



OSHA Direction

U.S. DEPARTMENT OF LABOR

Occupational Safety and Health Administration

DIRECTION NUMBER: DIR 11-01 (CPL 03)

EFFECTIVE DATE: January 18, 2011

SUBJECT: National Emphasis Program – Microwave Popcorn Processing Plants

ABSTRACT

- Purpose:** This Direction describes policies and procedures for implementing a National Emphasis Program to identify and reduce or eliminate exposures to butter-flavoring chemicals used in microwave popcorn manufacturing facilities.
- Scope:** This Direction applies OSHA-wide.
- References:**
- A. OSHA Instruction CPL 02-00-148, November 9, 2009, Field Operations Manual (FOM).
 - B. OSHA Notice 10-06 (CPL 02) - Site-Specific Targeting 2010 Effective, August 18, 2010.
 - C. OSHA Instruction CPL 02-02-038 (CPL 2-2.38D), March 20, 1998, Inspection Procedures for the Hazard Communication Standard.
 - D. OSHA Instruction CPL 02-00-120 (CPL 2-0.120), September 25, 1998, Inspection Procedures for the Respiratory Protection Standard.
 - E. Memorandum for Regional Administrators, Area Directors, State Plan Designees, Consultation Program Managers, October 12, 2004, Subject: Popcorn/Flavoring Establishment Assistance.
 - F. NIOSH Health Hazard Evaluation Report: Gilster-Mary Lee Corporation. Publication # HETA 2000-0401-2991.
 - G. OSHA Publication, Hazard Communication Guidance for Diacetyl and Certain Food Flavorings Containing Diacetyl.

- H. OSHA Instruction CPL 02-02-072, August 27, 2007, Rules of Agency Practices and Procedures Concerning OSHA Access to Employee Medical Records.
- I. OSHA Safety and Health Information Bulletin (SHIB), Respiratory Disease Among Employees in Microwave Popcorn Processing Plants, September 24, 2007.
- J. OSHA Instruction CPL 03-00-011, October 30, 2009, National Emphasis Program-Facilities that Manufacture Food Flavorings Containing Diacetyl.
- K. OSHA Direction CPL 03-00-05, July 27, 1997, National Emphasis Program Microwave Popcorn Processing Plants.
- L. NIOSH Health Hazard Evaluation Report: Report on an Investigation of Buttermilk Flavoring Exposures and Respiratory Health at a Bakery Mix Production Facility. Publication # HETA 2008-0230-3096.

Cancellations: None.

State Impact: Notice of Intent and Adoption Required. See Paragraph VI.

Action Offices: OSHA National, Regional and Area Offices, State Plan and State Consultation Offices

Originating Office: Office of Health Enforcement

Contact: Directorate of Enforcement Programs
Office of Health Enforcement
200 Constitution Avenue, NW
Washington, DC 20210
202-693-2190

By and Under the Authority of

David Michaels, PhD, MPH
Assistant Secretary

Executive Summary

In January 2006, the National Institute for Occupational Safety and Health (NIOSH) released a Health Hazard Evaluation Report on their investigation at a microwave popcorn production facility. Several former workers from this facility were diagnosed with bronchiolitis obliterans, a severe obstructive lung disease. Following this investigation and the evaluation of lung function tests and air sampling results, NIOSH determined that inhalation exposure to butter-flavoring chemicals such as diacetyl present a risk for occupational lung disease. In 2010, a NIOSH study indicated that 2,3-pentanedione, a diacetyl substitute, produces similar health effects as diacetyl in rats. Similarly, a 2010 National Institute of Environmental Health Sciences (NIEHS) study also demonstrated effects in rats and mice from exposure to 2,3-pentanedione. This updated Direction establishes a National Emphasis Program (NEP) that focuses on 2,3-pentanedione, 2,3-hexanedione, 2,3-heptanedione and all other related diacetyl substitutes that share the same alpha-diketone structure, as well as substitutes diacetyl trimer and acetoin. It will also provide guidance on targeting, inspection procedures, engineering controls, work practice controls and compliance assistance.

Significant Changes

This Direction revises the previous Microwave Popcorn initiative by the Occupational Safety and Health Administration to include 2,3-pentanedione and other related diacetyl substitutes such as 2,3-hexanedione and 2,3-heptanedione.

Table of Contents

I.	Purpose	1
II.	Scope	1
III.	References	1
IV.	Cancellations	2
V.	Action Offices.....	2
VI.	Federal Program Change.....	2
VII.	Expiration	2
VIII.	Significant Changes.....	2
IX.	Application	3
X.	Background.....	3
XI.	National Emphasis Program Goals.....	8
XII.	Program Procedures.....	8
XIII.	OSHA's Response Efforts and Outreach.....	10
XIV.	Inspection Procedures.....	12
XV.	Consultation.....	24
Appendix A.	Establishment List of NAICS and SIC Codes	
Appendix B.	Health Care Form Letter	
Appendix C.	Sample Hazard Alert Letter	
Appendix D.	Guidelines for Air Sampling	
Appendix E.	Description of Hazard at Gilster-Mary Lee, Jasper, Missouri	
Appendix F.	CSHO Guidance for Worker Interviews	
Appendix G.	Recommended Engineering and Work Practice Controls	
Appendix H.	Safety & Health Precautions for Compliance Staff	
Appendix I.	References	

- I. Purpose. This Direction describes policies and procedures for implementing a National Emphasis Program (NEP) to identify and reduce or eliminate exposures to butter-flavoring chemicals including diacetyl substitute 2,3-pentanedione and other alpha-diketone compounds used in microwave popcorn manufacturing facilities.
- II. Scope. This Direction applies OSHA-wide.
- III. References.
 - A. OSHA Instruction CPL 02-00-148, November 9, 2009, Field Operations Manual (FOM).
 - B. OSHA Notice 10-06 (CPL 02) - Site-Specific Targeting 2010 (SST-10) Effective, August 18, 2010.
 - C. OSHA Instruction CPL 02-02-038 (CPL 2-2.38D), March 20, 1998, Inspection Procedures for the Hazard Communication Standard.
 - D. OSHA Instruction CPL 02-00-120 (CPL 2-0.120), September 25, 1998, Inspection Procedures for the Respiratory Protection Standard.
 - E. Memorandum for Regional Administrators, Area Directors, State Plan Designees, Consultation Program Managers, October 12, 2004, Subject: Popcorn/flavoring Establishment Assistance.
 - F. NIOSH Health Hazard Evaluation Report: Gilster-Mary Lee Corporation. Publication # HETA 2000-0401-2991.
 - G. OSHA Publication, Hazard Communication Guidance for Diacetyl and Certain Food Flavorings Containing Diacetyl.
 - H. OSHA Instruction CPL 02-02-072, August 27, 2007, Rules of Agency Practices and Procedures Concerning OSHA Access to Employee Medical Records.
 - I. OSHA Safety and Health Information Bulletin (SHIB), Respiratory Disease Among Employees in Microwave Popcorn Processing Plants, September 24, 2007.
 - J. OSHA Instruction CPL 03-00-011, October 30, 2009, National Emphasis Program-Facilities that Manufacture Food Flavorings Containing Diacetyl.
 - K. OSHA Direction CPL 03-00-05, July 27, 2007, National Emphasis Program Microwave Popcorn Processing Plants.
 - L. NIOSH Health Hazard Evaluation Report: Report on an Investigation of Buttermilk Flavoring Exposures and Respiratory Health at a Bakery Mix

Production Facility. Publication # HETA 2008-0230-3096.

- IV. Cancellations. None. This NEP revises and updates CPL 03-00-005, July 27, 2007, National Emphasis Program-Microwave Popcorn Processing Plants which expired after one year and was not renewed. Compliance Directive 03-00-011, October 30, 2009, National Emphasis Program-Facilities that Manufacture Food Flavorings Containing Diacetyl is currently in effect and will expire at the end of three years.
- V. Action Offices.
- A. Responsible Office Directorate of Enforcement Programs, Office of Health Enforcement.
- B. Action Offices National, Regional and Area Offices; Consultation Project Managers.
- C. Information Offices OSHA National Offices.
- VI. Federal Program Change Notice of Intent and Adoption Required. This Direction describes a Federal program change which establishes a new National Emphasis Program (NEP) to identify and reduce or eliminate employee exposures to flavoring chemicals used in microwave popcorn manufacturing facilities. The Direction adds 2,3-pentanedione and all related diacetyl substitutes to the list of flavoring chemicals included in the previous (2007) NEP on popcorn manufacturing facilities (CPL 03-00-005). Because this is a significant national initiative, States where employees have exposures to these flavoring chemicals must participate in this emphasis effort. A list of manufacturers of microwave popcorn is available on the Directorate of Enforcement Programs Intranet Web Page. States must code inspections under this NEP in accordance with the instructions in paragraph XIV.J of this Direction.
- The State's notice of intent must indicate whether the State's emphasis program will be identical to or different from the Federal program. The State's implementing policies and procedures are expected to be at least as effective as those in this direction and must be available for review. If the State's program differs from the Federal one, the State may either post its different emphasis program on its State plan website and provide the link to OSHA or provide an electronic copy to OSHA with information on how the public may obtain a copy. OSHA will provide summary information on the State responses to this instruction on its Web site.
- VII. Expiration. This Direction will expire one (1) year from the date of issuance. However, at the end of the one-year period, OSHA will re-evaluate our efforts to determine whether it is necessary to continue this NEP.
- VIII. Significant Changes. This Direction revises and updates the previous National Emphasis Program-Microwave Popcorn Processing Plants CPL 03-00-005 (July 27, 2007), to include 2,3-pentanedione, a diacetyl substitute, and all other related substitutes sharing

the same alpha-diketone structure.

IX. Application. This Direction applies to all establishments that manufacture and process microwave popcorn, and in which butter-flavoring chemicals are used. The following popcorn manufacturing establishments do not fall within the scope of the NEP: Facilities that Manufacture Food Flavorings Containing Diacetyl.

X. Background.

In May 2000, the Missouri Department of Health and Senior Services (MDHSS) received information concerning eight individuals who had worked at the same microwave popcorn processing facility and appeared to have developed bronchiolitis obliterans, a rare, fixed obstructive disease of lung airways that impairs breathing. A ninth case was discovered later in the same Jasper, Mo. plant. The nine individuals had been employed at this microwave popcorn production facility for eight months to 17 years. They first noticed breathing problems five months to nine years (median, 1.5 years) after starting work at this facility. Five of the former workers had worked in the mixing room where butter flavorings and oil are mixed. The other four had worked on the packaging lines where popcorn and the oil/flavorings mixture are added to microwaveable bags and packaged for shipment. The workers reported similar symptoms, including progressive shortness of breath, persistent cough, and unusual fatigue. Five of the nine workers were placed on a lung transplant candidate list (Ref. 1). One of the workers died in April 2006 without receiving a lung transplant. She had worked for 18 months at the plant during the mid-1990s.

Using information supplied by the employer relating to the eight original cases, the initial incidence of disease for the microwave popcorn mixing and packaging areas was determined. The four ill individuals who worked in the mixing area represented 31 percent of the estimated 13 persons who worked in that area between 1992 and 2000. The other four ill workers who worked on the packaging line never worked in the mixing area and represented 1.4 percent of the estimated 272 personnel who worked in this area between 1992 and 2000.

Since the incidence of bronchiolitis obliterans raised concern, MDHSS continued to investigate the illnesses and the conditions at the facility, and requested technical assistance from the National Institute for Occupational Safety and Health (NIOSH) in August 2000.

Based on the results of their initial investigation, NIOSH researchers concluded that the bronchiolitis obliterans identified in the eight former workers was most likely caused by occupational exposure to volatile butter-flavoring ingredients, including diacetyl (Ref. 2). NIOSH used diacetyl as a marker of exposure to volatile flavorings in other working areas of the plant. Area sample results indicated that diacetyl concentrations ranged from below the limit of detection ≤ 0.25 parts per million (ppm) to 97.9 ppm. To protect workers during the initial and subsequent phases of the investigation, NIOSH and MDHSS recommended the installation and use of exposure controls in the facility. These

controls included general dilution ventilation, local exhaust ventilation of tanks that contained butter flavorings, process isolation, and personal protective equipment (respiratory, skin and eye protection). NIOSH evaluated data from several follow-up medical and environmental surveys at this facility to assess the effects of these exposure controls on worker health. NIOSH published an Alert on flavorings-related lung disease (Ref. 3) and created a Safety and Health Topics page on this subject on its website (Ref. 4).

Since 2000, NIOSH investigated a total of six microwave popcorn manufacturing facilities, including the Jasper, Mo. plant described above. Additional cases of lung disease characterized by fixed airways obstruction, including bronchiolitis obliterans, have been recognized among workers at these microwave popcorn plants as well as among those who manufacture flavorings for foods outside the microwave popcorn manufacturing industry (Ref. 3, 5). NIOSH's survey identified six workers with clinical findings consistent with bronchiolitis obliterans. These involved one mixer at each of three plants and three packaging line workers at a fourth plant (Ref. 5). Analysis of air samples for diacetyl at the plants where these six individuals worked indicated much lower mean concentrations than those found in comparable areas of the Jasper, Mo. plant- 0.6 ppm (1.6 percent of the mean in Jasper) or less in the mixing areas for the three mixers and 0.3 ppm (16 percent of the mean in Jasper) in the packaging area for the three packagers (Ref.5). Since these cases occurred at much lower levels of diacetyl than those initially measured in the Jasper, Mo. plant, NIOSH concluded that worker exposure to butter-flavoring chemicals should be limited as much as possible (Ref. 5).

In 2007 OSHA issued the NEP for Microwave Popcorn Processing Plants CPL 03-00-005 (July 27, 2007). The NEP targeted 42 (19 Federal, 23 State Plan) facilities that were known to manufacture microwave popcorn. A total of 36 inspections were conducted (14 Federal, 22 State Plan). However, since becoming aware of the effects of diacetyl, some microwave popcorn manufacturers substituted other chemicals that impart the same butter flavor as diacetyl. These buttery substitutes are preferred instead of natural butter because natural butter could not withstand the manufacturing process. Some of the known substitutes are 2,3-pentanedione, diacetyl trimer, and acetoin. While some employers have attempted to phase out the use of diacetyl, others still prefer its buttery flavor and continue to use it. (Ref. 6).

In July 2008, NIOSH received a Health Hazard Evaluation (HHE) request from a California facility. This facility, a bakery mix production facility, in the past used a liquid buttermilk flavoring containing 15-20% diacetyl. The facility has since reformulated its buttermilk flavoring with alpha-diketone compounds. NIOSH reported that 2,3-pentanedione was the major alpha-diketone substitute found. Other diacetyl substitutes found included 2,3-hexanedione, 2,3-heptanedione, and acetoin. The reformulated compound was also found to contain less than 1% diacetyl. The results of NIOSH's sampling detected measurable concentrations of 2,3-pentanedione in the production room. However, NIOSH did not find measurable concentrations of diacetyl using fully validated methods. NIOSH assessed 23 workers' lung function using spirometry, and found that four workers had a restrictive pattern ranging from mild to

moderately severe but none reported an obstructive pattern. Higher than expected rates of shortness of breath were observed among surveyed workers and two workers reported asthma-like symptoms that diminished once they were away from the work environment.

Fixed Airways Obstruction and Bronchiolitis Obliterans

The lung disease identified in the NIOSH investigations is characterized by spirometry (lung or pulmonary function tests, PFT) findings of fixed airways obstruction. Airways obstruction is diagnosed when the person tested has difficulty blowing air out of the lungs. A fixed obstruction means that there is no improvement in lung function even after administration of asthma medication (i.e., bronchodilators). Symptoms of fixed airways obstruction include cough, fatigue, and shortness of breath upon exertion. Symptoms usually have a gradual onset, but in some cases severe symptoms have occurred suddenly with rapid progression of lung disease. Symptoms generally do not improve when workers go home for the weekend or go on vacation. In some instances, lung function tests have indicated that workers had fixed airways obstruction even in the absence of respiratory symptoms (Ref. 3).

According to the Centers for Disease Control and Prevention (CDC), bronchiolitis obliterans is “a rare, severe lung disease characterized by cough, dyspnea (shortness of breath) on exertion, and airways obstruction that does not respond to bronchodilators” (Ref. 7). Established occupational risk factors for this chronic lung disease include inhalation of toxic fumes, grain dusts, mineral dusts, welding fumes, and irritant gases (Ref. 8). Bronchiolitis obliterans also has been associated with other types of inhalational injuries, infectious agents (viruses and atypical bacteria), allergic reactions, drugs, and a variety of medical conditions such as connective tissue disorders (Ref. 8, 9). In a number of cases, the disease is idiopathic (i.e., there is no known cause). The symptoms of bronchiolitis obliterans can occur in some cases as quickly as 4-6 hours after exposure to certain kinds of toxic substances, resulting in acute respiratory distress (Ref. 9). Weeks later, the worker may develop irreversible respiratory obstruction (Ref. 9). The original eight cases from the plant in Jasper, Mo. did not have a history of acute toxic exposure and likely developed lung disease over a longer period of time. They failed to show improvement in pulmonary function following oral corticosteroid treatment (Ref. 1).

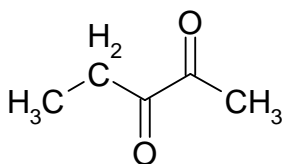
Diacetyl

Diacetyl (2,3-butanedione), an alpha-diketone, is used to produce a butter flavor in foods and occurs naturally in some foods, such as dairy products, wine, and beer (Ref. 10, 11, 12). NIOSH identified diacetyl as one of the most common volatile organic compounds (VOCs) found during investigations of microwave popcorn and flavoring manufacturing facilities. Diacetyl may be found in other types of flavorings in addition to butter flavorings. For example, diacetyl was used in the production of a vanilla flavoring powder during a NIOSH investigation of a California flavoring manufacturing facility (Ref. 13). Diacetyl reacts with the amino acid arginine (Ref. 14) and inhibits enzymes containing arginine that are important for protecting cells from oxidative damage (Ref. 15, 16). Diacetyl does not have an

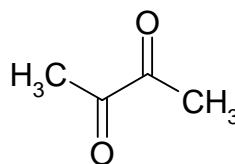
OSHA PEL or a NIOSH Recommended Exposure Limit (REL), although OSHA has initiated rulemaking for flavorings containing diacetyl pursuant to its authority under Section 6(b) of the Occupational Safety and Health Act. Diacetyl has been detected and used as a marker for flavoring exposure in NIOSH investigations in microwave popcorn and flavoring manufacturing facilities where cases of fixed obstructive lung disease, including bronchiolitis obliterans, have been diagnosed (Ref. 5, 13). However, in some facilities, flavoring manufacturers have replaced diacetyl with alternative flavoring chemicals such as, 2,3-pentanedione (acetyl propionyl) and diacetyl trimer in formulating butter and other flavorings.

2,3-Pentanedione (acetyl propionyl)

The chemical 2,3-pentanedione is a yellow liquid that exists as an alpha-diketone. It shares the same alpha-diketone structure as diacetyl and may share the same mechanism of toxicity. The diacetyl substitute 2,3-pentanedione provides a buttery flavor like diacetyl; however, it is less water soluble than diacetyl.



2,3-Pentanedione
C₅H₈O₂



Diacetyl (2,3-butanedione)
C₄H₆O₂

As a result of the structural similarity of 2,3-pentanedione to diacetyl and the lack of toxicity studies regarding 2,3-pentanedione, NIOSH and NIEHS each conducted a study about the health effects of exposure to this chemical.

The first, a study by NIOSH entitled *Airway Epithelial Toxicity of the Flavoring agent, 2,3-Pentanedione*, investigated the acute respiratory toxicity of 2,3-pentanedione. After 6 hours of being exposed to 2,3-pentanedione, the rats in this study exhibited airway epithelial changes including degeneration, apoptosis (programmed cell death), necrosis (tissue death) and neutrophilic (a white blood cell) inflammation, with nasal epithelium being most affected. As exposure concentration increased, epithelium damage and inflammation increased in severity. This inhalation study indicates that 2,3-pentanedione injures the airways in a similar manner as diacetyl. Injuries are predominantly to the nasal epithelium, but effects are also in deeper airways. Additionally, after 2,3-pentanedione inhalation, clinical and histopathologic toxicity are delayed. (Ref. 17).

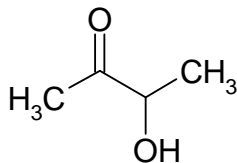
The other study, conducted by NIEHS and entitled *Inhalation Toxicity of Acetyl Propionyl in Rats and Mice*, investigated the toxicity of 2,3-pentanedione in the upper respiratory tract. The results showed that these rats and mice exhibited acute suppurative and necrotizing rhinitis (inflammation in the nasal tissues consisting of pus and tissue death), marked acute erosive and necrotizing tracheitis (inflammation in the trachea

consisting of ulcers and tissue death), and most showed acute maxillary sinusitis (Ref. 18). These results indicate that inhaled 2,3-pentanedione causes similar respiratory tract toxicity as that of diacetyl.

Other Diacetyl substitutes: 2,3-hexanedione, 2,3-heptanedione, diacetyl trimer, and acetoin

At the California facility, in addition to 2,3-pentanedione, NIOSH indicated that 2,3-hexanedione and 2,3-heptanedione were present at levels below the minimum detectable concentrations. These substitutes share the same alpha-diketone structure as diacetyl. However, their increased carbon chain length makes them less water soluble, possibly resulting in deeper lung penetration and consequently resulting in greater toxicity (Ref. 6). Diacetyl trimer, another substitute that was developed to replace diacetyl in the bakery industry, is thought to release diacetyl under certain conditions of manufacturing when heated and in the presence of water. Also upon inhalation of this trimer, it is believed that diacetyl is released in the moist environment of the respiratory tract.

Acetoin (acetyl methyl carbinol), an alpha-hydroxyl ketone, has been consistently found during investigations of microwave popcorn manufacturing plants. NIOSH also identified acetoin as a predominant chemical in the production room of a California flavoring manufacturing plant (Ref. 13). Acetoin was also found in a diacetyl manufacturing facility where four workers developed bronchiolitis obliterans (Ref. 19). Acetoin is very similar in chemical structure to diacetyl, and sometimes exists as the dimer. It is anticipated that some acetoin may be metabolized to diacetyl in humans. The National Toxicology Program is planning inhalation toxicology studies on acetoin as part of a testing nomination for artificial butter flavoring and its ingredients (Ref. 20).



Acetoin (acetyl methyl carbinol)
C₄H₈O₂

Over the years manufacturers have used a number of combinations to attain a buttery flavor, such as diacetyl and acetoin, acetyl propanyl and acetoin, and other combinations. (Acetoin alone is not as effective as diacetyl at creating a buttery flavor.) Because the toxicology of these diacetyl substitutes is only now being studied, NIOSH recommends that they not be considered safe, and, therefore, that exposures be controlled by using engineering controls, work practices and respiratory protection.¹

Currently, OSHA does not have a specific standard or a permissible exposure limit (PEL)

¹ The flavoring chemical 2-Nonanone is also used as a substitute; however, it does not impart a buttery flavor and its use is not wide-spread.

for diacetyl, 2,3-pentanedione or any of the other alpha-diketone substitutes, nor has NIOSH recommended an exposure level. OSHA does, however, have permissible exposure limits for a number of other flavoring chemicals such as methyl ethyl ketone, acetaldehyde, furfural and acetic acid. These flavorings have been identified in analysis of butter-flavoring chemicals at a flavoring manufacturing facility and may also be found in popcorn manufacturing facilities (Ref. 6).

XI. National Emphasis Program Goals.

- A. To minimize and/or eliminate worker exposure to the hazards associated with microwave popcorn manufacturing. Reduction and/or elimination of chemical exposures will help to reduce and prevent the occurrence of skin and eye injuries as well as occupational lung injury and illness, including fixed airways obstruction and bronchiolitis obliterans, lung dysfunction, and restrictive airways obstruction.
- B. To accomplish this goal, OSHA will implement a combined effort that includes inspection targeting, direction on methods of controlling chemical hazards, and extensive compliance assistance.
- C. Inspections will be directed at those facilities that were previously targeted within the SIC/NAICS codes listed, and other establishments known to manufacture microwaveable popcorn.

XII. Program Procedures.

A. Site Selection.

1. Targeting Sources.

- a. Inspections conducted under this NEP will focus on facilities where workers are manufacturing or processing microwave popcorn.
- b. The previous list of facilities identified as manufacturing microwave popcorn is included on the Directorate of Enforcement Programs' (DEP) Intranet website. **All** such establishments on this list within the Area Office's (A.O.) jurisdiction will be scheduled for inspection.

NOTE: This list is for internal scheduling purposes **only** and shall not be released to the public.

- c. Sites not included on the DEP Intranet listing of known establishments, but known to the A.O. to be manufacturers of microwaveable popcorn, shall be added to the inspection targeting

list for that A.O. and scheduled for inspection.

NOTE: **All** establishments identified by the A.O. must be added to the list.

- d. Appendix A contains a list of NAICS and SIC codes for establishments that may be using butter-flavoring chemicals, including diacetyl substitutes in the manufacture of microwave popcorn.

2. Inspection Scheduling.

- a. All establishments on DEP's Intranet list or known by the A.O. shall be scheduled.
- b. In addition, whenever an office becomes aware of a previously unknown popcorn manufacturing establishment within any of the identified NAICS/SIC codes listed in Appendix A, the establishment shall be added to the DEP intranet list. For reporting purposes, all enforcement inspections under this NEP will be reported as "Health" inspections on the IMIS.

3. Deletions.

Any facility that has received a comprehensive inspection where worker exposures to butter-flavoring chemicals including diacetyl substitutes 2,3-pentanedione, 2,3-hexanedione and 2,3-heptanedione have been specifically evaluated within the last two (2) years by OSHA shall be deleted from the list if the case file documents that the employer has instituted feasible engineering and work practice controls, provided respirators (where necessary) and appropriate personal protective equipment, and such protections have been found to be effective.

B. Complaints and Referrals.

Complaint or referral inspections alleging worker exposure to any other hazards at microwave popcorn processing facilities shall be expanded to address the issues covered under this NEP. For further guidance, Compliance Safety and Health Officers (CSHOs) should refer to CPL 02-00-148, November 9, 2009, Field Operations Manual (FOM), Chapter 9.

C. Programmed Inspections.

Some establishments may be selected for inspection under the Site Specific Targeting 2010 inspection plan (SST-10) or also under one or more other OSHA initiatives (National Emphasis (NEP) or Local Emphasis (LEP) Programs). This

NEP, which is based on microwave popcorn butter-flavoring hazards, shall be run **concurrently** with the SST-10 plan; however, the NEP inspections have priority.

Whenever an establishment is scheduled for an inspection on the current cycles of both the NEP plan and the SST-10 plan, the inspections may be scheduled at the same time. CSHOs shall use all IMIS codes applicable for the inspection. The employer's Data Universal Numbering System (DUNS) number must also be recorded for each inspection.

In cases when an establishment is scheduled for an inspection under both the SST-10 plan and this NEP, an inspection limited in scope to the safety and health issues targeted by the NEP program must be conducted even if all CSHO-calculated DART rates for the establishment are found to be below the SST-10 inspection thresholds.

D. Expanding Scope of Inspection.

Inspections under this NEP shall normally be limited to the butter-flavoring chemicals hazards described in this Direction, but the CSHO may expand the scope of the inspection if other safety and health hazards or violations are observed. CSHO should refer to CPL 02-00-148, November 9, 2009, Field Operations Manual (FOM) for further guidance. If the facility also has potential exposures to flavoring chemicals other than butter-flavorings (e.g., cheddar cheese, jalapeno, almond, etc.) the CSHO shall expand the scope of the inspection to address the related exposures as well.

XIII. OSHA's Response Efforts and Outreach.

- A. OSHA has already responded to NIOSH's findings by conducting the following outreach activities:
1. In response to NIOSH's August 2001 Interim Report on its investigation of the Missouri popcorn manufacturing facility, in February 2002, OSHA's Directorate of Enforcement Programs issued a memorandum to Regional Administrators and Area Directors alerting them to NIOSH's findings at the Missouri facility. The memorandum advised the field to investigate these types of exposures whenever they encountered workers working around popcorn butter-flavoring chemicals. In addition, the agency mailed hazard alert letters to locations where microwave popcorn manufacturing was occurring.
 2. In September 2002, OSHA's Region VII established an Alliance with the Popcorn Board to use their collective expertise to help foster a culture of prevention, best practices and technical knowledge.
 3. In October 2002, OSHA's Region VII published a brochure entitled

Recommended Preventative and Control Measures to Reduce the Risk of Obstructive Lung Disease Among Workers in the Microwave Popcorn Packaging Industry.

4. In October 2003, OSHA posted to its website an update of its Safety and Health Topics: Chemical Sampling Information File on Diacetyl, which included information on toxicology and health effects of this chemical.
5. In October 2004, OSHA's Directorate of Enforcement Programs, and Cooperative and State Programs, issued a memorandum to Regional Administrators, Area Directors, State Plan Designees, and Consultation Program Managers encouraging them to contact employers that may have workers exposed to the potential hazards in this industry. This NEP supersedes the 2004 memo. The field was provided with copies of the NIOSH alert titled *Preventing Lung Disease in Workers Who Use or Make Flavorings*. Letters were mailed to locations where microwave popcorn manufacturing was occurring.
6. In September 2007, OSHA issued a safety and health information bulletin (SHIB) entitled, *Respiratory Disease Among Workers in Microwave Popcorn Processing Plants*.
7. In September 2007, OSHA issued a guidance document entitled *Hazard Communication Guidance for Diacetyl and Certain Food Flavorings Containing Diacetyl*.
8. In September 2007, OSHA's Directorate of Enforcement Programs issued CPL 03-00-005, September 24, 2007, *National Emphasis Program- Microwave Popcorn Processing Plants*.
9. In October 2009, OSHA's Directorate of Enforcement Programs issued CPL 03-00-011, October 30, 2009, *National Emphasis Program – Facilities that Manufacture Food Flavorings Containing Diacetyl*.

B. Additional Outreach Activities.

1. Area Offices may undertake the following:
 - a. Contact local hospitals, occupational health clinics, and local occupational physicians and alert them via mail about this revised NEP that includes 2,3-pentanedione and the other alpha-diketone diacetyl substitutes described above. See Appendix B for a form letter developed specifically for the healthcare industry.
 - b. Contact temporary employment agencies, alerting them to this revised NEP so that they can inform their workers and clients who

use or may be exposed to butter-flavoring chemicals including the diacetyl substitutes while on assignments.

XIV. Inspection Procedures.

This section outlines procedures for conducting inspections and preparing citations for hazards related to worker exposures to butter-flavoring chemicals. For further guidance, CSHOs should consult the OSHA directives, appendices, and other references provided below.

Appendix E provides a description of hazardous conditions that may be encountered at a popcorn processing facility.

A. Opening Conference.

1. During the opening conference, the CSHO shall initially confirm that the employer uses butter-flavoring chemicals in the manufacture of microwave popcorn.
2. CSHOs must explain the goals of this NEP to the employer and provide copies of the Popcorn SHIB, the Hazard Communication Guidance Document for Diacetyl and Food Flavorings, NIOSH's Gilster-Mary Lee HHE report, if they were not provided previously.
<http://www.cdc.gov/niosh/hhe>

Note: CSHOs may choose to provide a copy of NIOSH's report to the employer for copying or inform the employer that a copy can be accessed at <http://www.cdc.gov/niosh/hhe/reports>.

3. CSHOs must request copies of MSDSs for all butter-flavoring chemicals used at the facility. In preparation, CSHOs should also review their previous inspection files (including archived files dating back to 2007) and specifically review all previous MSDSs for any references to substitutes.
4. CSHOs must request information on any hazard analyses performed at the facility for the following:
 - a. 29 CFR 1910.132(d): Hazard assessment and equipment selection: OSHA's Personal Protective Equipment (PPE) standards require employers to assess their workplaces to determine if hazards are present, or are likely to be present, which necessitate the use of PPE (29 CFR 1910.132). If such hazards are present or are likely to be present, employers must ensure that workers use the appropriate PPE to protect their eyes, face, hands and extremities, depending on the nature of the hazard (29 CFR §§1910.132, .133, .138). The employer is responsible for both the quality of the

hazard assessment and the adequacy of the PPE selected.

- b. 29 CFR 1910.134(d): Selection of Respirators: The NIOSH finding of severe lung disease in workers at several microwave popcorn manufacturing plants demonstrates that “inhalation exposure to butter-flavoring chemicals is a risk for occupational lung disease” (Ref. 9). Accordingly, employers in the microwave popcorn manufacturing industries that use butter flavoring ingredients **must conduct** the evaluation required by §1910.134(d)(1)(iii) of the Respiratory Protection standard.

The hazard evaluation requirement is performance-oriented, and a variety of estimation techniques may be used to characterize worker exposures, depending upon the nature of the chemical products, processes, operating environment, and other factors.

Where a substance is used that may pose a respiratory hazard, the employer **must** assess the nature and magnitude of the hazard relative to the conditions of use in its workplace, considering both normal operating conditions and reasonably foreseeable emergencies.

- c. 29 CFR 1910.1200(d): Hazard determination: OSHA’s Hazard Communication standard requires that employers who choose not to rely on the evaluation of a hazardous chemical performed by a chemical manufacturer or importer must conduct their own evaluation in accord with §1910.1200(d)(2) and (d)(3), and consider the available scientific evidence concerning that chemical.

B. Walkaround and Records Review.

1. Material Safety Data Sheets (MSDSs). CSHOs must thoroughly review the MSDSs for all flavoring chemicals used in the microwave popcorn production process to ensure they are in compliance with the requirements of 29 CFR 1910.1200(g). If any deficiency is found, referrals **shall** be made to the appropriate Area Offices pursuant to OSHA Instruction CPL 02-02-038 (CPL 2-2.38D)-Inspection Procedures for the Hazard Communication Standard.
 - a. CSHOs should be aware that some MSDSs for diacetyl, 2,3-pentanedione and other butter-flavoring chemicals as well as diacetyl substitutes may be inadequate. In fact, NIOSH reported that, at the California facility, none of the MSDSs it reviewed listed diacetyl or any of the other alpha-diketone substitutes that were detected. Review the health effects and personal protective

equipment sections to determine whether hazard information adequately addresses respiratory, eye, and dermal hazards associated with flavorings containing diacetyl or diacetyl substitutes.

- b. For additional information, CSHOs should refer to OSHA's "Hazard Communication Guidance for Diacetyl and Food Flavorings Containing Diacetyl."

2. Injury/Illness Records. CSHOs must review the employer's injury and illness records (at least 2007 to present) to identify any workers with recorded illnesses or symptoms associated with exposure to diacetyl and or other butter-flavoring chemicals.

- a. CSHOs shall investigate log entries for any type of respiratory issues such as: chronic bronchitis, asthma, emphysema, pneumonia, fume/vapor respiratory inflammation and other similar entries that could potentially be misdiagnosed as not related to exposure to butter-flavorings. Skin or eye injuries involving chemicals should also be investigated.

NOTE: When reviewing the OSHA 300 logs, CSHOs should investigate and follow-up on entries such as asthma, respiratory abnormality, toxic effects and other similar notations. Most often, physicians unfamiliar with bronchiolitis obliterans, a rare disease, may incorrectly diagnose the worker's illness. Consult with the Office of Occupational Medicine (OOM) for further guidance.

- b. CSHOs shall follow up (review additional information) on entries that may be recorded with any of those symptoms and may consult with the Office of Occupational Medicine (OOM) to evaluate whether these symptoms could be associated with exposure to butter-flavorings.
- c. CSHOs shall interview **all** workers whose names are recorded on the logs who reported any of these symptoms. To identify other cases of respiratory illness which may not have been recorded, CSHOs shall interview workers who are working in areas where they may be exposed to flavoring chemicals.

Appendix F contains a worker questionnaire to assist with these interviews.

- d. CSHOs should attempt to obtain any contact information for workers whose names appear on the log but are no longer working at the facility, and interview them if possible.

3. Medical Access Orders. Based on information obtained from illness/injury records and interviews, CSHOs may need to review additional worker medical information. When accessing worker medical information, CSHOs should follow the procedures in 29 CFR 1913.10 and obtain a written medical access order. CSHOs may also consider obtaining specific written consent from a worker pursuant to 29 CFR 1910.1020(e)(2)(ii), and should ensure that the agency or agency worker is listed on the consent form as the designated representative to receive the information. For further guidance see CPL 02-02-072 Rules of agency practices and procedures concerning OSHA access to employee medical records p. 21, paragraph 2.

4. Production Process Evaluation. CSHOs must request and review the employer's production and processing records.
 - a. Document the types and quantities of flavoring chemicals used to formulate the various batches of flavors, and how often the batches are made.

 - b. Determine whether the employer has any existing ingredients that are heated and if so, to what temperature.

 - c. Evaluate and document how frequently butter-flavorings are directly handled (e.g., measuring, pouring, mixing, transferring, etc.) and the extent to which engineering controls, work practices, and protective equipment are implemented during these operations. The primary means for controlling exposures are local exhaust ventilation to remove contaminants at their source, enclosing production processes or exposure sources, isolation of the processes or exposure sources, substitution of less hazardous materials and general dilution ventilation. Areas of particular concern include mixing areas where butter-flavoring chemicals are mixed, poured, heated and added to heated oil, production areas where ingredients are mixed, packaging lines where popcorn and oil/flavorings are added to microwaveable bags and packaged for shipping and quality assurance or quality control areas where multiple bags are popped and tested. CSHOs should also verify that the ventilation systems are functioning properly.

 - d. Evaluate workers' respirator usage, if any, and request a copy of the employer's respiratory protection program. CSHOs should also obtain copies of spirometry test results. If other PPE (i.e. eye and skin protection) is provided document the type.

NOTE: NIOSH has used **diacetyl**, as a marker of exposure to

volatile butter-flavorings at microwave popcorn manufacturing facilities. CSHOs should be aware that diacetyl is used in varying percentage amounts depending on the flavor and batch. Likewise, flavoring substitutes such as **2,3-pentanedione, 2,3-hexanedione, 2,3-heptanedione, diacetyl trimer, and acetoin** may be also used in varying percentages. Therefore, monitoring should particularly include those batches containing the greatest percentage of diacetyl and or 2,3-pentanedione and other substitutes described above. Also, powdered flavoring chemicals and flavoring pastes may represent potential respiratory hazards via inhalation of volatile chemicals or respirable particles.

The Salt Lake Technical Center (SLTC) is currently developing a method for sampling 2,3-pentanedione. Laboratory work on the fully-validated 2,3-pentanedione method has been completed and the method is currently under internal review. SLTC chemists are confident that the method will provide accurate and reliable results at the 0.5 ppm level, but the method has not yet been officially approved. Diacetyl, acetoin, and 2,3-pentanedione can be determined from the same sample at the 0.5 ppm level. The 2,3-pentanedione method can be extended to screen samples for 2,3-hexanedione and 2,3-heptanedione also at the 0.5 ppm level, but this use of the method has not been validated.

- e. Document if employees received training on health hazards associated with diacetyl.

5. Exposure Monitoring. CSHOs must conduct full-shift personal air monitoring and short-term personal air monitoring for diacetyl, 2,3-pentanedione and other alpha-diketone substitutes used during operations involving direct handling of butter-flavorings and other hazardous substances as appropriate. For some butter-flavoring chemicals, monitoring to assess short-term exposure limits (STELs), ceiling (C) or OSHA PELs may be necessary. Area sampling should also be done.

NIOSH has also found the following chemicals with OSHA PELs to be present at facilities it investigated.

- Acetaldehyde - PEL 200 ppm (8-hours)
- Furfural - PEL 5 ppm (8-hours)
- Acetic Acid - PEL 10 ppm (8-hours)

- a. CSHOs are to use the available MSDSs, production and process information, as well as the listing of other flavoring chemicals provided in Appendix D, in determining whether additional

monitoring for other flavoring chemicals as well as butter-flavoring chemicals should be performed. CSHOs should consult with the Regional Offices to determine whether to conduct additional monitoring. If the MSDS does not list all ingredients contact the manufacturer for more information on the flavoring composition.

- b. NIOSH has identified the mixing room as an area associated with exposure to butter-flavoring ingredients and an increased potential for lung disease in workers. Air monitoring should also be conducted in the mixing rooms, as well as in the following areas of the worksite, where applicable.
 - Rooms where flavoring tanks are located
 - Production line(s)
 - Quality assurance laboratory(ies)
 - Packaging area(s) and
 - During cleaning and maintenance activities.
- c. Appendix D provides Guidelines for Air Sampling.
- d. If available, obtain copies of the employers' exposure monitoring records.

C. Citation Guidance.

1. The General Duty Clause.

- a. Where all the elements for a General Duty Clause violation can be established, the Area Director (AD), in consultation with the Regional Solicitor (RSOL), shall consider issuing a citation.

Elements of a General Duty Clause violation are:

- The employer failed to keep the workplace free of a hazard to which workers of that employer were exposed;
- The hazard is recognized by the employer or its industry;
- The hazard was causing or was likely to cause death or serious physical harm; and
- There were feasible and useful means to correct the hazard.

The CSHO must initially determine whether workers have

experienced, or are experiencing, respiratory symptoms consistent with exposures to butter-flavoring chemicals similar to those documented in the NIOSH studies, and that there was exposure to those chemicals. The following types of evidence will be necessary to establish a General Duty Clause violation:

- Documented instances of obstruction of airways, lung disease or lung-function abnormalities in current workers,
- Documented worker exposure to diacetyl, 2,3-pentanedione or other alpha-diketone substitutes such as 2,3-hexanedione and 2,3-heptanedione.
- Evidence of feasible and effective measures that the employer could have implemented to reduce or eliminate exposures to diacetyl, 2,3-pentanedione, and other butter flavoring chemicals (such as installing engineering controls, instituting work practices, or providing adequate respiratory protection), and
- Expert opinion evidence.

- b. When workplace conditions/operations are similar to those observed by NIOSH during its evaluation of the industry (see Appendix E) and the employer has provided no protective measures, but there are no identifiable worker respiratory illnesses present, Area Offices may consider issuing 5(a)(1) citations only after consulting with the National Office.

NOTE: When the criteria for a 5(a)(1) citation are not met, then a Hazard Alert Letter (HAL) may be issued (see Appendix C).

- c. Sample Alleged Violation Description (AVD) for citing worker exposures to butter-flavoring ingredients containing diacetyl or diacetyl substitutes

Note: Sample AVD language is presented as a model to assist CSHOs in developing citations. Care should be taken to tailor citations to reflect the conditions found at particular facilities and to give notice to cited establishments of the violative conduct.

Section 5(a)(1) of the Occupational Safety and Health Act: The employer did not furnish employment and a place of employment which were free from recognized hazards that were causing or likely to cause death or serious physical harm to workers, in that workers were required to perform tasks that exposed them to an

inhalation hazard from diacetyl, 2,3-pentanedione or butter-flavoring ingredients containing diacetyl and 2,3-pentanedione. NIOSH investigations found that employees working in mixing rooms and in areas near non-isolated tanks of oil and butter-flavoring ingredients had a higher prevalence of respiratory symptoms and airways obstruction [5].

(a) (LOCATION)(DATE)(IDENTIFY SPECIFIC OPERATION/TASK(S) AND DEPARTMENTS, DESCRIBE CONDITIONS, INCLUDING EXPOSURE LEVELS) An evaluation of this operation/task(s) indicated that workers required to perform this task were exposed to a hazard which caused, or was likely to cause, severe lung disease and obstruction of lung airways.

Abatement: Although some risk factors may be reduced or eliminated by implementing a single means of abatement, in most cases a process that includes analysis of the worksite, instituting appropriate controls, and training and education will provide the most effective method of addressing the risks.

The employer may adopt any measures that are effective in substantially reducing or eliminating the hazard.

Abatement controls include engineering, training and education, and administrative and work practice controls: *(List all recommended controls and practices not used by the employer). See Appendix G for a list of recommended engineering and work practice controls. Selection and use of the appropriate respiratory protection is highly recommended and may be used to supplement engineering and administrative controls when not feasible, and must comply with the requirements of 29 CFR 1910.134. Worker illnesses may also be reduced by identifying exposed workers, using medical questionnaires to identify workers with respiratory symptoms of lung dysfunction and airway obstruction and referring symptomatic workers to physicians who specialize in occupational or pulmonary medicine for appropriate medical treatment.*

NOTE: CSHOs may consult information from NIOSH Health Hazard Evaluation Report: Gilster-Mary Lee Corporation. Publication # HETA 2000-0401-2991.

2. OSHA PEL.

Where exposures are in excess of the permissible exposure limits (PELs), ceiling limits (C) or STELs, for substances listed in Table Z-1, cite the applicable sections of 29 CFR 1910.1000. An employer's failure to implement feasible

engineering or work practice controls for those substances listed in §1910.1000 should be cited under §1910.1000(e). Citations of this standard shall not be issued to require specific volumes of air to reduce such exposures. Thus, when it is not feasible to achieve compliance through administrative or engineering controls, PPE or other protective measures must also be used to prevent employee exposure to air contaminants from exceeding the prescribed limits.

3. Respirator Protection Standard.

- a. CSHOs shall cite 29 CFR 1910.134(d)(1)(iii) where employers fail to conduct an initial hazard evaluation to identify potential respiratory hazards of employees who are exposed or may be exposed to flavoring chemicals.
- b. Where the employer uses respirators, but fails to comply with a requirement in the respirator standard, cite the applicable sections of 29 CFR 1910.134. See FOM Chapter 4.XII
 - No overexposure is required to issue citations under this standard but when overexposures are found, this standard may be cited in conjunction with the General Duty Clause or 29 CFR 1910.1000 as appropriate.

4. PPE Standards.

Where flavoring chemicals having irritant properties are present and workers' eyes and skin are potentially exposed to such chemicals, cite the applicable PPE standard (29 CFR §§1910.132, .133, .138).

- a. Chemical goggles or other appropriate eye protection must be used when there is a potential for splash or vapor exposure to a substance that is likely to cause injury to the eye.
- b. Chemical-resistant gloves, or sleeves or other appropriate protection for exposed skin must be used when handling liquid, paste, or powdered-flavoring ingredients that could cause dermal injury. CSHOs should consult the MSDS for the appropriate gloves.

Note: Since butter-flavorings vary among manufacturers, CSHOs should recommend that employers communicate with their flavoring manufacturer and their protective equipment vendor to select the appropriate glove material.

- c. The employer must also provide training for exposed workers as

indicated in 29 CFR 1910.132. This training must include information on when and how to use appropriate PPE.

- d. In addition, employers must provide information on the value, limitations and maintenance of this equipment in accordance with 29 CFR 1910.132 and .134.

D. Other Applicable Requirements.

1. Hazard Communication.

- a. Workers who may be exposed to popcorn butter-flavoring chemicals and flavoring ingredients, including diacetyl, are required to be trained on the hazards of the chemicals in the workplace pursuant to 29 CFR 1910.1200(h)(3).
- b. Workers must be informed of the signs and symptoms of any respiratory, skin or eye conditions associated with exposures to butter-flavoring chemicals, as identified by NIOSH.
- c. Employers must ensure that all MSDS are readily accessible to workers.

NOTE: CSHOs should be aware there are over 2,000 chemically-defined flavoring substances which are used to formulate flavors and employers may use varying combinations. However, existing MSDSs and labels may not include the newer information regarding the health effects of diacetyl, 2,3-pentanedione, and other diketones or popcorn food flavoring chemicals. Therefore, CSHOs should ensure that all containers, including those used for mixing process chemicals, are labeled with the appropriate hazard warnings. Some chemicals may be exempt due to coverage under the Federal Food, Drug and Cosmetic Act (21 U.S.C. 301 *et seq.*). However, even if a chemical is covered by the FDA, it must be labeled pursuant to the HCS once it is transferred into in-house containers.

Citation Guidance: Detailed inspection and citation guidance, including guidance on how to address inadequate MSDSs, is contained in OSHA Instruction CPL 02-02-038 (CPL 2-2.38D)- Inspection Procedures for the Hazard Communication Standard.

2. Exposure and Medical Records.

- a. Interview the workers to determine whether they understand their rights to review their medical and exposure records, as well as their

rights regarding the confidentiality of such records.

- b. CSHOs must review the employer's recordkeeping program to ensure that the required information is collected and recorded as required by 29 CFR 1904.
- c. When reviewing the worker medical records, ensure that the confidentiality of these records is protected, in accordance with 29 CFR 1913.10. See CPL 02-02-072 Rules of agency practices and procedures concerning OSHA access to employee medical records.
- d. Evaluate the employer's method of ensuring the confidentiality of worker medical records.

Citation Guidance: Where there are violations, CSHOs should cite the applicable sections of 29 CFR 1904 or 1910.1020.

3. Flammable and combustible liquids.

Chemicals such as 2,3-pentanedione, diacetyl, and the other alpha-diketone substitutes are highly flammable liquids that produce highly flammable vapors. Other popcorn butter-flavoring chemicals may also be flammable. Therefore, during the course of an investigation attention should be paid to the handling and storage of these chemicals. Flammables are to be kept in closed containers, and during transfers, the containers should be bonded and grounded.

Citation Guidance: The requirements of 1910.106(e) should be cited when appropriate.

NOTE: CSHOs should be aware of the requirements to use intrinsically safe equipment (i.e. cameras, sampling equipment) when working around flammable liquids and vapors.

4. Confined Space, Logout/Tagout, and Compressed Air.

Popcorn processing facilities and facilities using flavoring substances generally use large containers and tanks for storage and mixing. CSHOs should determine whether any permit-required confined spaces exist at a facility and the employer's procedures for cleaning this equipment.

Citation Guidance: All applicable requirements of 29 CFR 1910.146 shall be cited when workers are required to enter containers that may be considered confined spaces. CSHOs must

also investigate whether or not lockout and tagout procedures are required, and if so, cite all applicable sections of 29 CFR 1910.147. Compressed air may not be used for cleaning, except when reduced to less than 30 pounds per square inch (psi). If the employer is using compressed air for cleaning confined spaces, then the employer should sample during this activity and 29 CFR 1910.242(b), Compressed air used for cleaning should be cited when appropriate.

E. Hazard Alert Letters.

Where a determination is made not to issue a 5(a)(1) citation but cases of illnesses related to exposures to popcorn flavoring chemicals, including diacetyl and diacetyl substitutes, can be documented, or other evidence of a hazard exists, a hazard alert letter (HAL) should be sent to the employer. The HAL should recommend specific actions that would assist in the reduction of illnesses and include a notification that a follow-up inspection may be conducted. A sample Hazard Alert Letter is included in Appendix C.

F. Follow-up Inspections.

1. Where citations are issued for overexposure to regulated flavoring chemicals, or exposure to unregulated flavoring chemicals such as 2,3-pentanedione, follow-up site visits must be conducted to determine whether the employer has implemented appropriate abatement measures, including engineering controls or work practices and providing respirators and other appropriate PPE where necessary.
2. After abatement verification the Area Office will send all relevant information to the Regional Office. Information includes:
 - Area Office
 - Inspection Number
 - Follow-up Inspection Number(s)
 - Inspection Dates
 - Company Name
 - Initial Sampling Results
 - Follow-up Sampling Results
 - Abatement Measures

G. Program Evaluation.

This NEP will be evaluated using data collected from case files and follow-up site visit reports submitted by each Area Office to the Regional Offices. Each Region shall designate an individual as the Popcorn Flavoring Chemical Coordinator, who will work with the Office of Health Enforcement.

H. Coordination.

1. National Office. This NEP will be coordinated by the Directorate of Enforcement Programs (DEP) - Office of Health Enforcement (OHE). All questions and comments should be directed to the Office of Health Enforcement. OHE will coordinate with the Directorate of Technical Support and Emergency Management (DTSEM), Office of Occupational Medicine (OOM) and other offices for assistance as needed.
2. Regional Office. Each Regional Administrator will identify a coordinator for this NEP. The coordinator will be responsible for collecting the data required under Section XIV.F.2.

I. Federal Agencies. Executive Order 12196, Section 1-201, and 29 CFR 1960.16 require Federal Agencies to follow the enforcement policy and procedures contained in this Direction.

J. IMIS Coding Instructions. The instruction below is for recording popcorn butter-flavoring chemicals inspections under this popcorn NEP. The majority of inspections conducted under this NEP will be "Health" inspections and should be coded as such. When this NEP is conducted in conjunction with an SST inspection, the OSHA-1 Forms must be marked as "programmed planned" in item 24, and in item 21, Inspection Category must be recorded as "H". In addition, the "NEP" value of "SSTARG10" will be recorded in Item 25d along with the NEP code "POPCORN."

If during an SST inspection (or other safety-related inspections) popcorn butter-flavoring chemical hazards are observed, the NEP code for "POPCORN" will be recorded.

This "POPCORN" code applies to the following enforcement forms:
OSHA-1, OSHA-7, OSHA-36, OSHA-90 and OSHA-55.

Consultation. Whenever a visit is made in response to this NEP, Consultation request/visit forms are to be completed with the NEP code "POPCORN" in item 25 on Form-20, and in item 28 on Form-30.

XV. Consultation. When appropriate, 21(d) Consultation Projects are encouraged to develop their own outreach activities and plan to address exposures to popcorn flavoring chemicals.

APPENDIX A
Establishment List of NAICS and SIC Codes

This appendix contains a list of SIC and NAICS Codes which may be involved in microwaveable popcorn butter-flavoring production and/or the use of popcorn flavors containing diacetyl and/or diacetyl substitutes to manufacture foods, beverages and other consumer products. This should not be considered an exhaustive listing; instead, it is a list of those facilities codes NIOSH has identified as using popcorn butter-flavoring chemicals, as well as facilities codes reported by Dun & Bradstreet as butter-flavored microwave popcorn manufacturers.

SIC Code	Industry Title	NAICS Code
2099	Popcorn packaged except popped, as well as manufacturing of prepared foods	311340
2087	Flavoring extracts, and flavoring syrups	311942
2096	Popcorn balls, candy covered popcorn	311919
2064	Candy and other candy covered popcorn products	311330
2043	Breakfast foods/non chocolate Confectionary Manufacturing (1)*	311340
0723	Post-harvest Crop Activities (except Cotton Ginning) (1)*	115114
2099	Other miscellaneous food Manufacturing (13)*	311999
2068	Confectionary and Nut Stores (1)*	445292

Note: The * represents the number of facilities that were found within these codes to manufacture microwave popcorn.

APPENDIX B

Healthcare Form Letter

Area Office Header

Date

Name of Healthcare Provider

Address of Health Care Provider

Dear _____:

Subject: Occupational Lung Disease Among Workers in the Microwave Popcorn Manufacturing Industry

The Occupational Safety and Health Administration Region/Area office is revising its alert to healthcare professionals of the occurrence of occupational lung disease among workers who are exposed to butter flavoring ingredients in the microwave popcorn manufacturing industry. In the previous 2007 alert, health care professionals were informed that in 2000, the National Institute for Occupational Safety and Health (NIOSH) investigated a microwave popcorn manufacturing facility in Missouri where nine workers developed bronchiolitis obliterans, a severe, potentially fatal, pulmonary disease. The investigation concluded that there was an increased risk for occupational lung disease among workers with inhalational exposure to butter flavorings. Since this initial investigation, additional cases of occupational lung disease including bronchiolitis obliterans have been recognized among workers at other microwave popcorn manufacturing plants. Diacetyl, a butter-flavoring chemical, has been detected in NIOSH investigations where cases of fixed obstructive lung disease, including bronchiolitis obliterans, have been diagnosed in microwave popcorn manufacturing facilities.

Additionally, in March 2010 NIOSH and NIEHS each revealed the results of two studies on the health effects of diacetyl substitutes, particularly 2,3-pentanedione: *Inhalation Toxicity of Acetyl Propionyl in Rats and Mice*, by D.L. Morgan *et al.* and *Airway Epithelial Toxicity of the Flavoring Agent, 2,3-pentanedione*, by A.F. Hubbs *et al.* The results of both studies indicated that the diacetyl substitute 2,3-pentanedione, which some manufacturers have used as a replacement for diacetyl, has caused similar health effects such as those found in the workers who were exposed to diacetyl. This substitute, and other substitutes such as 2,3-hexanedione and 2,3-heptanedione, may pose similar threats to workers, and are thought to be even more harmful than diacetyl itself. As a result, OSHA has revised its 2007 Popcorn National Emphasis Program (NEP) and those Microwave Popcorn Manufacturing facilities covered under the previous NEP will be reinspected to determine whether workers are exposed to the substitutes.

The following factors should be looked at:

Occupational History:

The occupational history should include a description of current and past jobs, as well as information about workplace exposures to chemicals (including flavoring ingredients). It is important to ask if any other workers are experiencing respiratory symptoms or are known to have developed lung disease. Additional information about workplace exposures to flavoring chemicals can be found in Material Safety Data Sheets (MSDS) or by contacting manufacturers. Diacetyl is listed by the CAS number 431-03-8 and 2,3-pentanedione is listed by the CAS number 600-14-6.

Symptoms:

Symptoms experienced by workers in the recent California study include cough (usually non-productive), nose, eye and skin symptoms that improved when workers were away from work (e.g., nights, weekends, vacations). These workers had higher than expected rates of shortness of breath and asthma when compared to the national adult population. Other symptoms related to exposure to butter flavorings may include eye, nose, throat and skin irritation, fever, night sweats and weight loss. Symptoms are usually gradual in onset but severe symptoms may occur suddenly. Bronchiolitis obliterans is a rare disease and workers with disease may be misdiagnosed as having asthma, chronic bronchitis, emphysema, and other lung diseases.

Medical Evaluation:

The occupational lung disease identified in the NIOSH investigations is characterized by fixed airways obstruction on spirometry after challenge with bronchodilators. Spirometry findings may also include evidence of restriction. Spirometry should follow criteria established by the American Thoracic Society (ATS) guidelines for standardization of spirometry which can be obtained through the ATS website:
<http://www.thoracic.org/sections/publications/statements/index.html>.

Additional studies such as diffusing capacity are usually normal, but lung volumes may show hyperinflation. Chest radiographs are also usually normal. If fixed airways obstruction is present and bronchiolitis obliterans is suspected, referral to pulmonary and radiographic specialty care is optimal to ensure correct diagnosis and follow-up of this rare and severe lung disease. Bronchiolitis obliterans is usually diagnosed by findings on paired inspiratory and expiratory high resolution computerized tomography scans (CT or CAT scans).

More information about occupational lung disease related to flavoring exposure is available at:

<http://www.osha.gov/SLTC/flavoringlung/index.html>
<http://www.cdc.gov/niosh/docs/2004-110/>

OSHA is dedicated to saving lives, preventing injuries and illnesses and protecting America's working men and women. For more information about OSHA programs, visit our website at www.osha.gov.

Sincerely,

Area Director

Enclosure(s)

Appendix C Sample Hazard Alert Letter

Note: This letter must be adapted to the specific circumstances noted in each inspection. The letter below is an example of the type of letter that may be appropriate in some circumstances. If the employer has implemented, or is in the process of implementing efforts to address hazardous conditions, those efforts should be recognized and encouraged, if appropriate.

Italicized comments are for OSHA compliance use only and should not be included in the letter.

Dear Employer:

An inspection of your workplace and evaluation of your OSHA recordkeeping logs at *(location)* on *(date)* disclosed the following workplace condition(s) which have been associated with the development of occupational lung disease in workers and are consistent with worker illnesses that can be caused by conditions related to exposure to butter-flavoring chemicals.

[Include a general description of working conditions for each task/job associated with respiratory disease or fixed airway obstruction, such as lack of ventilation, lack of PPE, inappropriate PPE, etc.]

The results of sampling showed exposure(s) above the detection limit(s) for the unregulated butter-flavoring chemical(s) or the permissible exposure limit for OSHA regulated chemical(s) *(name chemicals)*. In the interest of workplace safety and health, I recommend that you voluntarily take the necessary steps to materially reduce or eliminate your workers' exposure to the conditions listed above.

Based on the results of its own studies, NIOSH has found that the following recommended engineering and work practice controls can help reduce worker exposures to popcorn butter-flavoring chemicals as well as other food flavoring chemicals.

1. Engineering Controls

Engineering controls are the first line of defense in worker protection. Therefore, employers should provide appropriate engineering controls and should train their workers in the use of those controls and in work practices to ensure that worker exposures to popcorn butter flavoring chemicals are minimized. The following engineering controls are recommended:

- Isolation of the mixing room from the rest of the plant using walls, doors, or other appropriate barriers.
- Equipping the mixing room with a separate ventilation system or ensuring that negative air pressure (relative to the rest of the plant) is maintained in the mixing room to avoid the outward migration of contaminated air to adjacent areas of the plant.

- Reducing the operating temperature of the holding and mixing tanks to that necessary to prevent solidification of the flavoring mixture (normally <120° F). This aids in reducing the volatilization of components not limited to the butter flavoring and their release into the workroom air.
- Equipping the head space of the mixing and holding tanks where flavorings are added to oil or held in pure form with local exhaust ventilation directed out of the plant.
- Automation of the mixing process.
- Covering the flavoring and finished oil tanks and ventilating the headspace to reduce emissions into the room.
- Eliminating spillage from overfilling tanks, leaks in seals and fittings, and manual transfer of materials, all of which have been identified as sources of emissions.
- Establishing standard procedures for cleaning workplace tanks and containers, and spills. Use vacuum cleaners equipped with high-efficiency particulate air (HEPA) filters as much as possible to clean residual powders from equipment.
- Reducing dust exposure during bag dumping by installing commercially available bag dumping stations equipped with local exhaust ventilation (three-sided canopy hood) and bag disposal.
- Putting lids on transfer buckets to avoid residual vapor release and/or placing buckets in a ventilated area following transfer; or pumping flavoring from smaller to larger tanks to avoid manual transfer altogether.
- Adding flavorings at room temperature.
- If flavoring must be heated prior to adding it to the flavoring tank or mixing tank, transfer the flavoring to the tank via a pumping system rather than manual transfer.
- Providing additional general dilution ventilation using axial flow wall fans.
- Storing volatile flavoring substances in cooled storage areas, with their own air handler that has minimum circulation.
- Isolation of cleaning areas, and ensuring that vessels used for powdered butter-flavoring chemicals are not cleaned with compressed air. When vessel entry is necessary, ensuring compliance with the confined space entry requirements.
- Maintaining good housekeeping in any areas where flavorings substances or their ingredients are handled.
- Providing adequate ventilation in quality control laboratories.

2. Personal Protective Clothing and Equipment

a. Skin and Eye Protection

To minimize skin contact, ensure that appropriate protective clothing is worn in areas where popcorn butter flavoring and other food flavoring chemicals are being mixed or processed. Protective clothing includes garments worn over the worker's skin. To be effective, personal protective equipment must be appropriate to the hazard it is meant to protect against; individually selected; properly fitted and periodically refitted; conscientiously and properly worn; regularly maintained; and replaced as necessary.

In addition, employers must:

- Perform a workplace hazard assessment in accordance with 29 CFR 1910.132(d) to determine if hazards are present, or are likely to be present which necessitate the use of personal protective equipment (PPE);
- Provide and ensure the use of chemical-resistant gloves or sleeves or other appropriate protection when there is potential for dermal injury, chemical goggles or appropriate eye protection, and protective clothing when a potential eye or skin exposure exists, and
- Train workers on the limitations and use of PPE required during the handling of microwave popcorn processing operations.

b. Respiratory Protection

The following requirements and recommendations will assist microwave popcorn employers utilizing respiratory protection:

- Employers requiring the use of respiratory protection must establish, implement, and maintain a written respiratory protection program in accordance with 29 CFR 1910.134(c);
- Workers must receive training annually and be medically evaluated prior to using respiratory protection;
- Workers must be fit tested prior to being required to use respirators;
- Employers must provide workers with clean respirators and ensure that respirators are being stored in a manner to protect them from damage or contamination;
- A NIOSH certified half-facepiece negative-pressure respirator with organic vapor cartridges and particulate filters is the minimum level of respiratory protection recommended for entry into mixing areas;
- Powered air-purifying respirators or supplied-air respirators are also appropriate and will provide a higher level of protection.

3. Training and Information

Employers must comply with the OSHA Hazard Communication standard, 29 CFR 1910.1200. In particular, employers must ensure that workers exposed to hazardous chemicals, including diacetyl, are trained in and have access to the following information:

- The specific nature of the operations in their workplace where exposure to diacetyl and other butter-flavoring chemicals may occur;
- Material Safety Data Sheets (MSDSs) for flavoring chemicals containing diacetyl, 2,3-pentanedione and other diacetyl flavoring chemical substitutes;
- The signs and symptoms of butter-flavoring chemical exposure;
- Encourage workers to report new, persistent, or worsening symptoms to their personal physician and to a designated individual at the workplace;

- The importance of avoiding skin contact when working with chemicals that can cause dermal effects;
- The engineering controls the employer is using to reduce worker exposures to diacetyl and other flavoring chemicals;
- Specific work practices that should be used to reduce exposure to these chemicals;
- The use of appropriate protective equipment, including respirators and skin protection;
- Methods that may be used to detect the presence of diacetyl or other butter-flavoring chemicals in the workplace, such as workplace monitoring; and
- The results of any industrial hygiene sampling the employer or others have conducted for levels of diacetyl or other butter-flavoring chemicals used in microwave popcorn processing.

4. Medical Surveillance

A medical screening program will enable employers to identify workers experiencing adverse health effects from exposure to butter flavorings. Spirometry, or pulmonary function testing (PFT), measure the breathing capacity of the lungs and is the best available test for early detection of decreasing or abnormal lung function among exposed workers. It is recommended that employers:

- Perform a baseline spirometry test for all newly-hired workers and ask each worker to complete a health questionnaire before starting work in areas where butter flavorings are used.
- At a minimum, perform an annual evaluation for symptoms (i.e., health questionnaire) and annual spirometry for all workers exposed to volatile butter flavorings and food flavorings containing diacetyl.
- Consider the use of serial spirometry to detect declines in lung function that may be due to flavorings.

[Please refer to the OSHA SHIB, Respiratory Disease Among Workers in Microwave Popcorn Processing Plants, for more information on medical screening.]

Using the above components, together with information gathered during the inspection, describe the specific conditions or weaknesses and suggest methods of abatement.

You may voluntarily provide this Area Office with progress reports on your efforts to address these conditions. OSHA may return to your worksite to further examine the conditions noted above.

Enclosed is a list of available resources that may be of assistance to you in preventing work-related injuries and illnesses in your workplace.

If you have any questions, please feel free to call [name and phone number] at [address].

Sincerely,
Area Director

Enclosure

APPENDIX D

Guidelines for Air Sampling

This appendix first lists air sampling procedures for 2,3-pentanedione, diacetyl, and powdered flavorings (as PNOR, respirable fraction or total dust). The procedure for sampling 2,3-pentanedione can be used to screen for 2,3-hexanedione and 2,3-heptanedione; however, this use of the method has not been fully tested. Procedures for sampling other flavoring chemicals are listed in the accompanying table.

Diacetyl air concentrations were the highest in the mixing rooms of six facilities that NIOSH investigated. Most often the facilities have an open process with large tanks of heated mixtures of soybean oil, butter flavorings, coloring and salt. Flavorings can be supplied as powders, liquids or pastes. The flavorings are often measured in open containers and poured into open tanks of heated soybean.

CSHOs should ensure that both full-shift personal exposure monitoring and area monitoring are conducted on employees who handle flavorings and in rooms where flavoring tanks are located, as well as on the production line and in the quality assurance and packaging areas. When applicable, short-term (STELs, Ceilings, etc.) exposure monitoring should be conducted, such as during tasks in which flavorings are mixed or transferred. CSHOs should be aware that some employers may substitute powdered flavorings, which are not as volatile when mixed. However, this powdered flavoring form does become airborne and CSHOs should be prepared to conduct total and respirable dust sampling depending on particle size. CSHOs should specify on their sample submission paperwork (i.e. Form OSHA-91A) that collected powdered-flavorings dust samples should not be heated during analysis because the volatile flavorings could evaporate.

1. 2,3 -PENTANEDIONE:

Synonyms: acetyl propanal; acetyl propionyl; β,γ -dioxopentane; beta, gamma-dioxopentane; 2,3-pentadione.

OSHA IMIS Code Number: P110

Chemical Abstracts Service (CAS) Registry Number: 600-14-6

NIOSH, Registry of Toxic Effects (RTECS) Identification Number: SA1850000

Chemical Description and Physical Properties: yellow to green-yellow liquid with a butter odor

Molecular formula: $C_5H_8O_2$

Molecular weight: 100.12

Boiling point: 110-112°C

Melting point: -52°C

Vapor pressure: 2.67 kPa @ 20°C

Potentially hazardous incompatibilities: heat; electrostatic charge may ignite vapors; oxidizing agents; reducing agents; strong bases.

Laboratory Sampling and Analytical Method

Sampling media: Two specially dried Silica Gel Tubes in series. Each tube has a single 600-mg 20/40 mesh section and a glass-fiber filter, the filter faces forward when sampling. SKC 226-183, or equivalent. Use an opaque tube holder or wrap tubes with aluminum foil or other opaque material while sampling.

Maximum volume: 9 liters minimum flow rate: 0.05 L/min for long-term sampling; 3 liters at 0.2 L/min for short-term sampling.

Note: Separate the two tubes and cap both ends of each tube as soon as possible after sampling. Individually seal the two tubes. Protect tubes from light after sampling.

Analytical method: Gas Chromatography; GC/FID

Analytical solvent: (95:5) ethanol:water

Method reference: OSHA Analytical Method (OSHA 1016-in review)

Method classification: Fully Validated-but not released

2. DIACETYL:

Synonyms: Biacetyl; 2,3-Butanedione; 2,3-Butadione; 2,3-Diketobutane; Dimethyldiketone; Dimethylglyoxal; Glyoxal, dimethyl.

OSHA IMIS Code Number: D740

Chemical Abstracts Service (CAS) Registry Number: 431-03-8

NIOSH, Registry of Toxic Effects (RTECS) Identification Number: EK2625000

Chemical Description and Physical Properties: Green-yellow liquid

Molecular formula: C₄H₆O₂

Molecular weight: 86.09

Boiling point: 88°C

Vapor pressure: 7 kPa @ 20°C

Melting point: -3°C

Potentially hazardous incompatibilities: strong oxidizers, bases, reducing agents, metals

Laboratory Sampling and Analytical Method

Sampling media: Two specially dried Silica Gel Tubes in series. Each tube has a single 600-mg 20/40 mesh section and a glass-fiber filter, the filter faces forward when sampling. SKC 226-183, or equivalent. Use an opaque tube holder or wrap tubes with aluminum foil or other opaque material while sampling.

Maximum volume: 9 liters minimum flow rate: 0.05 L/min for long-term sampling; 3 liters at 0.2 L/min for short-term sampling.

Note: Separate the two tubes and cap both ends of each tube as soon as possible after sampling. Individually seal the two tubes. Protect tubes from light after sampling.

Analytical method 1: Gas Chromatography; GC/ECD

Analytical solvent: (95:5) ethanol:water with 2 mg/mL PFBHA reagent

Method reference: OSHA Analytical Method ([OSHA 1012](#))

Method classification: Fully Validated

Analytical method 2: Gas Chromatography; GC/FID

Analytical solvent: (95:5) ethanol:water

Method reference: OSHA Analytical Method ([OSHA 1013](#))

Method classification: Fully Validated

3. POWDERED FLAVORINGS: use methods for PNOR (Particulates not otherwise regulated)

Particulates not otherwise regulated (Respirable Fraction)(Synonyms: Dust, (Respirable Nuisance); "Inert" dusts; Nuisance dusts; PNOR [Note: Includes all inert or nuisance dusts, whether mineral, inorganic, not listed specifically in 1910.1000.]

OSHA IMIS Code Number: 9130

IMIS Name History: Dust, (Respirable Nuisance) prior to 9/1/89

Laboratory Sampling/Analytical Method:

Sampling media: tared 37-mm diameter low-ash polyvinyl chloride filter preceded by 10 mm Nylon Cyclone

Maximum volume: 816 Liters **minimum volume:** 408 Liters **flow rate:** 1.7 L/min

Current analytical method: Gravimetric

Method reference: OSHA Analytical Method ([OSHA PV2121](#))

Method classification: Partially Validated

Note: OSHA personnel can obtain tared sampling media from SLTC.

Note: If the filter is not overloaded, samples can be collected up to an 8-hour period.

Particulates not otherwise regulated (Total Dust)

Synonyms: Dust, (Total); "Inert" dusts; Nuisance dusts; PNOR [Note: Includes all inert or nuisance dusts, whether mineral, inorganic, not listed specifically in 1910.1000.]

OSHA IMIS Code Number: 9135

IMIS Name History: Dust, (Total) prior to 9/1/89

Laboratory Sampling/Analytical Method:

Sampling media: tared 37-mm diameter low-ash polyvinyl chloride filter

Maximum volume: 960 Liters **maximum flow rate:** 2.0 L/min--DO NOT USE A CYCLONE--

Current analytical method: Gravimetric

Method reference: OSHA Analytical Method ([OSHA PV2121](#))

Method classification: Partially Validated

Note: OSHA personnel can obtain tared sampling media from SLTC.

Note: If the filter is not overloaded, samples can be collected up to an 8-hour period.

Note: CSHOs should contact SLTC for further guidance.

Below is a table showing other flavoring chemicals, PELs, and analytical methods.

**APPENDIX D
FLAVORING SUBSTANCES**

FEMA No. and Priority¹	CAS No. and OSHA IMIS² No.	Substance	Synonyms	PEL	IDLH³	Respiratory Acute^{3,4}	Analytical Method²	Sampling Medium²	Air Volume and Sampling Rate²
1231 Low	78-92-2 0461	<i>sec</i> -Butyl alcohol	2-Butanol; Butylene hydrate; 2-Hydroxybutane; Methyl ethyl carbinol ³	TWA 150 ppm (450 mg/m ³)	2000 ppm	Irritating to respiratory tract	NIOSH 1401	Charcoal tube (100/50 mg)	10 L 0.2 L/min
2003 High	75-07-0 0010	Acetaldehyde	Acetic aldehyde; ethanal; ethyl aldehyde ³	TWA 200 ppm (360 mg/m ³)	2000 ppm	Mildly irritating to respiratory tract	OSHA 68	HMP-coated XAD-2 tube (450/225 mg)	3 L 0.05 L/min
2006 High	64-19-7 0020	Acetic acid	Acetic acid (aqueous); glacial acetic acid (pure compound); ethanoic acid; methane-carboxylic acid ³	TWA 10 ppm (25 mg/m ³)	50 ppm	Pulmonary edema	OSHA PV2119	Charcoal tube (100/50 mg)	48 L 0.2 L/min
2008 High	513-86-0 A624	Acetoin	Acetyl methyl carbinol; 1-hydroxyethyl methyl ketone; gamma-hydroxy-beta oxybutane; 3-hydroxy-2,3-butanone; 2,3-butanone; dimethylketol ²	None	No Data in NPG		OSHA 1012 or OSHA 1013	Two specially dried silica gel tubes in series (600 mg)	9 L 0.05 L/min 3 L 0.2 L/min
2035 High	870-23-5	Allyl mercaptan	2-Propene-1-thiol ⁵	None	No Data in NPG				
2053 High	12124-99-1	Ammonium sulfide	Ammonium sulfide; ammonium sulphide; ammonium hydrogen sulfide; ammonium hydrosulfide; ammonium mercaptan; ammonium sulfhydrate; monoammonium sulfide ⁶	None	No Data in NPG	Strong irritant to skin and mucous membranes ⁵			
2055 Low	123-92-2 1530	Isoamyl acetate	Banana oil; isopentyl acetate; 3-methyl-1-butanol acetate; 3-methylbutyl ester of acetic acid; 3-methyl-butyl ethanoate ³	TWA 100 ppm (525 mg/m ³)	1000 ppm	Irritating to respiratory tract	OSHA PV2142	Charcoal tube (100/50 mg)	10 L 0.2 L/min
2057	123-51-3 1532	Isoamyl alcohol	Primary isoamyl alcohol; fermentation amyl alcohol; fusel oil; isobutyl carbinol; isopentyl alcohol; 3-methyl-1-butanol ³	TWA 100 ppm (360 mg/m ³)	500 ppm	Irritating to respiratory tract	NIOSH 1402	Charcoal tube (100/50 mg)	10 L 0.2 L/min

**APPENDIX D
FLAVORING SUBSTANCES**

FEMA No. and Priority¹	CAS No. and OSHA IMIS² No.	Substance	Synonyms	PEL	IDLH³	Respiratory Acute^{3,4}	Analytical Method²	Sampling Medium²	Air Volume and Sampling Rate²
2127 High	100-52-7 B105	Benzaldehyde	Benzoic aldehyde; benzenecarbonyl; benzene carbaldehyde ³	None	No Data in NPG				
2147 Low	100-53-8	Benzyl mercaptan	α -Toluenethiol; benzylthiol ⁵	None	No Data in NPG	Toxic by inhalation and ingestion; irritant to tissue ⁵			
2170 Low	78-93-3 0430	2-Butanone	Ethyl methyl ketone; MEK; methyl acetone; methyl ethyl ketone ³	TWA 200 ppm (590 mg/m ³)	3000 ppm	Irritating to respiratory tract	OSHA 1004	Anasorb CMS (150/75 mg) SKC 575-002 Passive Sampler 3M 3520 Organic Vapor Monitor	12 L 0.05 L/min 5 to 240 min 5 to 240 min
2174 Low	123-86-4 0440	Butyl acetate	n-Butyl acetate; n-butyl ester of acetic acid; butyl ethanoate ³	TWA 150 ppm (710 mg/m ³)	1700 ppm [10%LEL]	Irritating to respiratory tract	OSHA 1009	Charcoal tube (100/50 mg) SKC 575-002 Passive Sampler 3M 3520 Organic Vapor Monitor	10 L 0.2 L/min 15-240 min 15-240 min
2175 Low	110-19-0 1534	Isobutyl acetate	Isobutyl ester of acetic acid; 2-methylpropyl acetate; 2-methylpropyl ester of acetic acid; b-methylpropyl ethanoate ³	TWA 150 ppm (700 mg/m ³)	1300 ppm [10%LEL]	Irritating to respiratory tract	OSHA 1009	Charcoal tube (100/50 mg) SKC 575-002 Passive Sampler 3M 3520 Organic Vapor Monitor	10 L 0.2 L/min 15-240 min 15-240 min
2178 Low	71-36-3 0460	Butyl alcohol	n-Butyl alcohol; 1-butanol; n-butanol; 1-hydroxy-butane; n-propyl carbinol ³	TWA 100 ppm (300 mg/m ³)	1400 ppm [10%LEL]	Irritating to respiratory tract	NIOSH 1401	Charcoal tube (100/50 mg)	10 L 0.2 L/min

**APPENDIX D
FLAVORING SUBSTANCES**

FEMA No. and Priority¹	CAS No. and OSHA IMIS² No.	Substance	Synonyms	PEL	IDLH³	Respiratory Acute^{3,4}	Analytical Method²	Sampling Medium²	Air Volume and Sampling Rate²
2179 Low	78-83-1 1536	Isobutyl alcohol	IBA; isobutanol; isopropylcarbinol; 2-methyl-1-propanol ³	TWA 100 ppm (300 mg/m ³)	1600 ppm	Irritating to respiratory tract	NIOSH 1401	Charcoal tube (100/50 mg)	10 L 0.2 L/min
2219 Low	123-72-8	Butyraldehyde	Butaldehyde; <i>n</i> -butanal; <i>n</i> -butylaldehyde; butyric aldehyde ⁵	None	No Data in NPG		NIOSH 2539 (OSHA modified)	HMP-coated XAD-2 tube (150/75 mg)	5 L 0.05 L/min
2220 High	78-84-2 R237	Isobutyraldehyde	2-Methylpropanal; isobutyric aldehyde; isopropylformaldehyde; isobutnal; methyl propanal; valine aldehyde; isobutaldehyde; 2-methylpropionaldehyde ³	None	No Data in NPG		NIOSH 2539 (OSHA modified)	HMP-coated XAD-2 tube (150/75 mg)	5 L 0.05 L/min
2221 High	107-92-6 B709	Butyric acid	Butanoic acid; ethylacetic acid; propylformic acid ³	None	No Data in NPG		SLTC in-house literature file	Silica Gel tube (520/260 mg)	18 L 0.1 L/min
2222 High	79-31-2	Isobutyric acid	2-Methylpropanoic acid ³	None	No Data in NPG				
2230 Low	76-22-2 0522	Camphor	2-Camphonone; Synthetic camphor; Gum camphor; Laurel camphor ³	2 mg/m ³	200 mg/m ³	Irritating to respiratory tract, skin, and eyes	NIOSH 1301	Charcoal tube (100/50 mg)	24 L 0.2 L/min
2286 Low	104-55-2	Cinnamaldehyde	3-Phenylpropenal; cinnamyl aldehyde; cinnamic aldehyde ⁵	None	No Data in NPG				
2370 High	431-03-8 D740	Diacetyl	Biacetyl; 2,3-butanedione; 2,3-diketobutane; dimethyldiketone; dimethylglyoxal; glyoxal, dimethyl ²	None	No Data in NPG		OSHA PV2118 ⁷	Two silica gel tubes in-series (150/75 mg each)	3 L 0.05 L/min
2370 High	431-03-8 D740	Diacetyl	Biacetyl; 2,3-butanedione; 2,3-diketobutane; dimethyldiketone; dimethylglyoxal; glyoxal, dimethyl ²	None	No Data in NPG		OSHA 1012 or OSHA 1013	Two specially dried silica gel tubes in series (600 mg)	9 L 0.05 L/min 3 L 0.2 L/min
2414 Low	141-78-6 1040	Ethyl acetate	Acetic ester; acetic ether; ethyl ester of acetic acid; ethyl ethanoate ³	TWA 400 ppm (1400 mg/m ³)	2000 ppm [10%LEL]	Irritating to respiratory tract	NIOSH 1457	Charcoal tube (100/50 mg); ship cold to lab	6 L 0.2 L/min

**APPENDIX D
FLAVORING SUBSTANCES**

FEMA No. and Priority¹	CAS No. and OSHA IMIS² No.	Substance	Synonyms	PEL	IDLH³	Respiratory Acute^{3,4}	Analytical Method²	Sampling Medium²	Air Volume and Sampling Rate²
2418 High	140-88-5 1050	Ethyl acrylate	Ethyl acrylate (inhibited); ethyl ester of acrylic acid; ethyl propenoate ³	TWA 25 ppm (100 mg/m ³) [skin]	Ca [300 ppm]	Irritating to respiratory tract	OSHA 92	TBC coated Charcoal tube (110/55 mg)	12 L 0.05 L/min
2419 Low	64-17-5 1060	Ethyl alcohol	Alcohol; ethanol; EtOH; grain alcohol; cologne spirit ³	TWA 1000 ppm (1900 mg/m ³)	3300 ppm [10%LEL]	Irritating to respiratory tract	OSHA 100	Two Anasorb 747 tubes in-series (400/200 mg); separate tubes after sampling	12L 0.05 L/min
2434 Low	109-94-4 1155	Ethyl formate	Ethyl ester of formic acid; ethyl methanoate ³	TWA 100 ppm (300 mg/m ³)	1500 ppm	Irritating to respiratory tract	NIOSH 1452	Charcoal tube (100/50 mg)	10 L 0.2 L/min
2487 High	64-18-6 1310	Formic acid	Formic acid (85%–95% in aqueous solution); hydrogen carboxylic acid; methanoic acid ³	TWA 5 ppm (9 mg/m ³)	30 ppm	Corrosive, Pulmonary edema	OSHA ID 186SG	Charcoal tube (400/200 mg) ship cold to lab	48 L 0.2 L/min
2489 High	98-01-1 1325	Furfural	Fural; 2-furancarboxaldehyde; furfuraldehyde; 2-furfuraldehyde ³	TWA 5 ppm (20 mg/m ³) [skin]	100 ppm	Irritating to respiratory tract	OSHA 72	Petroleum-base Charcoal tube (100/50)	180 L 1.0 L/min
2491 Low	98-00-0 1330	Furfuryl alcohol	2-Furylmethanol; 2-hydroxymethylfuran ³	TWA 50 ppm (200 mg/m ³)	75 ppm	Irritating to respiratory tract	NIOSH 2505	Porapak Q tube (150/75 mg)	25 L 0.05 L/min
2525	56-81-5 1363	Glycerol	Glycerin (anhydrous); glyceryl alcohol; 1,2,3-propanetriol; trihydroxypropane ³	TWA 15 mg/m ³ (total) TWA 5 mg/m ³ (resp)	No Data in NPG	Irritating to respiratory tract	OSHA PV2121	Tared 37-mm low-ash PCV filter	960 L 2.0 L/min (Total Dust) 10-mm Nylon Cyclone; 816 L 1.7 L/min (Respirable Fraction)
2544	110-43-0 1675	2-Heptanone	Amyl methyl ketone; n-amyl methyl ketone; methyl (n-amyl) ketone ³	TWA 100 ppm (465 mg/m ³)	800 ppm	Irritating to respiratory tract	NIOSH 1301	Charcoal tube (100/50 mg)	25 L 0.2 L/min
2676 Low	79-20-9 1650	Methyl acetate	Methyl ester of acetic acid; methyl ethanoate ³	TWA 200 ppm (610 mg/m ³)	3100 ppm [10%LEL]	Irritating to respiratory tract	NIOSH 1458	Charcoal tube (100/50 mg)	7 L 0.2 L/min

**APPENDIX D
FLAVORING SUBSTANCES**

FEMA No. and Priority ¹	CAS No. and OSHA IMIS ² No.	Substance	Synonyms	PEL	IDLH ³	Respiratory Acute ^{3,4}	Analytical Method ²	Sampling Medium ²	Air Volume and Sampling Rate ²
2691 Low	96-17-3	2-Methylbutr-aldehyde	2-Methylbutanal ⁵	None	No Data in NPG				
2692 Low	590-86-3 I201	3-Methylbutyr-aldehyde	Isovaleral; isovaleral; isovaleric aldehyde; 3-methylbutyraldehyde ⁵	None	No Data in NPG		SLTC in-house literature file	Three DNP-coated filters; two stacked, one separated by a cassette ring; store collected samples in dark	3 L 0.05 L/min
2716 High	74-93-1 1643	Methyl mercaptan	Mercaptomethane; methanethiol; methyl sulfhydrate ³	C 10 ppm (20 mg/m ³)	150 ppm	Irritating to respiratory tract	OSHA 26	Mercuric acetate-coated 37-mm glass fiber filter	20 L 0.2 L/min
2731 Low	108-10-1 1385	4-Methyl-2-pentanone	Isobutyl methyl ketone; methyl isobutyl ketone; MIBK; hexone ₃	TWA 100 ppm (410 mg/m ³)	500 ppm	Irritating to respiratory tract	OSHA 1004	Anasorb CMS (150/75 mg) SKC 575-002 Passive Sampler 3M 3520 Organic Vapor Monitor	12 L 0.05 L/min 5 to 240 min 5 to 240 min
2742 Low	554-12-1	Methyl propionate	Propionic acid, methyl ester; methyl propanoate; methyl propylate; propanoic acid, methyl ester ⁶	None	No Data in NPG				
2746 High	75-18-3 D650	Methyl sulfide	Dimethyl sulfide; dimethyl sulphide; thiobismethane; DMS; methylthiomethane; 2-thiopropene; 2-thiopropane ³	None	No Data in NPG		SLTC in-house literature file	Charcoal tube (100/50 mg)	5 L 0.1 L/min
2841	600-14-6 P110	2,3-Pentanedione	Acetyl propanal; acetyl propionyl; β,γ-dioxopentane; beta, gama-dioxopentane; 2,3-pentadione ²	None	No Data in NPG		OSHA 1016 (in-review as of 07-2010)	Two specially dried silica gel tubes in series (600 mg)	10 L 0.05 L/min 3 L 0.2 L/min
2842 Low	107-87-9 2010	2-Pentanone	Ethyl acetone; methyl propyl ketone; MPK ³	TWA 200 ppm (700 mg/m ³)	1500 ppm	Irritating to respiratory tract	NIOSH 1300	Charcoal tube (100/50 mg)	10 L 0.2 L/min

**APPENDIX D
FLAVORING SUBSTANCES**

FEMA No. and Priority¹	CAS No. and OSHA IMIS² No.	Substance	Synonyms	PEL	IDLH³	Respiratory Acute^{3,4}	Analytical Method²	Sampling Medium²	Air Volume and Sampling Rate²
2908 High	110-89-4 R269	Piperidine	Cyclopentimine; azacyclohexane; cypentil; hexahydropyridine; hexazane; pentamethyleneimine; pentaethyleneimine; pyridine, hexahydro ³	None	No Data in NPG				
2923 High	123-38-6 P129	Propionaldehyde	Propanal; propyl aldehyde; propionic aldehyde ⁵	None	No Data in NPG	suffocating odor ⁵	NIOSH 2539 (OSHA modified)	HMP-coated XAD-2 tube (150/75 mg)	5 L 0.05 L/min
2925 Low	109-60-4 2180	Propyl acetate	n-Propyl acetate; n-propyl ester of acetic acid ³	TWA 200 ppm (840 mg/m ³)	1700 ppm	Irritating to respiratory tract	NIOSH 1450	Charcoal tube (100/50 mg)	10 L 0.2 L/min
2926 Low	108-21-4 1540	Isopropyl acetate	Isopropyl ester of acetic acid; 1-methylethyl ester of acetic acid; 2-propyl acetate ³	TWA 250 ppm (950 mg/m ³)	1800 ppm	Irritating to respiratory tract	NIOSH 1454	Charcoal tube (100/50 mg)	9 L 0.2 L/min
2928 Low	71-23-8 2170	Propyl alcohol	n-Propyl alcohol; ethyl carbinol; 1-propanol; n-propanol ³	TWA 200 ppm (500 mg/m ³)	800 ppm	Irritating to respiratory tract	NIOSH 1401	Charcoal tube (100/50 mg)	10 L 0.2 L/min
2929 Low	67-63-0 1560	Isopropyl alcohol	Dimethyl carbinol; IPA; isopropanol; 2-propanol; sec-propyl alcohol; rubbing alcohol ³	TWA 400 ppm (980 mg/m ³)	2000 ppm [10%LEL]	Irritating to respiratory tract	OSHA 109	Two Anasorb 747 tubes in-series (400/200 mg); separate tubes after sampling; ship cold to lab	18 L 0.2 L/min
2943 Low	110-74-7	Propyl formate	Pormic acid, propyl ester; propyl methanoate; propylformate ⁶	None	No Data in NPG				
2944 Low	625-55-8	Isopropyl formate	Formic acid, isopropyl ester; isopropyl formate; isopropyl methanoate; isopropylformate ⁶	None	No Data in NPG				
2966 High	110-86-1 2220	Pyridine	Azabenzene; azine ³	TWA 5 ppm (15 mg/m ³)	1000 ppm	Irritating to respiratory tract	SLTC in-house file	Two XAD-7 tubes in-series (100/50 mg); separate tubes after sampling	10 L 0.1 L/min

**APPENDIX D
FLAVORING SUBSTANCES**

FEMA No. and Priority ¹	CAS No. and OSHA IMIS ² No.	Substance	Synonyms	PEL	IDLH ³	Respiratory Acute ^{3,4}	Analytical Method ²	Sampling Medium ²	Air Volume and Sampling Rate ²
3039 High	7446-09-5 2290	Sulfur dioxide	Sulfurous acid anhydride; sulfurous oxide; sulfur oxide ³	TWA 5 ppm (13 mg/m ³)	100 ppm	Irritating to respiratory tract	NIOSH 6004 Use OSHA 1011 if also sampling for hydrogen sulfide	MCEF filter followed by Na ₂ CO ₃ -coated cellulose filter Special sampling tube containing uncoated GFF followed by Na ₂ CO ₃ -coated GFF followed by two AgNO ₃ -coated silica gel beds (200/200 mg)	200 L 1.5 L/min 12 L 0.05 L/min 7.5 L 0.5 L/min ceiling 5 L 0.5 L/min H ₂ S peak
3173 Low	5077-67-8	1-Hydroxy-2-butanone		None	No Data in NPG				
3217 High	764-40-9	2,4 Pentadienal		None	No Data in NPG				
3218 High	764-39-6	2-Pentenal		None	No Data in NPG				
3219 High	107-85-7	Isopentylamine	1-Amino-3-methylbutane ⁶	None	No Data in NPG				
3223 High	108-95-2 2040	Phenol	Carbolic acid; hydroxybenzene; monohydroxy-benzene; phenyl alcohol; phenyl hydroxide ⁵	TWA 5 ppm (19 mg/m ³) [skin]	250 ppm	Corrosive, Pulmonary edema	OSHA 32	XAD-7 tube (100/50 mg)	24 L 0.1 L/min
3233 Low	100-42-5 2280	Styrene	Ethenyl benzene; phenylethylene; styrene monomer; styrol; vinyl benzene ³	TWA 100 ppm Ceiling 200 ppm	700 ppm	Irritating to respiratory tract	OSHA 89 OSHA	TBC-coated Charcoal tube (100/50 mg)	12 L 0.05 L/min

**APPENDIX D
FLAVORING SUBSTANCES**

FEMA No. and Priority ¹	CAS No. and OSHA IMIS ² No.	Substance	Synonyms	PEL	IDLH ³	Respiratory Acute ^{3,4}	Analytical Method ²	Sampling Medium ²	Air Volume and Sampling Rate ²
				600 ppm (5-minute maximum peak in any 3 hours)			1014	006 Passive Sampler 3M 3520 Organic Vapor Monitor	15 to 240 min 15 to 240 min
3326 Low	67-64-1 0040	Acetone	Dimethyl ketone; ketone propane; 2-propanone ³	TWA 1000 ppm (2400 mg/m ³)	2500 ppm [10%LEL]	Irritating to respiratory tract	OSHA 69	Carbosieve S-III tube (130/65 mg)	3 L/0.05 L/min
3368 Low	141-79-7 1635	4-Methyl-3-penten-2-one	Isobutenyl methyl ketone; isopropylideneacetone; methyl isobutenyl ketone; mesityl oxide ³	TWA 25 ppm (100 mg/m ³)	1400 ppm [10%LEL]	Irritating to respiratory tract	NIOSH 1301	Charcoal tube (100/50 mg)	10 L 0.2 L/min
3382 Low	1629-58-9	1-Penten-3-one	Ethyl vinyl ketone ⁶	None	No Data in NPG				
3407 Low	497-70-0	2-Methyl-2-butenal		None	No Data in NPG				
3417 Low	625-33-2	3-Penten-2-one	Ethylidene acetone; methyl propenyl keto ⁶	None	No Data in NPG				
3478 Low	109-79-5 0480	1-Butanethiol	Butanethiol; n-butanethiol; 1-mercaptobutane; n-butyl mercaptan ³	TWA 10 ppm (35 mg/m ³)	500 ppm	Irritating to respiratory tract	SLTC in-house literature file	Mercuric acetate-coated 37-mm glass fiber filter	20 L 0.2 L/min
3521 High	107-03-9	Propanethiol	3-Mercapto-propane; propane-1-thio; propyl mercaptan; n-propyl mercaptan ³	None	No Data in NPG				
3523 High	123-75-1	Pyrrolidine	Azacyclopentane, prolamine, pyrrole, tetrahydro-; tetrahydropyrrole, tetramethyleneimi ⁶	None	No Data in NPG				
3536 Low	624-92-0	Dimethyl disulfide	Methyl disulfide; dimethyl disulfide; dimethyldisulphide, dimethyldisulfide, disulphide, dimethyl; disulfide, dimethyl; 2, 3-dithiabutane; DMDS	None	No Data in NPG		SLTC in-house literature file	Charcoal tube (100/50 mg)	10 L 0.1 L/min

**APPENDIX D
FLAVORING SUBSTANCES**

FEMA No. and Priority ¹	CAS No. and OSHA IMIS ² No.	Substance	Synonyms	PEL	IDLH ³	Respiratory Acute ^{3,4}	Analytical Method ²	Sampling Medium ²	Air Volume and Sampling Rate ²
			Evolution ⁶						
3537	108-83-8 0924	2,6-Dimethyl-4-heptanone	Diisobutyl ketone; DIBK; sym-diisopropyl acetone; isovalerone; valerone ³	TWA 50 ppm (290 mg/m ³)	500 ppm	Irritating to respiratory tract	NIOSH 1300	Charcoal tube (100/50 mg)	25 L 0.2 L/min
3553 Low	78-59-1 1538	Isophorone	Isoacetophorone; 3,5,5-trimethyl-2-cyclohexenone; 3,5,5-trimethyl-2-cyclohexen-1-one ³	TWA 25 ppm (140 mg/m ³)	200 ppm	Irritating to respiratory tract	NIOSH 2508	Petroleum-based Charcoal tube (100/50 mg)	12 L 0.2 L/min
3584 Low	616-25-1	1-Penten-3-ol	Ethyl vinyl carbinol; 1-pentenol-3 ⁶	None	No Data in NPG				
3646 Low	107-86-8	3-Methyl-2-butenal	3-Methyl-2-butenal; 3, 3-dimethylacrylaldehyde; 3, 3-dimethylacrolein; 3-methylcrotonaldehyde; senecioaldehyde ⁶	None	No Data in NPG				
3647 Low	556-82-1	3-Methyl-2-buten-1-ol	2-Buten-1-ol, 3-methyl-; dimethylallyl alcohol; gamma, gamma-dimethylallyl alcohol; 3, 3-dimethylallyl alcohol; prenil; prenyl alcohol ⁶	None	No Data in NPG				
3667 Low	101-84-8 2047	Diphenyl ether	Diphenyl oxide; phenoxy benzene; phenyl oxide; phenyl ether ³	TWA 1 ppm (7 mg/m ³)	100 ppm	Irritating to respiratory tract	SLTC in-house file	XAD-7 tube (100/50 mg)	20 L 0.2 L/min
3779 High	7783-06-4 1480	Hydrogen sulfide	Hydrosulfuric acid; sewer gas; sulfuretted hydrogen ³	C 20 ppm 50 ppm [10-minute maximum peak]	100 ppm	Irritating to respiratory tract, Pulmonary edema	OSHA 1008	Special sampling tube containing uncoated GFF followed by Na ₂ CO ₃ -coated GFF followed by two AgNO ₃ -coated silica gel beds (200/200 mg)	12 L 0.05 L/min 7.5 L 0.5 L/min ceiling 5 L 0.5 L/min Peak

**APPENDIX D
FLAVORING SUBSTANCES**

FEMA No. and Priority ¹	CAS No. and OSHA IMIS ² No.	Substance	Synonyms	PEL	IDLH ³	Respiratory Acute ^{3,4}	Analytical Method ²	Sampling Medium ²	Air Volume and Sampling Rate ²
3860 Low	624-89-5	Methyl ethyl sulfide		None	No Data in NPG				
3897 High	75-33-2 S248	2-Propanethiol	Isopropanethiol; 2-propanethion; 2-mercaptopropane ³	None	No Data in NPG				
3898 High	5724-81-2	1-Pyrrolidine		None	No Data in NPG				
3909 Low	108-94-1 0830	Cyclohexanone	Anone; cyclohexyl ketone; pimelic ketone ³	TWA 50 ppm (200 mg/m ³)	700 ppm	Irritating to respiratory tract	OSHA 1	Chromosorb 106 tube (100/50 mg)	10 L 0.2 L/min
3946 Low	583-60-8 1765	2-Methylcyclohexanone	<i>o</i> -Methylcyclohexanone ³	TWA 100 ppm (460 mg/m ³) [skin]	600 ppm	Irritating to respiratory tract	NIOSH 2521	Porapak Q tube (150/75 mg)	6 L 0.05 L/min
3965 Low	78-96-6 A606	1-Amino-2-propanol	Isopropanolamine; 1-aminopropan-2-ol; aminopropyl alcohol; 2-hydroxypropylamine ³	None	No Data in NPG		OSHA PV2122	NTIC-coated XAD-2 tube (80/40 mg)	20 L 0.1 L/min
	Not applicable 9135	Particulates not otherwise regulated (Total Dust)	PNOR (Total Dust)	15 mg/m ³			OSHA PV2121	Tared 37-mm low-ash PCV filter	960 L 2.0 L/min
	Not applicable 9130	Particulates not otherwise regulated (Respirable Fraction)	PNOR (Respirable Fraction)	5 mg/m ³			OSHA PV2121	Tared 37-mm low-ash PCV filter	10-mm Nylon Cyclone; 816 L 1.7 L/min

Notes:

¹ The high/flow Priority notations were assigned by the Flavoring Extract Manufacturers Association (FEMA). The priority levels were assigned based on inhalation exposure data, chemical structure, and volatility. FEMA stated that the higher priority chemicals pose a greater risk of respiratory injury, whereas, the lower priority chemicals pose a hazard only in more extreme circumstances of exposure.

NPG = NIOSH Pocket Guide to Chemical Hazards (referenced below).

References:

- ² OSHA Chemical Sampling Information http://osha.gov/dts/chemicalsampling/toc/toc_chemsamp.html
- ³ NIOSH Pocket Guide to Chemical Hazards. <http://www.cdc.gov/niosh/npg>
- ⁴ International Chemical Safety Cards. <http://www.cdc.gov/niosh/ipcs/ipscard.html>
- ⁵ Lewis, R.J. *Hawley's Condensed Chemical Dictionary*, 14th Edition [CD-ROM] Wiley Interscience: New York, 2002.
- ⁶ ChemWatch Material Data Safety Sheet. <http://osha.chemwatch.us> (accessed May 22, 2007 by paid subscription).
- ⁷ Persons wishing to sample diacetyl may find it more convenient to use OSHA Method 1012 or OSHA Method 1013. Acetoin can be determined from the same sample.

Appendix E

Description of Hazard at Gilster-Mary Lee, Jasper, Missouri

Introduction:

The microwave popcorn manufacturing plant evaluated by NIOSH in 2000 is located in Jasper, Mo. The facility has been in operation since 1986 and packages popcorn (microwave and plain popcorn kernels) for both national and international distribution.

Process Description:

Whole kernel corn from Missouri and Nebraska is air-cleaned on arrival, treated with an organophosphate insecticide, and transferred to silos. From the silo, the corn is processed by screening and air-cleaning on a gravity table. The corn is then sent to either the polyethylene packaging area or the microwave production area.

Packaging area: In the polyethylene packaging area, corn is packaged in polyethylene bags by machine without the addition of flavorings or additives. After packaging, the bags are boxed, stacked, wrapped in plastic, and transported to the warehouse by a forklift.

Microwave production area: In the microwave production area, the corn is prepared and packaged using a series of steps.

- In the flavor mixing area, where five of the ill former workers worked, salt, butter flavorings, and coloring agents are mixed by a single person and manually added to a large tank of heated soybean oil. This process produces visible dust, aerosols, and vapors with a strong buttery odor. High levels of diacetyl, methyl ethyl ketone, 2-nonanone, acetoin, acetaldehyde, and acetic acid were found.

Concentrations of diacetyl were found from 0.25 ppm to 97.9 ppm. The mean concentration was 32 ppm. Following the use of engineering controls, the mean dropped to 0.46 ppm.

- Following mixing, the oil/flavoring mixture is piped into holding tanks in the packaging area and maintained at a temperature of 140°F to keep the mixture from solidifying.
- In the packaging area – where four of the ill workers worked – the oil/flavoring mixture and the kernel popcorn are added to microwavable bags, and the bags are then wrapped in plastic and placed into boxes for distribution. The boxes are stacked on pallets and enclosed in plastic wrap. The pallets are sent to the warehouse.

Appendix F CSHO Guidance for Worker Interviews

*This appendix contains some questions that may assist CSHOs during worker interviews. This is not a specific questionnaire, but these questions may help to assess possible health issues in workers in the microwave popcorn manufacturing industry. The questions do not need to be asked verbatim, but the topics can guide the interview. **It is very important to ask workers questions about a history of cough or breathing problems, and specifically ask if workers have ever been diagnosed with airways obstruction or bronchiolitis obliterans.** Please be aware that the answers to some of these questions may contain privileged medical information, which must be maintained in such a manner as to ensure worker confidentiality. The CSHO should also inform the worker that he/she is not a medical professional and cannot provide medical advice or treatment to the worker. The CSHO can provide the letter in Appendix B for the worker to take to his/her physician.*

A. Smoking history:

1. Do you currently smoke or have you smoked in the past? (If yes, ask how many packs/day and how long has the worker smoked, and when did the worker quit.)

B. Eye and Skin Irritation

Ask the worker about eye and skin irritation, and ask if the worker associates any symptoms with workplace exposure. For example:

1. Since working at the plant, have you had any symptoms of eye irritation, such as watery eyes, red eyes, burning or itching eyes?
2. Is there any exposure at work that you associate with eye irritation?
3. Have you seen a doctor for eye irritation? (If yes, ask if worker was given a specific diagnosis).
4. Since working at this plant have you developed any skin problems, such as itching, rash, eczema, blisters, or burns?
5. Is there any exposure at work that you associate with skin problems?
6. Have you seen a doctor for skin problems? (If yes, ask if worker was given a specific diagnosis).

C. Respiratory Symptoms and History

*Ask the worker about respiratory symptoms and ask if the worker associates any symptoms with workplace exposures. **Be sure to specifically ask workers about breathing difficulty and cough.***

1. **Do you usually have a cough?** If yes, when did the cough start?
2. Have you seen a doctor for your cough? (If yes, ask if worker was given a specific diagnosis.)
3. Have you ever had any symptoms of wheezing when you breathe? If yes, when did the wheezing start?)
4. Have you seen a doctor for your wheezing? (If yes, ask if worker was given a specific diagnosis.)
5. **Have you developed any trouble with your breathing, or do you ever feel short of breath?** (If yes, when did this start?)
6. How often do you have trouble with your breathing?
7. Does it ever get better?
8. Do you have breathing trouble when walking up a slight hill, or going up a flight of stairs, or hurrying on level ground? (If yes, please have worker describe when they have breathing difficulty).
9. Have you seen a doctor for your breathing problems? (If yes, ask if worker was given a specific diagnosis).
10. **Is there any exposure at work that you associate with any of your respiratory symptoms?**

*Ask worker if they have a history of any lung disease. **Be sure to specifically ask about any diagnosis of airways obstruction and bronchiolitis obliterans.***

1. Have you ever been diagnosed by a doctor with any lung or respiratory disease? For example: bronchitis, chronic bronchitis, pneumonia, emphysema, asthma, reactive airways disease.
2. If yes, what is your diagnosis and when were you diagnosed?
3. If yes, are you currently seeing a physician for this condition?
4. Have you ever been told by a doctor that you had airways obstruction or bronchiolitis obliterans?
5. Have you ever been told you had a lung disease or lung condition related to workplace exposures, including exposure to flavorings?

Appendix G

Recommended Engineering and Work Practice Controls

1. Engineering and work practice controls are the primary methods for controlling exposures in the workplace and include: local exhaust and general dilution ventilation, isolation of process or source, and restricted access to areas where hazardous materials are used or stored.
 - NOTE: NIOSH has recommended that the use of respiratory protection be **mandatory** for all mixers and workers entering the mixing room, until such time as the production process is reengineered or enclosed to eliminate exposures to flavoring chemicals.

2. CSHOs should investigate the employer's process to determine whether any of the following recommended engineering and work practice controls, which have been shown to help reduce worker exposures, are being utilized where applicable. CSHOs should also investigate whether other control measures not listed below have been implemented. Recommended controls include:
 - a. Isolation of the mixing room from the rest of the plant using walls, doors, or other appropriate barriers.
 - b. Equipping the mixing room with a separate ventilation system or ensuring that negative air pressure (relative to the rest of the plant) is maintained in the mixing room to avoid the outward migration of contaminated air to adjacent areas of the plant.
 - c. Reducing the operating temperature of the holding and mixing tanks to that necessary to prevent solidification of the flavoring mixture (normally <math><120^{\circ}</math> F). This aids in reducing the volatilization of components not limited to the butter-flavoring and their release into the workroom air.
 - d. Equipping the head space of the mixing and holding tanks where flavorings are added to oil or held in pure form with local exhaust ventilation directed out of the plant.
 - e. Automation of the mixing process.
 - f. Covering the flavoring and finished oil tanks and ventilating the headspace to reduce emissions into the room.

- g. Eliminating spillage from overfilling tanks, leaks in seals and fittings, and manual transfer of materials, all of which have been identified as sources of emissions. Establish standard procedures for cleaning workplace tanks and containers, and spills.
- h. Reducing dust exposure during bag dumping by installing commercially available bag dumping stations equipped with local exhaust ventilation (three-sided canopy hood) and bag disposal.
- i. Putting lids on transfer buckets to avoid residual vapor release and/or placing buckets in a ventilated area following transfer or pumping flavoring from smaller to larger tanks to avoid manual transfer altogether.
- j. Adding flavorings at room temperature.
- k. If a flavoring must be heated prior to adding it to the flavoring tank or mixing tank, transfer the flavoring to the tank via a pumping system rather than manual transfer.
- l. Providing additional general dilution ventilation using axial flow wall fans.
 - o Note: During the cold months, adequate tempered make-up air is required.
- m. Storing of volatile flavoring substances in cooled storage areas, with their own air handler that has minimum circulation.
- n. Isolation of cleaning areas, and ensuring that vessels used for powdered butter-flavoring chemicals are not cleaned with compressed air. When vessel entry is necessary, ensuring compliance with the confined space entry requirements.
- o. Maintaining good housekeeping in any areas where flavorings substances or their ingredients are handled.
- p. Providing adequate ventilation in quality control laboratories.

Appendix H

Safety & Health Precautions for Compliance Staff

General

1. CSHOs should avoid all exposure to diacetyl and other butter-flavoring chemicals to the extent possible.
2. If a CSHO's exposure is unavoidable during inspection or sampling activities, the CSHO should wear full-face or half-face Air-Purifying Respirators (APRs) with organic vapor/HEPA combo filters. In addition, CSHOs should wear protective clothing, such as disposable coveralls, and protective gloves. If there is any potential for contact with skin from splashes, or particulates, and the CSHO has only a half-face APR, also wear chemical splash goggles to protect eyes and/or a face shield.

The CSHO will review the employer's hazard assessment during the opening conference. Special attention shall be given to the types of personal protective equipment required by the employer for his/her workers. This will assist the CSHO in determining his or her own PPE needs prior to entering the facility. A CSHO must be vigilant about wearing PPE that is appropriate for the operations being performed at the establishment.

Appendix I

References:

1. Akpınar-Elci, M., et al. Bronchiolitis obliterans syndrome in popcorn production plant workers. *Eur. Respir. J.* 24(2):298-302, 2004.
2. Kreiss, K., et al., Clinical bronchiolitis obliterans in employees at a microwave-popcorn plant. *New Engl. J. Med.* 347(5): 330-338, 2002.
3. NIOSH Alert. Preventing Lung Disease in Workers Who Use or Make Flavorings. NIOSH Publication No. 2004-110.
<http://www.cdc.gov/niosh/topics/flavorings>
4. NIOSH Safety and Health Topic: Flavorings-Related Lung Disease.
<http://www.cdc.gov/niosh/topics/flavorings>
5. Kanwal, R., et al., Evaluation of Flavorings-Related Lung Disease Risk at Six Microwave Popcorn Plants. *J. Occup. Environ. Med.* 48(2):149-157, 2006.
6. Day, G., et al., NIOSH Health Hazard Evaluation Report, HETA # 2008-0230-3096, Report on an Investigation of Buttermilk Flavoring Exposures and Respiratory Health at a Bakery Mix Production Facility, Los Angeles, California, November 2009.
7. Centers for Disease Control and Prevention. Fixed obstructive lung disease in employees at a microwave popcorn factory — Missouri, 2000-2002. *MMWR Weekly* 51(16): 345-347, 2002.
8. King, T., Jr., Overview of bronchiolitis. *Clinics in Chest Medicine* 14(4): 607-610, 1993.
9. Epler, G., The spectrum of bronchiolitis obliterans. *Chest* 83(2): 161-162, 1983.
10. FEMA. *Respiratory Health and Safety in the Flavor Manufacturing Workplace*. The Flavor and Extract Manufacturing Association of the United States, August 2004.
11. National Library of Medicine: Hazardous Substances Data Bank: Diacetyl, <http://toxnet.nlm.nih.gov> (Retrieved November 7, 2006).
12. OSHA. Chemical Sampling Information, Diacetyl. Retrieved: November 27, 2006. http://www.osha.gov/dts/chemicalsampling/data/CH_231710.html
13. Kanwal, NIOSH Health Hazard Evaluation Report, HETA # 2006-0303-3034, Report on Severe Fixed Obstructive Lung Disease in Workers at a Flavoring Manufacturing Plant, Los Angeles, California April 2007.
14. Riordan, J.F., Arginyl residues and anion binding sites in proteins. *Mol. Cell. Biochem.* 26(2): 71-92, 1979.
15. Borders, C.L., Jr., et al. Essentiality of the active site arginine residue for the normal catalytic activity of Cu, Zn superoxide dismutase. *Biochem. J.* 230(3): 771-776, 1985.
16. Boggaram, V. and Mannervik, B. Essential arginine residues in the pyridine nucleotide binding sites of glutathione reductase. *Biochim. Biophys. Acta* 701(1): 119-126, 1982.
17. Hubbs, A.F., et al., Airway Epithelial Toxicity of the Flavoring Agent, 2,3-Pentanedione. SOT 2010 Annual Meeting.

18. Morgan, D.I., et al., Inhalation Toxicity of Acetyl Propionyl in Rats and Mice, SOT 2010 Annual Meeting.
19. van Rooy, et al., Bronchiolitis Obliterans Syndrome in Chemical Workers Producing Diacetyl for Food Flavorings. Am J of Respir and Crit Care Med. Sep 1;176(5): 498-504, 2007.
20. NEIHS. Chemical Information Review Document for Artificial Butter Flavoring and Constituents Diacetyl [CAS No. 431-03-8] and Acetoin [CAS No. 513-86-0]. January 2007
http://ntp.niehs.nih.gov/ntp/htdocs/Chem_Background/ExSumPdf/Artificial_butter_flavoring.pdf [Accessed May 20, 2008].
21. OSHA Instruction CPL 02-00-148 November 9, 2009 Field Operations Manual (FOM).
22. OSHA Notice 10-06 (CPL 02) Site-Specific Targeting 2010 (SST-10) Effective, August 18, 2010.
23. OSHA Instruction CPL 02-02-072, August 22, 2007, Rules of Agency Practices and Procedures Concerning OSHA Access to Employee Medical Records.
24. OSHA Instruction CPL 02-00-025 (CPL 2.25I), January 4, 1995, Scheduling System for Programmed Inspections.
25. OSHA Instruction CPL 02-02-038 (CPL 2-2.38D), March 20, 1998, Inspection Procedures for the Hazard Communication Standard.
26. OSHA Instruction CPL 02-00-120 (CPL 2-0.120), September 25, 1998, Inspection Procedures for the Respiratory Protection Standard.
27. Memorandum for Regional Administrators, Area Directors, State Plan Designees Consultation Program Managers, October 12, 2004, Subject: Popcorn/Flavoring Establishment Assistance.