MULTIPLE MYELOMA IN THE RAILROAD INDUSTRY

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I. INTRODUCTION.

The word "myeloma" means a tumor of the bone marrow. Most people develop many bone marrow tumors, hence the name "multiple myeloma." Multiple myeloma is a neoplasm of mature and immature plasma cells.[1] These plasma cells characteristically cause destruction of bone, leading to such troublesome complications as bone pain, compression, fractures, hypercalcemia and renal damage.[2] Abnormal radiographs of the skeleton are found in 80 percent or more of patients at diagnosis. Multiple punched-out osteolytic lesions involving the red bone marrow are typical.[3] Complete remission is rare, and a possible cure has been reported in only a few cases.[4] With standard therapy the clinical disease phase lasts an average of only 3 years. Virtually all patients with multiple myeloma succumb to their malignancy.[5] Based on all cases diagnosed in the geographic regions included in the U.S. SEER Program during 1983 to 1990, 5-year relative survival rates were 29 and 27 percent among men and

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1John Foerster, *Multiple Myeloma* in Wintrobe's Clinical Hematology Vol. 2, 2219 (G. Richard Lee, *et al*. eds., 9th ed. 1993); Dan L. Longo, *Plasma Cell Disorders* in Harrison's Principles of Internal Medicine, Vol. 2, 1621 (Kurt J. Isselbacher, *et al*. eds. 13th ed. 1994).

2Reiner Bartl, Bertha Frisch, and Wolfgang Wilmanns, *Bone and Marrow Findings in Multiple Myeloma and Related Disorders* in Neoplastic Diseases of the Blood 477, 492 (Peter H. Wiernik, *et al*. eds., 3d ed. 1996), *citing*, R. A. Kyle, E. D. Baryd, The Monoclonal Gammophathies: Multiple Myeloma and Related Plasma-Cell Disorders. Charles C. Thomas, Springfield, 1976; R. Bartle, B. Frisch, Biopsy of Bone in Internal Medicine: An Atlas and Sourcebook. Kluwer Academic Publishers, Dordrecht, 1993; H. Ludwig, Multiples Myelom. Springer, Berlin, 1982; R. A. Kyle, J. Jowsey, P. J. Keely, *et al*., *Multiple myeloma and bone disease*, 293 N. Eng. J. Med. 1334 (1975); R. S. Weinstein, *Bone involvement in multiple myeloma*, 93 Am. J. Med. 591 (1992); J. A. Kanis, A. J. P. Yates, R. G. G. Russell, *Hypercalcaemia and skeletal complications of myeloma* in Multiple Myeloma and other Paraproteinaemias 307 (I. W. Delamore ed. 1986).

3*Id*., *citing*, R. Bartle & B. Frisch, Biopsy of Bone in Internal Medicine: An Atlas and Sourcebook. Kluwer Academic Publishers, Dordrecht, 1993.

4*Id*. at 499, *citing*, R. A. Kyle, *IgD multiple myeloma: a cure at 21 years*. 29 Am. J. Haematol. 41 (1988).

5Bart Barlogie, *Plasma cell myeloma* in Williams Hematology 1109, 1123 (Ernest Beutler, *et al*. eds., 5th ed. 1995).

women, respectively, and for blacks and whites, respectively.6

Multiple myeloma is a disease of old age. Onset of the disease prior to age 40 is rare; thereafter age-specific incidence rates rise exponentially with age, with the rate of increase less rapid at older ages.[7] The incidence rate for males and females over the age of 80 is 65 and 37 per 100,000.[8] Since 1950, age adjusted mortality rates have risen continuously. The increase in the incidence of multiple myeloma from the 1950's to 1989 was among the highest observed for any cancer during that time interval.[9]

6L. A. G. Ries, B. A. Miller B. F. Hankey *et al*., (eds.) SEER Cancer Statistics Review: 1973-1991, National Cancer Institute, NIH Pub. No. 94-2789, Bethesda, 1994.

7Linda M. Pottern, *et al*. *Epidemiology of Multiple Myeloma* in Neoplastic Diseases of the Blood 441, 443 (Peter H. Wiernik, *et al*. eds., 3d ed. 1996), *citing*, S. S. Devesa, D. T. Silverman, J. L. Young, Jr., *et al*., *Cancer incidence and mortality trends among whites in the United States, 1947-1984*, 79 J. Nat'l Cancer Inst. 701 (1987),

8I. Turesson, O. Zettervall, J. Cuzik, *et al., Comparison of trends in the incidence of multiple myeloma in Malmo, Sweden, and other countries, 1950-79*, 310 N. Eng. J. Med. 421 (1984).

9Linda M. Pottern, *et al*. *Epidemiology of Multiple Myeloma* in Neoplastic Diseases of the Blood 441 (Peter H. Wiernik, *et al*. eds., 3d ed. 1996), *citing*, S. S. Devesa, *Descriptive epidemiology of multiple myeloma* in Epidemiology and Biology of Multiple Myeloma 3 (G. I. Obrams & M. Potter eds. 1991), B. A. Miller, L. A. G. Ries, B. F. Hankey *et al*., (eds.) SEER Cancer Statistics Review: 1973-1990, National Cancer Institute, NIH Pub. No. 93-2789, Bethesda, 1993.

According to the National Center for Health Statistics more than 8,000 Americans die from multiple myeloma every year. The median age at diagnosis is 72, somewhat older than the median age at diagnosis of all cancers.[10] The National Cancer Institute estimated that 12,000 new cases of multiple myeloma were diagnosed in the United States in 1994. The age-adjusted incident rates for whites is 4.1 per 100,000, and for blacks 9.1 per 100,000.[11] The lowest incidence rates are for Americans of Japanese and Chinese descent (1.7 per 100,000 and 2.3 per 100,000 respectively).[12]

II. OCCUPATIONAL EXPOSURES.

Epidemiologic case-control and cohort studies have failed to distinguish which of the various railroad crafts are potentially at elevated risk for the development of multiple myeloma. In case-control studies the evaluations are performed on such small groups that crafts cannot be tweaked out of the overall group. Nevertheless, analysis by type of industry has provided some support for the proposition that work on the railroad increases the risk for the development of multiple myeloma.

A. Railroad as an occupation.

Three studies have evaluated the potential for excess death due to multiple myeloma among railroad workers.

10M. Hjorth, E. Holmbert, S. Rodjer & J. Westin, *Impact of active and passive exclusions on the results of a clinical trial in multiple myeloma. The Myeloma Group of Western Sweden.* 80 Br. J. Haematol. 55-61 (1992)

11L. A. G. Ries, B. A. Miller B. F. Hankey *et al*., (eds.) SEER Cancer Statistics Review: 1973-1991, National Cancer Institute, NIH Pub. No. 94-2789 , Bethesda, 1994.

12Linda M. Pottern, *et al*. *Epidemiology of Multiple Myeloma* in Neoplastic Diseases of the Blood 441, 443 (Peter H. Wiernik, *et al*. eds., 3d ed. 1996).

1. In 1983, Howe reported the results of a mortality study among 43,826 retired Canadian railroad workers. The only exposure information available was occupation at the time of retirement. A small but statistically significant increased risk for respiratory, malignancies was found, with a positive dose-response relationship in probability of exhaust exposure. Although increased risk for hemolymphopoietic malignancies, including multiple myeloma, was not found, the authors noted that exposure misclassification and the failure to determine the cause of death in 5.6% of cases probably caused an underestimate of true risk among the retirees.[13]

2. A case-control study of 282 multiple myeloma cases nested in the large prospective Cancer Prevention Study II of the American Cancer Society demonstrated an increased risk among railroad workers. The relationship remain statistically significant (OR 7.1, CI 1.2-43.6) even after controlling for age, sex, ethnic group, education, history of diabetes, x-ray treatment, pesticide and herbicide exposure, and farming.[14]

3. Finally, in 1992, a study of Danish male road and railroad workers found statistically significant increased risk for multiple myeloma.[15]

B. Railroad specific exposures with multiple myeloma potential.

Railroad workers are exposed to a variety of substances and work under sundry circumstances which could potentiate the development of multiple myeloma. Although there are scant studies of job classifications within the railroad industry specifically designed to evaluate the risk of multiple myeloma, one can utilize studies from other industrial settings to support a causal relationship between various railroad exposures and myeloma.

13G. R. Howe, D. Fraser, J. P. Lindsay, B. Presnai, S. Z. Yu, *Cancer mortality (1956-1977) in relation to diesel fumes and coal exposure in a cohort of retired railway workers*, 70 J Natl Cancer-Inst 1015-1090 (1983).

14P. Boffetta, S. D. Stellman, L. Garfunkel, *A case-control study of multiple myeloma nested in the American Cancer Society prospective study*, 43 Int. J. Cancer 554-559 (1989).

15E. F. Heineman, J. H. Olsen, L. M. Pottern, M. Gomez, E. Raffin, A. Blair, *Occupational risk factors for multiple myeloma among Danish men*, 3(6) Cancer Causes Control 555-568 (1992).

1. Gasoline and diesel exhaust exposures.

a. Workers assigned to maintaining the track, bridge and building gangs and trackmen, are continually exposed to gasoline and diesel exhaust. They work with and along side diesel-fired and gasoline-fired tampers, ballast regulators, lining machines, spike hammers, air hammers, wrenches, painting tools, servicing machines, tie extractors, gauging machines, compressors, and vehicles.

b. Engineers and trainmen have the potential for diesel exhaust exposure.

c. Railroad shop or roundhouse workers have been found to have elevated exposure to exhaust particulates, both in Finland and in the United States. Specifically, roundhouse workers have been shown to have personal breathing zone exposures averaging 1.99 mg/m^3 total particulate matter, compared to mean locomotive cab exposures of 0.38 mg/m^3 [16] Railroad shop workers have been found to have elevated exposures to respirable particulate matter, even after adjustment for smoking with mean levels of .155-.192 mg/m^3 [17] Other exhaust-exposed workers provide support for railroad exposures.[18]

16M. Heino, R. Ketola, P. Makela, R. Makinen, R. Niemala, J. Stark, *et al. Work conditions and health of locomotive engineers. Noise, vibration, thermal climate, diesel exhaust constituents, ergonomics*, 4 (Suppl 3) Scand. J. Work Environ. Health 3-14 (1978).

17S. R. Woskie, T. J. Smith, S. K. Hammond, M. B. Schenker, E. Garshick, F. E. Speitzer, *Estimation of the diesel exhaust exposures of railroad workers. I. Current Exposures*, 13 Am. J. Ind. Med. 381-394 (1988); S. R. Woskie, T. J. Smith, S. K. Hammond, M. B. Schenker, E. Garshick, F. E. Speizer, *Estimation of the diesel exhaust exposures of railroad workers: II. national and historical exposures*, 13 Am. J. Ind. Med. 395-404 (1988).

18Bus garage workers exposed to both gasoline and diesel exhausts, have been found to have elevated dust exposures of 0.46 mg/m^3. U. Ulfvarson, R. Alexanderson, L. Aringer, E. Svensson, G. Hedesstierna, C. Hogstedt, *et al. Effects of exposure to vehicle exhaust on health*, 13 Scand. J. Work Environ. Health 505-512 (1987). Diesel bus garage workers have been shown to have elevated prevalences of cough, phlegm, and wheezing and changes in pulmonary function have exposure levels of .12-.61 mg/m^3 respirable dust. J. Gamble, W. Jones, S. Minshall, *Epidemiological-environmental study of diesel bus garage workers: Chronic effects of diesel exhaust on the respiratory system*, 23 Env. Res. 811-821 (1987). Swedish truck drivers on roll-on, roll-off ships, exposed primarily to diesel exhaust and who exhibit cross-shift pulmonary function changes have average total dust exposures of 0.13-1.0 mg/m^3. Ulfvarson, *supra*. In contrast, average annual suburban environmental levels for total suspended particulates have been reported at .06-.13mg/m^3 in St. Louis, MO. International Agency for Research on Cancer. IARC Monographs on the Evaluation of Carcinogenic Risks to Humans. Diesel and gasoline engine exhausts and some nitroamines. 46 (1989). Workers around diesel exhaust (roll-on, roll-off ships, bus garage staff) are also exposed to elevated levels benzene (up to .3 mg/m^3, or .09 PPM). Ulfvarson, *supra*.

d. Knowledge of harm.

See Yearly Proceedings of the AAR Medical & Surgical Section: 1965 at 166-170 (discusses diesel fumes being noxious, and containing by-products)

e. Exhausts have been linked to the development of multiple myeloma.[19]

2. Benzene exposures.

Laborers, painters, machinists, electricians, and carmen were all exposed to solvents, many of which contained benzene.[20] Benzene is a known human carcinogen, and has been causally related to multiple myeloma.

b. Knowledge of potential harm.

See Minutes of Annual Meetings of the Association of Railway Claim Agents: 1937 at 36 ("**Benzol poisoning.**" This anemia-producing affliction has fortunately become quite rare in American industry, but, as may be seen from the accompany Table, a few cases appear each year in an industrial state like Ohio. The differentiating chiefly involves pernicious anemia and other forms of aplastic anemia. Examination of the bone marrow, which can now be done by a simple puncture of the breast bone with a proper hypodermic needle, has aided greatly in our facility in studying this disease.) *Id*. at 36 ("**Poisoning by petroleum distillates**." An enormous number of workers are exposed to the distillates of petroleum in the nature of gasoline, motor fuel, petrol naphtha, petrol, ether, etc. Possible ramifications are discussed, including depletion of the fat in the brain and spinal cord, and other organs and tissues of the body, with the development of chronic nervous and circulatory

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19*Cf.* Peter B. Farmer, *Diesel fuel and exhaust emissions: Is there a human carcinogenic risk?* 350 Lancet 1118 (1997).

20Solvent exposure was previously discussed during the Railroad Section's program of the 1997 ATLA Annual Convention. *See* R. D. Hartley, *Solvent Exposure on the Railroad*, Reference Materials, Vol. II, 1901-1917, ATLA 1997 Annual Convention.

instabilities, and secondary infections. Reference is made to Hayhurst, Emery R., *Poisoning by Petroleum Distillates*, 5(2) Industrial Medicine 53-63 (1936).)

See Yearly Proceedings of the AAR Medical & Surgical Section: 1930 at 109-110 (The mask proposition [when spray painting] seems to be one of the best means of controlling the inhalation of these products [paints, lacquers, etc.]. "We made a previous recommendation -- I don't remember in what report -- that where these spray paints are used they should be used only in the open." "**If [the worker] is asphyxiated from any cause, he should have artificial respiration**, and I would think that possibly the general attention to the man, which might be included under making him as comfortable as possible, would include artificial respiration if he were suffocated."); 1931 at 99 (A member named Road requested that the Committee look into the hazards of spray painting. To prevent the injurious effects of inhaling the vapors, it is **recommended that a suitable mask** be provided employees engaged in this form of work.); 1946 at 28 (A compilation of recommendations by the Medical & Surgical Committee published since 1920 is re-issued. The minutes refer to the "Spray Painting" guideline of 1931 as "Suggestions as to methods of spray painting, **calculated to reduce the physical hazards therefrom**. 1931-39."); 1951 at 40 (Complaints of employees engaged in spray painting are apparently chiefly those of irritation of the skin, respiratory passages, and occasionally, eyes. When spraying in confined or improperly ventilated places, the employee should wear protective respirator. In some instances, in a very small confined space provided with only one opening for ventilation, a mask provided for supplying forced air from the outside is recommended. Goggles with easily cleaned lenses should furnish adequate protection for the eyes.); 1952 at 37, 1953 at 36, 1954 at 38 (reiterates almost the same language of the 1951 Proceedings); 1957 at 25 (The Committee recommends that the following statement be added to the 1951 statement: **"When spraying protective equipment and ventilation are necessary."**) 1965 at 166-170 (Minutes discuss paints, and more importantly, discuss the fact that the Pennsylvania Railroad used at the time an industrial hygienist to investigate any paint before it was approved by requesting the manufacturer give the Pennsylvania Railroad a complete breakdown of what is contained in the paint.)

3. Creosote exposures.

a. Bridge and building gangs and trackmen have been exposed to creosote treated timbers and ties. Maintaining the tracks requires the workers to handle and pick up creosoted ties with tie tongs and by hand. Many times workers unload the ties from a railroad car by pitching the timber out of the car. Ties had to be notched to fit properly in place. Notching splattered creosote on the workers. Planks on bridges need painted with creosote. Creosote has been associated

with multiple myeloma. *See* Section II(C)(3), *infra*.

b. Knowledge of potential harm.

See Yearly Proceedings of the AAR Medical & Surgical Section: 1922 at 54 (Creosote treated ties & other timbers causing burns discussed); 1927 at 82-83 (*Id*.); 1930 at 100 (Discussion of creosote substitute "Carbolineum" with similar irritating effects as creosote. Vaseline suggested as protection, with Isopropyl suggested to remove creosote.); 1931 at 101-102 (Discussion of why gloves for handling creosote are not a good idea. Reiterates 1930 discussions. **Recommends that cold weather be the time of year when creosote treated timbers are used.**); 1951 at 28 (Gloves which absorb creosote should not be worn. Recommends suitable clean clothing, the protection of exposed skin with protective creams, and thorough cleaning of skin after work. **Advised that** if a worker is found to have a **marked sensitivity to a material used, may require transfer** to other types of work not involving occupational exposure to the accused irritants.); 1952 at 25, 1953 at 24, 1956 at 26 (reiterates almost the same language of the 1951 Proceedings).

See Yearly Minutes of Annual Meetings of the Association of Railway Claim Agents: 1937 at 36 (Occasional claims and the resulting poisonings [from tar, asphalt, and creosote] are difficult to differentiate from non-industrial conditions.)

C. Epidemiologic studies supporting causation.

1. Engine exhaust studies.

A number of case-control studies from the United States, Sweden, and Denmark have revealed increased risk for multiple myeloma among workers exposed to engine exhausts.

a. A large, population-based, multicenter case-control study of American multiple myeloma cases has demonstrated a statistically significant increased risk (OR 1.8, CI 1.0-3.2) among individuals exposed to diesel, jet fuel, and automobile exhausts, coal fumes, and smoke, after adjustment for age, sex, race, and study site.[21]

21P. D. Morris, T. D. Koepacll, J. R. Daling, W. Taylor, J. L. Lyon, M. Swanson, *et al.*, *Toxic substance exposure and multiple myeloma: a case-control study*, 76(6) J. Natl. Cancer Inst. 987-994 (1986).

b. A case-control study of 131 Swedish multiple myeloma cases found a doubling of risk among cases with occupational exposure to engine exhaust, a risk which remained significant (RR 2.1, CI 1.2-3.9) after adjustment for a number of potential confounders, including age, fresh wood, creosote, concrete and brick work, sulfonyl urea, gamma radiation, ex-smoking, farming, and gender.[22]

c. A case-control study of 1,098 Danish males with multiple myeloma investigated occupation and exposures as potential associations. The investigators reported a 30% increase in the relative risk of contracting multiple myeloma for workers possibly exposed to diesel exhausts, although this finding was not statistically significant.[23]

d. A population-based case-control study of 275 multiple myeloma cases in northern Sweden showed increased risk in relation to engine exhausts (working with tractor, power saws, or as drivers), power saws, road workers, lumberjacks, and afforestation workers (RR 1.38, CI 0.92-2.09). The relative risk remained elevated after accounting for other exposures.[24]

e. A Danish case-control study of females diagnosed with multiple myeloma between 1970 and 1984 has shown increased risk for those individuals with possible or probable exposure to exhaust fumes.[25]

f. A Swedish cohort study of 14,225 truck drivers, exposed primarily to diesel exhaust demonstrated increased risks for all hemolymphopoietic malignancies, lymphatic leukemia and multiple myeloma, during the years 1970 to 1980. The risk for multiple myeloma was statistically significant (SMR 4.39, CI 1.42-10.24).[26]

22U. Flodin, M. Fredriksson, B. Persson, *Multiple myeloma and engine exhausts, fresh wood, and creosote: a case reference study*, 12 Am. J. Ind. Med. 519-529 (1987); *See also*, U. Flodin, M. Fredricksson, B. Persson, O. Axelson, *Chronic lymphatic leukemia and engine exhausts, fresh wood, and DDT: a case-referent study*, 45 Br. J. Ind. Med. 33-38 (1988).

23Heinerman E. F., Olsen J. H., Pottern L. M., Gomez M., Raffin E., Blair A. *Occupational risk factors for multiple myeloma among Danish men.* 3(6) Cancer Causes Control 555-568 (1992).

24Erikson M.& Karisson M., *Occupational and other environmental factors and multiple myeloma: a population based case-control study.* 49(2) Br. J. Ind. Med. 95-103 (1992).

25L. M. Pottern, E. R. Heineman, *et al., Multiple myeloma among Danish women: employment history and workplace exposures*, 3(5) Cancer Causes Control 427-432 (1992).

26E. Hanson, *A follow-up study on the mortality of truck drivers*, 23 Am. J. Ind. Med. 811-821 (1993).

g. Recently, a large case-control study of death certificates in 12,148 male multiple myeloma cases by the National Cancer Institute, found statistically significant increased risk among operators of graders and dozers compared to age-, race-, and gender-matched controls.[27]

2. Benzene in solvents.[28]

a. A 1972 study based on census reports of occupation and cancer in England, revealed an SMR of 1.26 for multiple myeloma when the occupation was painters and decorators.[29]

b. A cohort mortality study of 416 Swedish paint manufacturers, with at least 5 years of exposure to organic solvents between 1955 and 1975, showed an increased risk for death from all hemolymphopoietic malignancies. There was also a statistically significant increased risk for death from multiple myeloma (OR 5.49, CI 1.13-16.06), with evidence of increased risk with increased level of exposure. All of the multiple myeloma cases occurred more than 15 years from first exposure, with exposure periods ranging from 15 to 43 years.[30]

27L. W. Figgs, M. Dosemeci, A. Blair, *Risk of multiple myeloma by occupation and industry among men and women: a 24-state death certificate study*, 36(11) J. Occup. Med. 1210-21 (1994).

28In performing a causation analysis, the expert's opinion should be said to utilize deductive clinical reasoning. As the Reference Guide on Toxicology, contained in the Federal Judicial Center's *Reference Manual on Scientific Evidence*, indicates:

> An expert who opines that exposure to a compound caused a person's disease engages in deductive clinical reasoning. . . . The opinion is based on temporal relationship between the exposure and disease, and exposure to other disease-causing factors. This information is then compared to research data on the relationship between exposure and disease. The certainty of the expert's opinion depends on the strength of the research data demonstrating a relationship between exposure and the disease at the dose in question and the absence of other disease-causing factors (also known as *confounding factors*).

Reference Manual on Scientific Evidence, at 205 (1994). The manual cites as an example of deductive clinical reasoning based on known facts about the toxic effects of a chemical, and the individual's pattern of exposure, the article by Professor Bernard D. Goldstein, *Is Exposure to Benzene a Cause of Human Multiple Myeloma?*, 609 Annals N.Y. Acad. Sci. 225 (1990).

29A. M. Adelstein, *Occupational mortality: Cancer*, 15 Ann. Occup. Hyg. 53-7 (1972).

30I. Lundberg, *Mortality and cancer incidence among Swedish paint industry workers with long-*

c. In a study of 327 multiple myeloma cases within the Kaiser Permanente Medical Care Program, only 150 were found to have occupational information in their medical records. Despite the paucity of exposure information increased risks for multiple myeloma were detected for painters (6 cases v. 2 expected) and carpenters(10 cases v. 5 expected).[31]

d. A case-control study of 399 English patients with multiple myeloma showed increased risk among painters. The incidence of multiple myeloma for individuals in painting among the cases was 3.8%, and that among the controls was 2.0%, almost a doubling of the percentage[32]

e. A case-control study of New Zealand multiple myeloma cases showed a statistically significant increased risk among painters (OR 1.95, CI 1.05-3.65), especially
among spray or car painters, and especially among workers under age 60 (OR 4.23, CI 1.80-9.91).[33]

f. A multicenter study of American myeloma cases has shown a significant increased risk in workers exposed to paint-related products, including solvents and paint thinners (OR 1.6, CI 1.1-2.4).[34]

g. Lifetime job histories from a population-based, case-control study were analyzed to investigate the relationship between multiple myeloma and employment in various occupations and industries. An elevated risk for multiple myeloma was observed among persons ever employed as painters, odds ration (OR)=2.1[95% confidence interval (CI)=1.2-3.6]. The OR increased to 4.1 [95% CI=1.8-10.4] for those employed for 10 or more years.[35]

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term exposure to organic solvents, 12 Scand. J. Work Environ. Health 108-113 (1986).

31G. D. Friedman, *Multiple myeloma: Relation to propoxyphene and other drugs, radiation, and occupation*, 15(3) Int. J. Epid. 424-426 (1986).

32J. Cuzick & B. De Stavola, *Multiple myeloma - a case-control study*, 57 Br. J. Cancer 516-520 (1988).

33P. B. Bethwaite, N. Pearce, & N. Fraser, *Cancer risks in painters: study based on the New Zealand cancer registry*, 47 Br. J. Ind. Med. 742-746 (1990).

34Morris, *supra* n. 20.

35Paul A. Demers, *et al*. *A case-control study of multiple myeloma and occupation*, 23 Am. J. Ind. Med. 629-639 (1993).

h. The NIOSH study of the Pliofilm cohort from an elevated statistically significant risk of multiple myeloma in 1987.[36] Subsequent follow-up of that cohort has failed to demonstrate an elevated risk of multiple myeloma.

3. Creosote exposure.

Creosote is a wood preservative consisting of several distillation fractions of coal tar and containing mutagenic polycyclic aromatic hydrocarbons or PAHs, such as benzo[a]pyrene and benzanthracene.[37] Railroad ties are almost exclusively treated with creosote which liberates coal tar pitch volatiles when heated.[38] Creosote is commonly mixed with coal tar or heavy petroleum when used for treating railroad cross ties.[39] Chemicals in creosote may be absorbed through the skin and the lungs, and may accumulate in the body, particularly in fat tissue.[40]

Workers exposed to coal tar products (coal tar, creosote, pitch) have been shown to have excess risk for hemolymphopoietic malignancies,

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36R. A. Rinsky, *et al. Benzene and leukemia, an epidemiologic risk assessment*, 316 N. Eng. J. Med. 1044-1050 (1987).

37R. B. Bos, *et al., The presence of the mutagenic polycytic aromatic hydrocarbons, benzo(2)pyrene and benzo(2)anthracene in creosote P1*, 130 Mut. Res. 153-158 (1984).

38International Agency for Research on Cancer. IARC Monographs on the evaluation of carcinogenic risks to humans. Coal-tars and derived products. Lyon, France: IARC 35:83-145 (1985).

39D. A. Webb, Creosote, its biodegradation and environmental effects. Am. Wood-Preserves' Association 65-69 (1980); A. S. Todd & C. Y. Timbie, Industrial hygiene surveys of occupational exposure to wood preservative chemicals. Washington DC; US DHHS, PHS, CDC, NIOSH; 1983 Feb. 10. Contract No. 210-78-0060.

40Agency for Toxic Substances and Disease Registry. Toxicological profile for creosote. US PHS, ATSDR: Clement International Corporation, 1990. Contract No. 205-88-0608. Pub No. TP-90-09; Agency for Toxic Substances and Disease Registry. Toxicological profile for creosote. ["Draft" Update for Public Comment]. US PHS, ATSDR: Research Triangle Institute, 1994. Contract No. 205-93-0606.

including multiple myeloma.[41]

41B. Persson, A-M. Dehlander, M. Fredericksson, Brage H. Noorlind, C-G. Oblson, O. Axelson, *Malignant lymphomas and occupational exposures*, 46 Br. J. Ind. Med. 516-520 (1989) (Swedish case-referent study of malignant lymphomas, showed a statistically significant increased risk for both Hodgkin's lymphoma and non-Hodgkin's lymphoma among individuals exposed to creosote); M. Silverstein, *et al., Mortality among workers exposed to coal tar pitch volatiles and welding emissions. An exercise in epidemiologic triage*, 75 Am. J. Pub. Health 1283-1287 (1985).

In the Flodin case-control study of 131 cases of multiple myeloma, a crude relative risk of 6.0 ($p<0.01$) was calculated for multiple myeloma among workers exposed to creosote. The risk remained significantly elevated after adjustment for age, ex-smoking, gender, and exposure to fresh wood, exhaust, concrete and brickwork, sulfonylurea, gamma radiation, and farming. The authors characterized creosote exposure as "potent in its effect" on the risk for multiple myeloma.[42]

D. *Daubert* considerations.

1. One must consider at the outset that the railroad, relying on *Daubert* will contest the scientific viability of the causal connection between the exposure and the contraction of multiple myeloma.

2. *Daubert v. Merrell Dow Pharmaceuticals, Inc.*, 509 U.S. 579, 113 S.Ct. 2786 (1993) was intended to relax the admissibility requirements for expert scientific evidence. *U.S. v. Jones*, 107 F.3d 1147, 1158 (6th Cir. 1997).

a. However, "'[t]he Federal Rules of Evidence require a judge to undertake 'a preliminary assessment of whether the reasoning or methodology underlying the testimony is scientifically valid and of whether that reasoning or methodology properly can be applied to the facts in issue.'" *Smelser v. Norfolk Southern Railway Company*, 105 F.3d 299, 302 (6th Cir. 1997), *quoting*, *Frymire-Brinati v. KPMG Peat Marwick*, 2 F.3d 183, 186-187 (7th Cir. 1993) (quoting *Daubert v. Merrell Dow Pharmaceuticals, Inc.*, 509 U.S. 579, 592-593, 113 S.Ct. 2786, 2796-2797 (1993)). *See also, Cook v. American Steamship Co.*, 53 F.3d 733, 737-738 (6th Cir. 1995) (when performing this gatekeeping function, the trial court must use a two-step inquiry which examines the expert's opinion testimony for reliability and relevance).

b. Courts are to determine "whether the experts' testimony reflects 'scientific knowledge,' whether their findings are 'derived by the scientific method,' and whether their work product amounts to 'good science.'" *Smelser v. Norfolk Southern Railway Company*, 105 F.3d 299, 303 (6th Cir. 1997), *quoting*, *Daubert v. Merrell Dow Pharmaceuticals, Inc.*, (on Remand), 43 F.3d 1311, 1315 (9th Cir. 1995), *cert. denied*, ___ U.S. ___, 116 S.Ct. 189 (1995) (quoting *Daubert*, 509 U.S. at 590, 593, 113 S.Ct. 2795, 2797).

c. "An expert opinion that is based on scientifically valid

42Flodin, *supra* n. 21.

principles will satisfy Fed.R.Evid. 702; an expert's subjective belief or unsupported speculation will not." *Smelser*, 105 F.3d at 303, *quoting*, *Daubert* (on Remand), [43] F.3d at 1316.

d. When considering reliability, the trial court must focus on the soundness of the expert's methodology and not the correctness of his conclusions. *Id*., *quoting*, *Daubert* (on Remand), 43 F.3d at 1318. "[B]y defining evidentiary reliability in terms of scientific validity . . . the *Daubert* Court has instructed the courts that they are not to be concerned with the reliability of the conclusions generated by valid methods, principles, and reasoning." *U.S. v. Bonds*, 12 F.3d 540, 556 (6th Cir. 1993). *But cf*., *General Electric Company v. Joiner*, ___ U.S. ___, 118 S.Ct. 512, 519, 139 L.Ed.2d 508 (1997)("[C]onclusions and methodology are not entirely distinct from one another").

e. "The Supreme Court provided the following non-exclusive list of factors to assist the trial court in its inquire: (1) whether a theory or technique can be (and has been) test, (2) whether the theory or technique has been subjected to peer review and publication, (3) the known or potential rate of error in using a particular scientific technique and the existence and maintenance of standards controlling the technique's operation, and (4) whether the theory or technique has been generally accepted in the particular scientific field." *Glaser v. Thompson Medical Co., Inc.*, 32 F.3d 969, 972 (6th Cir. 1994).

f. Finally, utilization of the *Daubert* factors facilitates a determination of whether an expert's analysis is acceptable under "standards governing how scientists conduct their research and reach their conclusions." *Smelser*, 105 F.3d at 303, *quoting*, *Daubert* (on Remand), 43 F.3d at 1316.

3. To defeat the *Daubert* motion *in limine*, special attention must be paid to the expert's methodology.[43] The expert should be asked during his/her deposition the following:

> Q. Would you explain the methodology that you employed to determine that the plaintiff's multiple myeloma was the result of his exposure to exhausts, creosote, and/or to his work as a painter?

You want the expert to respond as follows:

43Plaintiff is required to establish the experts' methodology and/or the expert's technique is reliable. *In Re: Paoli*, 35 F.3d 717, 743 (1994).

A. I met with the plaintiff and took a past medical history, environmental history and occupational history, looking for evidence of any predisposing or contributing factors to his eventual development of multiple myeloma. I basically did a complete evaluation of all of the factors in his life that increase his risk for the multiple myeloma.

I also reviewed all available past medical records to assess the consistency of his history to me with the evidence in the medical records.

I also reviewed all of the depositions available, again looking for evidence that gives me a consistent and realistic picture of his occupational exposures.

I reviewed all of the materials supplied by the defendants including safety data sheets and product information.

I performed a literature search *via* computer, read occupational medicine journals, toxicology journals, and industrial hygiene journals. I considered not only the supporting medical literature, but also the literature that was in disagreement.

I examined him, performed a physical examination, reviewed all of the laboratory studies concerning his health both prior to, during and after his diagnosis, as well as his current studies, and I also updated my evaluation of him in 1997 and extended my history after having read testimony by various individuals.

I also reviewed the literature over a number of years, specifically in relation to his exposures, and, in essence, combined all of that information and arrived at what I believe to be the correct diagnosis, which is that he developed multiple myeloma as a result of his occupational

exposures to creosote, exhaust, and/or his work as a painter.[44]

III. Conclusion.

Establishing causation for multiple myeloma is not an easy task. One must command a complete understanding of the disease, the medical and scientific literature, the evidentiary hurdles, and establish exposure to substances that are associated with an elevated risk of the disease. It is only when armed with adequate knowledge that one has the ability to obtain restitution for workers that suffer the painful existence and ultimate death that result from multiple myeloma.

44Expert testimony in a multiple myeloma case in the United States District Court for the Northern District of Ohio similar to the foregoing was sufficient, when the various medical articles cited above were utilized, to defeat the railroad's *Daubert* motion *in limine*. *Fannin v. N&W Railway Co.* Case No. 5:93CV2594, January 12, 1998 Pretrial Conference Ruling (N.D. Ohio).