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OCCUPATIONAL SAFETY AND HEALTH
STANDARDS BOARD

August 21, 2006

Keith Umemoto
Executive Officer, Occupational Safety and Health Standards Board
2520 Venture Oaks Way, Suite 350
Sacramento, CA 95833

Mr. Len Welsh
Acting Director, Cal/OSHA
1515 Clay Street, Suite 1901
Oakland CA 94612

RE: **Petition for a California Emergency Temporary Standard for Diacetyl**

Dear Mr. Umemoto and Mr. Welsh:

Pursuant to Labor Code Section 144.6 and 142.2 the United Food and Commercial Workers' Union, Western States Council and the California Labor Federation hereby petition the Occupational Safety and Health Standards Board (OSH Standards Board) to immediately issue an Emergency Temporary Standard (ETS) for diacetyl (2,3-butanedione, CAS # 431-03-8), a chemical used in flavorings. Exposure to diacetyl has been associated with many cases of severe lung disease among workers in microwave popcorn facilities and in factories where flavorings are produced and used. While the disease has been labeled "popcorn workers lung" workers throughout the food industry are at risk if they are exposed to diacetyl.

An Emergency Standard is needed because workers will continue to be under grave danger of life-threatening illness during the time it would take for the OSHA Standards Board to set a permanent standard. Cases have been occurring among workers in flavorings plants in California since at least 2004.

Workers exposed to diacetyl are at continuing high risk for severe, irreversible and potentially fatal respiratory disease, called *bronchiolitis obliterans*, because there are no enforceable OSHA standards requiring exposures to be controlled.

Diacetyl is an artificial flavoring used to impart the taste of butter in popcorn, pastries, frozen foods and candy. Dozens of diacetyl-exposed workers employed at popcorn plants have developed occupational lung disease and at least one has died. There is strong evidence that *bronchiolitis obliterans* is caused by exposure to diacetyl. This evidence

comes from studies done by the National Institute for Occupational Safety and Health at the factories in which workers have developed the disease, as well laboratory studies in which animals have been exposed to diacetyl or butter flavoring, and developed severe lung damage.^{i,ii,iii,iv,v,vi,vii,viii,ix,}

The disease is not limited to popcorn factories; cases of work-related lung disease have been reported among diacetyl-exposed workers employed at factories at which the flavorings are produced.^x

According to the Division of Occupational Safety and Health (DOSH), there are 16-20 plants producing flavorings in the state of California.^{ix} Moreover, thousands of California food production workers may be exposed to diacetyl and/or other chemicals that make up butter flavoring in industries including food flavoring manufacture, microwave popcorn, butter, cheese, cake mixes and flours, cookies and crackers, candy, chocolate, flavored oils and syrups, potato chips and other snacks and frostings.

The Emergency Temporary Standard should require employers to:

1. Control airborne exposure to diacetyl to below 0.05 ppm averaged over an eight-hour work period. A ceiling limit should also be set. Both levels should be based upon scientific evidence in order to protect workers against a significant risk of suffering severe respiratory disease;
2. Provide NIOSH-approved air-purifying respirators with organic vapor cartridges and particulate filters or supplied-air respirators to all employees exposed above 0.05 ppm and to employees with any airborne exposure on request;
3. Provide medical surveillance and written notice of the degree of such exposure to all employees exposed above 0.05 ppm;
4. Conduct initial and periodic monitoring of airborne exposure to diacetyl.

We also urge the OSHA Standards Board to:

Begin rule-making proceedings to establish a permanent standard to protect workers from exposure to all flavorings. The permanent standard should include a permissible exposure limit and ceiling limit that protect workers against a significant risk, methods of compliance, a detailed medical surveillance program, appropriate exposure monitoring, training and information.

In addition, we urge Cal/OSHA to immediately:

1. Issue a bulletin to all employers and employees potentially exposed to diacetyl stating that exposure may result in severe illness. This bulletin will notify employers of the hazard and ways to protect workers; failure to take appropriate precautions to protect workers would be grounds for citations under the General Duty clause;

2. Conduct inspections at facilities where workers are exposed to diacetyl. In workplaces where dangerous or uncontrolled exposure occurs, citations should be issued under General Duty cause.

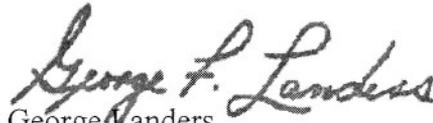
We have attached a statement submitted by forty-two leading occupational health physicians and scientists that accompanied the petition filed by the United Food and Commercial Workers International Union and the International Brotherhood of Teamsters to the Department of Labor on July 26, 2006 which summarizes the evidence that exposure to diacetyl poses a grave danger to workers, and supporting the call for immediate action to prevent irreversible lung disease among diacetyl-exposed workers. The statement of the physicians and scientists should be considered incorporated in this petition. As well, all of the references provided herein should be considered incorporated into the record.

On behalf of the thousands of California workers exposed to this highly hazardous chemical, we look forward to your timely and favorable response to this petition.

Respectfully Submitted,



Art Pulaski
Executive Secretary-Treasurer
California Labor Federation, AFL-CIO



George Landers
Executive Director
United Food and Commercial Workers
Western States Council

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Cc: Vickie Bradshaw, Secretary, Division of Industrial Relations

REFERENCES

- ⁱ Centers for Disease Control and Prevention. *Morbidity and Mortality Weekly Report*. Fixed obstructive lung disease in a microwave popcorn factory-Missouri, 2000-2002. 51:345-347 (Apr. 26, 2002). Available at: <http://www.cdc.gov/mmwr/preview/mmwrhtml/mm5116a2.htm>
- ⁱⁱ Kreiss K, et al. Clinical bronchiolitis obliterans in workers at a microwave-popcorn plant. *N Engl J Med*. 2002;347(5):330-338.
- ⁱⁱⁱ National Institute for Occupational Safety and Health. Preventing lung disease in workers who use or make flavorings. NIOSH Publication No. 2004-110, 2004. Available at: <http://www.cdc.gov/niosh/docs/2004-110/>
- ^{iv} Kanwal R, et al. Evaluation of flavorings-related lung disease risk at six microwave popcorn plants. *J Occup Environ Med*. 2006;48(2):149-157.
- ^v BASF. Report: study on the acute inhalation toxicity LC50 of diacetyl FCC as a vapor in rats 4-hour exposure. Project No. 1310247/927010, June 8, 1993. (Available at: <http://www.defendingscience.org/>)
- ^{vi} Hubbs AF, et al. Necrosis of nasal and airway epithelium in rats inhaling vapors of artificial butter flavoring. *Toxicol Appl Pharmacol*. 2002;185:128-135.
- ^{vii} Hubbs AF, et al. Inhalation toxicity of the flavoring agent, diacetyl (2,3-butanedione), in the upper respiratory tract of rats. *Toxicologist*. 2004 ;78(S-1):438-439. (Available at: <http://www.toxicology.org/AI/Pub/tox/2004Tox.pdf>)
- ^{viii} Michaels D, Monforton C. Scientific evidence in the regulatory system: Manufacturing uncertainty and the demise of the formal regulatory system. *J Law Policy* 2005;13(1): 17-41. Available at: <http://www.defendingscience.org/upload/Scientific-Evidence-in-the-Regulatory-System-Manufacturing-Uncertainty-and-the-Demise-of-the-Formal-Regulatory-System.pdf>
- ^{ix} Schneider A. Disease is swift, response is slow. *Baltimore Sun*. April 23, 2006. Available at: <http://www.baltimoresun.com/news/health/bal-te.flavoring23apr23,0,2684871.story?coll=bal-nationworld-utility>
- ^x Harrison R, Gelb A, Harber P. Department of Health Services, State of California. Food flavoring workers with bronchiolitis obliterans following exposure to diacetyl, California, May 15, 2006. Available at: http://www.capanet.org/pdfs/BO_cases_%20final_5_16_06.pdf

July 26, 2006

The Honorable Elaine L. Chao
Secretary of Labor
U.S. Department of Labor
200 Constitution Avenue, NW
Room S-2018
Washington, DC 20210

Dear Secretary Chao:

We are writing to express our strong support for the petition submitted by the United Food and Commercial Workers International Union and the International Brotherhood of Teamsters calling upon the Occupational Safety and Health Administration to issue an Emergency Temporary Standard (ETS) to protect workers exposed to the chemical diacetyl (2,3-butanedione, CAS # 431-03-8), and to initiate formal rulemaking for permanent regulations to protect workers exposed to diacetyl and other harmful flavoring-related chemicals.

Diacetyl is a commonly used food flavoring and is the primary constituent of artificial butter flavoring. There is compelling scientific evidence linking occupational exposure to diacetyl to *bronchiolitis obliterans*, a debilitating and sometimes fatal lung disease.

In the general population, *bronchiolitis obliterans* is rare. In the last few years, however, numerous cases have been reported to or identified by the National Institute for Occupational Safety and Health (NIOSH) among workers employed in factories where flavorings containing diacetyl are produced or used.¹ Dozens of workers employed at popcorn plants have developed occupational lung disease, and at least one has died. Several of these workers are on lung transplant lists.^{2,3,4}

The sentinel case of the recent outbreak of *bronchiolitis obliterans* was a Missouri microwave popcorn plant worker diagnosed with the condition in 1999. The physician who diagnosed the case notified Missouri's health department, which in turn notified the Centers for Disease Control and Prevention (CDC), NIOSH's parent agency. In August 2000, NIOSH began an investigation at the Jasper, Missouri microwave popcorn plant where eight current or former workers had developed the disease.⁵ In this investigation, NIOSH scientists found that respiratory symptoms were linked with exposure to diacetyl and butter flavor. Workers at this plant had chronic cough and shortness of breath at a rate 2.6 times higher than what would be expected in the U.S. population. Twice as many workers than expected reported being told by their physicians that they had asthma or chronic bronchitis. Lung function testing revealed that three times as many workers as expected had obstruction to airflow. These results were reported first in the CDC's *Morbidity and Mortality Weekly Report* and then in the *New England Journal of Medicine*.^{6,7} In all, NIOSH has conducted six investigations at 10

microwave popcorn facilities, finding respiratory impairment among workers at a majority of the plants.^{3,8,9,10,11,12}

Since the initial reports focused on individuals employed in microwave popcorn factories, the disease is often called “popcorn workers lung.”^{13,14} It has become clear, however, that the disease has struck workers in other segments of the food and flavoring industry, and is not limited to microwave popcorn facilities.¹⁵ The California Department of Health Services has recently reported two cases among diacetyl-exposed workers employed at factories at which the flavorings are produced.¹⁶

To pursue their investigations, NIOSH has developed sampling and analytical methods for measuring exposure to flavoring-related chemicals.¹⁷ At the Jasper, Missouri plant, diacetyl was measured in concentrations ranging as high as 98 parts per million parts air by volume (ppm), with a mean of 8.1 ppm.¹⁸ In their evaluation of six microwave popcorn plants (five of which had workers with flavoring-associated lung disease), NIOSH scientists reported that the “lowest mean TWA [time weighted average] diacetyl air concentrations that we measured in mixing areas (0.02 ppm personal exposure and 0.2 ppm area air concentration) were at a plant with an affected mixer.” On the basis of this finding, the NIOSH scientists concluded “it would seem prudent to maintain worker exposures to diacetyl below these levels.”¹⁹

The role of diacetyl in the development of *bronchiolitis obliterans* has been confirmed in studies of laboratory animals. In 1993, a manufacturer of diacetyl conducted a study, which was never reported to the government or published in scientific literature, in which rats were exposed to pure diacetyl. The study found that one four-hour period of exposure to diacetyl resulted in an “abundance of symptoms indicative for respiratory tract injury.”²⁰ Following the recent outbreak of cases among humans, NIOSH scientists conducted a study in which rats were exposed to airborne concentrations of heated butter flavoring, of which diacetyl was the primary constituent. The rats were exposed for a single, six-hour period. The scientists reported significant lung damage among rats whose exposure was as low as 203 ppm, which according to the authors was “not extraordinary when compared with levels measured in the workplace.”²¹ NIOSH scientists then conducted a study in which rats were exposed to pure diacetyl and found similar results.²² A toxicological study of guinea pigs exposed to diacetyl found exposure to the chemical caused adverse effects to respiratory tissue and structure.²³

Although the precise number of workers already suffering respiratory effects from exposure to diacetyl is unknown, the potential magnitude of the problem is sizeable. NIOSH is currently investigating 15 cases of respiratory disease, including some workers with *bronchiolitis obliterans*, among the employees at a single Cincinnati, Ohio flavor manufacturing plant.³

Additional research will provide useful data on the mechanism through which flavoring-related chemicals cause obstructive lung disease. However, NIOSH has already generated sufficient information for OSHA to issue rules to reduce exposure to these toxic chemicals. In their recent report, NIOSH scientists wrote that “(b)ecause entirely safe levels of occupational exposure to butter-flavoring chemicals are not known, it is important to limit

worker exposures as much as possible.”¹⁹ It is the regulatory responsibility of OSHA to protect workers from exposure to workplace hazards. OSHA has issued permissible exposure limits (PELs) and/or NIOSH has recommended exposure limits (RELs) for only 46 of the 1,037 flavoring ingredients considered by the flavorings industry to represent potential respiratory hazards.¹ This regulatory gap² needs to be addressed; for this reason, we support the United Food and Commercial Workers (UFCW) and the International Brotherhood of Teamsters (IBT) petition to OSHA to initiate formal rulemaking to establish a permanent standard to protect workers from lung disease caused by flavoring-related chemicals.

Until OSHA completes permanent rulemaking on flavoring-related chemicals, an ETS for diacetyl is essential. The data gathered by NIOSH indicate an appropriate emergency PEL would be below 0.2 ppm.¹⁹ In order to provide a sufficient margin of safety, the petition calls for an emergency temporary PEL of 0.05 ppm, averaged over an eight-hour day. Although other flavoring-related chemicals are likely to contribute to the adverse lung effects as well, controlling exposure to diacetyl, a known cause of *bronchiolitis obliterans* and a primary component of butter flavor, will also result in the reduction of exposure to other airborne contaminants in the workplace.

In summary, there is compelling epidemiologic and toxicological evidence linking exposure to diacetyl to severe respiratory impairment and disease. It is more than thirty months since NIOSH issued an alert calling upon employers to “minimize occupational exposures to flavorings or flavoring ingredients.”¹ It is now time for OSHA to use the scientific evidence to protect American workers from debilitating lung disease.

If you have any questions regarding this matter, please contact:

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REFERENCES

- ¹ National Institute for Occupational Safety and Health. Preventing lung disease in workers who use or make flavorings. NIOSH Publication No. 2004-110, 2004. Available at: <http://www.cdc.gov/niosh/docs/2004-110/>
- ² Michaels D, Monforton C. Scientific evidence in the regulatory system: Manufacturing uncertainty and the demise of the formal regulatory system. *J Law Policy* 2005;13(1): 17-41. Available at: <http://www.defending-science.org/upload/Scientific-Evidence-in-the-Regulatory-System-Manufacturing-Uncertainty-and-the-Demise-of-the-Formal-Regulatory-System.pdf>
- ³ Schneider A. Disease is swift, response is slow. *Baltimore Sun*. April 23, 2006. Available at: <http://www.baltimoresun.com/news/health/bal-te.flavoring23apr23.0.2684871.story?coll=baltimore-world-utility>
- ⁴ Akpınar-Elci M, Travis WD, Lynch DA, Kreiss K. Bronchiolitis obliterans syndrome in popcorn plant workers. *Eur Resp J* 2004;24: 298-302.
- ⁵ NIOSH Health Hazard Evaluation Report. HETA-2000-0401-2991: Gilster-Mary Lee Corporation, Jasper, Missouri. (January 2006). Available at: <http://www.cdc.gov/niosh/hhe/reports/pdfs/2000-0401-2991.pdf>
- ⁶ Centers for Disease Control and Prevention. *Morbidity and Mortality Weekly Report*. Fixed obstructive lung disease in a microwave popcorn factory-Missouri, 2000-2002. 51:345-347 (Apr. 26, 2002). Available at: <http://www.cdc.gov/mmwr/preview/mmwrhtml/mm5116a2.htm>
- ⁷ Kreiss K, et al. Clinical bronchiolitis obliterans in workers at a microwave-popcorn plant. *N Engl J Med*. 2002;347(5):330-338.
- ⁸ NIOSH Health Hazard Evaluation Report. HETA 2003-0112-2949: ConAgra Snack Foods, Marion, Ohio. (December 2004) Available at: <http://www.cdc.gov/niosh/hhe/reports/pdfs/2003-0112-2949.pdf>
- ⁹ NIOSH. Letter to Frank Morrison, Nebraska Popcorn, regarding HETA 2002-0089: Nebraska Popcorn, Clearwater, Nebraska. (July 2, 2003). Available at: <http://www.cdc.gov/niosh/hhe/reports/pdfs/2002-0089-letter.pdf>
- ¹⁰ NIOSH. Letter to Keith Heuermann, B.K. Heuermann Popcorn, regarding HETA 2001-0517, B.K. Heuermann Popcorn Inc., Phillips, Nebraska. (May 13, 2003) Available at: <http://www.cdc.gov/niosh/hhe/reports/pdfs/2001-0517-letter.pdf>
- ¹¹ NIOSH Health Hazard Evaluation Report. HETA 2001-0474-2943: American Pop Corn Company, Sioux City, Iowa. (July 2004). Available at: <http://www.cdc.gov/niosh/hhe/reports/pdfs/2001-0474-2943.pdf>
- ¹² NIOSH Health Hazard Evaluation Report. HETA-2002-0408-2915: Agrilink Foods Popcorn Plant, Ridgeway, Illinois. (October 2003). Available at: <http://www.cdc.gov/niosh/hhe/reports/pdfs/2002-0408-2915.pdf>
- ¹³ Schachter EN. Popcorn workers lung. *N Engl J Med*. 2002;347(5):360-361.

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- ¹⁴ Parmet AJ, Von Essen S. Rapidly progressive, fixed airway obstructive disease in popcorn workers: a new occupational pulmonary illness? *J Occup Environ Med.* 2002;44:216-218.
- ¹⁵ Lockey J.E. et al. Bronchiolitis obliterans in the food flavoring manufacturing industry. Abstract presented at the Annual Meeting of The American Thoracic Society, 20 May 2002. Available at: <http://www.abstracts2view.com/atsall/>
- ¹⁶ Harrison R, Gelb A, Harber P. Department of Health Services, State of California. Food flavoring workers with bronchiolitis obliterans following exposure to diacetyl, California, May 15, 2006. Available at: http://www.capanet.org/pdfs/BO_cases_%20final_5_16_06.pdf
- ¹⁷ Pendergrass SM. Method development for the determination of diacetyl and acetoin at a microwave popcorn plant. *Environ Sci Technol.* 2004;38(3):858-861.
- ¹⁸ Kullman G, et al. Characterization of respiratory exposures at a microwave popcorn plant with cases of bronchiolitis obliterans. *J Occup Environ Hyg.* 2005;2:169-178.
- ¹⁹ Kanwal R, et al. Evaluation of flavorings-related lung disease risk at six microwave popcorn plants. *J Occup Environ Med.* 2006;48(2):149-157.
- ²⁰ BASF. Report: study on the acute inhalation toxicity LC50 of diacetyl FCC as a vapor in rats 4-hour exposure. Project No. 1310247/927010, June 8, 1993. Available at: <http://www.defendingscience.org/>
- ²¹ Hubbs AF, et al. Necrosis of nasal and airway epithelium in rats inhaling vapors of artificial butter flavoring. *Toxicol Appl Pharmacol.* 2002;185:128-135.
- ²² Hubbs AF, et al. Inhalation toxicity of the flavoring agent, diacetyl (2,3-butanedione), in the upper respiratory tract of rats. *Toxicologist.* 2004 ;78(S-1):438-439. Available at: <http://www.toxicology.org/AI/Pub/tox/2004Tox.pdf>
- ²³ Fedan JS, Dowdy JA, Fedan KB, Hubbs AF. Popcorn worker's lung: In vitro exposure to diacetyl, an ingredient in microwave popcorn butter flavoring, increases reactivity to methacholine. *Toxicol Appl Pharmacol* (in press). Abstract: Proc Am Thorac Soc 2005 May; 2(Abstracts):A814.