



DEPARTMENT OF HEALTH AND HUMAN SERVICES

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National Institute for Occupational  
Safety and Health

Robert A. Taft Laboratories  
4876 Columbia Parkway  
Cincinnati OH 45226-1998

July 31, 2001

HETA 20010235

Brian Lewis  
PACE International Union  
3340 Perimeter Hill Drive  
Nashville, Tennessee 37211

Dear Mr. Lewis;

This letter is in response to your request to the National Institute for Occupational Safety and Health (NIOSH) for a Health Hazard Evaluation (HHE). Your request concerned exposure to perfluorooctanoic acid (PFOA) and perfluorooctane sulfonate (PFOS) among employees of the 3M Corporation in Cottage Grove, Minnesota. The request stated that employees had elevated blood fluoride levels. No health effects were noted. The request apparently stemmed from worker concerns regarding recent institution of engineering controls and the use of personal protective equipment (PPE) among employees in the fluorochemical department. In response to this request, I conducted telephone interviews with the Safety Director for the fluorochemical department, the local union president, and the Director of Occupational Medicine for 3M Corporation. This letter summarizes the findings of my evaluation and gives you information addressing your concerns.

### Background

#### *3M, Cottage Grove, Minnesota*

The 3M facility in Cottage Grove houses several divisions, one of which is the Specialty Materials Markets Group (previously known as the Chemical Division). The fluorochemical operations are one part of the Specialty Materials Markets Group.

Production of ammonium perfluorooctanoate (APFO), a synthetic surfactant, began in Cottage Grove in 1947. APFO dissociates rapidly in aqueous solution to PFOA. APFO is a white powder produced by an electrochemical process. It is then isolated and converted to a salt slurry, which in turn is converted to a salt cake, which is dried and packaged.<sup>1,2</sup> It was reported that the electrochemical cell used in the production of APFO is no longer running, but that drying and packaging of APFO still occurs in the Cottage Grove plant. Other fluorochemicals manufactured at Cottage Grove have perfluorooctane sulfonyl fluoride (POSF) as a precursor in a process similar to that described for PFOA. These compounds are transformed after absorption in the body to PFOS. Primary production of PFOS compounds has been at 3M facilities in Antwerp,

Belgium and Decatur, Alabama, with production in Cottage Grove being a much smaller operation. Therefore, published literature regarding health effects of PFOS have primarily included workers from Antwerp and Decatur, but should be applicable to Cottage Grove POSF production workers as well. POSF production was recently stopped in the Decatur facility and both POSF and APFO production are being phased out by 3M. There are currently approximately 33 workers in building 15, which is the main APFO production building and 10 to 20 workers in building 25, which the POSF production area.

Voluntary medical surveillance has been performed biennially since the 1970s on fluorochemical workers. Participation rates in the medical surveillance program during the 1990s were 50-70%.<sup>2</sup> Surveillance consists of a medical questionnaire, spirometry, a chemistry panel, urinalysis, and vital signs. Total serum fluorine levels were measured until the early 1990s when methods became available to analyze serum for specific fluorochemicals.

Serum PFOA levels in Cottage Grove employees ranged from 0-80 parts per million (ppm) with a mean of 5 ppm and a median of 1.1 ppm in 1993, from 0-114.1 ppm with a mean of 6.8 ppm and a median of 1.2 ppm in 1995, and from 0.1-81.3 ppm, with a mean of 6.4 ppm and a median of 1.3 ppm in 1997.<sup>2</sup> Serum PFOS levels in workers in 3M's Antwerp, Belgium, and Decatur, Alabama facilities ranged from 0-12.8 ppm (mean 2.19 ppm) in 1995 and 0.1-9.9 ppm (mean 1.75 ppm) in 1997.<sup>3</sup> Levels in 3M employees in corporate offices averaged 0.05 ppm.<sup>4</sup> Serum fluorine levels in the general population are reported to range from 0.01-0.13 ppm.<sup>5</sup>

### *Health Effects of PFOA*

Animal studies demonstrate that PFOA is absorbed by ingestion, inhalation, and dermal exposure and is not metabolized. It is eliminated primarily through the urine and feces. PFOA has an estimated half-life of 18-24 months in humans.<sup>5</sup> PFOA increases the incidence of liver, pancreas, and Leydig cell adenomas in lab animals.<sup>1,2</sup> The pancreatic adenomas may be due to mild elevations in cholecystokinin. PFOA also increased estradiol levels and decreased testosterone levels in rats.<sup>2</sup> It caused marked hepatic effects in animals, including liver enlargement, focal necrosis, changes in lipid metabolism, and reduced levels of lipids.<sup>6</sup>

Several epidemiologic studies have been conducted on PFOA workers at the Cottage Grove facility utilizing biennial medical surveillance data. Cholecystokinin levels were inversely related to serum PFOA levels, not elevated as seen in animal studies.<sup>2</sup> While one study found positive associations between serum fluorine levels and estradiol, prolactin, and thyroid stimulating hormone (TSH), and a negative relationship between serum fluorine and testosterone,<sup>7</sup> another did not find a significant relationship between serum PFOA levels and these hormones.<sup>1</sup> Gilliland and Mandel reported that in unadjusted analyses, total serum cholesterol, high density lipoprotein (HDL), low density lipoprotein (LDL), serum glutamic pyruvic transaminase (SGPT), gamma glutamyl transferase (GGT), or serum glutamic oxaloacetic transaminase (SGOT) were not correlated with total serum fluorine levels.<sup>6</sup> Ubel et al. found no evidence of adverse hepatic effects related to exposure to fluorochemicals.<sup>5</sup>

A retrospective cohort mortality study of Chemical Division workers employed during the time period 1948-1978 was performed.<sup>5</sup> This included both APFO and POSF workers. There was no excess of all-cause mortality, cancer-specific mortality, or any other cause of death. An update of this cohort through 1983 revealed an excess of prostate cancer mortality among men employed at least 10 years.<sup>8</sup> This was based on 4 prostate cancer deaths in the exposed workers. A further update of only PFOA workers through 1997 revealed no excess prostate cancer mortality risk, but did show a statistically nonsignificant increase in cerebrovascular disease mortality, although there was no dose-response relationship.<sup>9</sup> Mortality rates for all causes and for all cancers were lower than expected in the general population.

#### *Health Effects of PFOS*

PFOS concentrates in the liver and is excreted in both the urine and feces.<sup>3</sup> PFOS has an estimated half-life in serum of 1000-1500 days in humans.<sup>4</sup> Exposure in animals results in decreased serum cholesterol levels and metabolic wasting.<sup>3</sup> A study of PFOS production workers did not reveal statistically significant changes in hepatic enzymes, cholesterol, or other lipoproteins at serum PFOS levels less than 6 ppm.<sup>3</sup> Very few employees had serum PFOS levels higher than 6 ppm, therefore it was not possible to draw conclusions regarding exposure at those levels.

In a cohort mortality study of workers employed in the Alabama plant during the period 1961-1991, the all-cause mortality rates were statistically significantly lower than the general population.<sup>10</sup> Rates were also lower for all cancers combined but elevated for cancer of the lung, bronchus, and trachea, however, this elevation was not statistically significant. Cohort mortality was updated through 1998, and the all-cause mortality rates were still significantly lower than the general population.<sup>11</sup> However, there were three deaths from bladder cancer, resulting in a statistically significantly elevated rate. The author stated that it was unclear if these cases can be attributed to fluorochemical exposure, other occupational exposures, or non-occupational factors.

#### *Exposure Criteria*

The American Conference of Governmental Industrial Hygienists' (ACGIH®) Threshold Limit Value (TLV®) for APFO is 0.01 milligrams per cubic meter of air (mg/m<sup>3</sup>) as an 8-hour time-weighted average (TWA).<sup>12</sup> There is no NIOSH Recommended Exposure Limit (REL) or U.S. Department of Labor, Occupational Safety and Health Administration (OSHA) Permissible Exposure Limit (PEL) for APFO. The exposure limit for POSF set by 3M is 0.1 mg/m<sup>3</sup>.

3M developed an Occupational Biologic Limit Value (BLV) of 5 ppm for PFOA in March of 2000.<sup>13</sup> A BLV is defined as the best estimate of a level of a chemical substance or its metabolite(s) in a biological fluid that if present, even on a chronic basis, would not be expected to pose, or correlate with, a significant risk of adverse health effects. Workers with serum PFOA levels between 5 and 10 ppm undergo medical surveillance every 6 months compared to every 2 years for routine surveillance, but are allowed to remain in the work area as long as serum levels

decline on subsequent testing. Workers with levels > 10 ppm are removed from the area and monitored.

3M recently undertook an industrial hygiene assessment of the fluorochemical manufacturing process at the Cottage Grove facility. They identified work areas and tasks with potential exposures above the TLV for APFO. In response to these findings, process operator's job tasks were modified so that they were removed from the process areas and stationed primarily in an isolated control room. Entry into the process areas now requires PPE consisting of full-face respirators (either supplied air or air purifying, depending on the area), coveralls (either Tyvek® or rubber, depending on the area), nitrile gloves, and rubber boots. Access to the process areas is through a decontamination room. A large number of tasks with potential exposures above the TLV for APFO were identified, and action taken to reduce exposure including exhaust ventilation, machine enclosure, improved housekeeping, and improved worker training. None of the environmental air samples in non-process areas of the building, including the control room and decontamination rooms, had APFO concentrations above 0.002 mg/m<sup>3</sup>. Engineering controls and PPE similar to those added in the APFO area are utilized in the POSF production areas.

### **Conclusions and Recommendations**

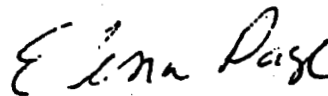
3M has an extensive medical surveillance and industrial hygiene monitoring program for fluorochemical workers at the Cottage Grove facility. Work areas have a combination of engineering controls, personal protective equipment, and administrative controls in place to reduce exposure to fluorochemicals. 3M has conducted or sponsored numerous animal and human health effects studies related to fluorochemical exposure. Most importantly, these fluorochemical manufacturing processes at Cottage Grove are being actively phased out.

Exposures to PFOA and PFOS at the levels encountered at 3M facilities have not been associated with adverse health effects. An epidemiologic study of POSF workers has identified a possible relationship between occupational exposure to POSF and bladder cancer. It should be noted that mortality studies may underestimate the incidence of bladder cancer since it is often not fatal. Conversely, other literature on the health effects of POSF has not indicated that it is a bladder carcinogen. Given the above, no conclusion can be drawn at this time concerning occupational exposures to POSF and bladder cancer.

I recommend that 3M continue current medical surveillance even after the phase-out of these products is complete, in order to more clearly ascertain the potential health effects of exposure to PFOA and PFOS. In addition, 3M should continue to update cohort mortality studies of these employees. 3M should closely follow available epidemiologic and clinical information regarding the potential risk of bladder cancer in workers exposed to POSF. Information available in the future may help determine if screening for bladder cancer among exposed employees would be useful.

I hope this information is helpful to you. This letter serves to close the file for this project. For the purpose of informing affected employees, copies of this report should be posted by the employer in a prominent place accessible to the employees for a period of 30 calendar days. If you have any further questions, please call me at (513) 841-4386.

Sincerely yours,



Elena H. Page, M.D., M.P.H.

Medical Officer

Medical Section

Hazard Evaluations and Technical

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cc:

Jeffrey Mandel, MD, MPH

## References:

1. Olsen GW, Gilliland FD, Burlew MM, Burris JM, Mandel JS, Mandel JH [1998]. An epidemiologic investigation of reproductive hormones in men with occupational exposure to perfluorooctanoic acid. *J Occup Environ Med.* 40(7):614-622.
2. Olsen GW, Burris JM, Burlew MM, Mandel JH [2000]. Plasma cholecystokinin levels and hepatic enzymes, cholesterol, and lipoproteins in ammonium perfluorooctanoate production workers. *Drug and Chemical Toxicology.* 23(4):603-620.
3. Olsen GW, Burris JM, Mandel JH, Zobel LR [1999]. Serum perfluorooctane sulfonate and hepatic and lipid clinical chemistry tests in fluorocarbon production workers. *J Occup Environ Med.* 41(9):799-806.
4. 3M [2000]. Draft initial assessment report: perfluorooctane sulfonic acid and its salts. Submitted to the United States Environmental Protection Agency.
5. Ubel FA, Sorenson SD, Roach DE [1980]. Health status of plant workers exposed to fluorocarbons - a preliminary report. *Am Ind Hyg Assoc J* 41:584-589.
6. Gilliland FD, Mandel JS [1996]. Serum perfluorooctanoic acid and hepatic enzymes, lipoproteins, and cholesterol: a study of occupationally exposed men. *Am J Ind Med.* 29:560-568.
7. Gilliland FD [1992]. Fluorocarbons and human health: studies in an occupational cohort. Doctoral dissertation, University of Minnesota. In: Olsen GW, Gilliland FD, Burlew MM, Burris JM, Mandel JS, Mandel JH [1998]. An epidemiologic investigation of reproductive hormones in men with occupational exposure to perfluorooctanoic acid. *J Occup Environ Med.* 40(7):614-622.
8. Gilliland FD, Mandel JS [1993]. Mortality among employees of a perfluorooctanoic acid production plant. *J Occup Environ Med.* 35(9):950-954.
9. Alexander BH [2001]. Mortality study of workers employed at 3M Cottage Grove facility. University of Minnesota School of Public Health.
10. Mandel JS, Johnson RA [1995]. Mortality study of employees at 3M plant in Decatur, Alabama. In: 3M [2000]. Draft initial assessment report: perfluorooctane sulfonic acid and its salts. Submitted to the United States Environmental Protection Agency.
11. Alexander BH [2001]. Mortality study of workers employed at 3M Decatur facility. University of Minnesota School of Public Health.
12. ACGIH [2001]. 2001 TLVs® and BEIs®: threshold limit values for chemical substances and physical agents. Cincinnati, OH: American Conference of Governmental Industrial Hygienists.
13. 3M [2000]. Documentation of an occupational biologic limit value for perfluorooctanoate.