Emission Factor Documentation for AP-42
Section 9.8.3

Pickles, Sauces, and Salad Dressings

Final Report

For U. S. Environmental Protection Agency
Office of Air Quality Planning and Standards
Emission Factor and Inventory Group

EPA Contract No. 68-D2-0159
Work Assignment No. II-03

MRI Project No. 4602-03

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Research Triangle Park, NC 27711

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NOTICE

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PREFACE

This report was prepared by Midwest Research Institute (MRI) for the Emission Factor and Inventory Group, Office of Air Quality Planning and Standards (OAQPS), U. S. Environmental Protection Agency (EPA), under EPA Contract No. 68-D2-0159. The EPA work assignment manager for this project is Mr. Dallas Safriet.

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1. INTRODUCTION

The document *Compilation of Air Pollutant Emissions Factors* (AP-42) has been published by the U. S. Environmental Protection Agency (EPA) since 1972. Supplements to AP-42 have been issued to add new emission source categories and to update existing emission factors. The EPA also routinely updates AP-42 in response to the needs of Federal, State, and local air pollution control programs and industry.

An emission factor is a representative value that attempts to relate the quantity of a pollutant released to the atmosphere with an activity associated with the release of that pollutant. Emission factors usually are expressed as the weight of pollutant divided by the unit weight, volume, distance, or duration of the activity that emits the pollutant. The emission factors presented in AP-42 may be appropriate to use in a number of situations, such as making source-specific emission estimates for areawide inventories for dispersion modeling, developing control strategies, screening sources for compliance purposes, establishing operating permit fees, and making permit applicability determinations. The purpose of this background report is to provide information to support preparation of AP-42 Section 9.8.3, Pickles, Sauces, and Salad Dressings.

This report contains five sections. Following this introduction, Section 2 gives a description of the pickles, sauces, and salad dressings industry including a brief characterization of the industry, an overview of the process, and the identification of emissions and emission control technology. Section 3 describes the literature search, screening of emission source data, and the EPA quality ranking system for emission data and emission factors. Section 4 describes the results of the literature search. Section 5 presents the proposed AP-42 Section 9.8.3, Pickles, Sauces, and Salad Dressings.

2. INDUSTRY DESCRIPTION

This section provides an overview of the U.S. production of pickled fruits and vegetables, sauces, and salad dressings. The section is divided into four subsections: industry characterization (2.1), process description (2.2), emissions (2.3), and emission control technology (2.4). This industry is classified in Standard Industrial Classification (SIC) Code 2035.

2.1 INDUSTRY CHARACTERIZATION[1]

This industry includes facilities that produce pickled fruits and vegetables, salad dressings, relishes, various sauces, and seasonings. The two vegetables that account for the highest production volume in the U.S. are cucumbers (pickles) and cabbage (sauerkraut). Olives are a very popular condiment in the U.S. but a large portion of the production for domestic consumption is imported. Sauces entail a wide diversity of products but two of the more common types are Worcestershire sauce and hot pepper sauces. Salad dressings are generally considered to be products added to and eaten with vegetable, fruit, meat, fish, and seafood salads. Mayonnaise and spoonable (semisolid) salad dressing may be used as sandwich spreads. In 1987, 21,500 people were employed in the industry. This employment figure represents a 2 percent decline from 1982. California, Georgia, Michigan, and Pennsylvania are the leading employment States in the industry.

2.2 PROCESS DESCRIPTION[2,3]

This section presents an overview of the processes used to produce pickled vegetables, sauces, and salad dressings.

2.2.1 Pickled Vegetables

In the U.S., vegetables are pickled commercially using one of two general processes: brining or direct acidification (with or without pasteurization), or various combinations of these processes. For sodium chloride brining, fresh vegetables are placed in a salt solution or dry salt is added to cut or whole vegetables whereupon the vegetables undergo a microbial fermentation process activated by the lactic acid bacteria, yeasts, and other microorganisms. Direct acidification of fresh or brined vegetables, through the addition of vinegar, is a major component of commercial pickling. This process may be accompanied by pasteurization, addition of preservatives, refrigeration, or a combination of these treatments.

While cucumbers, cabbage, and olives constitute the largest volume of vegetables brined or pickled in the U.S., other vegetables include peppers, onions, beans, cauliflower, and carrots. Because pickles and sauerkraut represent major commodities, their production is discussed in this section.

2.2.1.1 Pickles. In the United States, the term "pickles" generally refers to pickled cucumbers. Three methods currently are used to produce pickles from cucumbers: brine stock, fresh pack, and refrigerated. Smaller quantities are preserved by specialized brining methods to produce pickles for delicatessens and other special grades of pickles. Pickling cucumbers, which are grown specifically for this purpose, are harvested and transported to the processing plants. The cucumbers may be field graded and cooled, if necessitated by the temperature, prior to transport to the plants. A process flow diagram for the brine stock method is shown in Figure 2-1 and diagrams for the fresh pack and refrigerated methods are shown in Figure 2-2.

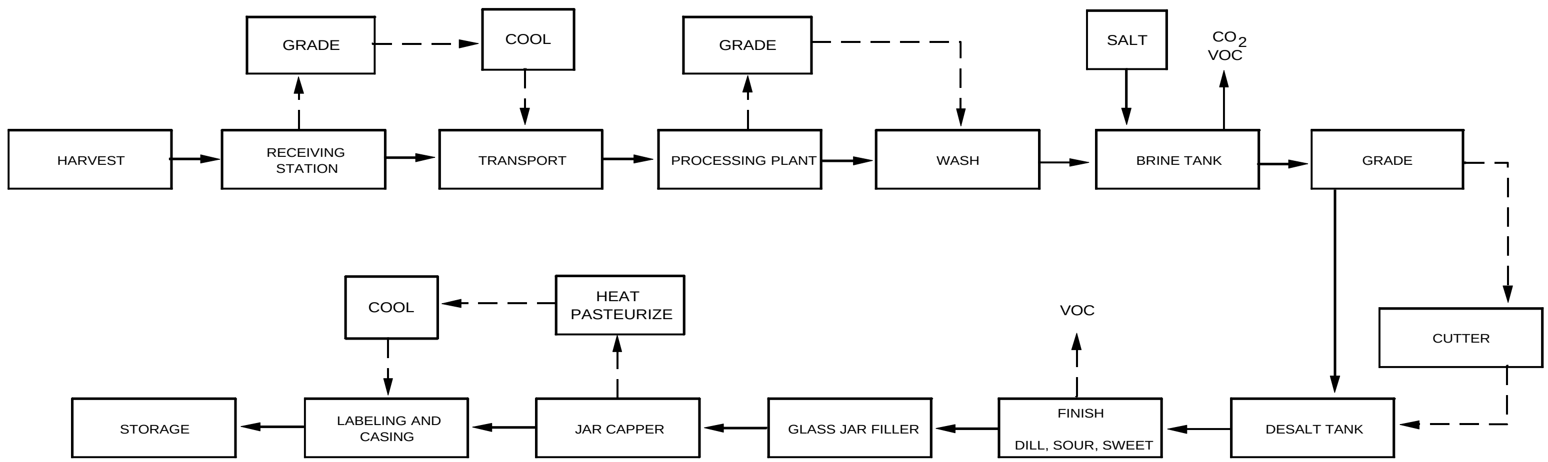

Figure 2-1: Process diagram for pickel production by the brine stock method

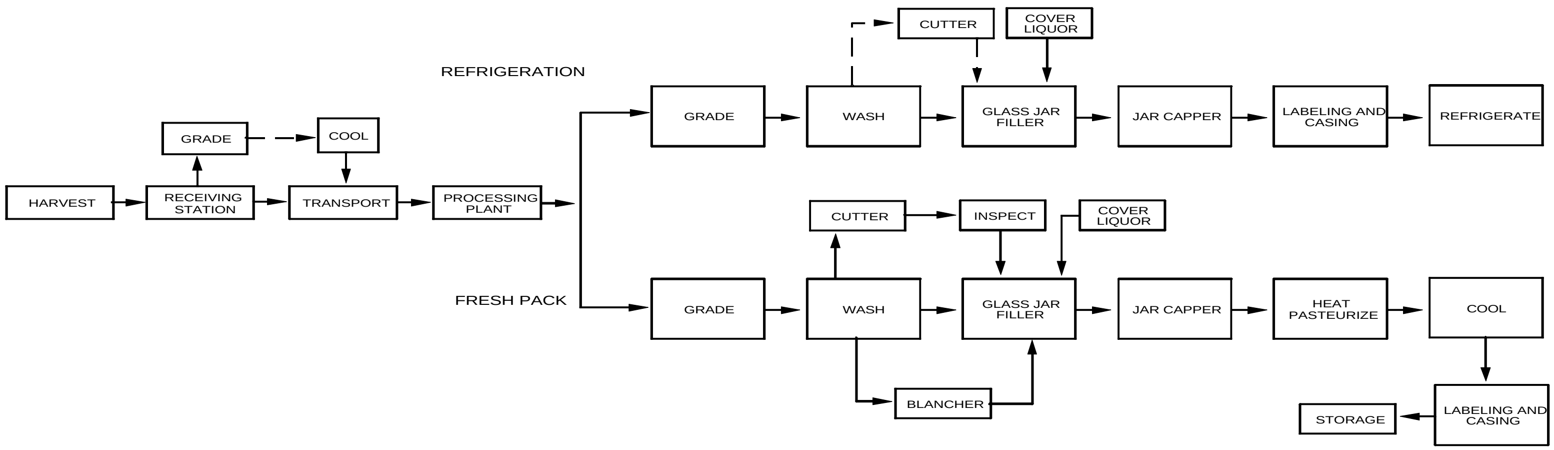

Figure 2-2: Process diagram for pickel production by the fresh pack and refrigeration methods

The brine stock process, shown in Figure 2-1, begins with brining the cucumbers through the addition of salt or a sodium chloride brining solution. The cucumbers undergo a fermentation process in which lactic acid is formed. During fermentation, the cucumbers are held in 5 to 8 percent salt; after fermentation, the salt content is increased weekly in 0.25 to 0.5 percent increments until the final holding strength is 8 to 16 percent salt. The cucumbers, called brine stock, are then graded and cut (optional), before being desalted by washing in an open tank with water at ambient temperature to obtain the desired salt level and processed into dill, sour, sweet, or other pickle products. Containers are filled with the cut or whole pickles, and sugar and vinegars are added. Preservatives are also added if the product is not pasteurized. The containers are then vacuum sealed and pasteurized (optional) until the temperature at the center of the cucumbers reaches about 74°C (165°F) for about 15 minutes. The product is then cooled, and the containers are labeled, packaged, and stored.

The fresh pack process, shown in Figure 2-2, begins with grading of the pickling cucumbers, followed by washing with water. The cucumbers are then either cut and inspected before packaging, or are sometimes "blanched" if they are to be packaged whole. The "blanching" process consists of rinsing the cucumber with warm water to soften the cucumber and make it easier to pack in the container. It is not a true blanching process with hot water as used with other canning operations. Containers are filled with the cut or whole cucumbers, and then salt, spices, and vinegars are added. The containers are then vacuum sealed and heated (pasteurized) until the temperature at the center of the cucumbers reaches about 74°C (165°F) for about 15 minutes. The product is then cooled, and the containers are labeled, packaged, and stored.

The refrigerated process, also shown in Figure 2-2, begins with grading of the pickling cucumbers, followed by washing with water. The washed cucumbers are packed into containers, and then salt, spices, vinegars, and preservatives (primarily sodium benzoate) are added. The containers are then vacuum sealed, labeled, and refrigerated at 1.1° to 4.4°C (34° to 40°F). In this process, the cucumbers are not heat-processed before or after packing.

2.2.1.2 Sauerkraut. The production of sauerkraut is the result of the natural fermentation of salted cabbage. In the sauerkraut process, shown in Figure 2-3, the cabbage is harvested, transported to the processing plant, washed, and prepared for the fermentation by coring, trimming, and shredding. The shredded cabbage is conveyed to a fermentation tank where salt is added up to a final concentration of 2 to 3 percent (preferably 2.25 percent), by weight. After salt addition, the mixture is allowed to ferment at ambient temperature in a closed tank. If insufficient salt is added or air is allowed to contact the surface of the cabbage, yeast and mold will grow on the surface and result in a softening of the final sauerkraut product. When fermentation is complete, the sauerkraut contains 1.7 to 2.3 percent acid, as lactic acid. Following fermentation, the sauerkraut is packaged in cans, plastic bags, or glass containers; cans are the most prevalent method. In the canning process, the sauerkraut, containing the original or diluted fermentation liquor, is heated to 85° to 88°C (185° to 190°F) by steam injection in a thermal screw and then packed into cans. The cans are steam exhausted, sealed, and cooled. After cooling, the cans are labeled, packed, and stored for shipment. In the plastic bag process, the sauerkraut, containing the fermentation liquor, is placed in plastic bags and chemical additives (benzoic acid, sorbic acid, and sodium bisulfite) introduced as preservatives. The bags are sealed and refrigerated. Small quantities, approximately 10 percent of the production, are packaged in glass containers, which may be preserved by heating or using chemical additives.

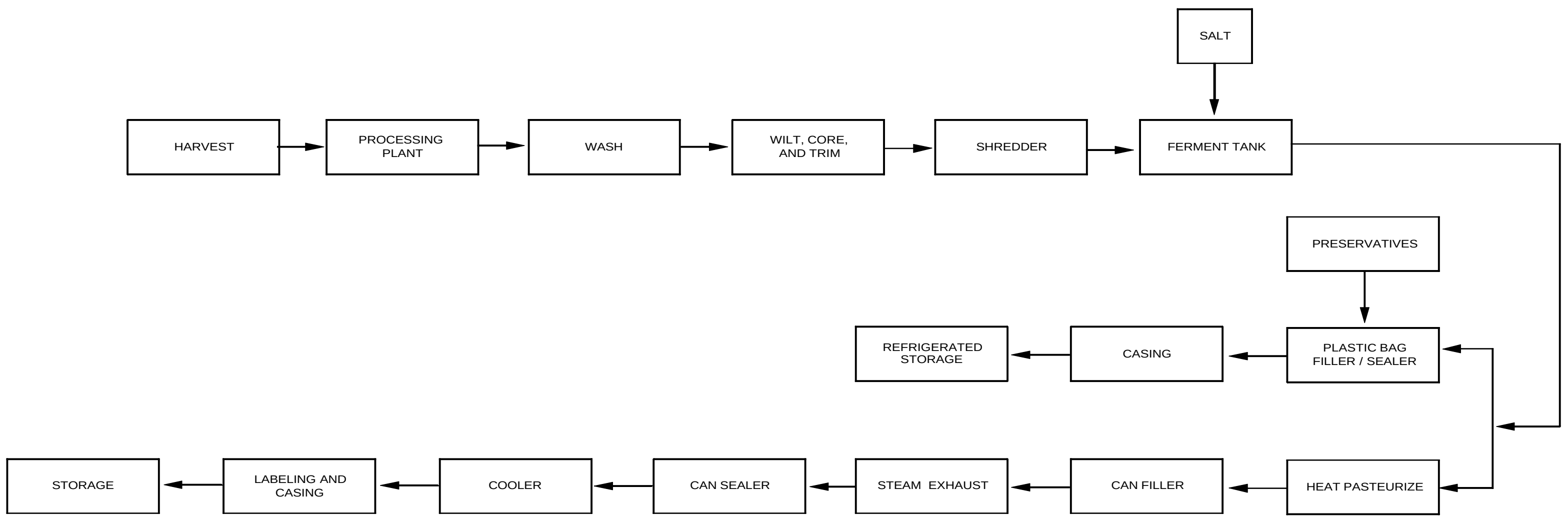

Figure 2-3: Process diagram for the production of sauerkraut

2.2.2 <u>Sauces</u>

Limited information is available on the processes used to produce the many types of sauces available. A typical sauce production operation involves the mixture of several ingredients, often including salts, vinegars, sugar, vegetables, and various spices. The mixture is allowed to ferment for a period of time, sealed in containers, and pasteurized to prevent further fermentation. The production processes for Worcestershire sauce and hot pepper sauces are briefly described as examples of sauce production.

2.2.2.1 <u>Worcestershire Sauce</u>. The name "Worcestershire Sauce" is now a generic term for a type of food condiment that originated in India. In the preparation of the true sauce, a mixture of vinegar, molasses, sugar, soy, anchovies, tamarinds, eschalots, garlic, onions, and salt is prepared and well mixed. Spices and flavorings are added and then water is added until the specific gravity of the entire solution is about 1.13 and the total solids content is about 30 percent by weight. The mixture is transferred to an aging tank, sealed, and allowed to mature and ferment over a period of time. The fermenting mixture is occasionally agitated to ensure proper blending. After fermentation is complete, the mixture is processed by filtration through a mesh screen which allows the finer particles of the mixture to remain in the liquid. The product is then pasteurized prior to bottling to prevent further fermentation. Following bottling, the product is cooled, labeled, and packaged. A properly prepared sauce will be a dark, almost black, liquid with about 25 percent visible sediment.

2.2.2.2 <u>Hot Pepper Sauce</u>. Hot sauce or pepper sauce is a generic name given to a large array of bottled condiments produced by several manufacturers in the U.S. The hot peppers, usually varieties of *Capsicum annum* and *Capsicum frutescens,* give the products their heat and characteristic flavor; vinegar is the usual liquid medium. The active ingredient is Oil of Capsaicin. Manufacturing processes vary by producer; however, in most, the harvested hot peppers are washed and either ground for immediate use or stored whole in brine for several months until processed. In processing, the whole peppers are ground, salt and vinegar added, and the mixture passed through a filter to remove seeds and skin. The end-product, a stable suspension of the pulp from the pepper, vinegar, and salt, is then bottled, labeled, and stored for shipment.

One manufacturer, McIlhenny Company of Avery Island, Louisiana, harvests the red peppers and grinds them the same day. A small amount of salt is added to the ground peppers and the mixture placed in oak barrels. The mixture is aged in the barrels for a minimum of 3 years prior to processing. After the aging process is complete, distilled vinegar is added to the ground peppers/salt and the mixture stirred at ambient temperature for 4 weeks. The mixture is then screened to remove the seeds and skin prior to being bottled.

2.2.3 <u>Salad Dressings</u>

Salad dressings (except products modified in calories, fat, or cholesterol) are typically made up of oil, vinegar, spices, and other food ingredients to develop the desired taste. These dressings are added to many types of foods to enhance flavor. There are U.S. FDA Standards of Identity for three general classifications of salad dressings: mayonnaise, spoonable (semisolid) salad dressing, and French dressings. All other dressings are nonstandardized and are typically referred to as "pourable."

Mayonnaise is a semisolid emulsion of edible vegetable oil, egg yolk or whole egg, acidifying ingredients (vinegar, lemon, or lime juice), seasonings (e.g., salt, sweeteners, mustard, paprika), citric acid, malic acid, crystallization inhibitors, and sequestrants to preserve color and flavor. The U.S. FDA

Standard of Identity requires the product to contain a minimum of 65 percent (by weight) edible vegetable oil. Mayonnaise is an oil-in-water type emulsion where egg is the emulsifying agent and vinegar and salt are the principal bacteriological preservatives. The production process begins with mixing water, egg, and dry ingredients and slowly adding oil while agitating the mixture. Vinegar is then added to the mixture and, after mixing is complete, containers are filled, capped, labeled, and stored or shipped. Improved texture and uniformity of the final product is achieved through the use of colloidalizing or homogenizing machines.

Salad dressing is a spoonable (semisolid) combination of oil, cooked starch paste base, and other ingredients. The product is regulated by a FDA Standard of Identity and must contain not less than 30 percent oil (by weight). During salad dressing production, the starch paste base is prepared by mixing starch (e.g., food starch, tapioca, wheat or rye flours) with water and vinegar. Optional ingredients include salt, nutritive carbohydrate sweeteners (e.g., sugar, dextrose, corn syrup, honey), any spice (except saffron and tumeric) or natural flavoring, monosodium glutamate, stabilizers and thickeners, citric and/or malic acid, sequestrants, and crystallization inhibitors. To prepare the salad dressing, a portion of the starch paste and other optional ingredients, except the oil, are blended and then the oil is slowly added to form a "preemulsion." When one-half of the oil is incorporated, the remainder of the starch paste is added at the same rate as the oil. After all of the starch paste and oil have been added, the mixture continues to blend until the ingredients are thoroughly mixed and then the mixture is milled to a uniform consistency. The salad dressing is placed into containers that are subsequently capped, labeled, and stored or shipped.

Liquid dressings, except French dressing, do not have a FDA Standard of Identity. They are pourable products that may contain vegetable oil and emulsifiers. These dressings may also contain catsup, tomato paste, vinegars, cheese, sherry, spices, and other natural ingredients. Liquid dressings are packaged either as separable products with distinct proportions of oil and aqueous phases or as homogenized dressings that are produced by the addition of stabilizers and emulsifiers. The homogenized dressings are then passed through a homogenizer or colloidalizing machine prior to bottling.

2.3 EMISSIONS

No source tests have been performed to quantify emissions resulting from the production of pickles, sauerkraut, sauces, or salad dressings. For most of these industries, processes are conducted in closed tanks or other vessels and would not be expected to produce significant emissions. For some products, in certain instances, the potential exists for emissions of particulate matter (PM) or odor (VOC).

Emissions of PM potentially could result from solids handling, solids size reduction, and cooking. If raw vegetables are transported directly from the field, the unloading of these vegetables could result in emissions of dust or vegetative matter. For those products that involve cooking or evaporative condensation in open vessels, PM emissions may be produced by condensation of vapors and may be in the low-micrometer or submicrometer particle-size range.

The VOC emissions are most usually associated with thermal processing steps (e.g., cooking or evaporative condensation) or other processing steps performed in open vessels. Thermal processing steps conducted in closed vessels generally do not result in VOC emissions. Gaseous compounds emitted from those steps conducted in open vessels may contain malodorous VOC.

Because no emission data are available that quantify any VOC, HAP, or PM emissions from any of these industries, emission factors cannot be developed.

2.4 EMISSION CONTROL TECHNOLOGY[4]

A number of VOC and particulate emission control techniques are potentially available to these industries. These options include the traditional approaches of wet scrubbers, dry sorbants, and cyclones. Other options include condensation and chemical reaction. No information is available for the actual controls used in these industries. The controls presented in this section are ones that theoretically could be used. The applicability of controls and the specific type of control device or combination of devices would vary from facility to facility depending upon the particular nature of the emissions and the pollutant concentration in the gas stream.

For general industrial processes, control of VOC from a gas stream can be accomplished using one of several techniques but the most common methods are absorption, adsorption, and afterburners. Absorptive methods encompass all types of wet scrubbers using aqueous solutions to absorb the VOC. The most common scrubber systems are packed columns or beds, plate columns, spray towers, or other types of towers. Gas absorption is a diffusion controlled, gas-liquid mass transfer process. Most scrubber systems require a mist eliminator downstream of the scrubber.

Adsorptive methods could include one of four main adsorbents: activated carbon, activated alumina, silica gel, or molecular sieves. Of these four, activated carbon is the most widely used adsorbent for VOC control while the remaining three are used for applications other than pollution control.

Condensation methods and scrubbing by chemical reaction may be applicable techniques depending upon the type of emissions. Condensation methods may be either direct contact or indirect contact with the shell and tube indirect method being the most common technique. Chemical reactive scrubbing may be used for odor control in selective applications but the technique is very specific.

Particulate control commonly employs methods such as venturi scrubbers, dry cyclones, wet or dry electrostatic precipitators (ESPs), or dry filter systems. The most common controls are likely to be the venturi scrubbers or dry cyclones. Wet or dry ESPs could be used depending upon the particulate loading of the gas stream. These three systems are commonly used for particulate removal in many types of general industrial facilities.

REFERENCES FOR SECTION 2

1. 1987 Census of Manufacturers, MC87-1-20-C, Industries Series, Preserved Fruits and Vegetables.

2. G. Fuller and G. G. Dull, "Processing of Horticultural Crops in the United States," in "Handbook of Processing and Utilization in Agriculture." CRC Press, Inc., Boca Raton, FL, 1983.

3. N.W. Desrosier, "Elements of Food Technology," AVI Publishing Company, Westport, CT, 1977.

4. H. J. Rafson, "Odor Emission Control for the Food Industry." Food Technology, June 1977.

3. GENERAL DATA REVIEW AND ANALYSIS PROCEDURES

3.1 LITERATURE SEARCH AND SCREENING

Review of emissions data began with a literature and source test search. First, EPA literature and data were reviewed including review of the AP-42 background files located in the Emission Factor and Inventory Group (EFIG) and data base searches on the Crosswalk/Air Toxic Emission Factor Data Base Management System (XATEF), the VOC/PM Speciation Data Base Management System (SPECIATE), and the Air Chief CD-ROM. New references were identified primarily through reviews of literature describing changes in the production of pickles, sauces, and salad dressings.

During the review of each document, the following criteria were used to determine the acceptability of reference documents for emission factor development:

1. The report must be a primary reference:

a. Source testing must be from a referenced study that does not reiterate information from previous studies.

b. The document must constitute the original source of test data.

2. The referenced study must contain test results based on more than one test run.

3. The report must contain sufficient data to evaluate the testing procedures and source operating conditions.

3.2 DATA QUALITY RATING SYSTEM[1]

Based on OAQPS guidelines, the following data are always excluded from consideration in developing AP-42 emission factors:

1. Test series averages reported in units that cannot be converted to the selected reporting units;

2. Test series representing incompatible test methods; and

3. Test series in which the production and control processes are not clearly identified and described.

If there is no reason to exclude a particular data set, data are assigned a quality rating based on an A to D scale specified by OAQPS as follows:

A—This rating requires that multiple tests be performed on the same source using sound methodology and reported in enough detail for adequate validation. Tests do not necessarily have to conform to the methodology specified by EPA reference test methods, although such methods are used as guides.

B—This rating is given to tests performed by a generally sound methodology but lacking enough detail for adequate validation.

C—This rating is given to tests that are based on an untested or new methodology or that lack a significant amount of background data.

D—This rating is given to tests that are based on a generally unacceptable method but may provide an order-of-magnitude value for the source.

The following are the OAQPS criteria used to evaluate source test reports for sound methodology and adequate detail:

1. Source operation. The manner in which the source was operated should be well documented in the report, and the source should be operating within typical parameters during the test.

2. Sampling procedures. The sampling procedures should conform to a generally accepted methodology. If actual procedures deviate from accepted methods, the deviations must be well documented. When this occurs, an evaluation should be made of how such alternative procedures could influence the test results.

3. Sampling and process data. Adequate sampling and process data should be documented in the report. Many variations can occur without warning during testing and sometimes without being noticed. Such variations can induce wide deviations in sampling results. If a large spread between test results cannot be explained by information contained in the test report, the data are suspect and are given a lower rating.

4. Analysis and calculations. The test reports should contain original raw data sheets. The nomenclature and equations used are compared to those specified by EPA (if any) to establish equivalency. The depth of review of the calculations is dictated by the reviewer's confidence in the ability and conscientiousness of the tester, which in turn is based on factors such as consistency of results and completeness of other areas of the test report.

3.3 EMISSION FACTOR QUALITY RATING SYSTEM[1]

The EPA guidelines specify that the quality of the emission factors developed from analysis of the test data be rated utilizing the following general criteria:

A—Excellent: The emission factor was developed only from A-rated test data taken from many randomly chosen facilities in the industry population. The source category* was specific enough to minimize variability within the source category population.

B—Above average: The emission factor was developed only from A-rated test data from a reasonable number of facilities. Although no specific bias was evident, it was not clear if the facilities tested represented a random sample of the industries. As in the A-rating, the source category was specific enough to minimize variability within the source category population.

* Source category: A category in the emission factor table for which an emission factor has been calculated.

C—Average: The emission factor was developed only from A- and B-rated test data from a reasonable number of facilities. Although no specific bias was evident, it was not clear if the facilities tested represented a random sample of the industry. As in the A-rating, the source category was specific enough to minimize variability within the source category population.

D—Below average: The emission factor was developed only from A- and B-rated test data from a small number of facilities, and there was reason to suspect that these facilities did not represent a random sample of the industry. There also may be evidence of variability within the source category population. Limitations on the use of the emission factor are footnoted in the emission factor table.

E—Poor: The emission factor was developed from C- and D-rated test data, and there was reason to suspect that the facilities tested did not represent a random sample of the industry. There also may be evidence of variability within the source category population. Limitations on the use of these factors are footnoted.

The use of the above criteria is somewhat subjective depending to a large extent on the individual reviewer. Details of how each candidate emission factor was rated are provided in Section 4.

REFERENCES FOR SECTION 3

1. *Technical Procedures for Developing AP-42 Emission Factors and Preparing AP-42 Sections*, EPA-454/B-93-050, U. S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC, October 1993.

4. POLLUTANT EMISSION FACTOR DEVELOPMENT

This section describes the references and test data that were evaluated to determine if pollutant emission factors could be developed for AP-42 Section 9.8.3, Pickles, Sauces, and Salad Dressings.

4.1 REVIEW OF SPECIFIC DATA SETS

No source tests or other documents that could be used to develop emission factors for the AP-42 section were located during the literature search.

4.2 DEVELOPMENT OF CANDIDATE EMISSION FACTORS

No emission factors were developed because no source tests or emissions data were found.

5. PROPOSED AP-42 SECTION 9.8.3

A proposed AP-42 Section 9.8.3, Pickles, Sauces, and Salad Dressings, is presented in the following pages as it would appear in the document.

[Not presented here. See instead final AP-42 Section 9.8.3.]