

**OREGON OCCUPATIONAL SAFETY AND HEALTH DIVISION
DEPARTMENT OF CONSUMER AND BUSINESS SERVICES**

PROGRAM DIRECTIVE

Program Directive: A-275
Issued: March 23, 2010
Revised: October 18, 2012

SUBJECT: National Emphasis Program (NEP): Diacetyl (Flavoring Chemicals)

PURPOSE: This program directive (PD) establishes policies and procedures for implementing a national emphasis program (NEP) to identify and eliminate or reduce hazards associated with exposures to flavoring chemicals in facilities that manufacture food flavorings containing diacetyl.

This NEP does not apply to diacetyl that occurs naturally, nor does it apply to facilities that use flavoring chemicals in the manufacturing of food products.

SCOPE: This program directive applies to Oregon OSHA Enforcement.

**REFERENCES
/SOURCES:**

[OSHA Directive CPL 03-00-005, July 27, 2007, National Emphasis Program -Microwave Popcorn Processing Plants.](#)

[OSHA Directive CPL 03-00-011, October 30, 2009, National Emphasis Program – Facilities that Manufacture Food Flavorings Containing Diacetyl.](#)

Oregon OSHA [Field Inspection Reference Manual \(FIRM\)](#)

APPLICATION: This directive applies to Oregon facilities that manufacture food flavorings containing diacetyl for all inspections addressing alleged diacetyl hazards in workplaces where Oregon OSHA has jurisdiction.

BACKGROUND: Diacetyl (also called 2, 3-butanedione) is a chemical that is used to impart a butter-like flavor to food products. These include: popcorn, cheese, cream cheese, cheesecake, ranch dressing, milk, yogurt, ice cream, buttermilk, butterscotch, coffee, caramel, vanilla, tea, toffee, chocolate, maple, brown sugar, hazelnut and other nut flavors, butter pecan, strawberry cream, vanilla cream, root beer float, chai, nutmeg, honey, graham cracker, vinegar, meat flavors (like gravy), malt, beer, and tequila.

Investigations evaluating lung disease used diacetyl as a marker of exposure. Animal studies of exposure to butter flavoring vapors, including diacetyl, have shown airway injury in rats after acute inhalation of these flavorings^{1,2}. These studies demonstrated that butter flavoring vapors are capable of causing severe airway injury in laboratory animals, but the causal relationship between diacetyl exposure and development of bronchiolitis obliterans, a rare and severe lung disease, has not been firmly established. Research continues on diacetyl and other flavoring chemicals to evaluate the relationship of exposure to butter flavorings and adverse health effects, including lung disease.

1 [Fixed Obstructive Lung Disease in Workers at a Microwave Popcorn Factory --- Missouri, 2000--2002](#). Centers for Disease Control and Prevention (CDC), Morbidity and Mortality Weekly Report (MMWR) 51(16);345-7, (2002, April 26).

2 Hubbs A., et al. "Necrosis of Nasal and Airway Epithelium in Rats Inhaling Vapors of Artificial Butter Flavoring". *Toxicology and Applied Pharmacology* 185(2002): 128-135.

CRITERIA WARRANTING AN INSPECTION:

A list of these facilities is posted on the Federal Directorate of Enforcement Programs (DEP) intranet web site for Federal OSHA and state-plan states.

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

Oregon OSHA plans to inspect the facilities in Oregon from this targeting list.

If the Compliance Safety/Health Officer (CSHO) determines during the opening conference that the employer does not manufacture food flavoring containing diacetyl, they will exit the facility without conducting an inspection.

PROCEDURES FOR AN INSPECTION:

CSHOs will follow existing policies and procedures for assessing the following:

- Permissible Exposure Limits ([OAR 437-002-0382](#))
- Respiratory Protection ([1910.134](#) and [PD A-233](#))
- Personal Protective Equipment ([437-002-0134](#) and [PD A-211](#))
- Hazard Communication ([1910.1200](#) and [PD A-150](#))
- Exposure and Medical Records ([1910.1020](#) and [PD A-266](#), and [A-91](#))
- Flammable and Combustible Liquids ([1910.106](#) and [PD A-17](#), [A-108](#), [A-48](#), and [A-115](#))
- Confined Spaces ([1910.164](#) and [PD A-62](#))

TRAINING:

CSHOs will receive training on this directive, including appendices, and will follow the protective measures contained in all the appendices listed below.

- Appendix A: List of flavorings containing diacetyl
- Appendix B: Guidelines for air sampling
- Appendix C: Description of hazards at flavoring manufacturing workplaces
- Appendix D: CSHO guidance for employee interviews
- Appendix E: Recommended engineering and work practice controls
- Appendix F: Safety & health precautions for compliance staff
- Appendix G: Additional references

RECORDING IN IMIS:

All inspections conducted under this NEP will be coded as “Health” inspections. Mark the OSHA-1 Forms as “programmed planned” in item 24, and the inspection category as “H” in item 21. In item 25d record the NEP code “FLAVRING.” For all inspections completed under this directive use the NEP code “FLAVRING.”

CANCELLATION:

This directive is effective immediately and will remain in effect until cancelled or superseded.

History: Issued 3-23-2010 Revised 10-18-2012

APPENDIX A

Flavorings that may contain diacetyl

Diacetyl may be considered both a chemical, because it has uses other than as a flavoring, and a flavoring in its own right. Butter distillate and natural butter distillate are simply terms for concentrated, but not 100 percent, diacetyl.

Both natural and artificial flavorings, as the terms are defined by the Food and Drug Administration (FDA), are relevant to this NEP. Do not stop inquiries because the employer represents that their business manufactures only “natural flavorings.” Natural flavoring may be just as hazardous as artificial flavorings; they are chemically identical.

Some foods, mainly dairy products, wine, and beer, all contain naturally-occurring diacetyl that is not added as a flavoring. This NEP does not cover the manufacturing of such food products.

The following table lists food flavorings that may contain diacetyl.

<u>Dairy Flavors</u>	<u>Hybrid Dairy Flavors</u> (contain a substantial dairy content)
Butter	Butter pecan
Cheese	Strawberry cream
Cream cheese	Vanilla cream
Cheesecake	Any other crème flavor (or “creamy” in the name)
Ranch dressing	
Milk	Root beer float
Yogurt	Chai
Ice cream	
Egg	
Sour cream	
Buttermilk	
Mayonnaise	
Starter distillate or Butter starter distillate	
<u>“Brown” Flavors</u>	<u>Other Flavors</u>
Butterscotch	Nutmeg
Coffee	Honey
Caramel	Graham cracker
Vanilla	Vinegar
Tea	Meat flavors (such as in gravy)
Toffee	Malt
Chocolate (esp. milk chocolate)	Wine ¹
Cocoa butter	Beer ¹

Cocoa	Tequila
Maple	
Brown sugar	
Marshmallow	
Hazelnut & Other nut flavors	
Peanut butter	
Praline	
Fruit flavors	
Strawberry	
Cranberry	
Raspberry	
Blackberry	
Boysenberry or other berry flavors	
Nearly any other kind of fruit flavor (e.g., banana, apple, grape, pear)	
Tomato	
Cider	

¹ Note: This NEP does not target exposures to naturally-occurring diacetyl in beer and wine.

APPENDIX B

Guidelines for Air Sampling

This appendix summarizes the procedures for obtaining air samples for diacetyl, acetoin, and other food flavoring chemicals. Air concentrations tend to be highest in flavor blending and during final flavoring packaging. Most often the facilities have an open process with large tanks of flavorings which can be supplied as powders, liquids, or pastes. The food flavorings are often weighed, measured, poured, and blended.

CSHOs should ensure that both full-shift personal monitoring and short-term personal monitoring, especially during pouring and blending, are conducted in the production room where flavoring tanks are located, as well as in the production line, quality control/assurance laboratories, and packaging areas. CSHOs should be aware that some employers may use powdered flavorings, which may become airborne. Therefore, CSHOs should be prepared to conduct both total and respirable dust sampling when necessary. Particulate not otherwise regulated (PNOR) sampling may not be useful to determine exposures for short-term operations. The CSHO can decide whether or not to take PNOR samples.

1. DIACETYL and ACETOIN

Diacetyl (IMIS: D740) and acetoin (IMIS: A624) are sampled at the same time using the sampling media specified below. This sampler will be cited in the new OSHA analytical methods and it is currently available from SKC. OSHA personnel can obtain these sampling tubes from the Occupational Health Lab in Portland.

Sampling Media: Two silica gel tubes in series each containing 600 mg sections of specially washed and dried silica gel, 20/40 mesh, with a glass-fiber filter plug (SKC 226-183 or equivalent).

NOTE: Wrap samples with aluminum foil, or other opaque material, during sampling to prevent sample loss caused by exposure to light. Use a tube holder to entirely enclose the sampler, protecting the employee from the sharp glass and preventing contamination of any food products with glass shards. Separate and cap the two tubes after sampling. Also wrap tubes with foil after separation.

TWA Sampling

Maximum volume: 9 liters
Maximum flow rate: 0.05 L/min
Maximum time: 180 mins

Short-Term Sampling

Maximum volume: 3 liters
Maximum flow rate: 0.2L/min
Maximum time: 15 mins

2. POWDERED FLAVORINGS

CSHOs should obtain bulk samples when possible and should request analysis for diacetyl those samples. Submit bulk samples in tightly sealed 20-mL glass scintillation vial. Vials should be approximately ¾ full and covered with aluminum foil.

Be certain to state that these samples may contain diacetyl and/or acetoin in the “Interferences and IH Comments to Lab” block on the form OSHA-91A.

(a) PNOR, Respirable Dust OSHA Method #2

OSHA IMIS Code Number: 9130

Sampling Media: Tared 37-mm diameter low-ash polyvinyl chloride filter preceded by a 10 mm Nylon cyclone

Maximum volume: 816 Liters

Maximum flow rate: 1.7 L/min

(b) PNOR, Total Dust OSHA Method #2

OSHA IMIS Code Number: 9135

Sampling Media: Tared 37-mm diameter low-ash polyvinyl chloride filter-DO NOT USE A CYCLONE

Maximum volume: 960 Liters

Maximum flow rate: 2.0 L/min

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

APPENDIX B 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
1231 Low	78-92-2 0461	sec-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 (400/200 mg)	48 L 0.2 L/min

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FLAVORING SUBSTANCES**

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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-butanolone; dimethylketol ²	None	No Data in NPG		NIOSH 2558	Anasorb CMS tube(150/75 mg)	10 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-butanolone; dimethylketol	None	No Data in NPG		OSHA 1012 ⁷ OSHA ⁸ 1013 ⁸	Two silica gel tubes in-series (600 mg with GFF)	TWA 9L 0.05L/min Short Term 3L 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
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			

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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)	10 L 0.2 L/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)	10 L 0.2 L/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
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; n-butanal; n-butyraldehyde; butyric aldehyde ⁵	None	No Data in NPG				
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				

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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	No PEL	No Data in NPG		OSHA 1012 ⁷ OSHA 1013 ⁸	Two silica gel tubes in-series (600 mg each with GFF)	TWA 9 L 0.05 L/min Short Term 3L 0.2L/min
2370 High	431-03-8 D740	Diacety	Biacetyl; 2,3-butanedione; 2,3-diketobutane; dimethyldiketone; dimethylglyoxal; glyoxal, dimethyl ²	No PEL	No Data in NPG		OSHA PV2118 ⁹	Two silica gel tubes in-series (150/75 mg each)	3L 0.05L/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
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 186SG	Charcoal tube (400/200 mg) ship cold to lab	48 L 0.2 L/min

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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
2691 Low	96-17-3	2-Methylbutraldehyde	2-Methylbutanal ⁵	None	No Data in NPG				
2692 Low	590-86-3 1201	3-Methylbutyraldehyde	Isovaleral; isovaleral; isovaleric aldehyde; 3-methylbutyraldehyde ⁵	None	No Data in NPG		SLTC in-house literature file	Three DNPH-coated filters; two stacked, one separated by a cassette ring; store collected samples in dark	3 L 0.05 L/min

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2716 High	74-93-1 1643	Methyl mercaptan	Mercaptomethane; methanethiol; methyl sulfhydrylate 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-thiapropene ³	None	No Data in NPG		SLTC in-house literature file	Charcoal tube (100/50 mg)	5 L 0.1 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
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			
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

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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	Formic 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
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	MCEF filter followed by Na ₂ CO ₃ -coated cellulose filter	200 L 1.5 L/min
3173 Low	5077-67-8	1-Hydroxy-2-butanone		None	No Data in NPG				

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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 ³	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 C 200 ppm 600 ppm (5-minute maximum peak in any 3 hours)	700 ppm	Irritating to respiratory tract	OSHA 89	TBC-coated Charcoal tube (100/50 mg)	12 L 0.05 L/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				

**APPENDIX B
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
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 Evolution ⁶	None	No Data in NPG		SLTC in-house literature file	Charcoal tube (100/50 mg)	10 L 0.1 L/min
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; prenyl; prenyl alcohol ⁶	None	No Data in NPG				

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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
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)	7.5 L 0.5 L/min ceiling 5 L 0.5 L/min Peak
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-Pyrroline		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	o-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

**APPENDIX B
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
	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

† OSHA Method PV2118 is suitable for diacetyl, but it would be more convenient to use either OSHA Method 1012 or Method 1013.

Notes / References:

¹ The high/low priority notations were assigned by the Flavor and 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. {Ref:17}

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/ipccard.html>

⁵ Lewis, R.J. *Hawley's Condensed Chemical Dictionary*, 14th Edition [CD-ROM] Wiley Interscience: New York, 2002.

⁶ ChemWatch Material Safety Data Sheet. <http://osha.chemwatch.us/> (accessed May 22, 2007 by paid subscription).

^{7,8} Air samples for both diacetyl and acetoin are collected on two single-section sampling tubes connected in series with flexible tubing. The two sampling tubes must be protected from light because light will decompose diacetyl and acetoin. If the protective tube cover is opaque it may be sufficient to protect the sampling tubes from light, otherwise wrap the sampler with aluminum foil. The two tubes must be separated, capped, and protected from light with aluminum foil or other opaque material after sampling. Two methods were fully validated at different levels for the analysis of samples; both diacetyl and acetoin are determined simultaneously. OSHA Method 1012 has been optimized for levels of about 50 parts-per-billion and uses post sampling chemical derivatization and analysis by gas chromatography with electron capture detection. The other method, OSHA Method 1013, has been streamlined for levels of about 500 parts-per-billion; and uses solvent extraction and analysis by gas chromatography with flame ionization detection. Samples are stable for at least two weeks before analysis; and up to 80% relative humidity in the sampled air has no effect on sample results when the specified sampling and analytical procedures are followed.

⁹ Persons wishing to sample for diacetyl may find it more convenient to use either OSHA Method 1012 or Method 1013 than OSHA Method PV2118. Methods 1012 and 1013 allow both diacetyl and acetoin to be determined from the same sample and permits a longer sampling time.

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

Appendix C

Hazards at Flavoring Manufacturing Workplaces

Introduction

The Flavor and Extract Manufacturers Association (FEMA) has identified the following conditions when significant exposures to diacetyl or other food flavoring chemicals may occur. However, CSHOs should examine **all** potential exposures, especially in the production room.

Production Room

In the production room, liquid and powdered flavors are formulated by manually scooping or pouring, combining several different chemical ingredients and mixing flavor compounds with food ingredients. Most often, open containers are used to pour and measure these ingredients, which are then transferred to open tanks for liquid flavorings, or blenders for powdered flavorings. In some instances, the flavoring is heated repeatedly, mixed, and then reheated again.

The following work practices can greatly reduce employee exposure to diacetyl and other food flavoring chemicals:

- Mix in fully or partially closed containers with local ventilation.
- Pipe, rather than pour, liquid flavoring substances into mixing containers.
- When pouring is necessary, pour slowly and carefully to prevent spilling.
- When possible, transfer liquids into mixing containers below the surface of solutions to minimize splashing.
- Pour powdered flavors slowly and close to the mixing container to minimize airborne particulates.
- Provide cold storage for flavoring chemicals to reduce evaporative emissions from pouring.
- When feasible, use a closed transfer process.
- Use lids on mixing and holding tanks while not in use.
- Add the powdered ingredients last to the liquid mixture, minimizing airborne particles.

Laboratory

Research and development (RD) and quality assurance and control laboratories provide opportunities for exposure to flavoring chemicals. NIOSH recommends using laboratory exhaust hoods whenever employees are required to handle open containers of flavoring chemicals.

Spray-Dry Manufacturing Process

The spray-drying manufacturing process is a process in which a flavor is attached to a carbohydrate substrate. This process includes flavors such as fruit, dairy, and savory flavors. In their finished form, the spray dried flavors are powders, and this process provides opportunities for inhalation exposure. Other sources of exposure during this process include blending and collecting powder product from the ribbon blender.

NIOSH recommends the following:

- Securing the top of the product bag to the outlet of the blender when unloading.
- Using a continuous liner to provide a continuous pull-down bag to contain any dust generated during collection.

- Using a local exhaust ventilation hood around the outlet to contain potential dust emissions.

Cleaning Operations

Tanks or other vessels that contain liquid flavors or mixtures are cleaned with steam or heated water. Tanks or vessels that contain powdered flavoring most often are cleaned with compressed air. These cleaning methods can result in increased exposures to employees. The cleaning areas should be isolated and contained to prevent the dissemination of airborne food flavoring chemicals. FEMA recommends an automated cleaning process, while NIOSH recommends that during cleaning, an initial wash down of the tank or vessel be done with cold water, followed by a rinse with warm water.

Appendix D CSHO Guidance for Employee Interviews

This appendix contains some questions that may assist CSHOs during employee interviews. The questions do not need to be asked verbatim, but they can guide the interview and may help assess employee health issues in the flavoring manufacturing industry. **It is very important to ask employees questions about a history of cough or breathing problems, and specifically ask if employees 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 to ensure employee confidentiality. The CSHO should also inform the employee that they are not a medical professional and cannot provide medical advice, diagnosis, or treatment to the employee.

A. Smoking History

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

B. Eye and Skin Irritation

Ask the employee about eye and skin irritation, and ask if the employee 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, red, 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, were you 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, were you given a specific diagnosis?**

C. Respiratory Symptoms and History

Ask the employee about respiratory symptoms and ask if the employee associates any symptoms with workplace exposures. Be sure to specifically ask employees about breathing difficulty and coughing.

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, were you 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, were you 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 completely better?**
8. **Do you have breathing trouble when walking up a slight hill, going up a flight of stairs, or hurrying on level ground? If yes, describe when you have breathing difficulty.**
9. **Have you seen a doctor for your breathing problems? If yes, were you given a specific diagnosis?**
10. **Is there any exposure at work that you associate with any of your respiratory symptoms?**

Ask employee 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 food flavorings containing diacetyl?**

Ask employee about former co-workers who developed respiratory illnesses.

Appendix E

Recommended Engineering and Work Practice Controls

1. Engineering and work practice controls are the primary methods for controlling exposures to hazardous flavoring chemicals in the workplace. They include local exhaust and general dilution ventilation, isolation of process or source, and restricted access to areas where the chemicals are used or stored.
 - NOTE: NIOSH recommends that the use of respiratory protection be **mandatory** for all mixers and employees entering the mixing room until 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 employee exposures to flavoring chemicals, are being used where applicable. CSHOs should also investigate if control measures not listed below have been implemented.

Recommended controls include:

 - a. Isolating flavoring production areas from the rest of the plant using walls, doors, or other appropriate barriers.
 - b. Equipping the production room and other areas where flavorings are handled with a separate ventilation system and ensuring that negative air pressure (0.04 w.g. \pm 0.02 w.g. relative to the rest of the plant) is maintained in those areas. This will control the outward migration of contaminated air to adjacent areas of the plant.
 - c. Installing movable exhaust hoods (flexible exhaust ducts) and ensuring the movable local exhaust ventilation (LEV) can be used where powder or liquid flavorings are manually blended, weighed, mixed, poured, transferred, packed, or handled (i.e., tank or blender filling operations, powder dumping operations, drum pouring operations, quality control operations, and compounding operations). The LEV should at a minimum achieve a capture velocity of 100 feet per minute (fpm) between the emission source and hood opening. Direct ventilation exhaust outside of the plant in a manner compliant with environmental regulations.
 - d. Reducing the operating temperature of the holding and mixing tanks to that necessary to prevent solidification of the flavoring mixture (normally $<120^{\circ}$ F). This aids in reducing the volatilization of components not limited to the butter or food flavorings containing diacetyl and their release into the workroom air.
 - e. Equipping the head space of flavoring blenders and tanks where flavorings are compounded or held in pure form with local exhaust ventilation or using a closed process to transfer flavorings. Ensuring the tank opening is a minimum of 100 fpm across the opening of the tank (face).
 - f. Automating the mixing process.
 - g. Covering the flavoring and finished oil tanks, and ventilating the headspace to reduce emissions into the room.
 - h. Eliminating spillage from overfilling tanks, leaks in seals and fittings, and the manual transfer of materials, all of which have been identified as sources of emissions.

- i. 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.
- j. Controlling exposure to flavoring powders during collection or dispensing of final product. Collection bags secured to the outlet and continuous liners used with local exhaust ventilation are options to control exposures to flavoring dust and volatile organic compounds (VOC).
- k. Using laboratory hoods in quality control and quality assurance areas where products are compounded or handled and exposure to VOCs or respirable dust may occur. Be sure to maintain a minimum face velocity of 100 fpm across the opening of the hood.
- l. Putting lids on transfer buckets to avoid residual vapor release, placing buckets in a ventilated area following transfer, or pumping flavoring from smaller to larger tanks to avoid manual transfer altogether.
- m. Adding flavorings at room temperature.
- n. If a flavoring must be heated prior to adding it to the flavoring tank or mixing tank, transferring the flavoring to the tank through a pumping system rather than by manual transfer.
- o. Providing additional general dilution ventilation using axial flow wall fans.
 - Note: During the cold months, adequate tempered make-up air is required.
- p. Storing volatile flavoring substances in cooled storage areas with their own air handler that has minimum circulation.
- q. Establishing and instituting standard procedures for cleaning workplace tanks, containers, and spills. Isolating cleaning areas and ensuring that vessels used for powdered flavoring chemicals are not cleaned with compressed air.
- r. When vessel entry is necessary, ensuring compliance with confined spaces entry requirements.
- s. Using a closed system cleaning process, clean-in-place (CIP), for tanks and blenders.
- t. Maintaining good housekeeping in any areas where flavoring chemicals are handled.

Appendix F

Safety & Health Precautions for Compliance Staff

General

The CSHO will review the employer's hazard assessment during the opening conference. Special attention shall be given to the PPE required by the employer for his employees. This will help the CSHO know what PPE to wear when entering the facility. A CSHO must be vigilant about wearing PPE that is appropriate for the operations at the establishment.

1. CSHOs should avoid all exposure to diacetyl and other food 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 with organic vapor cartridges and particulate filter and goggles. In addition, they should wear protective clothing, such as disposable coveralls and protective gloves. If there is any potential skin contact with splashes or particulates, and the CSHO has only a half-face air-purifying respirator (APR), they should also wear chemical splash goggles or a face shield to protect the eyes.
3. CSHOs must change their cartridges each day they enter a facility, even if they assume exposure to diacetyl and other food flavoring chemicals is limited. For example if the inspection takes more than one day to complete, then the CSHO must have one set of additional cartridges.

Appendix G

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