cardiovascular system.

With the exception of one report from the late 1800's, the effects of NG or EGDN on the male and female reproductive systems or on the developing fetus have not been evaluated. The possibility that workplace exposure to these compounds may affect reproduction merits further attention. Well-designed tests are needed to determine whether NG, EGDN, or their metabolites are potentially mutagenic or carcinogenic by inhalation, ingestion, or absorption through the skin.

The US Army Medical Research and Development Command is sponsoring studies of the toxicity of NG. Dilley [161] is studying the effects of exposure to NG by inhalation and through the skin on coronary blood flow in dogs. Lee et al [162,163] are studying the effects of short-term and long-term exposures to NG in rats, mice, and dogs. The potential carcinogenicity of NG administered orally to rats and mice is also being studied by Lee et al. Since these studies [161-163] are still in progress (1978), final results from them are not yet available.

VIII. REFERENCES

1. The American Table of Distances, publication No. 2. New York, Institute of Makers of Explosives, Safety Library, 1977, 17 pp
2. National Fire Codes--A Compilation of NFPA Codes, Standards, Recommended Practices, and Manuals; Combustible Solids, Dusts and Explosives. Boston, National Fire Protection Association, 1974, vol 3, pp 495-1 to 415-69,63-1 to 63-16
3. Von Oettingen WF: The Effects of Aliphatic Nitrous and Nitric Acid Esters on the Physiological Functions with Special Reference to Their Chemical Constitution, NIH bulletin No. 186. Federal Security Agency, US Public Health Service, National Institutes of Health, 1946, 76 pp
4. Dacre JC, Tew RW: Mammalian Toxicology and Toxicity to Aquatic Organisms of Nitroglycerin, A Waterborne Munitions Waste Pollutant--A Literature Evaluation. Springfield, Va, US Dept of Commerce, National Technical Information Service, 1974, vol 74, 37 pp (NTIS AD-777 902)
5. Urbanski T: Chemistry and Technology of Explosives--Vol II. Oxford, Pergamon Press, 1965, pp 34-61,142-49.
6. Rinkenbach WN: Explosives, in Kirk-Othmer Encyclopedia of Chemical Technology, ed 2 rev. New York, Interscience Publishers, 1965, vol 8, pp 581-95,602-06,635-42
7. Windholz M (ed.): The Merck Index--An Encyclopedia of Chemicals and Drugs, ed 9. Rahway, NJ, Merck and Co Inc, 1976, p 739
8. Weast RC (ed.): Handbook of Chemistry and Physics--A Ready-Reference Book of Chemical and Physical Data, ed 55. Cleveland, CRC Press Inc, 1974, pp C-288,C-314
9. Dean JA (ed.): Lange's Handbook of Chemistry, ed 11. New York, McGraw-Hill Book Co, 1973, pp 7-234 to 7-237
10. Christensen HE, Fairchild EJ (eds.): Registry of Toxic Effects of Chemical Substances, 1976 Edition, DHEW publication No. (NIOSH) 76-191. Rockville, Md, US Dept of Health, Education, and Welfare, Public Health Service, Center for Disease Control, National Institute for Occupational Safety and Health, 1976, pp 526,780,799
11. Einert C, Adams W, Crothers R, Moore H, Ottoboni F: Exposure to mixtures of nitroglycerin and ethylene glycol dinitrate. Am Ind Hyg Assoc J 24:435-47, 1963

12. Holmes LC, DiCarlo FJ: Nitroglycerin--The explosive drug. J Chem Educ 48:573-76, 1971
13. Plant observation reports and evaluation. Menlo Park, Calif, SRI International, Jan 1978, 506 pp (submitted to NIOSH under Contract No. CDC-99-74-31)
14. Klassen HJ, Humphrys JM: Manufacture of nitroglycerine by the Biazzi continuous process. Chem Eng Prog 49:641-46, 1953
15. Lindner V: Propellants, in Kirk-Othmer Encyclopedia of Chemical Technology, ed 2 rev. New York, Interscience Publishers, 1965, vol 8, pp 659-719
16. Key MM, Henschel AF, Butler J, Ligo RN, Tabershaw IR (eds.): Occupational Diseases--A Guide to their Recognition, rev, DHEW publication No. (NIOSH) 77-181. US Dept of Health, Education, and Welfare, Public Health Service, Center for Disease Control, National Institute for Occupational Safety and Health, 1977, pp 95,160-61,282-84
17. Brunton TL: Use of nitrite of amyl in angina pectoris. Lancet 1:97-93, 1867
18. Murrell W: Nitro-glycerin as a remedy for angina pectoris. Lancet 2:80-81, 113-15,151-52,225-27, 1879
19. Field AG: Nitro-glycerine or glonoine. Med Times Gaz 39:339, 1859
20. Hay M: The chemical nature and physiological action of nitro-glycerine. Practitioner 30:422-33, 1883
21. Darlington T: The effect of the products of high explosives, dynamite and nitro-glycerine on the human system. Med Rec 38:661-62, 1890
22. Laws GC: The effects of nitroglycerin upon those who manufacture it. J Am Med Assoc 31:793-94, 1898
23. Jennings JW: Cordite eating and cordite eaters. J R Army Med Corps 1:277-85, 1903
24. Laws CE: Nitroglycerin head. J Am Med Assoc 54:793, 1910
25. Ebright GE: The effects of nitroglycerin on those engaged in its manufacture. J Am Med Assoc 62:201-02, 1914
26. Bradbury JB: The Bradshaw lecture on some new vaso-dilators. Br Med J 2:1213-18, 1895

27. Haldane, J, Makgill RH, Mavrogordato AE: The action as poisons of nitrites and other physiologically related substances. *J Physiol* 11:160-89, 1897
28. Oltman TV, Crandall LA Jr: The acute toxicity of glyceryl trinitrate and sodium nitrite in rabbits. *J Pharmacol Exp Ther* 41:121-26, 1931
29. Hanlon JJ, Fredrick WG: Great lead controversy. *Arch Environ Health (Lett)* 12:676, 1966
30. Bresler RR: Nitroglycerin reactions among pharmaceutical workers. *Ind Med* 18:519-23, 1949
31. Martimor E, Cavigneaux A, Nicolas-Charles PJ: Mental disorders caused by occupational poisoning by nitroglycerin. *Arch Mal Prof Med Trav Secur Soc* 19:574-580, 1958
32. Schwartz AM: The cause, relief and prevention of headaches arising from contact with dynamite. *N Engl J Med* 235:541-44, 1946
33. Mountcastle VB (ed.): *Medical Physiology*, ed 13. St. Louis, The CV Mosby Co, 1974, vol 1, pp 367-72
34. Lange RL, Reid MS, Tresch DD, Keelan MH, Bernhard VM, Coolidge G: Nonatheromatous ischemic heart disease following withdrawal from chronic industrial nitroglycerin exposure. *Circulation* 46:666-78, 1972
35. Information Concerning the Development of the Criteria Document and Recommended Health Standard for Nitroglycerin. Unpublished report submitted to NIOSH by the US Dept of the Army, US Army Environmental Hygiene Agency, Aberdeen Proving Ground, Md, Aug 1977, 47 pp
36. Occupational Health and Industrial Hygiene Evaluation--Nitroglycerin, special study No. 99-005-72. Baraboo, Wis, US Dept of the Army, Army Environmental Hygiene Agency, Badger Army Ammunition Plant, 1971, 62 pp
37. Barsotti M: [Stenocardiac attacks in workers engaged in the manufacture of dynamites containing nitroglycol.] *Med Lavoro* 45:544-48, 1954 (Ita)
38. Bartalini E, Cavagna G, Foa V: Epidemiological and clinical features of occupational nitroglycol poisoning in Italy. *Med Lav* 58:618-23, 1967
39. Jacob JC, Maroun FB: Peripheral neuropathy in a person sensitive to dynamite. *Can Med Assoc J* 101:102-04, 1969
40. Lanfranchi A, Beraud P: [Chronic intoxication by nitrated compounds in workers of explosives plants.] *Presse Med* 77:795-96, 1969 (Fre)

41. Maccherini I, Camarri E: [Nitroglycol poisoning.] *Med Lav* 50:193-201, 1959 (Ita)
42. Prerovska I, Teisinger J: Clinical picture of chronic intoxication with dinitrodiglycol. *Prac Lek* 17:41-43, 1965
43. Rubino GF, Scansetti G, Crotti L: [Effects of chronic exposure to nitroglycol in dynamite manufacture.] *Minerva Med* 47:1124-28, 1956 (Ita)
44. Hanova M: [Electrocardiographic changes induced by ethylene glycol dinitrate and glyceryl trinitrate.] *Bratisl Lek Listy* 45:220-24, 1965 (Slo)
45. Orlando E, Raffi GB, Miraglia G: Electrocardiographic patterns in workers chronically exposed to nitroglycol. *Lav Um* 18:455-61, 1966
46. Keogh JP, Longarini AE, Platt BB: Nonatheromatous Ischemic Heart Disease Induced by Nitrates--Two Cases and An Epidemiological Investigation. Unpublished report submitted to NIOSH by Baltimore City Hospitals, Dept of Medicine, Baltimore, Nov 1977, 15 pp
47. Powell M, Lomax MA: The toxic effects of handling and firing explosives in coal mines. *Ann Occup Hyg* 2:141-51, 1960
48. Klock JC: Nonocclusive coronary disease after chronic exposure to nitrate--Evidence for physiologic nitrate dependence. *Am Heart J* 89:510-13, 1975
49. Trainor DC, Jones RC: Headaches in explosive magazine workers. *Arch Environ Health* 12:231-34, 1966
50. Oral deposition of Dr. John H. Foulger on Oct 1, 1975, in the case of Helen J. Stoleson vs United States of America, Civil No. 74-C-297, in the US District Court of the Western District of Wisconsin, 1975, 110 PP
51. Foulger JH: Medical control of industrial exposure to toxic chemicals. *Ind Med Surg* 12:214-25, 1943
52. Foulger JH: Preventive medicine in industry, in *Modern Occupational Medicine*. Philadelphia, Lea and Febiger, 1954, pp 61-100
53. Hasegawa H, Sato M, Yoshikawa H, Sakabe H, Yamaguchi M, Hotta K: Nitroglycol poisoning in an explosives plant--2. *Bull Natl Inst Ind Health* 8:10-20, 1962
54. Forssman S, Masreliez N, Johansson G, Sundell G, Wilander O, Bostrom G: Medical examination of workers engaged in the manufacture of nitroglycerine and ethylene glycol dinitrate in the Swedish

- explosives industry, in Proceedings of the Twelfth International Congress on Occupational Health, Helsinki, International Congress on Occupational Health, 1957, vol 3, pp 254-58
55. Kubota J: Problems of nitroglycol (Ng) poisoning in Japan, in Sangro P, Akoun G, Beale HL (eds.): Proceedings of the International Congress of Occupational Health, 14th, Madrid, 1963, International Congress Series. Amsterdam, Excerpta Medica, 1964, vol 2, pp 812-14
 56. Symanski H: [Severe health injuries resulting from occupational exposure to nitroglycol.] Arch Hyg Bakteriol 136:139-58, 1952 (Ger)
 57. Bille S, Sivertssen E: [Sudden death in an explosives worker.] Nord Med 70:842-43, 1963 (Nor)
 58. Carmichael P, Lieben J: Sudden death in explosives workers. Arch Environ Health 7:424-39, 1963
 59. Kannel WB, Dawber TR, Kagan A, Revotskre N, Stokes J: Factors of risk in the development of coronary heart disease--Six year follow-up experience--The Framingham study. Ann Intern Med 55:33-50, 1961
 60. Hueper WC: The etiology and the causative mechanism of arteriosclerosis and atheromatosis. Medicine 20:397-442, 1941
 61. Hueper WC: Arteriosclerosis, in Massey FC (ed.): Clinical Cardiology. Baltimore, Williams Wilkins Co, 1953, pp 545-613
 62. Yamagawa M: [Incidence of nitroglycol poisoning and its prevention in our country.] Kogyo Kayaku Kyokaishi 26:236-42, 1965 (Jap)
 63. Lund RP, Haggendal J, Johnsson G: Withdrawal symptoms in workers exposed to nitroglycerine. Br J Ind Med 25:136-38, 1968
 64. Yagoda H, Goldman FH: Analysis of atmospheric contaminants containing nitrate groupings. J Ind Hyg Toxicol 25:440-44, 1943
 65. Morikawa Y, Muraki K, Ikoma Y, Honda T, Takamatsu H: Organic nitrate poisoning at an explosives factory--Plethysmographic study. Arch Environ Health 14:614-21, 1967
 66. Planques J, Bazex A, Dupre A: [Cutaneous and nervous allergic reactions induced by dynamite.] Arch Mal Prof Med Trav Secur Soc 20:187-88, 1959 (Fre)
 67. Ryan FP: Erythroderma due to peritrate and glyceryl trinitrate. Br J Dermatol 87:498-500, 1972
 68. Matsushita T, Tadokoro Y: An electroencephalographic study for chronic nitroglycol poisoning. Ind Health 13:237-41, 1975

69. Styblova V: [The neurotoxic effect of explosives.] *Cesk Neurol* 29:378-81, 1966 (Cze)
70. Gross E, Kiese M, Resag K: [Absorption of ethylene glycol dinitrate through the skin.] *Arch Toxicol* 18:194-99, 1960 (Ger)
71. Williams AF, Murray WJ, Gibb BH: Determination of traces of ethyleneglycol dinitrate (and nitroglycerine) in blood and urine. *Nature* 210:816-17, 1966
72. Sundell L, Gotell P, Axelson O: Effects of nitroglycerin and nitroglycol exposure, in Zenz C (ed.): *Occupational Medicine--Principles and Practical Applications*. Chicago, Year Book Medical Publishers Inc, 1975, pp 826-32
73. Gotell P: Environmental and clinical aspects of nitroglycol and nitroglycerin exposure. *Occup Health Saf* 45:50-51, 1976
74. Blumenthal HP, Fung HL, McNiff EF, Yap SK: Plasma nitroglycerin levels after sublingual, oral, and topical administration. *Br J Clin Pharmacol* 4:241-42, 1977
75. Hogstedt C, Axelson O: Nitroglycerine-Nitroglycol exposure and the mortality in cardio-cerebrovascular diseases among dynamite workers. *J Occup Med* 19:675-78, 1977
76. Gross E, Bock M, Hellrung F: [Toxicology of nitroglycol as compared to that of nitroglycerin.] *Arch Exp Pathol Pharmacol* 200:271-304, 1942 (Ger)
77. Frimmer M, Gross E, Kiese M, Absag K: [Resorption of ethylene glycol dinitrate through the lungs.] *Arch Toxicol* 18:200-04, 1960 (Ger)
78. Stein W: [Mechanism of the effect of continued inhalation of nitroglycol.] *Arch Gewerbepathol Gewerbehyg* 15:19-36, 1956 (Ger)
79. Gross E, Kiese M, Resag K: [Absorption of glyceryl trinitrate (nitroglycerin) through the skin.] *Arch Toxicol* 18:331-34, 1960 (Ger)
80. Bandelin FJ, Pankratz RE: Colorimetric determination of organic nitro compounds used as vasodilators. *Anal Chem* 30:1435-37, 1958
81. Bogaert MG, De Schaepdryver AF: Tolerance towards glyceryl trinitrate (Trinitrin) in dogs. *Arch Int Pharmacodyn Ther* 171:221-24, 1968
82. Bogaert MG: Tolerance towards glyceryltrinitrate (Trinitrin) in rabbits. *Arch Int Pharmacodyn Ther* 172:228-30, 1968
83. Needleman P, Johnson EM Jr: Mechanism of tolerance development to organic nitrates. *J Pharmacol Exp Ther* 184:709-15, 1973

84. Heppel LA, Hilmoie RJ: Metabolism of inorganic nitrite and nitrate esters--II. The enzymatic reduction of nitroglycerin and erythritol tetranitrate by glutathione. *J Biol Chem* 183:129-38, 1956
85. DiCarlo FJ, Crew MC, Haynes LJ, Melgar MD, Gala RL: The absorption and biotransformation of glyceryl trinitrate-1,3-C14 by rats. *Biochem Pharmacol* 17:2179-83, 1968
86. Needleman P, Krantz JC: The biotransformation of nitroglycerin. *Biochem Pharm* 14:1225-30, 1965
87. Clark DG, Litchfield MH: Metabolism of ethylene glycol dinitrate and its influence on the blood pressure of the rat. *Br J Ind Med* 24:320-25, 1967
88. Litchfield MH: Aspects of nitrate ester metabolism. *J Pharm Sci* 60:1599-1607, 1971
89. Nickerson M: Vasodilator drugs, in Goodman LS, Gilman A (eds.): *The Pharmacological Basis of Therapeutics*, ed 4. New York, The Macmillan Co, 1970, pp 745-63
90. Litchfield MH: Recent views on the mechanisms of nitrate ester metabolism. *Drug Metab Rev* 2:239-64, 1973
91. DiCarlo FJ: Nitroglycerin revisited--Chemistry, Biochemistry, Interactions. *Drug Metab Rev* 4:1-38, 1975
92. Needleman P: Organic nitrate metabolism, in Elliott HW (ed.): *Annual Review of Pharmacology and Toxicology*. Palo Alto, Calif, Annual Reviews Inc, 1976, vol 16, pp 81-93
93. Komura S, Yoshitake Y: Alcohol preference and nitroglycol poisoning in C57BL mice. *Jpn J Stud Alcohol* 6:85-87, 1971
94. Komura S: Effects of ethyleneglycol dinitrate and related compounds on ethanol preference and ethanol metabolism. *Acta Pharmacol Toxicol* 35:145-54, 1974
95. Takayama S: Carcinogenicity of molsidomine and nitroglycerin in rats. *Pharmacometrics* 9:217-28, 1975
96. Suzuki K, Sudo K, Yamamoto T, Hashimoto K: The carcinogenicity of N-ethoxycarbonyl-3-morpholinonydnonimine (molsidomine) in comparison with nitroglycerin in C57BL/6Jms mice. *Pharmacometrics* 9:229-42, 1975
97. Kononova SD, Korolev AM, Eremenko LT, Gumanov LL: [The mutagenic effect of some esters of nitric acid on bacteriophage T4B.] *Genetika* 8:101-08, 1972 (Rus)

98. Bogaert MG, Rosseel MT, DeSchaepdryver AF: Biotransformation of glyceryltrinitrate in rabbits. Arch Int Pharmacodyn Ther 177:487-91, 1969
99. Robbins SL: Pathologic Basis of Disease. Philadelphia, WB Saunders Co, 1974, pp 648-49
100. Yee HT, Fosdick LB, Bourne HG Jr: Nitroglycerin and nitroglycol exposure in an explosives plant. Am Ind Hyg Assoc J 20:45-49, 1959
101. Linch AL, Charsha RC: Development of a freeze-out technique and constant sampling rate for the portable "Uni-Jet" air sampler. Am Ind Hyg Assoc J 21:325-29, 1960
102. Information Concerning the Development of the Criteria Document and Recommended Health Standard for Nitroglycerin. Unpublished report submitted to NIOSH by the Dept of the Army, Aberdeen Proving Ground, Md, US Army Environmental Hygiene Agency, Dec 1977, 7 pp
103. Barrett WJ, Dillon HK, James RH: Sampling and Analysis of Four Organic Compounds Using Solid Sorbents No. 1. Unpublished report submitted to NIOSH by Southern Research Institute, Birmingham, Ala, 1974, 125 pp
104. National Institute for Occupational Safety and Health: Certified Equipment, HEW publication No. (NIOSH) 76-145. Morgantown, W Va, US Dept Health, Education, and Welfare, Public Health Service, Center for Disease Control, NIOSH, 1975, pp 1-2
105. Nitroglycerin and ethylene glycol dinitrate (nitroglycol) in air--Physical and Chemical Analysis Branch Method No. 203, in NIOSH Manual of Analytical Methods, ed 2, DHEW publication No. 77-157-A. Cincinnati, US Dept of Health, Education, and Welfare, Public Health Service, Center for Disease Control, NIOSH, 1977, vol 1, pp 203-1 to 203-7
106. Sacharov K, Proctor G, Sentz F: Report of Survey--Atlas Powder Company--Post Office Box 271--Tamaqua, Pa. Harrisburg, Pa, Commonwealth of Pennsylvania Dept of Health, Division of Occupational Health, 1964, 9 pp
107. Ethylene Glycol Dinitrate and/or Nitroglycerin--Standards Completion Program Validated Method No. S216, in NIOSH Manual of Analytical Methods, ed 2, DHEW publication No. (NIOSH) 77-157-C. Cincinnati, US Dept of Health, Education, and Welfare, Public Health Service, Center for Disease Control, National Institute for Occupational Safety and Health, 1977, vol 3, pp S216-1 to S216-11
108. Pellizzari ED, Bunch JE, Berkley RE, McRae J: Collection and analysis of trace organic vapor pollutants in ambient atmospheres--The performance of a Tenax GC cartridge sampler for hazardous vapors. Anal Lett 9:45-63, 1976

109. Pristera F, Halik M, Castelli A, Fredericks W: Analysis of explosives using infrared spectroscopy. Anal Chem 32:495-508, 1960
110. Horwitz W (ed.): Official Methods of Analysis of the Association of Official Analytical Chemists, ed 11. Washington, DC, AOAC, 1970, pp 687-88
111. Evendijk JE: [Separation and identification of explosive powder components by two-dimensional thin-layer chromatography.] Explosivstoffe 16:152-54, 1968 (Ger)
112. Frey M: [Recent methods in the analysis of propellants--Report No. 1. Polarographic analysis of propellants.] Explosivstoffe 12:149-57, 1964 (Ger)
113. Cannon JH, Heuermann RF: Rapid assay for nitroglycerin tablets. J Assoc Off Agric Chem 34:716-20, 1951
114. Dzottzoti SK: [Quantitative Potentiometric determination of some nitro esters.] Azerb Khim Zh 2:81-85, 1961 (Rus)
115. Leichnetz K (ed.): Detector Tube Handbook--Air Investigations and Technical Gas Analysis with Drager Tubes, ed 3. Lubeck, Federal Republic of Germany, Dragerwerk AG Lubeck, 1976, pp 104-08
116. Evaluation of Operating Characteristics of Otto Fuel Detector, MK-15 Mod 0, Environmental Chemistry Special Study No. 52-001-75/76. Cincinnati, Navy Environmental Health Center, Sept 1975, 37 pp
117. Coldwell BB: The application of ultra-violet light and diphenylamine to spot tests for explosives. Analyst 84:665-67, 1959
118. Sopranetti A, Reich HU: [Contribution to the gas chromatographic analysis of propellants.] Explosivstoffe 20:197-202, 1972 (Ger)
119. Ehrner-Samuel H: Gas chromatographic determination of nitroglycerine, nitroglycol and propylene glycol dinitrate in blood with an electron capture detector, in Hygiene--Toxicology--Occupational Diseases--15th International Congress on Occupational Health, Vienna, Sept 19-24, 1966, vol 3, pp 201-05
120. Otto Fuel II Analysis. Unpublished report submitted to NIOSH by the US Dept of the Navy, Navy Environmental Health Center, Laboratory Division, Cincinnati, 3 pp
121. Cavagna G, Bartalini E, Locati G: Environmental control of health hazards in a dynamite factory--Past and present. Med Lav 58:501-05, 1967

122. American Conference of Governmental Industrial Hygienists, Committee on Industrial Ventilation: Industrial Ventilation--A Manual of Recommended Practice, ed 15. Lansing, Mich, ACGIH, 1978, pp 1-1 to 14-8
123. American National Standards Institute Inc: Fundamentals Governing the Design and Operation of Local Exhaust Systems, ANSI Z9.2-1971. New York, ANSI, 1971
124. Hagopian JH, Bastress EK: Recommended Industrial Ventilation Guidelines, HEW publication No. (NIOSH) 76-162. Cincinnati, US Dept of Health, Education, and Welfare, Public Health Service, Center for Disease Control, National Institute for Occupational Safety and Health, Division of Physical Sciences and Engineering, 1976, 330 pp
125. Criteria for a Recommended Standard....Occupational Exposure to Nitric Acid, DHEW publication No. (NIOSH) 76-141. Rockville, Md, US Dept Health, Education, and Welfare, Public Health Service, Center for Disease Control, National Institute for Occupational Safety and Health, 1976, 78 pp
126. Criteria for a Recommended Standard....Occupational Exposure to Sulfuric Acid, DHEW publication No. (NIOSH) 74-128. Rockville, Md, US Dept Health, Education, and Welfare, Public Health Service, Center for Disease Control, National Institute for Occupational Safety and Health, 1974, 90 pp
127. National Fire Codes--A Compilation of NFPA Codes, Standards, Recommended Practices, and Manuals; Building Construction and Facilities. Boston, National Fire Protection Association, 1974, vol 4, pp 91-1 to 91-29
128. Recommended Industry Safety Standards, publication No. 6. New York, Institute of Makers of Explosives, Safety Library, 1977, 46 pp
129. National Fire Codes--A Compilation of NFPA Codes, Standards, Recommended Practices, and Manuals; Electrical. Boston, National Fire Protection Association, 1974, vol 5, pp 70-286 to 70-316
130. National Fire Codes--A Compilation of NFPA Codes, Standards, Recommended Practices, and Manuals; Occupancy Standards and Process Hazards. Boston, National Fire Protection Association, 1974, vol 9, pp 77-1 to 77-64
131. Safety in the Transportation, Storage, Handling, and Use of Explosives, publication No. 17. New York, Institute of Makers of Explosives, Safety Library, 1977, 61 pp
132. Shangraw RF, Contractor AM: New developments in the manufacture and packaging of nitroglycerin tablets. J Am Pharm Assoc 12:633-36, 1972

133. Medical and Industrial Hygiene Considerations for Nitroglycerin Operations. Aberdeen Proving Ground, US Dept of the Army, Army Environmental Hygiene Agency, Feb 1976, 7 pp
134. Edmont-Wilson Job-fitted Gloves and Protective Clothing. Coshocton, Ohio, Becton, Dickinson and Co, Edmont-Wilson, 1976, pp 14-16
135. Blasters' Handbook--A Manual Describing Explosives and Practical Methods of Use, ed 15. Wilmington, Del, EI du Pont de Nemours and Co Inc, Explosives Dept, Sales Development Section, 1969, 525 pp
136. Weeks R W Jr, Dean BJ, Yasuda SK: Detection limit of chemical spot tests toward certain carcinogens on metal, painted and concrete surfaces. Anal Chem 48:2227-33, 1976
137. Sansone EB, Slein MW: Application of the microbiological safety experience to work with chemical carcinogens. Am Ind Hyg Assoc J 37:711-19, 1976
138. Your Guide to Explosives Regulation--1976. US Dept of the Treasury, Bureau of Alcohol, Tobacco, and Firearms, 1976, 203 pp
139. Do's and Dont's--Instructions and Warnings, publication No. 4. New York, Institute of Makers of Explosives, Safety Library, 1973, 14 pp
140. Agricultural Blasting, publication No. 11. New York, Institute of Makers of Explosives, Safety Library, 1976, 35 pp
141. Explosives and Blasting Safety. Unpublished report submitted to NIOSH by Bureau of Mines, Sept 1977, 10 pp
142. Portable Instruments. Pittsburgh, Mine Safety Appliances Co, 1976, section 3, pp 14-15
143. Suggested Code of Regulations for the Manufacture, Transportation, Storage, Sale, Possession, and Use of Explosive Materials, publication No. 3. New York, Institute of Makers of Explosives, Safety Library, 1974, 67 pp
144. Cook WA: Maximum allowable concentrations of industrial atmospheric contaminants. Ind Med 14:936-46, 1945
145. Report of the Sub Committee on Threshold Limits, in Proceedings of the Eighth Annual Meeting of the American Conference of Governmental Industrial Hygienists, Chicago, Apr 7-13, 1946, pp 54-55
146. Threshold Limit Values Adopted at the Eleventh Annual Meeting of the American Conference of Governmental Industrial Hygienists, Detroit, Apr 1949, 2 pp

147. American Conference of Governmental Industrial Hygienists, Committee on Threshold Limit Values: Documentation of Threshold Limit Values. Cincinnati, ACGIH, 1962, p 77
148. Elkins HB: The Chemistry of Industrial Toxicology. New York, John Wiley and Sons Inc, 1950, pp 160-61
149. American Conference of Governmental Industrial Hygienists: Threshold Limit Values for 1962. Cincinnati, ACGIH, 1962, pp 6-8
150. American Conference of Governmental Industrial Hygienists: Threshold Limit Values for 1963. Cincinnati, ACGIH, 1963, pp 5,7
151. American Conference of Governmental Industrial Hygienists: Threshold Limit Values for 1964, Cincinnati, ACGIH, 1964, pp 8,11
152. American Conference of Governmental Industrial Hygienists, Committee on Threshold Limit Values: Documentation of Threshold Limit Values, rev. Cincinnati, ACGIH, 1966, p 84
153. Melville KI: Nitrites, nitrates and miscellaneous drugs, in Drill VA (ed.): Pharmacology in Medicine--A Collaborative Textbook, ed 2. New York, McGraw-Hill Book Co, 1958, pp 482-504
154. American Conference of Governmental Industrial Hygienists: Threshold Limit Values of Air-borne Contaminents [sic] for 1968--Recommended and Intended Values. Cincinnati, ACGIH, 1968, pp 8-11
155. American Conference of Governmental Industrial Hygienists, Committee on Threshold Limit Values: Documentation of the Threshold Limit Values for Substances in Workroom Air, ed 3, 1971. Cincinnati, ACGIH, 2nd printing, 1974, pp 110-11
156. Litchfield MH: The determination of the di- and mononitrates of ethylene glycol and 1,2-propylene glycol in blood by colorimetric and gas-chromatographic methods. Analyst 93:653-59, 1968
157. American Conference of Governmental Industrial Hygienists: TLV's--Threshold Limit Values for Substances in Workroom Air Adopted by the ACGIH for 1972. Cincinnati, ACGIH, 1972, pp 17,22
158. Nitroglycerin (Glycerol trinitrate), AIHA Hygienic Guide Series. Akron, Ohio, American Industrial Hygiene Association, 1960, 2 pp
159. Occupational Exposure Limits for Airborne Toxic Substances, Occupational Safety and Health Series No. 37. Geneva, International Labour Office, 1977, pp 112-13,160-61
160. Keogh J: Health hazards of nitroglycerin and nitroglycol, publication No. 16. Denver, Colo, Oil, Chemical and Atomic Workers International Union, OCAW Health and Safety Office, 1977, 19 pp

161. Dilley JV: Evaluation of the occupational health hazards of nitroglycerin using mammalian models--Final report. Menlo Park, Calif, SRI International, Aug 1977, 36 pp
162. Lee CC, Ellis HV, Kowalski JJ, Hodgson JR, Hwang SW, Short RD, Bhandari JC, Sanyer JL, Reddig TW, Minor JL, Helton DO: Mammalian toxicity of munition compounds--Phase II--Effects of multiple doses--Part I. Trinitroglycerin--Progress report No. 2. Kansas City, MO, Midwest Research Institute, Nov 1977, 192 pp
163. Lee CC, Dilley JV, Hodgson JR, Helton DO, Wiegand WJ, Roberts DN, Andersen BS, Halfpap LM, Kurtz LD, West N: Mammalian toxicity of munition compounds--Phase I. Acute oral toxicity primary skin and eye irritation, dermal sensitization, and disposition and metabolism--Final report No. 1. Kansas City, MO, Midwest Research Institute, July 1975, 113 pp
164. Organic solvents in air--Physical and Chemical Analysis Branch Method No. 127, in NIOSH Manual of Analytical Methods, ed 2, DHEW publication No. (NIOSH) 77-157-A. Cincinnati, US Dept of Health, Education and Welfare, Public Health Service, Center for Disease Control, National Institute for Occupational Safety and Health, 1977, vol 1, 127-1 to 127-7