AP42 Section: 9.6.1

External Review Requests and correspondence

1997

Note: This material is related to a section in *AP42, Compilation of Air Pollutant Emission Factors, Volume I Stationary Point and Area Sources.* AP42 is located on the EPA web site at www.epa.gov/ttn/chief/ap42/

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Tom Lapp

From: Tom Lapp
Sent: Wednesday, July 09, 1997 1:58 PM
To: 'ryan.ron@epamail.epa.gov'
Subject: SCCs for AP-42 9.6.1

Ron -- I have a new email address: tlapp@mriresearch.org

We are preparing the Final Report for AP-42 Section 9.6.1, Natural and Processed Cheese and would like to add SCCs for three sources. Section 9.6.1 is a new section and is a subset under the generic heading Section 9.6, Dairy Products. Currently, two SCCs are listed in FIRE for Section 9.6 but no emission factors are presented. My suggested additions to FIRE are listed below. In addition, a copy of the proposed new AP-42 section is attached as a file for your reference.

Current SCCs in FIRE:

3-02-030-01	Milk:Spray Dryer	lb per ton product
3-02-030-99	Other Not Classified	lb per ton product

Proposed Additions:

3-02-030-10	Whey Dryer	lb per ton dried product
3-02-030-11	Whey Dryer and Bagger	lb per ton dried product
3-02-030-20	Cheese Dryer	lb per ton dried product

We could add SCCs for coagulation, curd treatment, ripening, and cheese grinding/grating/shredding but no emission factors are available for these sources.

Any comments or revisions to these SCCs would be appreciated.

Thanks for your help.

Cheese.ap4

Tom

Tom Lapp

From: RON RYAN[SMTP:RYAN.RON@EPAMAIL.EPA.GOV]
Sent: Thursday, August 14, 1997 3:59 PM
To: SUMMERS.JAKE@EPAMAIL.EPA.GOV; vkriegsm@rtp.pes.com
Subject: SCC request - cheese

please add 2 sccs to AFS and FIRE:

3-02-030-10	Whey Dryer	lb/ton dry product
3-02-030-20	Cheese Dryer	lb/ton dry product

thanks.

MIDWEST RESEARCH INSTITUTE
Suite 350
401 Harrison Oaks Blvd.
Cary, N.C. 27513
Telephone (919) 677-0249
Fax (919) 677-0065

FAX TRANSMISSION

phone 608 267 7541

TO: Joe Brehm, Wis. DNR

FROM: Amy M. Marshall ext 5135

TIME: 2:30

DATE: ~~10/3/96~~ 10/4/96

THIS FAX CONSISTS OF 1 PAGES (INCLUDING THIS PAGE)
RECEIVING FAX NUMBER: 608 267 - 0560
VERIFICATION PHONE NUMBER: ______

COMMENTS:
Thanks for returning my call the other day; I have the following cheese manufacturing test reports and have some questions (we got these out of the STIRS database):

1. Kraft Foods, Wausau, WI   Mar 1993   Parmesan Cheese Dryer
   -- are there more recent tests here? (For cheese or whey dryers >Mar 1993)

2. Do the following facilities have cheese production or do they receive the whey from other facilities (in other words, is the whey dryer part of a cheese manufacturing plant)?

Alto Dairy, Waupun, WI	Apr 1989	Whey Dryer
Ellsworth Coop Creamery	Nov 1988	Whey Dryer
F&A Dairy, Dresser, WI	Mar 1988	Whey Dryer
Northland Food Corp, Shawano, WI	Apr 1986	Whey Dryer

3. The following tests were for spray dryers, but we don't know what kind. Can you help?
   Northland Foods Corp, Appleton, WI, 11/29-12/1/88, file ref. 4530, rev. by Brad Pyle, spray dryer
   Allied Processors, Boyceville, WI, Oct 3-4, 1991, spray dryer, file ref. 4530, rev. by John Stoffel

4. Do you have any other test reports for cheese dryers?

5. On a different subject, do you have any tests for Dairy Farms (e.g., ammonia, windblown particulate, VOC)? There was a study recently done in S. California on these pollutants from dairy farms.

Thanks!

Amy

478/FRM

4/15/93

American Cheese Society
c/o Food Work
34 Downing St.
New York, NY 10014
(212)727-7939
Ari Weinzweig, Pres.

Was referred to: Gerd Stern, President of American Cheese Society
In Food & Galliee
(201) 569-3175

Mr. Stern wasn't in. He is to return my call tomorrow. Should be in by 9:00 a.m. their time.

4/16/93 Returned my call. Left a message on my phone mail.

4/19/93 - Contacted Mr. Stern.

Mr. Stern said the cheese industry is doing very well. It is a healthy industry and a healthy product.

The government is reducing the production of milk, there is a surplus, but cheese production is still going up. Milk production is going down, people are eating less butter but still eating cheese.

As for changes in the industry in the last five to ten years, there are smaller cheese plants and larger cheese plants. Middle size or medium, are not economical. More specialty cheeses are being made.

Mr. Stern is the president of the American Cheese Society. It consists of 600 members, 100 of which are cheese makers.

For any data on air emissions from cheese making you would need to contact Kraft, Borden or Con Agri.

Whey and Curds are waste products and potential polluters. Whey is now collected and processed into protein with advanced technology. Small quantities are fed to farm animals. Now the thing to be careful of is the wash water - it contains disinfectants.

What processing involves in laymen's terms: Fermenting milk using bacterial cultures, making cheese. Some is sold fresh, some aged.

He would be happy to be a reviewer. His fax number is 201-569-3073.

* For any further questions I recommend you call Mr. Stern.

4/15/93

United States Cheese Makers Association
Three S. Pinckney St. Ste. 215
Madison, WI 53703
(608) 255-2027
Linda A. Leger, Exec. Dir.

Executor Director will return our call.

FILE COPY

Emission Factor Documentation for AP-42
Section 9.6.1

Natural and Processed Cheese

Draft Report

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

EPA Contract 68-D2-0159
Work Assignment No. 4-04

MRI Project No. 4604-04

March 1997

MRI

MIDWEST RESEARCH INSTITUTE
Suite 350
401 Harrison Oaks Boulevard
Cary, North Carolina 27513-2412
Telephone (919) 677-0249
FAX (919) 677-0065

April 3, 1997

Mr. Dallas Safriet
Emission Factor and Inventory Group (MD-14)
U. S. Environmental Protection Agency
Research Triangle Park, NC 27711

Subject: Review and Update of Food and Agricultural Sections, Chapter 9, AP-42
EPA Contract No. 68-D2-0159; Work Assignment 4-04
MRI Project No. 4604-04

Dear Dallas:

Enclosed are four copies of the Draft Report entitled "Emission Factor Documentation for AP-42, Section 9.6.1, Natural and Processed Cheese." The current draft report is acceptable for distribution for industry comment.

A copy of the report was sent to you previously; these four copies are to be sent to the reviewers shown on the attached page. If you have any questions, please contact me at 677-0249, ext. 5258, or Ms. Amy Marshall at ext. 5135.

Sincerely,

Tom Lapp

Tom Lapp
Principal Environmental Scientist

Enclosure

SECTION 9.6.1, NATURAL AND PROCESSED CHEESE

Draft Report Reviewers

1. Mr. Joe Brehm
   Wisconsin DNR
   PO Box 7921
   101S Webster St.
   Madison, WI 53707-7921

2. Mr. Thomas Gallagher
   United Dairy Industry Association
   10225 W. Higgins Rd.
   Suite 900
   Rosemont, IL 60018-5616

3. Ms. Maureen Killough
   American Cheese Society
   1523 Judah St.
   San Francisco, CA 94122

4. Mr. David Todd
   California Air Resources Board
   2020 L Street
   PO Box 2815
   Sacramento, CA 95814

Emission Factor Documentation for AP-42
Section 9.6.1

Natural and Processed Cheese

Draft Report

For U. S. Environmental Protection Agency
Office of Air Quality Planning and Standards
Emission Factor and Inventory Group
Research Triangle Park, NC 27711

Attn: Mr. Dallas Safriet (MD-14)

EPA Contract 68-D2-0159
Work Assignment No. 4-04

MRI Project No. 4604-04

March 1997

NOTICE

This document is a preliminary draft. It has not been formally released by the U. S. Environmental Protection Agency and should not at this stage be construed to represent Agency policy. It is being circulated for comments on its technical merit and policy implications.

PREFACE

This report was prepared by Midwest Research Institute (MRI) for the Office of Air Quality Planning and Standards (OAQPS), U. S. Environmental Protection Agency (EPA), under Contract No. 68-D2-0159, Work Assignment No. 4-04. Mr. Dallas Safriet was the requester of the work.

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1. INTRODUCTION

The document *Compilation of Air Pollutant Emission Factors* (AP-42) has been published by the U. S. Environmental Protection Agency (EPA) since 1972. Supplements to AP-42 have been routinely published to add new emission source categories and to update existing emission factors. AP-42 is routinely updated by EPA to respond to new emission factor needs of EPA, 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 report is to provide background information from test reports and other information to support preparation of AP-42 Section 9.6.1, Natural and Processed Cheese.

This background report consists of five sections. Section 1 includes the introduction to the report. Section 2 gives a description of the cheese production industry. It includes a characterization of the industry, a description of the different process operations, a characterization of emission sources and pollutants emitted, and a description of the technology used to control emissions resulting from these sources. Section 3 is a review of emission data collection procedures. It describes the literature search, the screening of emission data reports, and the quality rating system for both emission data and emission factors. Section 4 details how the new AP-42 section was developed. It includes the review of specific data sets and a description of how candidate emission factors were developed. Section 5 presents the AP-42 Section 9.6.1, Natural and Processed Cheese. Supporting documentation for the emission factor development is presented in the Appendices.

2. INDUSTRY DESCRIPTION

This section provides an overview of the U.S. production of natural and processed cheese. It is divided into four subsections: industry characterization (2.1), process description (2.2), emissions (2.3), and emission control technology (2.4). The production of natural and processed cheese, except for cottage cheese, is classified in Standard Industrial Classification (SIC) Code 2022; cottage cheese is classified in SIC Code 2026.

2.1 INDUSTRY CHARACTERIZATION[1-3]

Cheese represents the largest percentage of world milk consumption (34 percent), followed by butter (33 percent), liquid milk (27 percent), and powdered milk (6 percent). Approximately one-third of the cow's milk produced in the United States is used to make cheese. Most of the cheese produced in the United States is made from a type of cow's milk, such as cream, whole milk, lowfat milk, and skim milk. However, goat's and sheep's milk may also be used in cheese production.

The total value of shipments for the natural and processed cheese industry (SIC 2022) was $18.2 billion in 1992. This figure has steadily increased since 1977. The total number of industry establishments in the United States in 1995 was 432. The U. S. is one of the largest producers of cheese in the world. In 1995, natural cheese production in the United States, excluding cottage cheeses, totalled 6.9 billion pounds, and processed cheese production totalled 2.3 billion pounds. Wisconsin is the leading producer of cheese in the U. S., accounting for over 30 percent of all cheese production in the country. Table 2-1 presents 1995 production data for types of cheese and cheese products in the United States. Figure 2-1 shows the distribution of cheese manufacturing facilities in the United States (States with less than three facilities are not shown).

2.2 PROCESS DESCRIPTION[4-9]

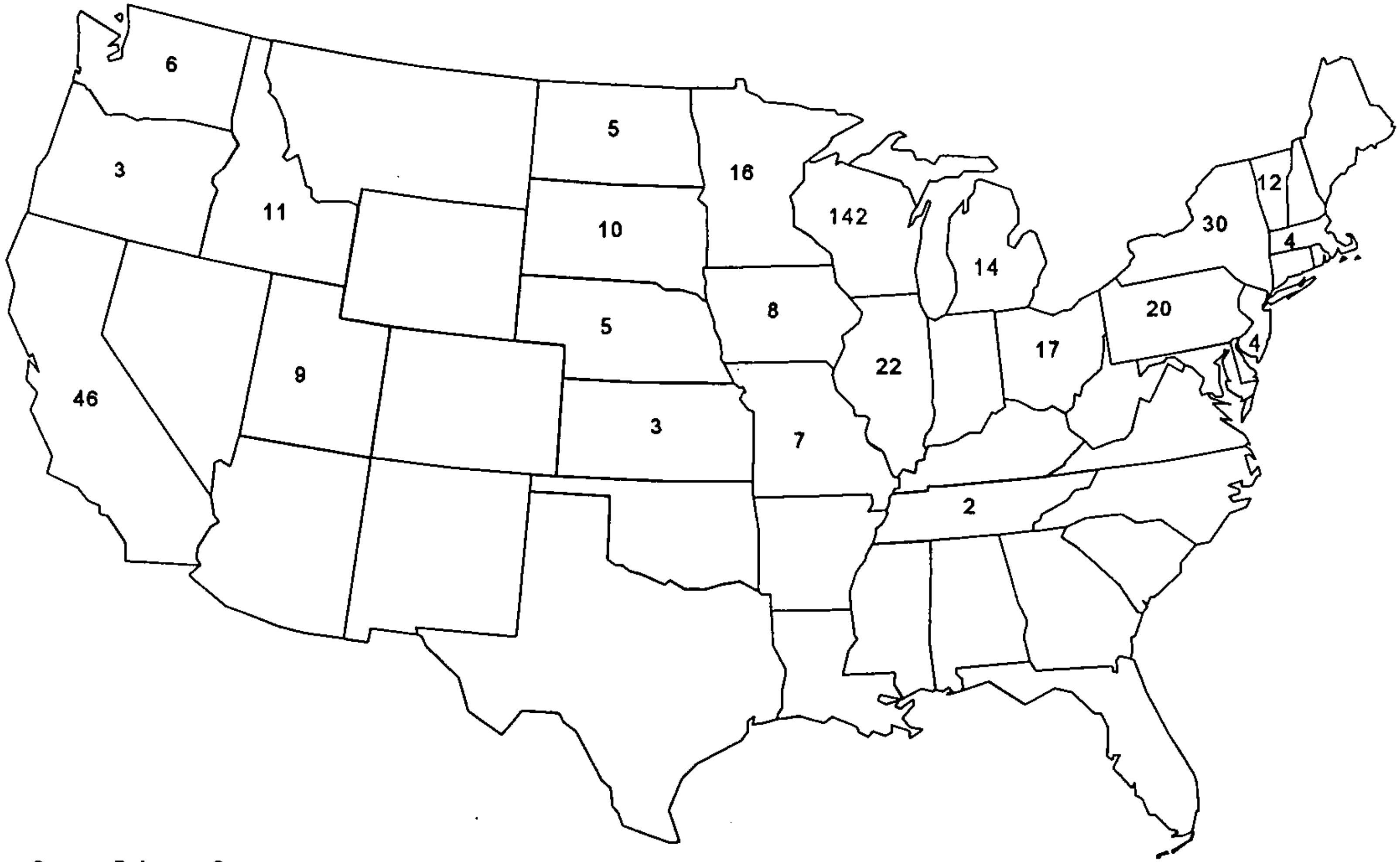
The basic concepts behind the production of cheese have changed little over its history. The basic process in which curd is formed from milk either by bacterial fermentation or addition of rennet (or a combination of these) to develop lactic acid; the subsequent removal of whey from the curd; and the further treatment of the curd to produce the many varieties of cheese remains very much the same. Some small factories in the United States still rely on traditional cheesemaking procedures, with much of the

TABLE 2-1. PRODUCTION OF CHEESE AND CHEESE PRODUCTS IN THE UNITED STATES

Type of cheese	No. of plants	Production (1,000 pounds)
Cheddar	207	2,425,042
Other American[1]	14	703,526
Part skim	8	24,008
Swiss	44	221,713
Muenster	46	109,129
Brick	23	10,426
Limburger	1	868
Blue[2]	12	36,593
Cream and Neufchatel	33	602,219
Mozzarella	132	2,094,908
Other italian	97	547,11
Other types	109	164,691
Total natural cheese	432	6,940,239
Processed cheese	35	1,472,213
Processed cheese foods and spreads	30	831,636
Cold pack cheese and cheese foods	20	35,699
Total processed cheese	57	2,339,548

[1]Includes Colby, Monterrey, and Jack.
[2]Includes Gorgonzola.

Source: Reference 2



Source: Reference 2.

Figure 2-1. Locations of cheese manufacturing facilities in the U.S.

work done by individuals. Most large-scale facilities, however, have mechanized the process, relying on sophisticated equipment and automated processes.

The modern manufacture of natural cheese consists of four basic steps: coagulation, drainage, salting, and ripening. Processed cheese manufacture incorporates extra steps, including cleaning, blending, and melting. Dairy products, such as milk or butter, may also be added to the processed cheese, especially if it is intended for spreading. No two cheese varieties are produced by the same method. However, manufacturing different varieties of cheese does not require widely different procedures, but rather slight variations in one or more steps, a change in the order of the process steps, special applications, and/or different ripening practices. The character of a particular variety of cheese is influenced by moisture content; the types of microorganisms added; the temperatures and acidities of the production processes; the ripening conditions; and the percentage of fat in the milk used to make the cheese. Table 2-2 provides descriptions of several types of natural cheeses. Table 2-3 details variations in the cheesemaking process characteristic of particular cheese varieties. The process described in this section is a generic description; steps specific to a single cheese variety are mentioned but are not discussed in detail.

Popular types of natural cheeses include unripened (e.g., cottage cheese, cream cheese), soft (e.g., Brie, Camembert), semi-hard (e.g., Brick, Muenster), hard (e.g., Colby, Cheddar), blue veined (e.g., Blue, Gorgonzola), cooked hard cheeses (e.g., Swiss, Parmesan), and pasta filata (stretched curd, e.g., Mozzarella, Provolone). Examples of processed cheeses include American cheese and various cheese spreads, which are made by blending two or more varieties of cheese or blending portions of the same type of cheese that are in different stages of ripeness.

2.2.1 Natural Cheese Manufacture

The following sections describe the steps in the manufacture of natural cheese. Figure 2-2 presents a general process diagram.

TABLE 2-2. CHARACTERISTICS OF SEVERAL TYPES OF NATURAL CHEESES

Processing	Characteristics	Typical varieties
Curd particles kept matted together	Close texture; firm body	Cheddar
Curd particles kept separate	More open texture	Colby, Monterrey
Bacteria-ripened throughout interior with eye formation	Gas holes or eyes throughout the cheese	Swiss, Gouda, Samsoe, Edam
Prolonged curing period	Granular texture; brittle body	Parmesan, Romano
Pasta filata	Plastic curd; threadlike or flaky	Provolone, Mozzarella
Mold-ripened throughout interior	Visible grains of mold; piquant, spicy flavor	Blue, Roquefort, Stilton, Gorgonzola
Surface ripened primarily by bacteria and yeasts	Surface growth; soft, smooth, waxy body; mild to robust flavor	Brick, Limburger
Surface ripened primarily by mold	Edible crust; soft, creamy interior; pungent flavor	Camembert, Brie
Curd coagulated primarily by acid	Delicate, soft curd	Cream, Neufchatel, Cottage
Protein of whey or whey and milk coagulated by acid and heat	Sweetish cooked flavor of whey	Ricotta, Gjetost

Source: Reference 6

TABLE 2-3. DIFFERENCES IN SELECTED CHEESEMAKING STEPS

Type of cheese	Primary coagulating agent/time	Cooking temp., °C (F°)	Primary draining method	pH	Salting, %	Pressing	Ripening period
Blue	Rennin (30 min.)	33.3 (92)	Vat drain	5.4	dry (5.0)	In molds, no surface weights	60 days minimum; 3-4 mos. usually; 9 mos. for more flavor
Brick	Rennin (25 min.)	35.6 (96)	Vat drain	5.4	Brine (1.5)	In molds, surface weights	4-8 weeks
Camembert	Rennin (45 min.)	32.2 (90)	Dip	5.1	Dry (1.5)	In molds, no surface weights	4-5 weeks
Cheddar	Rennin (25 min.)	37.8 (100)	Vat drain	5.2	Dry (1.5)	Horizontal hydraulic press	60 days minimum; 3 to 6 mos. usually; 12 or longer for sharp flavor
Cottage	Acid (5 hr)	48.9 (120)	Vat drain	4.6	Dry (1.0)	Vat packing	Unripened
Cream	Acid (5 hr)	57.2 (135)	Hoop	4.6	Dry (1.0)	Bag packing	Unripened
Mozzarella	Rennin (30 min)	32.2 (90)	Vat drain	5.3	Brine (0.7)	Bag packing	Unripened to 2 months
Provolone	Rennin (20 min.)	47.8 (118)	Vat drain	5.3	Brine (1.5)	Vat packing	6-14 months
Ricotta	Acid (30 min.)	80.0 (176)	Hoop	5.9	Dry (0.5)	Can packing	Unripened
Romano	Rennin (20 min.)	46.7 (116)	Dip	5.3	Dry (5.0)	In molds, surface weights	5 mos min.; 12 mos for grating
Swiss	Rennin (30 min.)	53.3 (128)	Dip	6.2	Brine (1.6)	Vertical hydraulic press	2 mos min.; 2-9 mos usually

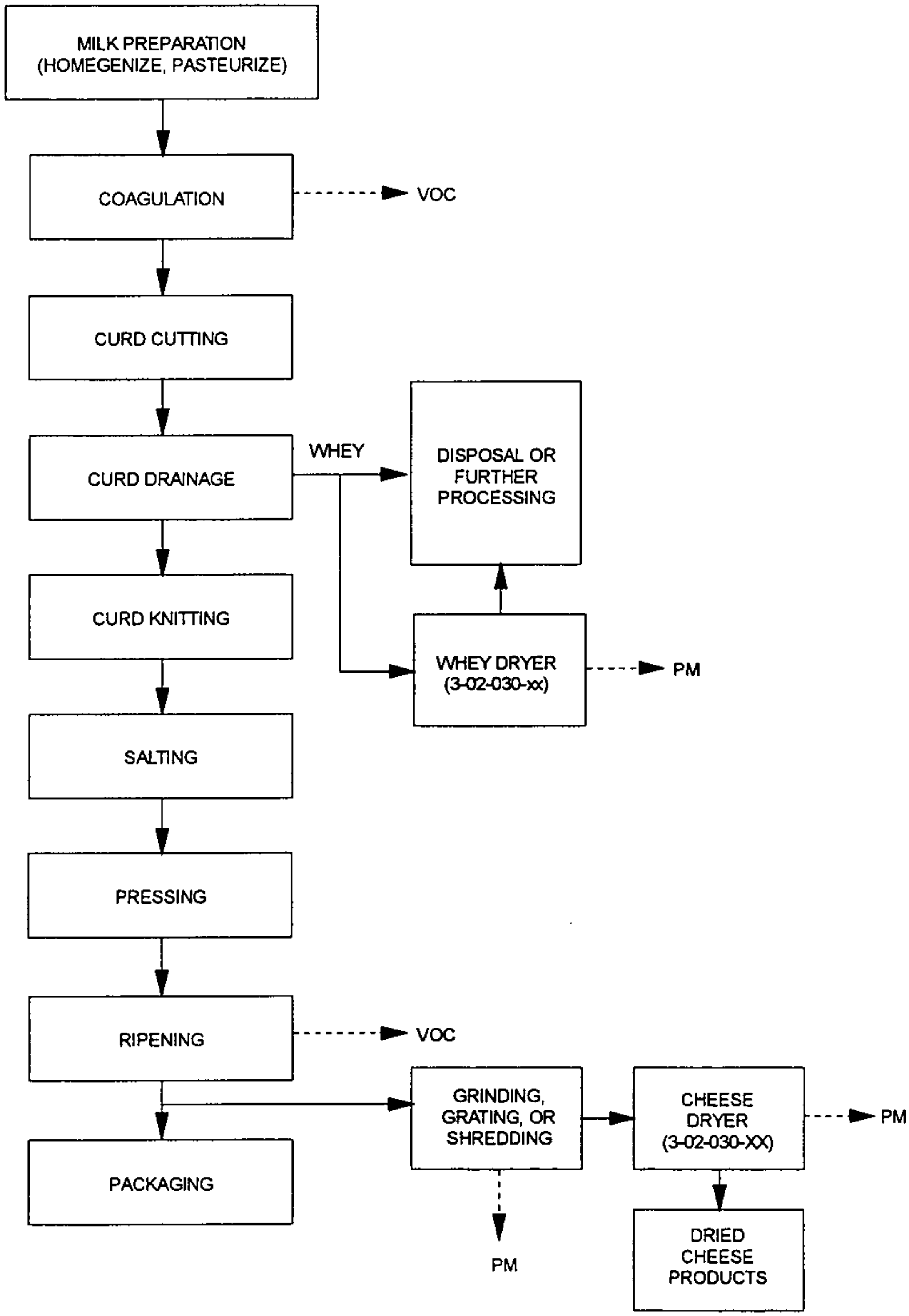


Figure 2-2. Natural cheese manufacture.

2.2.1.1 Milk Preparation. Cheese can be made from cow, ewe, goat, or buffalo milk. Table 2-4 shows the varieties of milk used to produce different types of cheese. Cow's milk is the most widely produced and known milk in cheese processing. Cheese can be made from almost any form of milk, including whole milk, skim milk, buttermilk, or cream. In the past, raw milk was used almost exclusively in cheesemaking; however, a focus on public safety has forced manufacturers to use heat-treated or pasteurized milk.

The milk is stored in silo tanks at the cheesemaking plant. These tanks are insulated or cooled to keep the milk at the optimum storage temperature. In the tanks, the milk is agitated by a mechanical rotary blade from top to bottom to prevent cream formation. After storage, the milk is homogenized to ensure a constant fat level in the milk. A standardizing centrifuge, which skims off the surplus fat as cream through a control valve, is often used to obtain the fat level appropriate for different varieties of cheese.

Homogenized milk is used in soft cheeses such as Brie, Camembert, and cream. This type of milk results in less moisture and fat loss during ripening and an increased surface area of fat globules, which accelerates hydrolysis of milkfat by mold enzymes. For other cheeses, milk is filtered or clarified to remove suspended matter in the milk. In Swiss cheese, clarified milk improves the size and uniformity of eye formation; in Cheddar cheese, clarification improves the texture and firmness of the cheese.

Following standardization, the milk is ready for heat treatment, which is necessary to destroy harmful microorganisms and bacteria. Small volume factories are equipped with open and/or closed vats, presses, and a hot water or steam boiler for heat treatment. Large-scale factories rely on enclosed heat exchangers, which may be the tubular type or the multi-plate type. All equipment and systems involved in milk processing are connected so that outside air does not come in contact with the milk being processed. After pasteurization any disease-bearing bacteria present in the milk are destroyed, and the milk is ready for coagulation.

2.2.1.2 Coagulation. Coagulation, or clotting of the milk, is the basis of cheese production. Coagulation is brought about by physical and chemical modifications to the constituents of milk and leads to the separation of the solid part of milk (the curd) from the liquid part (the whey).

TABLE 2-4. TYPES OF MILK USED TO PRODUCE DIFFERENT VARIETIES OF CHEESE

Cheese type	Cow's milk whole	Cow's milk lowfat	Cow's milk skim	Goat's milk	Sheep's milk	Cream
Blue	X			X		
Brick	X					
Camembert	X					
Cheddar	X					
Colby	X					
Cottage			X			X
Cream	X					X
Edam			X			
Feta	X			X	X	
Gouda		X				
Limburger	X	X				
Monterrey Jack	X	X	X			
Mozzarella	X	X				
Muenster	X					
Neufchatel	X	X				X
Parmesan		X				
Provolone	X					
Ricotta	X	X	X			
Romano		X		X		
Roquefort					X	
Stilton	X					X
Swiss		X				

Source: Reference 9.

Coagulation is the physicochemical change of the casein in milk, due to the action of lactic acid and/or enzymes, into a protein network called a coagulum or gel. To initiate coagulation, milk is mixed with a starter, which is a culture of harmless, active bacteria which will impart certain characteristics and qualities to the cheese. The starter sours the milk by fermenting the lactose (milk sugar) to lactic acid which creates the acid conditions necessary for a special enzyme, rennet, to act. Lactic acid causes the following reaction to occur:

Calcium Caseinate + Lactic Acid + Rennet --> Calcium Lactate + Casein

During coagulation, whey droplets appear on the surface of the coagulum and grow into a liquid envelope; the curd is in a gel-like form. The coagulum decreases in volume as it expels water and solid constituents. Most of the fat and protein from the milk are retained in the curd, but nearly all of the lactose and some of the minerals, protein, and vitamins escape into the whey. Coagulation takes place in large pans, vats, or tanks, depending on the size of the cheesemaking facility.

Temperature and coagulation time vary and influence properties of the coagulum, such as cohesion. The temperature for milk coagulation is carefully controlled, and varies with the type of cheese being made. For most kinds of cheeses, it is between 22°C (72°F) and 35°C (95°F). Curd produced primarily by acid coagulation results in the delicate, soft curd in cottage and cream cheeses. Table 2-3 provides the primary coagulating agent and the coagulating time necessary for different varieties of cheese.

2.2.1.3 Curd Treatment. After formation in the coagulating vats, the curd is cut into small pieces. Cutting the curd speeds expulsion of the whey and contributes to a uniform cook-through of the curd by increasing the surface area. The cutting occurs in the process vessel and is accomplished by hand or by using mechanical cutting devices. The curd particles are cut into various sizes depending on the variety of cheese being made. For example, cutting the curd into small cubes reduces the moisture content of the curd, whereas creating larger cubes causes the curd to retain more moisture.

Following the cutting step, the curd is heated, or cooked, which contracts the curd particles to remove whey, develop texture, and establish moisture control. Cooking involves exposing the cut curds and whey to heat for specific time periods while agitating the product. Cooking may take place in many different forms, including direct steam, jacketed water, and radio-frequency. Cooking temperatures may vary depending on the variety of cheese being produced, from 32°C (90°F) for Mozzarella cheese (a high-moisture cheese) to 53°C (128°F) for Swiss cheese (a low-moisture cheese). For some high-moisture cheeses (for example, Colby and Monterrey), the curds are washed with cool water to increase the moisture content of the curd. Table 2-3 provides the cooking temperatures required to produce typical varieties of cheeses.

2.2.1.4 Curd Drainage. The next step in cheese manufacture, drainage, involves separating the whey from the curd. Drainage reduces the curd to a definite water content and controls the demineralization (migration of calcium into the whey) and the removal of lactose from the curd. The process can be accelerated by either heat treatment or mechanical treatment, such as cutting, stirring, oscillating, or pressing.

In large-scale facilities, the draining system typically consists of a long rectangular tank with a moveable screen belt as a base. One end of the tank has a liquid-tight, but moveable door. The curd/whey mixture travels along a conveyor from the curd vat into the tank. The whey drains through the base screen, leaving the curd level and dry. After the curd is dry, it moves through the open end of the tank and is cut into blocks. These blocks can then be filled into cheese hoops for further draining and pressing.

Other types of draining methods include vat drainage, hoop drainage, and dipping. During vat drainage, cubes of curd are left immersed in the whey and agitated to prevent them from sticking together; the whey is later decanted and hoop drainage sometimes follows. For hoop drainage, a mass of curd is put into cloth-lined cylindrical metal hoops. The whey separates from the curd by draining through the cloth. This process is usually accompanied by lateral pressing. The dipping method involves ladling the curds out of the vat into perforated molds. The whey is slowly drained off through the activity of lactic acid bacteria and the turning of the molds. Table 2-3 gives the primary draining methods for a variety of cheeses.

For some cheeses, special applications and procedures occur immediately before, during, or after the draining stage. For example, internally ripened, or blue-veined, cheeses (e. g., Blue, Roquefort) are usually seeded with penicillium powder prior to drainage. Cooked hard cheeses (e. g., Parmesan) are stirred and warmed to accelerate and complete the separation of the whey. Flavorings can also be added to cheeses during the drainage stage.

The separated whey may be treated and disposed of; shipped offsite in liquid or concentrated form for use as animal feed; used to make whey cheese; dried for lactose, mineral, or protein recovery; or dried for use as a food additive or use in the manufacture of processed cheese. Fluid cheese whey is very rich nutritionally, retaining many of the nutrients of the milk used in the cheese manufacture. In the manufacture of whey cheese, the whey is strained, heated, and stirred; milk is added to facilitate formation of the curd; and stirring is stopped when a thick layer of curd forms on the surface. Heating is stopped when the curd layer breaks, and the curd layer is removed and drained. When drained sufficiently, the solid cheese is soft and has a short shelf life. The whey cheese may also be salted and dried.

2.2.1.5 Curd Knitting. Knitting, or transforming, the curd allows the accumulating lactic acid to chemically change the curd; knitting also includes salting and pressing. This step leads to the characteristic texture of different varieties of cheese and, therefore, varies according to the particular variety. It is during this stage that Cheddar cheese is "cheddared"; that Brick and Blue cheeses undergo preliminary packaging; that Provolone and Mozzarella cheeses are pulled and processed (these cheeses are then kneaded, drawn, shaped, and smoothed); that a bean gum or some other type of gum is added to cream cheese to stabilize and stiffen it; and that a creaming agent (cream and/or milk) is added to cottage cheese. During this period, specific pH levels are controlled to produce different varieties of cheese (see Table 2-3).

After knitting, the cheese is salted. This step consists of manually or mechanically spreading coarse salt over the curd surfaces or immersing the pressed cheese in a salt solution or brine. In some instances, the cheese is loaded on racks that are lowered into brine tanks. Large tanks may circulate the brine throughout the tank to speed up the process.

Salting further completes the drainage of the cheese by helping remove residual water. It also affects rind formation, growth of microorganisms, and enzyme activity. Salting the cheese improves its flavor, texture, and appearance. When the salting process is finished, the salt is concentrated in the surface layers of the cheese but continues to migrate into the cheese over time, creating a concentration gradient. The salt content of most varieties of cheese varies from about one percent in cottage and cream cheeses to about five percent in Parmesan and Blue cheeses. Table 2-3 provides the salting method and salt percentage necessary to produce a particular variety of cheese.

The next step, pressing, determines the characteristic shape of the cheese by compacting the texture, extruding free whey from the curds, and completing the curd knitting. Pressing involves confining the wet, warm curds in a constricted wooden or metal form or cloth bag. Depending on the type of cheese, external weights (often hydraulic pressure plates) are used, or the curd is allowed to rest on itself in a vat for a fixed period of time. With some cheeses, vertical pressing is used; others require vacuum pressing to remove occluded air and give a close knit body. Multi-row, tunnel automated presses have become common in large facilities. See Table 2-3 for the different pressing practices for various cheeses.

2.2.1.6 Ripening. During the ripening or curing stage, varieties of cheeses acquire their own unique textures, aromas, appearances, and tastes through complex physical and chemical changes. During ripening, the cheese is populated by microorganisms and will be transformed during ripening by the action of enzymes originally present in the curd or produced by bacterial synthesis during ripening. The body and rind of the cheese are the sites of complex biochemical reactions that are controlled as much as possible by adjusting temperature, humidity, and duration of ripening. For all cheeses, the purpose of ripening is to allow beneficial bacteria and enzymes to transform the fresh curd into a cheese of a specific flavor, texture, and appearance. Unripened cheeses include cottage and cream cheeses and are generally ready for consumption after the curd has been collected. Because they are not ripened, they usually have a bland flavor and soft body.

Some cheeses require the application of a special ripening agent to create a particular taste or texture. For example, some cheeses rely wholly on surface bacteria and yeast applied to their exteriors for curing and ripening; these cheeses are called "surface-ripening" cheeses and include Brick, Brie, Camembert, Limburger, and Muenster. Others require injection of particular bacteria and molds (e. g., Blue) or gas-forming microorganisms (e. g., Swiss).

For those cheeses ripened primarily by surface bacteria, cheese makers massage the surface of a freshly salted cheese block to uniformly spread the desirable bacteria. In a mechanized process, the bacteria are smeared onto the surface of the cheese block with a cheese brushing machine. The bacteria break down part of the cheese protein during ripening, resulting in the characteristic flavor and aroma of Brick and Muenster cheeses.

For those cheeses ripened primarily by mold, mold spores are injected into the cheese after draining (e. g., Blue cheese) or smeared in a manner similar to those ripened by bacteria (e. g., Brie cheese). For those that are injected, air passages are bored into the cheese to encourage the growth of the mold. This process results in the crumbly texture and characteristic flavor of Blue and Roquefort cheeses.

Three types of rooms are used in succession for ripening cheeses: the drying room; the cellars or other premises for preripening or ripening; and the cold room for storage. Each room is thermally insulated and maintained at a constant temperature and humidity by an air conditioning system. After salting, the cheeses are placed in the drying room at 10° to 14°C (50° to 57°F) and 60 to 80 percent relative humidity. Excess water that appears on the surface of the cheese is quickly removed by the cool air. The cheeses are kept in this environment for several hours to several days. Preripening is sometimes carried out for soft cheeses at a slightly higher temperature and lower humidity than the end stages of ripening, but most of the time, ripening is carried out under constant conditions. It is important to maintain the ripening room at the atmospheric conditions and temperatures appropriate for the desired variety of cheese, since the ripening process has a major influence on the texture and taste of a cheese. Some ripening rooms are also equipped to function as cold storage rooms and can keep the unwrapped cheeses at a very low temperature and high humidity to prevent the cheeses from drying out. However, it is more practical to have a specialized cold storage room, for short term storage before shipment, that keeps wrapped cheeses at 1° to 5°C (34° to 51°F) without the need to maintain a high humidity, because maintaining a high humidity consumes a great deal of energy. Because of the importance of maintaining a controlled humidity and temperature, most manufacturers have ripening rooms where the temperature and humidity are automatically controlled with regulated ventilation. In facilities where large amounts of cheese are conveyed to and from storage, racks or grids on wheels are commonly used, which allows the cheese to be automatically turned.

It is during the ripening stage that the rind or crust forms on the cheese's surface. The rind first appears as an outer layer of curd that is denser and less moist than the rest of the curd. The rind controls the loss of moisture from the internal part of the cheese and regulates the escape of gases released during ripening.

Conditions during ripening vary for different cheeses. For example, soft cheeses are usually ripened 12 to 30 days at 10° to 14°C (50° to 57°F) and 90 to 95 percent humidity, while Cheddar cheeses can be ripened from 3 months to a year at 5° to 12°C (41° to 54)°F) and 87 to 95 percent humidity. Cheeses ripened by internal mold (blue-veined cheeses) usually require 15 to 60 days at 4° to 12°C (39° to 54°F) and 85 to 95 percent humidity. Changes in composition during ripening include lactose fermentation and degradation of lactic acid, hydrolysis of fats and conversion of fatty acids, and degradation of proteins and conversion of amino acids. See Table 2-3 for a list of the curing and ripening conditions for different cheeses.

2.2.1.7 <u>Preserving and Packaging</u>. Modern cheese packaging protects the food from microorganisms and saves on waste and moisture loss. Ripened cheeses must undergo special procedures during packaging for preservative reasons. Unripened cheeses (cottage and cream cheeses) are packaged immediately after the curd is collected. These cheeses are packaged by automatic machines in moisture-proof containers. Because these cheese are highly perishable, they must be immediately refrigerated.

Many ripened cheeses are coated in wax to protect the cheese from mold contamination and to reduce the rate of moisture loss. Cheeses that naturally develop a thick, tightly woven rind, such as Swiss, do not require waxing. Before waxing, the cheese must be dried on the cheese shelves at 10° to 16°C (50° to 60°F) at a relative humidity of 65 to 70 percent for 3 days. The cheese must be turned daily to facilitate drying. To wax fresh cheese, a paraffin wax block is placed in a steam pressure, electric-heated wax tank. The wax is heated and the cheese is then submerged in the wax for 5 to 6 seconds and allowed to dry for 1 minute. After the wax has cooled and solidified, it is rinsed with warm water to enhance surface luster. If necessary, the cheese may be rewaxed within a few days. The cheese is then ready for commercial packaging.

A second method of ripened cheese packaging involves applying laminated cellophane films to unwaxed cheese surfaces. The most common packaging film consists of two laminated cellophane sheets and a brown paper overlay necessary for shipping. A variation includes a metal foil wrap. During packaging, a mechanical lifter applies a sheet of film to a block of cheese traveling along a conveyor. The block then reaches an evacuator area where the air between the cheese and the film is removed, resulting in an air-tight seal. A similar process is used to vacuum-pack rindless cheese. This procedure involves wrapping the cheese in a film and exposing the product to high heat (approximately 77°C [171°F]) to shrink the film to tightly conform to the cheese. Prior to heat shrinkage, the package is subjected to a partial vacuum.

2.2.2 Processed Cheese Manufacture

Nearly one-third of all cheese produced in the United States consists of processed cheese and processed cheese products. There are many different types of final products in processed cheese manufacture. These cheeses are distinguished from one another not only by their composition (cheese used, texture, additives, etc.) but by their presentation as individual portions, individual slices, rectangular blocks, or special presentation as cylinders or tubes.

Processed cheese was developed around the end of the 19th century when several European countries wanted to export cheeses to hot-climate countries but had problems keeping the product cool throughout manufacture and distribution. Soft cheese could simply be put into cans and heat treated to effectively pasteurize the cheese, but this process did not work for hard cheeses. For hard cheeses, the rind must be removed and the cheese warmed to about 80°C (176°F) and stirred with sodium citrate or sodium polyphosphates to form a mixture which can be packaged while hot and cooled to form a gel.

Processed cheese is made by pasteurizing, emulsifying, and blending natural cheese and contains no other ingredients. Processed cheese foods, spreads, and cold pack cheeses contain additional ingredients, such as nonfat milk solids and condiments. Several varieties of natural cheeses may be mixed (emulsifying salts are always added to this mixture) and powdered milk, whey, cream or butter, and water may be added. The mixture is then heated and stirred to evenly distribute the ingredients and create a homogenous mixture. The following section describes the basic steps necessary for producing pasteurized process cheese, the most common processed cheese.

2.2.2.1 Pasteurized Process Cheese. Cheeses are selected to be processed from both mild and sharp cheeses by choosing those whose flavor and texture will readily blend to produce a uniform product. For example, American cheese is made from Cheddar and Colby cheeses. Once selected, the cheeses must be analyzed for their fat and moisture contents to determine the proper amount of emulsifiers and salts to be added.

Cheese surfaces are cleaned by scraping and trimming, and the rinds are removed. After cleaning, the cheese blocks are ground. The cheese mixture then passes through continuous cookers, where the mixture is heated to 130° to 145°C (266° to 293°F) for 2 to 3 minutes. The temperature and time are closely monitored to avoid browning and thickening of the product. At this point, the melted cheese separates into a fat and serum. Emulsifiers are added to disperse the fat, which creates a uniform, homogenous mass. Soon after the emulsifiers are added, the cheese mass becomes smooth in texture. At this point, additives such as spices, flavorings, binding agents, and preservatives may be added if the cheese is to undergo further processing.

The molten cheese is removed quickly from the cookers and is pumped or dropped into packaging hoppers. The cheese is packaged in the absence of oxygen to inhibit the growth of mold. The cheese is usually wrapped in lacquered aluminum foil or in aluminum foil-lined cardboard or plastic boxes. For sliced processed cheese, the molten cheese is spread uniformly by chilled steel rollers and cut by rotary knives to consumer size.

2.2.2.2 Other Processed Cheeses. Other cheese products are manufactured using procedures similar to pasteurized process cheese. For example, to produce pasteurized process cheese food, one or more of the following optional dairy ingredients are added: cream, milk, skim milk, buttermilk, and/or cheese whey. The result is a processed cheese food that is higher in moisture and lower in fat than pasteurized process cheese. Processed cheese intended for spreading undergoes a creaming step after heating, which includes mechanical kneading of the hot cheese and addition of various dairy products, such as milk, which promotes creaming, and whey, which reduces the viscosity of the mixture. An edible stabilizer and gums or gelatins are also added to give the food a spreading quality. Other processed cheese products include cold-packed cheese, cold-packed cheese food, and reduced fat cheeses. Processed cheeses may be enhanced with salt, artificial colorings, spices or flavorings, fruits, vegetables, and meats.

Grated and powdered cheeses are produced by removing the moisture from one or more varieties of cheeses and grinding, grating, or shredding the cheese(s). Mold-inhibiting ingredients and anticaking agents may be added as well. For example, a Cheddar cheese powder may contain aged Cheddar cheese, sodium phosphate, salt, lactic acid, and color, and have a moisture content of 3 to 4 percent. A grated cheese usually has 14 to 18 percent moisture. Dehydration takes such forms as tray drying, spray or atomized drying, and freeze drying. Popular types of grated cheese include Parmesan, Romano, Mozzarella, and Cheddar. Cheese powders, such as those made from Cheddar cheese, may be used to flavor pasta, or added to bread dough, potato chips, or dips.

2.3 EMISSIONS

Particulate emissions from cheese manufacture occur during cheese drying and whey drying, and may occur when cheese is grated or ground before drying. Cheese dryers are used in the manufacture of grated or powdered cheeses. Whey dryers are used in some facilities to dry the whey after it has been separated from the curd following coagulation. Emissions of CO_2 occur during drying, but may be primarily due to fuel combustion, especially if the dryer is direct-fired. VOC emissions may occur during the coagulation and/or ripening stages.

2.4 EMISSION CONTROL TECHNOLOGY

Particulate emissions from cheese and whey dryers are controlled by wet scrubbers or fabric filters. Cyclones are also used to control particulate emissions and for product recovery.

REFERENCES FOR SECTION 2

1. *1992 Census of Manufactures: Dairy Products*, U.S. Department of Commerce, Bureau of Census, Washington, DC, 1994.

2. U. S. Department of Agriculture, National Agriculture Statistics Service, *Dairy Products 1995 Summary*, Washington, DC, April 1996. http://usda.mannlib.cornell.edu/reports

3. B. Battistotti, et al., *Cheese: A Guide to the World of Cheese and Cheesemaking*, Facts On File Publications, NY, 1984.

4. A. Eck, ed., *Cheesemaking: Science and Technology*, Lavoisier Publishing, New York, 1987.

5. A. Meyer, *Processed Cheese Manufacture*, Food Trade Press Ltd., London, 1973.

6. *Newer Knowledge of Cheese and Other Cheese Products*, National Dairy Council, Rosemont, IL, 1992.

7. M.E. Schwartz, *Cheesemaking Technology*, Noyes Data Corporation, Park Ridge, NJ, 1973.

8. F. Kosikowski, *Cheese and Fermented Milk Foods*, Edwards Brothers, Ann Arbor, MI, 1977.

9. New Standard Encyclopedia, Vol.4, "Cheese," Standard Educational Corporation, Chicago, IL, pp. 238-240.

3. GENERAL DATA REVIEW AND ANALYSIS PROCEDURES

3.1 LITERATURE SEARCH AND SCREENING

Data for this investigation were obtained from a number of sources within the Office of Air Quality Planning and Standards (OAQPS) and from outside organizations. The Factor Information and Retrieval (FIRE), Crosswalk/Air Toxic Emission Factor Data Base Management System (XATEF), and VOC/PM Speciation Data Base Management System (SPECIATE) data bases were searched for identification of the potential pollutants emitted and emission factors for those pollutants.

Information on the industry, including number of plants, plant location, and annual production capacities, was obtained from the *Census of Manufactures* and the USDA's *Dairy Products 1995 Summary*. The Aerometric Information Retrieval System (AIRS) data base also was searched for data on the number of plants, plant location, and estimated annual emissions of criteria pollutants. A number of sources of information were investigated specifically for emission test reports and data. The Source Test Information Retrieval System (STIRS) data base was searched for test reports from cheese manufacturing facilities. The EPA library was searched for additional test reports. Using information obtained on plant locations, State and Regional offices were contacted about the availability of test reports. In addition, representative trade associations, including the American Cheese Society, were contacted for assistance in obtaining information about the industry and emissions.

To screen out unusable test reports, documents, and information from which emission factors could not be developed, the following general criteria were used:

1. Emission data must be from 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. For example, a technical paper was not included if the original study was contained in the previous document. If the exact source of the data could not be determined, the document was eliminated.

2. The referenced study should contain test results based on more than one test run. If results from only one run are presented, the emission factors must be down rated.

3. The report must contain sufficient data to evaluate the testing procedures and source operating conditions (e. g., one-page reports were generally rejected).

A final set of reference materials was compiled after a thorough review of the pertinent reports, documents, and information according to these criteria.

3.2 DATA QUALITY RATING SYSTEM[1]

As part of the analysis of the emission data, the quantity and quality of the information contained in the final set of reference documents were evaluated. The following data were excluded from consideration:

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

2. Test series representing incompatible test methods (i.e., comparison of EPA Method 5 front half with EPA Method 5 front and back half);

3. Test series of controlled emissions for which the control device is not specified;

4. Test series in which the source process is not clearly identified and described; and

5. Test series in which it is not clear whether the emissions were measured before or after the control device.

Test data sets that were not excluded were assigned a quality rating. The rating system used was that specified by EFIG for preparing AP-42 sections. The data were rated as follows:

A — Multiple tests that were performed on the same source using sound methodology and reported in enough detail for adequate validation. These tests do not necessarily conform to the methodology specified in EPA reference test methods, although these methods were used as a guide for the methodology actually used.

B — Tests that were performed by a generally sound methodology but lack enough detail for adequate validation.

C — Tests that were based on an untested or new methodology or that lacked a significant amount of background data.

D — Tests that were based on a generally unacceptable method but may provide an order-of-magnitude value for the source.

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

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

2. Sampling procedures. The sampling procedures conformed to a generally acceptable methodology. If actual procedures deviated from accepted methods, the deviations are well documented. When this occurred, an evaluation was made of the extent to which such alternative procedures could influence the test results.

3. Sampling and process data. Adequate sampling and process data are documented in the report, and any variations in the sampling and process operation are noted. 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 contain original raw data sheets. The nomenclature and equations used were compared to those (if any) specified by EPA to establish equivalency. The depth of review of the calculations was dictated by the reviewer's confidence in the ability and conscientiousness of the tester, which in turn was 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 quality of the emission factors developed from analysis of the test data was rated using the following general criteria:

A — Excellent: Developed only from A-rated test data taken from many randomly chosen facilities in the industry population. The source category is specific enough so that variability within the source category population may be minimized.

B — Above average: Developed only from A-rated test data from a reasonable number of facilities. Although no specific bias is evident, it is not clear if the facilities tested represent a random sample of the industries. The source category is specific enough so that variability within the source category population may be minimized.

C — Average: Developed only from A- and B-rated test data from a reasonable number of facilities. Although no specific bias is evident, it is not clear if the facilities tested represent a random sample of the industry. In addition, the source category is specific enough so that variability within the source category population may be minimized.

D — Below average: The emission factor was developed only from A- and B-rated test data from a small number of facilities, and there is reason to suspect that these facilities do 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 noted in the emission factor table.

E — Poor: The emission factor was developed from C- and D-rated test data, and there is reason to suspect that the facilities tested do 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 these criteria is somewhat subjective and depends to an extent upon the individual reviewer. Details of the rating of each candidate emission factor are provided in Section 4.

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REFERENCE FOR SECTION 3

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

4. REVIEW OF SPECIFIC DATA SETS

This section describes how the AP-42 section on natural and processed cheese was developed. First, descriptions of data sets that were reviewed for this report are presented, followed by a discussion of how candidate emission factors were developed from the data.

4.1 REVIEW OF SPECIFIC DATA SETS

Seven emission test reports containing data on particulate emissions from cheese and whey drying were reviewed. Emission factors were developed from all seven documents. A review of the references is provided in the following paragraphs.

4.1.1 Reference 1

This report documents a March 30, 1993, particulate emissions test conducted on a Parmesan cheese dryer controlled by a scrubber. The dryer is direct-fired with natural gas and has a rated capacity of 6,250 pounds of dry product per hour. Testing was performed at the both inlet and outlet of the scrubber. Particulate emissions were quantified using Method 5 and included measurements of both filterable and condensible PM (organic and inorganic). Orsat analysis was used to measure CO_2 emissions. Three test runs were performed at the control device inlet and outlet. Each run lasted 1 hour and no problems were reported. No details about the process were given and an average production rate during testing was reported. These data are rated B, except for the condensible inorganic PM (CIPM) data from the scrubber outlet testing. These data are not rated because they were higher than the CIPM data from the inlet testing. Therefore, the CIPM test data from the scrubber outlet were not used to develop emission factors.

4.1.2 Reference 2

This report documents a particulate emissions test conducted December 28, 1988, on a Cheddar cheese dryer controlled by a venturi scrubber. The dryer is direct-fired with natural gas. Particulate emissions were measured using Method 5 and included measurements of filterable, condensible inorganic, and condensible organic PM. Orsat analysis was used to measure CO_2 emissions. Three 1-hour test runs were conducted at the outlet of the control device, and no problems were reported during the test. No details on the process were given and an average production rate during testing was reported. These data are rated B.

4.1.3 Reference 3

This report documents a particulate emissions test on a Cheddar cheese dryer conducted on March 29, 1990. The dryer tested is a spray dryer direct-fired with natural gas. It is controlled by a venturi scrubber. Three one-hour runs were conducted using Method 5. Filterable, condensible inorganic, and condensible organic PM were measured, and no problems were reported during testing. Orsat analysis was used to measure CO_2 emissions. No details about the process were given. These data are rated B.

4.1.4 Reference 4

This report documents a particulate emissions test on a whey dryer. The whey is dried in two stages. First, the whey concentrate is sprayed under pressure into the primary dryer; then, the partially dehydrated powder passes to a secondary dryer for final drying. The emission source tested was the primary dryer, which is fired with natural gas. The production rate during the test averaged 5,549 pounds of dry product per hour. Emissions from the dryer are controlled by two cyclones; no information was given on the types of cyclones or their operating parameters. Testing was stopped after two runs, when emissions did not look normal to plant personnel. It was discovered that a cyclone was plugged. Three more one-hour runs were then conducted, using Method 5 to measure filterable and condensible PM; runs 3-5 are reported in this document and were used to develop emission factors. Orsat analysis was used to measure CO_2 emissions. These data are rated B.

4.1.5 Reference 5

This test report documents particulate emissions testing on a whey drying and bagging process on March 29, 1988. The dryer has a rated capacity of 2,500 pounds of dry product per hour (5,000 pounds per hour at 50 percent moisture) and is direct-fired with natural gas. The drying system emissions are controlled by a venturi scrubber followed by a cyclone. Emissions from the bagging operation are controlled by a baghouse, with emissions from the baghouse vented back to the main exhaust duct, just before the venturi scrubber. There are also four product recovery cyclones, but emissions from these cyclones are kept within the dryer system. Method 5 was used to measure filterable, condensible organic, and condensible inorganic PM emissions; three 1-hour runs were conducted. Orsat analysis was used to measure CO_2 emissions. No problems were reported during the test. These data are rated A.

4.1.6 Reference 6

This report documents particulate emissions testing conducted on a whey dryer on November 8, 1988. The dryer is direct-fired with natural gas and has a rated output capacity of 4,000 pounds per hour. Particulate emissions from the dryer are controlled by a fabric filter system. Method 5 was used to measure filterable, condensible organic, and condensible inorganic PM emissions; only two 100-minute runs were performed (the sampling time was increased because of poor flow distribution). Orsat analysis was used to measure CO_2 emissions. No details about the process were given. These data are rated B.

4.1.7 Reference 7

This report documents particulate testing on a whey dryer on April 20, 1989. The whey slurry is sprayed into the drying chamber of the dryer and falls onto a moving belt where additional drying and cooling take place. Emissions are controlled by a series of cyclones, followed by a wet scrubber. The dryer has a normal production rate of 22,000 to 27,000 pounds per hour at 50 to 54 percent solid whey concentrate. Measurements of condensible and filterable PM emissions were made using Method 5. Emissions of CO_2 were measured using Orsat analysis. Three 72-minute runs were performed. During Run 3, there were problems maintaining the spray pattern in the dryer and plugging in the dry powder receiver, but these events do not appear to have influenced the test results. The average production rate during testing was reported. These data are rated B. The condensible organic PM data are not rated because the tare weight of the particulate was less than the measured blank weight; a value of zero was used for that data.

4.2 DEVELOPMENT OF CANDIDATE EMISSION FACTORS

Table 4-1 summarizes the emission data used to develop emission factors for cheese and whey drying during natural and processed cheese manufacturing. The candidate emission factors for natural and processed cheese manufacture are presented in Table 4-2. The following paragraphs describe how the data presented in Table 4-1 were used to develop candidate emission factors for the draft AP-42 section on natural and processed cheese.

TABLE 4-1. SUMMARY OF TEST DATA FOR NATURAL AND PROCESSED CHEESE MANUFACTURING

Process	APCD	Pollutant	No. of runs	Data rating	Emission factor lb/ton Min	Emission factor lb/ton Max	Emission factor lb/ton Avg	Emission factor kg/Mg Avg	Ref. No.
Cheese dryer	None	Filterable PM	3	B	0.47	0.83	0.63	0.32	1
Cheese dryer	Wet scrubber	Filterable PM	3	B	0.16	0.43	0.27	0.14	1
Cheese dryer	None	Condensible organic PM	3	B	0.024	0.060	0.043	0.021	1
Cheese dryer	Wet scrubber	Condensible organic PM	3	B	0.021	0.048	0.033	0.017	1
Cheese dryer	None	Condensible inorganic PM	3	B	0.12	0.46	0.25	0.13	1
Cheese dryer	Wet scrubber	Condensible inorganic PM	3	NR	0.26	0.58	0.47	0.23	1
Cheese dryer	None	CO_2	3	B	64	98	75	38	1
Cheese dryer	Wet scrubber	CO_2	3	B	68	100	80	40	1
Cheese dryer	Venturi scrubber	Filterable PM	3	B	4.3	5.1	4.6	2.3	2
Cheese dryer	Venturi scrubber	Condensible inorganic PM	3	B	0.30	0.47	0.39	0.19	2
Cheese dryer	Venturi scrubber	Condensible organic PM	3	B	0.13	0.58	0.36	0.18	2
Cheese dryer	Venturi scrubber	CO_2	3	B	1,000	2,000	1,500	770	2
Cheese dryer	Venturi scrubber	Filterable PM	3	B	2.0	3.6	2.6	1.3	3
Cheese dryer	Venturi scrubber	Condensible inorganic PM	3	B	0.12	0.29	0.19	0.094	3
Cheese dryer	Venturi scrubber	Condensible organic PM	3	B	0.73	1.1	0.92	0.46	3
Cheese dryer	Venturi scrubber	CO_2	3	B	1,400	1,400	1,400	700	3
Whey dryer	Cyclone	Filterable PM	3	B	0.72	0.85	0.77	0.39	4
Whey dryer	Cyclone	Condensible PM	3	B	0.63	1.0	0.75	0.38	4
Whey dryer	Cyclone	CO_2	3	B	330	430	360	190	4
Whey drying and bagging	Venturi scrubber	Filterable PM	3	A	0.40	0.45	0.42	0.21	5

TABLE 4-1. (continued)

Process	APCD	Pollutant	No. of runs	Data rating	Emission factor				Ref. No.
					lb/ton			kg/Mg	
					Min	Max	Avg	Avg	
Whey drying and bagging	Venturi scrubber	Condensible inorganic PM	3	A	0.14	0.44	0.28	0.14	5
Whey drying and bagging	Venturi scrubber	Condensible organic PM	3	A	0.082	0.15	0.11	0.053	5
Whey drying and bagging	Venturi scrubber	CO_2	3	A	200	390	270	140	5
Whey dryer	Fabric filter	Filterable PM	2	B	1.9	2.4	2.2	1.1	6
Whey dryer	Fabric filter	Condensible inorganic PM	2	B	0.011	0.083	0.047	0.024	6
Whey dryer	Fabric filter	Condensible organic PM	2	B	0.056	0.14	0.10	0.048	6
Whey dryer	Fabric filter	CO_2	2	B	440	1,000	720	360	6
Whey dryer	Wet scrubber	Filterable PM	3	B	0.65	0.86	0.76	0.38	7
Whey dryer	Wet scrubber	Condensible inorganic PM	3	B	0.020	0.059	0.044	0.022	7
Whey dryer	Wet scrubber	Condensible organic PM	3	NR	0.0	0.0	0.0	0.0	7
Whey dryer	Wet scrubber	CO_2	3	B	370	480	440	220	7

TABLE 4-2. CANDIDATE EMISSION FACTORS FOR NATURAL AND PROCESSED CHEESE MANUFACTURE

Source	Control	Pollutant	Average emission factor			
			lb/ton	kg/Mg	Rating	Ref.
Cheese dryer	None	Filterable PM	0.63	0.32	D	1
	None	Cond. inorg. PM	0.25	0.13	D	1
	None	Cond. org. PM	0.043	0.021	D	1
	None	CO_2	75	38	D	1
	Wet scrubber	Filterable PM	2.5	1.2	D	1,2,3
	Wet scrubber	Cond. inorg. PM	0.29	0.15	D	2,3
	Wet scrubber	Cond. org. PM	0.44	0.22	D	1,2,3
	Wet scrubber	CO_2	990	500	D	1,2,3
Whey dryer	Cyclone	Filterable PM	0.77	0.39	D	4
	Cyclone	Condensible PM	0.75	0.38	D	4
	Cyclone	CO_2	360	190	D	4
	Fabric filter	Filterable PM	2.2	1.1	D	6
	Fabric filter	Cond. inorg. PM	0.047	0.024	D	6
	Fabric filter	Cond. org. PM	0.1	0.048	D	6
	Fabric filter	CO_2	720	360	D	6
	Wet scrubber	Filterable PM	0.76	0.38	D	7
	Wet scrubber	Cond. inorg. PM	0.044	0.022	D	7
	Wet scrubber	Cond. org. PM	0	0	NR	7
	Wet scrubber	CO_2	440	220	D	7
Whey drying and bagging	Venturi scrubber	Filterable PM	0.42	0.21	D	5
	Venturi scrubber	Cond. inorg. PM	0.28	0.14	D	5
	Venturi scrubber	Cond. org. PM	0.11	0.053	D	5
	Venturi scrubber	CO_2	270	140	D	5

4.2.1 General Procedures

The data sets were screened and evaluated, and the candidate emission factors were rated according to the criteria presented in Sections 3.2 and 3.3 of this report. The candidate emission factors generally were developed by grouping the data from similar combinations of source and control device, discarding inferior data sets, and averaging the emission factor derived from each data set. Factors for particulate and CO_2 emissions from cheese dryers and whey dryers are presented in kg/Mg and lb/ton.

4.2.2 Cheese Dryers

Because there were only three tests for cheese dryers, the data were combined and emission factors for filterable PM, condensible organic PM, condensible inorganic PM, and CO_2 were developed for uncontrolled dryers and for dryers controlled by a wet scrubber. The condensible inorganic PM factor from Reference 1 that was not rated was excluded from the emission factor calculations. All data used were rated B. Due to the small amount of data available, these factors are rated D.

4.2.3 Whey Dryers

There were four tests with emissions data from whey drying. Data from three tests were used to develop emission factors for filterable PM, condensible organic PM, condensible inorganic PM, and CO_2 emissions from whey dryers. Factors were developed from A- and B-rated data and are rated D. The factor for condensible organic PM emissions from whey dryers controlled by a scrubber was not rated because of analysis problems. Data from one test were used to develop emission factors for filterable PM, condensible PM, and CO_2 for whey drying and bagging operations. These factors are rated D since they were developed using data from only one B-rated test.

REFERENCES FOR SECTION 4

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3. *Results of the March 29, 1990 Particulate Emission Compliance Test on the Rogers Dryer at the Land O'Lakes Cheese Division Plant Located in Spencer, Wisconsin.* Interpoll Laboratories, Inc., Circle Pines, MN. April 18, 1990.

4. *Whey Dryer Emission Test at Northland Food Cooperative, Shawano, WI, April 9-10, 1986.* Badger Laboratories and Engineering Co., Inc., Appleton, WI. April 30, 1986.

5. *Results of the March 29, 1988 Particulate Emission Compliance Test on the Whey Dryer at the F&A Dairy in Dresser, Wisconsin.* Interpoll Laboratories, Circle Pines, MN. April 12, 1988.

6. *Results of the November 8, 1988 Particulate Emission Compliance Test on the Whey Dryer at the Ellsworth Coop Creamery in Ellsworth, Wisconsin.* Interpoll Laboratories, Circle Pines, MN. December 9, 1988.

7. *Whey Dryer Emission Tests at Alto Dairy, Waupun, WI, April 20, 1989.* Badger Laboratories, Appleton, WI. June 9, 1989.

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This is preliminary material, in draft form, for purposes of review. This material must not be quoted, cited, or in any other way considered or used as final work.

9.6.1 Natural And Processed Cheese

9.6.1.1 General[1-3]

The United States is one of the largest producers of cheese in the world. The total number of industry establishments in the United States in 1995 was 432. In 1995, total natural cheese production in the U. S., excluding cottage cheeses, was 6.9 billion pounds, and total processed cheese production was 2.3 billion pounds. Wisconsin is the leading producer of cheese in the United States, accounting for over 30 percent of all cheese production in the country.

Popular types of natural cheeses include unripened (e. g., cottage cheese, cream cheese), soft (e. g., Brie, Camembert), semi-hard (e. g., Brick, Muenster, Roquefort, Stilton), hard (e. g., Colby, Cheddar), blue veined (e. g., Blue, Gorgonzola), cooked hard cheeses (e. g., Swiss, Parmesan), and pasta filata (stretched curd, e. g., Mozzarella, Provolone). Examples of processed cheeses include American cheese and various cheese spreads, which are made by blending two or more varieties of cheese or blending portions of the same type of cheese that are in different stages of ripeness.

9.6.1.2 Process Description[4-9]

The modern manufacture of natural cheese consists of four basic steps: coagulation, drainage, salting, and ripening. Processed cheese manufacture incorporates extra steps, including cleaning, blending, and melting. No two cheese varieties are produced by the same method. However, manufacturing different cheeses does not require widely different procedures, but rather the same steps with variations during each step, the same steps with a variation in their order, special applications, or different ripening practices. Table 9.6.1-1 presents variations in the cheesemaking process characteristic of particular cheese varieties. This section includes a generic process description; steps specific to a single cheese variety are mentioned but are not discussed in detail.

9.6.1.2.1 Natural Cheese Manufacture -

The following sections describe the steps in the manufacture of natural cheese. Figure 9.6.1-1 presents a general process diagram.

Draft Table 9.6.1-1. DIFFERENCES IN SELECTED CHEESEMAKING STEPS

Type of Cheese	Primary Coagulating Agent/Time	Cooking Temp. °C (F°)	Primary Draining Method	pH	Salting, %	Pressing	Ripening Period
Blue	Rennin (30 min.)	33.3 (92)	Vat drain	5.4	Dry (5.0)	In molds, no surface weights	60 days minimum; 3-4 mos. usually; 9 mos. for more flavor
Brick	Rennin (25 min.)	35.6 (96)	Vat drain	5.4	Brine (1.5)	In molds, surface weights	4-8 weeks
Camembert	Rennin (45 min.)	32.2 (90)	Dip	5.1	Dry (1.5)	In molds, no surface weights	4-5 weeks
Cheddar	Rennin (25 min.)	37.8 (100)	Vat drain	5.2	Dry (1.5)	Horizontal hydraulic press	60 days minimum; 3-6 mos. usually; 12 or longer for sharp flavor
Cottage	Acid (5 hr)	48.9 (120)	Vat drain	4.6	Dry (1.0	Vat packing	Unripened
Cream	Acid (5 hr)	57.2 (135)	Hoop	4.6	Dry (1.0)	Bag packing	Unripened
Mozzarella	Rennin (30 min.)	32.2 (90)	Vat drain	5.3	Brine (0.7)	Bag packing	Unripened to 2 months
Provolone	Rennin (20 min.)	47.8 (118)	Vat drain	5.3	Brine (1.5)	Vat packing	6-14 months
Ricotta	Acid (30 min.)	80.0 (176)	Hoop	5.9	Dry (0.5)	Can packing	Unripened
Romano	Rennin (20 min.	46.7 (116)	Dip	5.3	Dry (5.0)	In molds, surface weights	5 months min.; 12 months for grating
Swiss	Rennin (30 min.	53.3 (128)	Dip	6.2	Brine (1.6)	Vertical hydraulic press	2 months min.; 2-9 months usually

Source: Reference 8

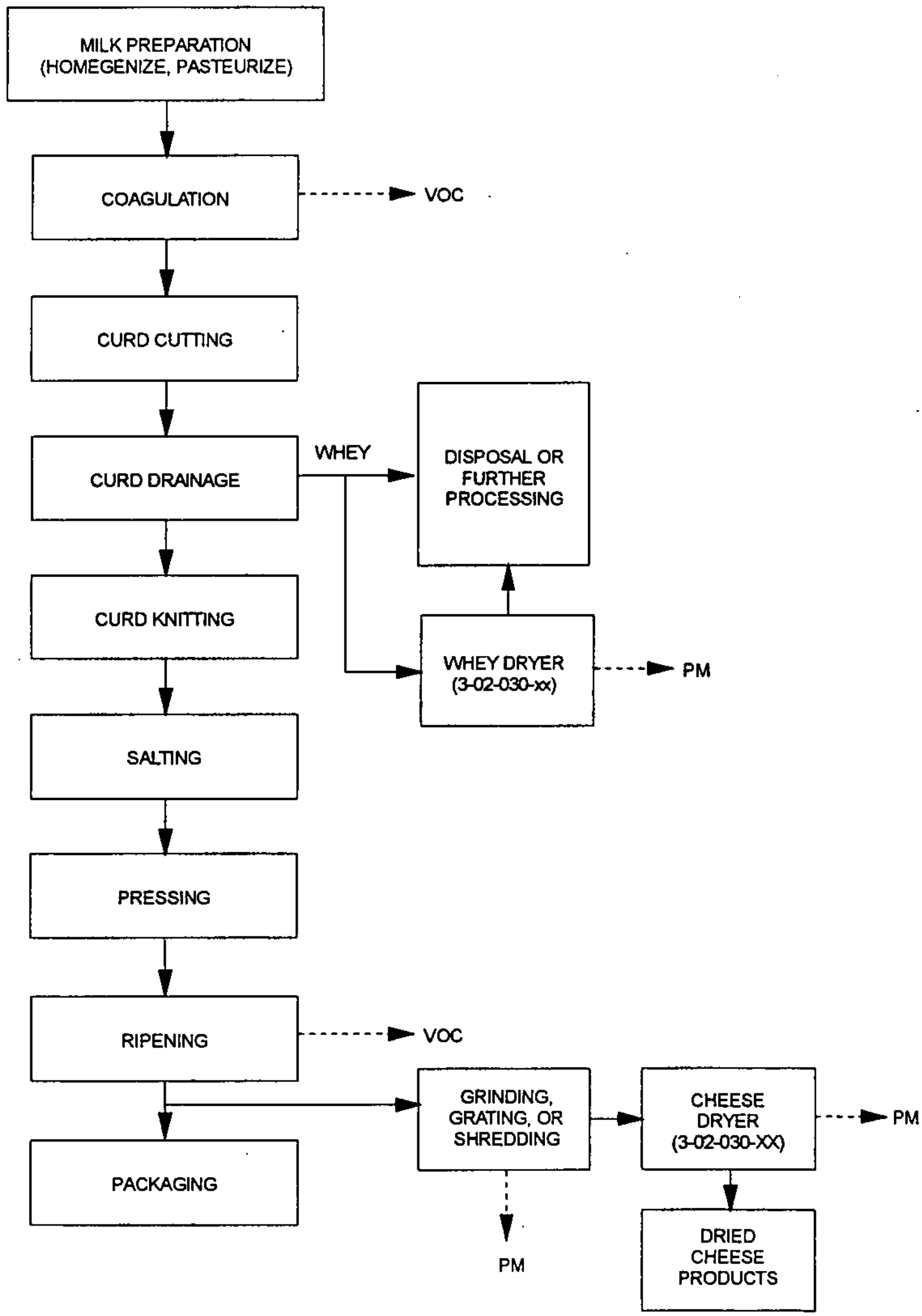

Figure 9.6.1-1. Natural cheese manufacture.
(Source Classification Code in parentheses.)

Milk Preparation -

Cow's milk is the most widely used milk in cheese processing. First, the milk is homogenized to ensure a constant fat level in the milk. A standardizing centrifuge, which skims off the surplus fat as cream, is often used to obtain the fat level appropriate for different varieties of cheese. Following standardization, the milk is ready for heat treatment, which is necessary to destroy harmful micro-organisms and bacteria.

Coagulation -

Coagulation, or clotting of the milk, is the basis of cheese production. Coagulation is brought about by physical and chemical modifications to the constituents of milk and leads to the separation of the solid part of milk (the curd) from the liquid part (the whey). To initiate coagulation, milk is mixed with a starter, which is a culture of harmless, active bacteria. The enzyme rennet is also used in coagulation. Most of the fat and protein from the milk are retained in the curd, but nearly all of the lactose and some of the minerals, protein, and vitamins escape into the whey. Table 9.6.1-1 provides the primary coagulating agent and the coagulating time necessary for different varieties of cheese.

Curd Treatment -

After the curd is formed, it is cut into pieces to speed whey expulsion and increase the surface area. The curd is cut into various sizes, depending on the variety of cheese being made. Cutting the curd into small cubes reduces the moisture content of the final cheese, whereas creating larger cubes increases the moisture content.

Following the cutting step, the curd is cooked, which contracts the curd particles and acts to remove whey, develop texture, and establish moisture control. The cut curds and whey are heated and agitated. Table 9.6.1-1 provides the cooking temperatures required to produce typical varieties of cheeses.

Curd Drainage -

The next step in cheese manufacture, drainage, involves separating the whey from the curd. Drainage can be accelerated by either heat treatment or mechanical treatment, such as cutting, stirring, oscillating, or pressing. After the curd is dry, it is cut into blocks which can then be filled into cheese hoops for further draining and pressing. Table 9.6.1-1 gives the primary draining methods for a variety of cheeses.

For some cheeses, special applications and procedures occur immediately before, during, or after the draining stage. For example, internally ripened, or blue veined, cheeses (e. g., Blue, Roquefort) are usually seeded with penicillium powder prior to drainage. Cooked hard cheeses (e. g., Parmesan) are stirred and warmed to accelerate and complete the separation of the whey. The separated whey may be treated and disposed of; shipped offsite in liquid or concentrated form for use as animal feed; used to make whey cheese; dried for lactose, mineral, or protein recovery; or dried for use as a food additive or use in the manufacture of processed cheese.

Curd Knitting -

Knitting, or transforming, the curd allows the accumulating lactic acid to chemically change the curd; knitting also includes salting and pressing. This step leads to the characteristic texture of different cheeses. It is during this stage that Provolone and Mozzarella cheeses are pulled and processed (these cheeses are then kneaded, drawn, shaped, and smoothed); that a bean gum or some other type of gum is added to cream cheese to stabilize and stiffen it; and that a creaming agent (cream and/or milk) is added to cottage cheese. During this period, specific pH levels are controlled to produce different varieties of cheese (see Table 9.6.1-1).

To salt the cheese, coarse salt is spread over the surface of the cheese or the pressed cheese is immersed in a salt solution. Salting further completes the drainage of the cheese and also affects rind formation, growth of microorganisms, and enzyme activity. Table 9.6.1-1 provides the salting method and salt percentage necessary to produce a particular variety of cheese.

Pressing determines the characteristic shape of the cheese by compacting the texture, extruding free whey from the curds, and completing the curd knitting. Pressing involves confining the wet, warm curds in a form or cloth bag. With some cheeses, vertical pressing is used; others require vacuum pressing to remove occluded air and give a close knit body. See Table 9.6.1-1 for the different pressing practices for various cheeses.

Ripening -

During the ripening or curing stage, varieties of cheeses acquire their own unique textures, aromas, appearances, and tastes through complex physical and chemical changes that are controlled as much as possible by adjusting temperature, humidity, and duration of ripening. For all cheeses, the purpose of ripening is to allow beneficial bacteria and enzymes to transform the fresh curd into a cheese of a specific flavor, texture, and appearance. Cottage and cream cheeses are not ripened, and usually have a bland flavor and soft body.

Some cheeses require the application of a special ripening agent to create a particular taste or texture. For example, some cheeses rely wholly on surface bacteria and yeast applied to their exteriors for curing and ripening (e. g., Brick, Brie, Camembert); others require injection of particular bacteria and molds (e. g., Blue) or gas-forming microorganisms (e. g., Swiss). It is during the ripening stage that the rind or crust forms on the cheese's surface. The rind controls the loss of moisture from the internal part of the cheese and regulates the escape of gases released during ripening.

Preserving And Packaging -

Modern cheese packaging protects the food from microorganisms and prevents moisture loss. Ripened cheeses must undergo special procedures during packaging for preservative reasons. Unripened cheeses are packaged immediately after the curd is collected and must be immediately refrigerated.

Many ripened cheeses are coated in wax to protect the cheese from mold contamination and to reduce the rate of moisture loss. Cheeses that naturally develop a thick, tightly woven rind, such as Swiss, do not require waxing. A second method of ripened cheese packaging involves applying laminated cellophane films to unwaxed cheese surfaces. The most common packaging film consists of two laminated cellophane sheets and a brown paper overlay necessary for shipping. A variation includes a metal foil wrap.

9.6.1.2.2 Processed Cheese Manufacture -

Nearly one-third of all cheese produced in the United States consists of processed cheese and processed cheese products. There are many different types of final products in processed cheese manufacture. These cheeses are distinguished from one another not only by their composition but by their presentation as individual portions, individual slices, rectangular blocks, or special presentation as cylinders or tubes.

Processed cheese is made by pasteurizing, emulsifying, and blending natural cheese. Processed cheese foods, spreads, and cold pack cheeses contain additional ingredients, such as nonfat milk solids and condiments. Several varieties of natural cheeses may be mixed, and powdered milk, whey, cream or butter, and water may be added. The following section describes the basic steps necessary for producing pasteurized process cheese, the most common processed cheese.

Pasteurized Process Cheese -

Cheeses are selected to be processed from both mild and sharp cheeses. For example, American cheese is made from Cheddar and Colby cheeses. Once selected, the cheeses must be analyzed for their fat and moisture contents to determine the proper amount of emulsifiers and salts to be added. Cheese surfaces are cleaned by scraping and trimming, and the rinds are removed. After cleaning, the cheese blocks are ground in massive grinders, combined, and the cheese mixture is heated. At this point, the melted cheese separates into a fat and serum. Emulsifiers are added to disperse the fat, and create a uniform, homogenous mass. At this point, additives such as spices, flavorings, binding agents, and preservatives may be added if the cheese is to undergo further processing.

The molten cheese is removed quickly from the cookers and is pumped or dropped into packaging hoppers. The cheese is packaged in the absence of oxygen to inhibit the growth of mold. The cheese is usually wrapped in lacquered aluminum foil or in aluminum foil-lined cardboard or plastic boxes. For sliced processed cheese, the molten cheese is spread uniformly by chilled steel rollers and cut by rotary knives to consumer size.

Other Processed Cheeses -

Other processed cheeses that are similar to the above in manufacturing are also commonly produced. For example, to produce pasteurized process cheese food, one or more of the following optional dairy ingredients are added: cream, milk, skim milk, buttermilk, and/or cheese whey. The result is a processed cheese food that is higher in moisture and lower in fat than pasteurized process cheese. Processed cheese intended for spreading undergoes a creaming step after heating, which includes mechanical kneading of the hot cheese and addition of various dairy products and other additives. Other processed cheese products include cold-packed cheese, cold-packed cheese food, and reduced fat cheeses. All processed cheeses may be enhanced with salt, artificial colorings, spices or flavorings, fruits, vegetables, and meats.

Grated and powdered cheeses are produced by removing the moisture from one or more varieties of cheeses and grinding, grating, or shredding the cheese(s). Mold-inhibiting ingredients and anti-caking agents may be added as well. Dehydration takes such forms as tray drying, spray or atomized drying, and freeze drying. Popular types of grated cheese include Parmesan, Romano, Mozzarella, and Cheddar. Cheese powders, such as those made from Cheddar cheese, may be used to flavor pasta, or added to bread dough, potato chips, or dips.

9.6.1.3 Emissions And Controls

Particulate emissions from cheese manufacture occur during cheese or whey drying, and may occur when the cheese is grated or ground before drying. CO_2 emissions from drying may be primarily from the combustion of fuel, especially in the case of direct-fired dryers. Cheese dryers are used in the manufacture of grated or powdered cheeses. Whey dryers are used in some facilities to dry the whey after it has been separated from the curd following coagulation. VOC emissions may occur in the coagulation and/or ripening stages. Particulate emissions from cheese and whey dryers are controlled by wet scrubbers or fabric filters. Cyclones are also used to control particulate emissions or for product recovery. Emission factors for cheese drying and whey drying in natural and processed cheese manufacture are shown in Table 9.6.1-2.

Draft Table 9.6.1-2. CANDIDATE EMISSION FACTORS FOR NATURAL AND PROCESSED CHEESE MANUFACTURE

Source/Control	Pollutant	Average emission factor			
		lb/ton	kg/Mg	Rating	Ref.
Cheese dryer/Uncontrolled (SCC 3-02-030-xx)	Filterable PM	0.63	0.32	D	1
	Cond. inorg. PM	0.25	0.13	D	1
	Cond. org. PM	0.043	0.021	D	1
	CO_2	75	38	D	1
Cheese dryer/Wet scrubber (SCC 3-02-030-xx)	Filterable PM	2.5	1.2	D	1,2,3
	Cond. inorg. PM	0.29	0.15	D	2,3
	Cond. org. PM	0.44	0.22	D	1,2,3
	CO_2	990	500	D	1,2,3
Whey dryer/Cyclone (SCC 3-02-030-xx)	Filterable PM	0.77	0.39	D	4
	Condensible PM	0.75	0.38	D	4
	CO_2	360	190	D	4
Whey dryer/Fabric filter (SCC 3-02-030-xx)	Filterable PM	2.2	1.1	D	6
	Cond. inorg. PM	0.047	0.024	D	6
	Cond. org. PM	0.1	0.048	D	6
	CO_2	720	360	D	6
Whey dryer/Wet scrubber (SCC 3-02-030-xx)	Filterable PM	0.76	0.38	D	7
	Cond. inorg. PM	0.044	0.022	D	7
	Cond. org. PM	0	0	NR	7
	CO_2	440	220	D	7
Whey dryer and bagger/ Venturi scrubber (SCC 3-02-030-xx)	Filterable PM	0.42	0.21	D	5
	Cond. inorg. PM	0.28	0.14	D	5
	Cond. org. PM	0.11	0.053	D	5
	CO_2	270	140	D	5

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References For Section 9.6.1

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APPENDIX A.

Excerpts from Reference 1
(Kraft Foods, Inc., March 30, 1993)

Sec 9.6.1

Kraft Foods
Wausau, WI
Fluidized Bed Cheese Dryer

Report Number: 4232-93-2251

Report Issued: May 7, 1993

AIR EMISSION TEST REPORT

RESULTS OF SOURCE
EMISSION TEST
PERFORMED ON ~~PARMESAN CHEESE DRYER~~
KRAFT FOODS, INC.
WAUSAU, WISCONSIN
MARCH 30, 1993

March 30, 1993

Submitted to:

KRAFT FOODS, INC.
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Submitted by:

TWIN CITY TESTING CORPORATION
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Received 9/10/93

Reviewed: 9/23/93

Prepared by:	Approved by:
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Source and Ambient Testing	Director
Air Quality Services	IH/Biological Services

twin city testing

INTRODUCTION

Twin City Testing Corporation (TCT) was contracted by Kraft Foods, Inc. to perform a source emission test on the parmesan cheese dryer at the Kraft Foods facility located in Wausau, Wisconsin. The inlet and outlet exhaust gases from the air scrubber for this process was tested for particulate emissions on March 30, 1993. This report presents the results of the test program along with all substantiating documentation.

The TCT sampling team consisted of Messrs. Al Trowbridge, Jim Tryba, Jerry Wallerius and Brad Lavold. The test proceedings were witnessed by Rhonda O'Leary, Environmental Engineer for the Wisconsin Department of Natural Resources.

TEST RESULTS

The results of the particulate emission tests are summarized in Table 1. The data indicates an average particulate emission rate for the inlet gases of 2.46 pounds per hour and a rate of 2.04 pounds per hour for the outlet gases.

Opacity observations could not be made due to adverse meteorological conditions. There were no problems encountered during the test proceedings.

Table 1
Summary of emission test results
Kraft Foods, Inc., Wausau Wisconsin
Air Scrubber for Parmesan Cheese Dryer
March 30, 1993

Parameter	INLET Average	OUTLET Average
Effluent Temperature, °F	79	76
Effluent Moisture Content, % v/v	3.50	2.95
Effluent Composition, % v/v dry;		
Carbon Dioxide	0.23	0.23
Oxygen	20.30	20.30
Effluent Volumetric Flow Rate;		
Actual Conditions, acfm	13950	14457
Dry Standard Conditions, dscfm	12441	13293
Isokinetic Variation, %	101.8	99.2
Effluent Particulate Concentration;		
Pounds/Hour	2.46	2.04
Pounds/1000 pounds stack gas	0.0423	0.0331

Standard Conditions: 68°F, 29.92 in. Hg. Particulate concentration and emission rates are based on analysis of the sampling train front and back catches.

PROCESS DATA

Kraft Foods utilizes an air scrubber to control the particulate emissions for their parmesan cheese ~~drying process~~ dry product. The production records indicated an average production rate of ~~6,600~~ 5300 pounds dry product per hour. Please refer to Appendix E for process data details. Rated at 6,250 Lb dry product/Hr.

TEST PROCEDURES

The EPA Methods referenced below are described in Appendix A of the Code of Federal Regulations, Title 40, Part 60 (40 CFR 60).

The number of sampling points and their location with in the source stack/duct was determined per EPA Method 1 which is entitled "Sample and velocity traverses for stationary sources". In this method the number of sampling points is based on the length of straight, undisturbed flow both before and after the sampling port location. The following data is specific to the source tested:

	Inlet	Outlet
Stack diameter, inches:	36.0	33.75
Required number of sampling points:	24	24
Number of sampling points used:	24	24
Sampling point distribution;		
Number of sampling ports:	2	2
Number of sampling points per port:	12	12
Particulate test sampling time;		
Time at each point, minutes:	2.5	2.5
Test run total time, minutes:	60.0	60.0

Effluent flow measurements were made per EPA Method 2 which is entitled "Determination of stack gas velocity and volumetric flow rate (Type S pitot tube)". Gas velocity pressure (head) and temperature data were obtained during each EPA Method 5 particulate test run by traversing each of the sampling points defined by EPA Method 1. This data along with gas density (EPA Method 3) and moisture content (EPA Method 4) data was used to calculate the gas velocity at each sampling point. The source volumetric flow rate was calculated by multiplying the average gas velocity by the stack/duct cross-sectional area at the point of measurement. Velocity pressure (head) measurements were made using a Type S pitot tube constructed to the design specifications detailed in EPA Method 2. Such pitot tubes have a base line coefficient of 0.84.

The density of the effluent was determined per EPA Method 3 which is entitled "Gas analysis for the determination of dry molecular weight". A multi-point, integrated gas sample was collected simultaneously with each EPA Method 5 particulate test run. The gas sample was analyzed for carbon dioxide and oxygen concentrations with a standard Orsat analyzer using commercially prepared solutions. For calculations of gas density the balance of the gas was assumed to be nitrogen and carbon monoxide.

The effluent moisture content was determined per EPA Method 4 which is entitled "Determination of moisture content in stack gases". Data for making a gas moisture content determination was collected simultaneously with each EPA Method 5 particulate test run. The gas moisture content was calculated from the mass and/or volume of liquid collected in the Method 5 sampling train cold box impingers and the volume of gas sampled.

The effluent particulate concentration was determined per EPA Method 5 which is entitled "Determination of particulate emissions from stationary sources". For each test run, particulate matter was with drawn from the gas stream at each of the EPA Method 1 defined sampling points and collected on a glass fiber filter which was maintained at $248 \pm 25^{\circ}F$. Water vapor, organic vapors and other matter in vapor form which passed through the filter was collected in an ice-cooled impinger trap who's exit temperature was maintained at less than $68^{\circ}F$. Sampling was performed using a Grasby-Nutech Model 2010 Method 5 stack sampling system which employed an inconel lined probe and nozzle. Particulate emissions included analyses of both the front and back (condensible organics) catches.

Source category: Natural and Processed Cheese
Plant name: Kraft Foods
Process: Parmesan Cheese Dryer

Filename 961ref1.wq1
Location: Wausau, WI
Test date March 30, 1993

Date: 02/28/97
Ref. No.: 1
Process rate basis: dry product

Source	Type of control	Pollutant	Run No.	Test Method	Isokinetic %	Gas volume, DSCF	Volum. flow rate DSCFM	Mass, g	Concen. gr/DSCF	Emission rate, lb/hr	Process rate, ton/hr	Emission factor kg/Mg	Emission factor lb/ton	Emission factor Rat.
Spray Dryer	none	Filterable PM	1	EPA 5	101.5	44.87	12,217	0.044	0.015	1.6	2.65	0.30	0.60	
		Filterable PM	2		101.5	47.13	12,829	0.0611	0.020	2.2	2.65	0.42	0.83	
		Filterable PM	3		102.5	45.61	12,277	0.0348	0.012	1.2	2.65	0.23	0.47	
									gr/DSCF		Average	0.32	0.63	B
		Cond. Inorg. PM	1	EPA 5	101.5	44.87	12,217	0.0131	0.0045	0.47	2.65	0.089	0.18	
		Cond. Inorg. PM	2		101.5	47.13	12,829	0.0089	0.0029	0.32	2.65	0.060	0.12	
		Cond. Inorg. PM	3		102.5	45.61	12,277	0.0344	0.0117	1.23	2.65	0.23	0.46	
									gr/DSCF		Average	0.13	0.25	B
		Cond. Org. PM	1	EPA 5	101.5	44.87	12,217	0.0033	0.0011	0.12	2.65	0.023	0.045	
		Cond. Org. PM	2		101.5	47.13	12,829	0.0044	0.0014	0.16	2.65	0.030	0.060	
		Cond. Org. PM	3		102.5	45.61	12,277	0.0018	0.0006	0.063	2.65	0.012	0.024	
									%		Average	0.021	0.043	B
		CO2	1	Orsat	NA	NA	12,217	NA	0.20	170	2.65	32	64	
		CO2	2		NA	NA	12,829	NA	0.30	260	2.65	49	98	
		CO2	3		NA	NA	12,277	NA	0.20	170	2.65	32	64	
									gr/DSCF		Average	38	75	B
Spray Dryer	scrubber	Filterable PM	1	EPA 5	100.4	45.47	13,766	0.0284	0.0097	1.1	2.65	0.21	0.43	
		Filterable PM	2		99.9	42.51	12,947	0.0152	0.0055	0.61	2.65	0.12	0.23	
		Filterable PM	3		97.4	42.23	13,167	0.0101	0.0037	0.41	2.65	0.078	0.16	
									gr/DSCF		Average	0.14	0.27	B
		Cond. Inorg. PM	1	EPA 5	100.4	45.47	13,766	0.0172	0.0058	0.69	2.65	0.13	0.26	
		Cond. Inorg. PM	2		99.9	42.51	12,947	0.0365	0.013	1.5	2.65	0.28	0.55	
		Cond. Inorg. PM	3		97.4	42.23	13,167	0.0374	0.014	1.5	2.65	0.29	0.58	
									gr/DSCF		Average	0.23	0.47	NR
		Cond. Org. PM	1	EPA 5	100.4	45.47	13,766	0.0032	0.0011	0.13	2.65	0.024	0.048	
		Cond. Org. PM	2		99.9	42.51	12,947	0.002	0.0007	0.1	2.65	0.015	0.030	
		Cond. Org. PM	3		97.4	42.23	13,167	0.0014	0.0005	0.1	2.65	0.011	0.021	
									%		Average	0.017	0.033	B
		CO2	1	Orsat	NA	NA	13,766	NA	0.20	190	2.65	36	72	
		CO2	2		NA	NA	12,947	NA	0.30	270	2.65	50	100	
		CO2	3		NA	NA	13,167	NA	0.20	180	2.65	34	68	
											Average	40	80	B

Basis for rating: Process rate the average during testing; condensible organic PM greater on scrubber outlet than the inlet
Problems noted:
Other notes:

APPENDIX B.

Excerpts from Reference 2
(Land O'Lakes, December 28, 1988)

ccd 1/11/93 TL

Ref 2
Sec 9.6.1

Interpoll Laboratories, Inc.
4500 Ball Road N.E.
Circle Pines, Minnesota 55014-1819

TEL: (612) 786-6020
FAX: (612) 786-7854

RESULTS OF THE DECEMBER 28, 1988 PARTICULATE EMISSION COMPLIANCE TEST ON THE ROGERS DRYER AT THE LAND O' LAKES PLANT LOCATED IN SPENCER WISCONSIN

Drying Cheddar Cheese

Submitted to:

LAND O' LAKES
P.O. Box 116
Minneapolis, Minnesota 55440

Attention: Dale Harris

Approved by:

Kathleen Eickstadt

Kathleen Eickstadt
Senior Data Analyst
Field Testing Division

Report Number 8-2695
December 30, 1988
KE/klq

1 INTRODUCTION

On December 28, 1988 Interpoll Laboratories personnel conducted a particulate emission compliance test on the Rogers Dryer at the Land O' Lakes Plant located in Spencer, Wisconsin. On-site testing was performed by E. Trowbridge and C. Mosser. Coordination between testing activities and plant operation was provided by Dale Harris of Land O' Lakes Inc. The test was witnessed by Neal Baudhuin of the Wisconsin Department of Natural Resources.

The dryer tested is a C. E. Rogers custom designed spray dryer. It is direct fired with natural gas and has a rated capacity of 1980 LB/HR of dry product. Particulate emissions from the dryer are controlled by a C. E. Rogers wet venturi scrubber.

Evaluations were performed in accordance with EPA Methods 1 - 5, CFR Title 40, Part 60, Appendix A (revised July 1, 1987). A preliminary determination of the gas linear velocity profile was made before the first particulate determination to allow selection of the appropriate nozzle diameter required for isokinetic sample withdrawal. An Interpoll Labs sampling train which meets or exceeds specifications in the above-cited reference was used to extract particulate samples by means of a heated glass-lined probe. Wet catch samples were collected in the back half of the Method 5 sampling train and analyzed as per Wisconsin DNR protocol.

An integrated flue gas sample was extracted simultaneously with each particulate sample using a specially designed gas sampling system. Integrated flue gas samples were collected in 44-liter Tedlar bags housed in a protective aluminum container. After sampling was complete, the bags were sealed and returned to the laboratory for Orsat analysis. Prior to sampling, the Tedlar bags are leak checked at 15 IN.HG. vacuum with an in-line rotameter. Bags with any detectable inleakage are discarded.

Testing on the Dryer was conducted from two test ports oriented at 90 degrees on the Stack. These test ports are located approximately twelve feet downstream of the nearest flow disturbance and approximately six feet upstream of the stack exit. A 24-point traverse was used to collect representative particulate samples. Each traverse point was sampled 2.5 minutes to give a total sampling time of 60 minutes per run.

The important results of the test are summarized in Section 2. Detailed results are presented in Section 3. Field data and all other supporting information are presented in the appendices.

TABLE 1. Summary of the Results of the December 28, 1988 Particulate Emission Compliance Test on the Rogers Dryer at the Land O'Lakes Plant Located in Spencer, Wisconsin.

ITEM			Run 1	Run 2	Run 3
Date of test			12-28-88	12-28-88	12-28-88
Time runs were done	(HRS)		1308/1411	1445/1548	1605/1709
Process rate	(LB/HR)	Cheddar Cheese	2005	2005	2005
Volumetric flow					
actual	(ACFM)		44985	45558	45960
standard	(DSCFM)		38171	38534	38062
Gas temperature	(DEG-F)		110	110	110
Moisture content	(%V/V)		4.33	4.65	6.62
Gas composition	(%V/V,dry)				
carbon dioxide			0.62	0.75	0.40
oxygen			20.18	20.28	20.42
nitrogen			79.20	78.97	79.18
Isokinetic variation	(%)		98.2	100.2	101.3
Particulate concentration					
actual	(GR/ACF)		.0154	.0129	.0129
standard	(GR/DSCF)		.0181	.0153	.0156
Part. emission rate	(LB/HR)		5.94	5.04	5.09

* Dry + organic/inorganic wet catch

Source category: Natural and Processed Cheese
Plant name: Land O'Lakes
Process: Cheddar Cheese Dryer

Filename 961ref2.wq1
Location: Spencer, WI
Test date Dec 28, 1988

Date: 03/03/97
Ref. No 2
Process rate basis dry product

Source	Type of control	Pollutant	Run No.	Test Method	Isokinetic %	Gas volume, DSCF	Volum. flow rate DSCFM	Mass, g	Concen. gr/DSCF	Emission rate, lb/hr	Process rate, ton/hr	Emission factor kg/Mg	Emission factor lb/ton	Emission factor Rat.
Spray Dryer	wet scrubber	Filterable PM	1	EPA 5	98.2	37.50	38,171	0.0377	0.016	5.1	1.0025	2.5	5.1	
		Filterable PM	2		100.2	38.63	38,534	0.0337	0.013	4.4	1.0025	2.2	4.4	
		Filterable PM	3		101.3	38.57	38,062	0.0332	0.013	4.3	1.0025	2.2	4.3	
									gr/DSCF		Average	2.3	4.6	B
		Cond. Inorg. PM	1	EPA 5	98.2	37.50	38,171	0.0022	0.0009	0.30	1.0025	0.15	0.30	
		Cond. Inorg. PM	2		100.2	38.63	38,534	0.0036	0.0014	0.48	1.0025	0.24	0.47	
		Cond. Inorg. PM	3		101.3	38.57	38,062	0.0030	0.0012	0.39	1.0025	0.20	0.39	
									gr/DSCF		Average	0.19	0.39	B
		Cond. Org. PM	1	EPA 5	98.2	37.50	38,171	0.0043	0.0018	0.58	1.0025	0.29	0.58	
		Cond. Org. PM	2		100.2	38.63	38,534	0.0010	0.0004	0.13	1.0025	0.066	0.13	
		Cond. Org. PM	3		101.3	38.57	38,062	0.0029	0.0012	0.38	1.0025	0.19	0.38	
									%		Average	0.18	0.36	B
		CO2	1	Orsat	NA	NA	38,171	NA	0.62	1,600	1.0025	800	1600	
		CO2	2		NA	NA	38,534	NA	0.75	2,000	1.0025	1000	2000	
		CO2	3		NA	NA	38,062	NA	0.40	1,000	1.0025	500	1000	
											Average	770	1500	B

Basis for rating: No details on process, average production rate used
Problems noted:
Other notes: Process rate>rated capacity of 1980 lb/hr; process rate assumed to be correct

APPENDIX C.

Excerpts from Reference 3
(Land O'Lakes, March 29, 1990)

1 Land O'Lakes
Spencer, WI

Interpoll Laboratories, Inc.
4500 Ball Road N.E.
Circle Pines, Minnesota 55014-1819

TEL: (612) 786-6020
FAX: (612) 786-7854

Rogers Dryer
March 29, 1990

RESULTS OF THE MARCH 29, 1990 PARTICULATE EMISSION COMPLIANCE TEST ON THE ROGERS DRYER AT THE LAND O' LAKES CHEESE DIVISION PLANT LOCATED IN SPENCER, WISCONSIN

Drying Cheddar Cheese

Submitted to:

LAND O' LAKES
Box 116
Minneapolis, Minnesota 55440

Attention: John Schmeling

Approved by:

Received 5/3/90

Kathleen Eickstadt
Senior Data Analyst
Field Testing Division

Report Number 0-3004
April 18, 1990
KE/des

1 INTRODUCTION

On March 29, 1990 Interpoll Laboratories personnel conducted a particulate emission compliance test on the Rogers Dryer at the Land O' Lakes Plant located in Spencer, Wisconsin. On-site testing was performed by D. Smith and C. Mosser. Coordination between testing activities and plant operation was provided by Carl Mueler of Land O' Lakes Inc. The test was witnessed by Joe Ancel of the Wisconsin Department of Natural Resources.

The dryer tested is a C. E. Rogers custom designed spray dryer. It is direct fired with natural gas and has a rated capacity of 1980 LB/HR of dry product. Particulate emissions from the dryer are controlled by a C. E. Rogers wet venturi scrubber.

Evaluations were performed in accordance with EPA Methods 1 - 5 and 9, CFR Title 40, Part 60, Appendix A (revised July 1, 1988). A preliminary determination of the gas linear velocity profile was made before the first particulate determination to allow selection of the appropriate nozzle diameter required for isokinetic sample withdrawal. An Interpoll Labs sampling train which meets or exceeds specifications in the above-cited reference was used to extract particulate samples by means of a heated stainless steel-lined probe. Wet catch samples were collected in the back half of the Method 5 sampling train and analyzed as per Wisconsin DNR protocol.

An integrated flue gas sample was extracted simultaneously with each particulate sample using a specially designed gas sampling system. Integrated flue gas samples were collected in 44-liter Tedlar bags housed in a protective aluminum container. After sampling was complete, the bags were sealed and returned to the laboratory for Orsat analysis. Prior to sampling, the Tedlar bags are leak checked at 15 IN.HG. vacuum with an in-line rotameter. Bags with any detectable inleakage are discarded.

Testing on the Dryer was conducted from two test ports oriented at 90 degrees on the Stack. These tests ports are located approximately 2.4 diameters downstream of the nearest flow disturbance and approximately 1.2 diameters upstream of the stack exit. A 24-point traverse was used to collect representative particulate samples. Each traverse point was sampled 2.5 minutes to give a total sampling time of 60 minutes per run.

The important results of the test are summarized in Section 2. Detailed results are presented in Section 3. Field data and all other supporting information are presented in the appendices.

TABLE 1. Summary of the Results of the March 29, 1990 Particulate Emission Compliance Test on the Rogers Dryer at the Land O' Lakes Plant located in Spencer, Wisconsin.

ITEM		Run 1	Run 2	Run 3
Date of test		03-29-90	03-29-90	03-29-90
Time runs were done	(HRS)	830/1003	1038/1142	1210/1312
Product Output*	(LBS/HR) — Cheddar Cheese	2373	2500	2500
Volumetric flow				
actual	(ACFM)	47057	48775	48163
standard	(DSCFM)	40756	40696	40147
Gas temperature	(DEG-F)	104	104	104
Moisture content	(%V/V)	6.82	7.13	7.12
Gas composition	(%V/V,dry)			
carbon dioxide		0.60	0.60	0.60
oxygen		20.30	20.30	20.40
nitrogen		79.10	79.10	79.00
Isokinetic variation	(%)	103.2	100.0	100.0
Particulate concentration				
actual	(GR/ACF)	.0139	.0104	.00913
standard	(GR/DSCF)	.0160	.0125	.0110
Part. emission rate	(LB/HR)	5.60	4.35	3.77

Note: Dry + Organic/Inorganic Wet Catch

* Moisture Content of Product = 2.7%

Source category: Natural and Processed Cheese
Plant name: Land O'Lakes
Process: Cheddar Cheese Dryer

Filename 961ref3.wq1
Location: Spencer, WI
Test date Mar 29, 1990

Date: 03/03/97
Ref. No 3
Process rate basis dry product

Source	Type of control	Pollutant	Run No.	Test Method	Isokinetic %	Gas volume, DSCF	Volum. flow rate DSCFM	Mass, g	Concen. gr/DSCF	Emission rate, lb/hr	Process rate, ton/hr	Emission factor kg/Mg	Emission factor lb/ton	Emission factor Rat.
Spray Dryer	wet scrubber	Filterable PM	1	EPA 5	103.2	43.81	40,756	0.0351	0.012	4.3	1.19	1.8	3.6	
		Filterable PM	2		100.0	42.40	40,696	0.0223	0.0081	2.8	1.25	1.1	2.3	
		Filterable PM	3		100.0	41.83	40,147	0.0196	0.0072	2.5	1.25	1.0	2.0	
									gr/DSCF		Average	1.3	2.6	B
		Cond. Inorg. PM	1	EPA 5	103.2	43.81	40,756	0.0014	0.0005	0.17	1.19	0.073	0.15	
		Cond. Inorg. PM	2		100.0	42.40	40,696	0.0012	0.0004	0.15	1.25	0.061	0.12	
		Cond. Inorg. PM	3		100.0	41.83	40,147	0.0029	0.0011	0.37	1.25	0.15	0.29	
									gr/DSCF		Average	0.094	0.19	B
		Cond. Org. PM	1	EPA 5	103.2	43.81	40,756	0.0090	0.0032	1.1	1.19	0.47	0.93	
		Cond. Org. PM	2		100.0	42.40	40,696	0.0108	0.0039	1.4	1.25	0.55	1.1	
		Cond. Org. PM	3		100.0	41.83	40,147	0.0072	0.0027	0.91	1.25	0.37	0.73	
									%		Average	0.46	0.92	B
		CO2	1	Orsat	NA	NA	40,756	NA	0.60	1,700	1.19	700	1400	
		CO2	2		NA	NA	40,696	NA	0.60	1,700	1.25	700	1400	
		CO2	3		NA	NA	40,147	NA	0.60	1,700	1.25	700	1400	
											Average	700	1400	B

Basis for rating: No details on process
Problems noted:
Other notes: Process rate > rated capacity of 1980 lb/hr; process rate assumed to be correct.

APPENDIX D.

Excerpts from Reference 4
(Northland Food Cooperative, April 9-10, 1986)

CHEMISTS
ENGINEERS

BADGER LABORATORIES & ENGINEERING CO. INC.

1110 S ONEIDA STREET • APPLETON, WISCONSIN 54915 • [414] 739-9213
TOLL FREE PHONE IN WISCONSIN 1-800-242-3556

NORTHLAND FOOD CO-OP

WHEY DRYER EMISSION TEST

at

MAY 08 1986

NORTHLAND FOOD COOPERATIVE
116 N. Main Street
Shawano, WI 54166

WHEY DRYER

Lactose Production

April 9 - 10, 1986

APRIL '86

Prepared By:

BADGER LABORATORIES & ENGINEERING CO., INC.
1110 S. Oneida Street
Appleton, WI 54915

April 30, 1986

Stephen C. Taylor

Stephen C. Taylor
Chief Chemist

WHEY DRYER EMISSION TEST

I. Introduction and Summary

Badger Laboratories & Engineering Co., Inc. was retained by Northland Foods of Shawano, WI to determine the concentration of particulate matter in the exhaust from a whey dryer. The purpose of the test was to show compliance with State of Wisconsin particulate limitations.

Emission tests were conducted April 9 & 10, 1986 by Sander E. Sundberg, PhD and Bruce Lamers. Larry Weix of the Wisconsin Department of Natural Resources visited the test site. The ambient temperature during the test was 45 - 55°F, wind was strong and gusty from the northwest. A total of five test runs were performed following U.S. EPA Methods.

The whey dryer emission did not look normal to Mr. Marquardt and the production was stopped after the second test. A cyclone was found to be plugged. This situation was corrected and testing resumed. Mr. Dick Marquardt is the company contact.

The exhaust gas ranged in temperature from 115 - 132°F. The sampling isokinetic rates were 98.0, 98.5, 98.4, 99.1 and 99.1 percent.

The results of the tests are as follows:

Test Run	Date	Volumetric Flow Rate scfh (dry)	Particulate Emission Rate lb./hr.	Particulate Concentration lb./1000 lb. Gas
1	4-9-86	1.314×10^6	5.3119	0.0540
2	4-9-86	1.323×10^6	6.6208	0.0669
3	4-9-86	1.324×10^6	4.7507	0.0480
4	4-9-86	1.322×10^6	3.8910	0.0393
5	4-10-86	1.324×10^6	4.1446	0.0418

The arithmatic average of the five results is 0.0500 lb/1000 lb. gas. The limitation on this source is 0.20 lb/1000 lb. gas.

II. Process Data

The stack carries exhaust gases from a whey dryer. The production rates measured by Northland Foods are as follows:

Test Run	Whe Powder Production Throughput Rate lb/hr.	
1	5732	
2	5602	
3	5313	5549
4	5594	
5	5595	

The normal average production rate is 5500 lb./hr.

The process uses natural gas as a fuel with propane as a standby fuel. The whey is sprayed into the primary dryer. The powder passes into a secondary dryer and is then bagged. The emission source tested is the exhaust from the primary dryer. There are two cyclones in place for collecting particulate fines.

Source category: Natural and Processed Cheese
Plant name: Northland Food Coop
Process: Whey Dryer

Filename 961ref4.wq1
Location: Shawano, WI
Test date Apr 9-10, 1986

Date: 02/28/97
Ref. No 4
Process rate basis dry product

Source	Type of control	Pollutant	Run No.	Test Method	Isokinetic %	Gas volume, DSCF	Volum. flow rate DSCFM	Mass, g	Concen. gr/DSCF	Emission rate, lb/hr	Process rate, ton/hr	Emission factor kg/Mg	Emission factor lb/ton	Emission factor Rat.
Spray Dryer (primary dryer)	cyclone	Filterable PM	3	EPA 5	98.4	38.83	22,064	0.0279	0.011	2.1	2.77	0.38	0.76	
		Filterable PM	4		99.1	39.04	22,038	0.0268	0.011	2.0	2.80	0.36	0.72	
		Filterable PM	5		99.1	39.09	22,063	0.0319	0.013	2.4	2.80	0.43	0.85	
									gr/DSCF		Average	0.39	0.77	B
		Condensible PM	3	EPA 5	98.4	38.83	22,064	0.0353	0.014	2.7	2.77	0.48	1.0	
		Condensible PM	4		99.1	39.04	22,038	0.0253	0.010	1.9	2.80	0.34	0.68	
		Condensible PM	5		99.1	39.09	22,063	0.0236	0.0093	1.8	2.80	0.31	0.63	
									%		Average	0.38	0.75	B
		CO2	3	Orsat	NA	NA	22,064	NA	0.60	910	2.77	170	330	
		CO2	4		NA	NA	22,038	NA	0.60	910	2.80	170	330	
		CO2	5		NA	NA	22,063	NA	0.80	1,200	2.80	220	430	
											Average	190	360	B

Basis for rating: No details on process
Problems noted: Cyclone plugged during runs 1 and 2, so runs 3-5 used.
Other notes:

APPENDIX E.

Excerpts from Reference 5
(F&A Dairy, March 29, 1988)

Interpoll Laboratories
4500 Ball Road N.E.
Circle Pines, Minnesota 55014

Telephone (612) 786-6020
Telecopier (612) 786-7854

RESULTS OF THE MARCH 29, 1988 PARTICULATE EMISSION COMPLIANCE TEST ON THE WHEY DRYER AT THE F & A DAIRY IN DRESSER, WISCONSIN

Submitted to:

STERNER INDUSTRIES
P.O. Box 70
Winsted, Minnesota 55395

Attention: Rolf Brown

Approved by:

Perry Lonnes, Ph.D.
President

Report Number 8-2528
April 12, 1988

I INTRODUCTION

On March 29, 1988, Interpoll Laboratories personnel conducted a particulate emission compliance test on the Whey Dryer at the F & A Dairy located in Dresser, Wisconsin. On-site testing was performed by J. Buresh and T. Hogan. Coordination between testing activities and plant operation was provided by John Nelson of F & A Dairy. The test was witnessed by Jim Ross of the Wisconsin Department of Natural Resources.

The Whey Dryer tested is a Sterner Industries tall form dryer. It is direct-fired with natural gas and has a rated capacity of 5000 LB/HR of wet product. Particulate emissions are controlled by a venturi wet scrubber.

Evaluations were performed in accordance with EPA Methods 1 - 5, CFR Title 40, Part 60, Appendix A (revised July 1, 1987). A preliminary determination of the gas linear velocity profile was made before the first particulate determination to allow selection of the appropriate nozzle diameter required for isokinetic sample withdrawal. An Interpoll sampling train which meets or exceeds specifications in the above-cited reference was used to extract particulate samples by means of a heated glass-lined probe. The back half of the Method 5 sampling train was used to collect samples for the determination of total condensible organic and inorganic compounds.

An integrated flue gas sample was extracted simultaneously with each particulate sample using a specially designed gas sampling system. Integrated flue gas samples were collected in 44-liter Tedlar bags. After sampling was complete, the bags were sealed and returned to the laboratory for Orsat analysis. Prior to sampling, the Tedlar bags are leak checked at 15 IN.HG. vacuum with an in-line rotameter. Bags with any detectable inleakage are discarded.

Testing on the Whey Dryer was conducted from two test ports oriented at 90 degrees on the stack. These test ports are located more than five diameters downstream of the nearest flow disturbance and ten diameters upstream of the stack exit. A 20-point traverse was used to extract representative particulate samples. Each traverse point was sampled three minutes to give a total sampling time of 60 minutes per run.

TABLE 1. Summary of the Results of the March 29, 1988 Particulate Emission Compliance Test on the Whey Dryer at the F & A Dairy Located in Dresser, Wisconsin.

ITEM		Run 1	Run 2	Run 3
Date of test		03-29-88	03-29-88	03-29-88
Time runs were done	(HRS)	931/1035	1111/1215	1250/1354
Process rate	(KLB/HR) wet basis	5.18	4.87	5.01
Volumetric flow				
actual	(ACFM)	19516	19509	19305
standard	(DSCFM)	16403	16590	16437
Gas temperature	(DEG-F)	103	100	100
Moisture content	(%V/V)	7.33	6.72	6.66
Gas composition	(%V/V,dry)			
carbon dioxide		0.93	0.43	0.50
oxygen		20.06	20.50	20.48
nitrogen		79.01	79.07	79.02
Isokinetic variation	(%)	99.4	98.7	98.7
Particulate concentration				
actual	(GR/ACF)	.0153	.0115	.00943
standard	(GR/DSCF)	.0182	.0135	.0111
Part. emission rate	(LB/HR)	2.56	1.93	1.56

* Dry + wet catch as per Wisconsin DNR protocol.

Source category:	Natural and Processed Cheese	Filename	961ref5.wq1	Date:	02/28/97
Plant name:	F&A Dairy	Location:	Dresser, WI	Ref. No	5
Process:	Whey Drying and Bagging Process	Test date	July 15, 1988	Process rate basis	dry product

Source	Type of control	Pollutant	Run No.	Test Method	Isokinetic %	Gas volume, DSCF	Volum. flow rate DSCFM	Mass, g	Concen. gr/DSCF	Emission rate, lb/hr	Process rate, ton/hr	Emission factor kg/Mg	Emission factor lb/ton	Emission factor Rat.
Whey dryer and whey bagging system	wet scrubber	Filterable PM	1	EPA 5	99.4	37.11	16,403	0.0272	0.0113	1.6	1.30	0.61	1.2	
		Filterable PM	2		98.7	37.26	16,590	0.0268	0.0111	1.6	1.22	0.65	1.3	
		Filterable PM	3		98.7	36.92	16,437	0.0244	0.0102	1.4	1.25	0.57	1.1	
									gr/DSCF		Average	0.61	1.2	A
		Cond. Inorg. PM	1	EPA 5	99.4	37.11	16,403	0.0194	0.0081	1.1	1.30	0.44	0.88	
		Cond. Inorg. PM	2		98.7	37.26	16,590	0.0106	0.0044	0.62	1.22	0.26	0.51	
		Cond. Inorg. PM	3		98.7	36.92	16,437	0.0060	0.0025	0.35	1.25	0.14	0.28	
									gr/DSCF		Average	0.28	0.56	A
		Cond. Org. PM	1	EPA 5	99.4	37.11	16,403	0.0068	0.0028	0.40	1.30	0.15	0.31	
		Cond. Org. PM	2		98.7	37.26	16,590	0.0035	0.0014	0.21	1.22	0.085	0.17	
		Cond. Org. PM	3		98.7	36.92	16,437	0.0035	0.0015	0.21	1.25	0.082	0.16	
									%		Average	0.11	0.21	A
		CO2	1	Orsat	NA	NA	16,403	NA	0.93	1,000	1.30	390	770	
		CO2	2		NA	NA	16,590	NA	0.43	490	1.22	200	400	
		CO2	3		NA	NA	16,437	NA	0.50	560	1.25	230	450	
											Average	270	540	A

Basis for rating:

Problems noted:

Other notes: Emissions from whey bagging ducted to a baghouse and then the wet scrubber that controls the dryer
Process rate given on wet basis in report and converted to dry basis

APPENDIX F.

Excerpts from Reference 6
(Ellsworth Coop., Creamery, November 8, 1988)

RECEIVED
DEC 21 1988
DNR-WCD

Interpoll Laboratories, Inc.
4500 Ball Road N.E.
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RESULTS OF THE NOVEMBER 8, 1988 PARTICULATE EMISSION COMPLIANCE TEST ON THE WHEY DRYER AT THE ELLSWORTH COOP CREAMERY IN ELLSWORTH, WISCONSIN

Submitted to:

ELLSWORTH COOP CREAMERY
232 North Wallace
Ellsworth, Wisconsin 54011

Attention: Duane Brenne
Supervisor, Whey Department

Approved by:

Kathleen Eickstadt

Kathleen Eickstadt
Senior Data Analyst
Field Testing Division

Report Number 8-2658
December 9, 1988
KE/klq

1 INTRODUCTION

On November 8, 1988 Interpoll Laboratories personnel conducted a particulate emission compliance test on the new Whey Dryer at the Ellsworth Coop Creamery located in Ellsworth, Wisconsin. On-site testing was performed by R. Rosenthal and D. Smith. Coordination between testing activities and plant operation was provided by Duane Brenne of the Ellsworth Coop Creamery. The test was witnessed by Tom Woletz of the Wisconsin Department of Natural Resources.

The Whey Dryer tested is a C.E. Rogers cone type dryer. It is direct-fired with natural gas and has a rated capacity of 4000 LB/HR of dry product. Particulate emissions are controlled by a baghouse.

Evaluations were performed in accordance with EPA Methods 1 - 5, CFR Title 40, Part 60, Appendix A (revised July 1, 1987). A preliminary determination of the gas linear velocity profile was made before the first particulate determination to allow selection of the appropriate nozzle diameter required for isokinetic sample withdrawal. An Interpoll Labs sampling train which meets or exceeds specifications in the above-cited reference was used to extract particulate samples by means of a heated glass-lined probe. Wet catch samples were collected in the back half of the Method 5 sampling train and analyzed as per Wisconsin DNR protocol.

An integrated flue gas sample was extracted simultaneously with each particulate sample using a specially designed gas sampling system. Integrated flue gas samples were collected in 44-liter Tedlar bags housed in a protective aluminum container. After sampling was complete, the bags were sealed and returned to the laboratory for Orsat analysis. Prior to sampling, the Tedlar bags are leak checked at 15 IN.HG. vacuum with an in-line rotameter. Bags with any detectable inleakage are discarded.

Testing on the Whey Dryer was conducted from a set of five test ports on the rectangular stack. These test ports are located five feet downstream of the nearest flow disturbance and 5'-3 1/2" upstream of the stack exit. A 25-point traverse was used to collect representative particulate samples. Each traverse point was sampled four minutes to give a total sampling time of 100 minutes per run (the sampling time was increased because of poor flow distribution at this test site). Only two particulate determinations were performed due to the length of each run.

The important results of the test are summarized in Section 2. Detailed results are presented in Section 3. Field data and all other supporting information are presented in the appendices.

TABLE 1. Summary of the Results of the November 8, 1988 Particulate Emission Compliance Test on the Exhaust Gas Stack at the Ellsworth Cooperative Creamery in Ellsworth, Wisconsin.

ITEM		Run 1	Run 2
Date of test		11-08-88	11-08-88
Time runs were done	(HRS)	1105/1257	1330/1515
Process rateLB/HR		3600.0	3500.0
Volumetric flow			
actual	(ACFM)	32425	30752
standard	(DSCFM)	27590	26000
Gas temperature	(DEG-F)	116	117
Moisture content	(%V/V)	3.98	4.40
Gas composition	(%V/V,dry)		
carbon dioxide		0.42	0.21
oxygen		20.46	20.61
nitrogen		79.12	79.18
Isokinetic variation	(%)	94.2	98.3
Particulate concentration			
actual	(GR/ACF)	.0164	.0138
standard	(GR/DSCF)	.0193	.0163
Part. emission rate	(LB/HR)	4.56	3.63

* Dry + organic/inorganic wet catch

Source category:	Natural and Processed Cheese	Filename	961ref6.wq1	Date:	01/20/97
Plant name:	Ellsworth Coop Creamery	Location:	Ellsworth, WI	Ref. No	6
Process:	Whey Dryer	Test date	Nov 8, 1988	Process rate basis:	dry product

Source	Type of control	Pollutant	Run No.	Test Method	Isokinetic %	Gas volume, DSCF	Volum. flow rate DSCFM	Mass, g	Concen. gr/DSCF	Emission rate, lb/hr	Process rate, ton/hr	Emission factor kg/Mg	Emission factor lb/ton	Emission factor Rat.
Spray Dryer	fabric filter	Filterable PM	1	EPA 5	94.2	36.44	27,590	0.043	0.018	4.3	1.80	1.2	2.4	
		Filterable PM	2		98.3	35.84	26,000	0.0351	0.015	3.4	1.75	0.96	1.9	
									gr/DSCF		Average	1.1	2.2	B
		Cond. Inorg. PM	1	EPA 5	94.2	36.44	27,590	0.0015	0.0006	0.15	1.80	0.042	0.083	
		Cond. Inorg. PM	2		98.3	35.84	26,000	0.0002	0.0001	0.019	1.75	0.0055	0.011	
									gr/DSCF		Average	0.024	0.047	B
		Cond. Org. PM	1	EPA 5	94.2	36.44	27,590	0.0010	0.0004	0.10	1.80	0.028	0.056	
		Cond. Org. PM	2		98.3	35.84	26,000	0.0025	0.0011	0.24	1.75	0.069	0.14	
									%		Average	0.048	0.10	B
		CO_2	1	Orsat	NA	NA	27,590	NA	0.93	1,800	1.80	500	1000	
		CO_2	2		NA	NA	26,000	NA	0.43	770	1.75	220	440	
											Average	360	720	B

Basis for rating: Only two runs performed due to production capacity
Problems noted:
Other notes:

APPENDIX G.

Excerpts from Reference 7
(Alto Dairy, April 20, 1989)

Alto Dairy
Waupun, WI
April 1989

CHEMISTS ENGINEERS BADGER LABORATORIES & ENGINEERING CO. INC.
1110 S ONEIDA STREET • APPLETON, WISCONSIN 54915 • (414) 739-9213
TOLL FREE PHONE IN WISCONSIN 1-800-242-3556

WHEY DRYER EMISSION TEST

Dried whey production

at

ALTO DAIRY
Waupun, WI

April 20, 1989

Prepared By:

BADGER LABORATORIES & ENGINEERING CO., INC.
1110 South Oneida Street
Appleton, WI 54915

June 9, 1989

Bruce F. Lamers
Project Manager

Stephen C. Taylor
Chief Chemist

Rec'd
6/30/89
SD

Received 7/28/89 Bureau

Alto Dairy - Waupun
Whey Dryer Emission Test

I. Introduction and Summary

Badger Laboratories & Engineering Co., Inc. was retained by Alto Dairy of Waupun, WI to determine the concentration of particulate matter in the exhaust from a Whey Dryer.

Emission tests were conducted April 20, 1989 by Bruce Lamers and Rick Hieptas. Linda Wiese of the Wisconsin Department of Natural Resources witnessed the testing. A total of three test runs were performed following U.S. EPA Methods. Mr. Bruce Westerveld is the company contact.

A summary of the results are as follows:

Particulate Emission Results

Test Run	Volumetric Flow Rate scfh (dry)	Isokinetic Ratio, %	Particulate Emission lb/hr.
1	5.165×10^6	97.5	4.23
2	5.153×10^6	99.0	5.75
3	5.234×10^6	99.2	5.18

The arithmatic average of the three results is 5.05 lb/hr. BTU. The limitation for this source 16.3 lb/hr. BTU.

II. Process Description

The stack carries exhaust gases from a Whey Dryer. Normal production rate is 22,000 - 27,000 lb/hr. at 50 - 54% solid whey concentrate. The production rate during the testing was 22,960 lb/hr. Alto Dairy measured 12,628 lb/hr. powder and 10,332 lb/hr. water during the time from 8:30 AM - 3:00 PM on April 20th.

This production rate gives a limitation for Particulate as follows:

Production Rate Limitation

$$\text{Limitation} = E = 3.59\ p^{0.62} \qquad \text{Where: } p = \text{Tons Production/Hr.}$$

$$= 3.59\ (11.48)^{0.62}$$

$$= 16.3\ \text{lb/hr.}$$

Source category: Natural and Processed Cheese
Plant name: Alto Dairy
Process: Whey Dryer

Filename 961ref7.wq1
Location: Waupun, WI
Test date Apr 20, 1989

Date: 02/28/97
Ref. No 7
Process rate basis: dry product

Source	Type of control	Pollutant	Run No.	Test Method	Isokinetic %	Gas volume, DSCF	Volum. flow rate DSCFM	Mass, g	Concen., gr/DSCF	Emission rate, lb/hr	Process rate, ton/hr	Emission factor kg/Mg	Emission factor lb/ton	Emission factor Rat.
Spray Dryer	wet scrubber	Filterable PM	1	EPA 5	97.5	36.06	86,068	0.013	0.0056	4.1	6.31	0.33	0.65	
		Filterable PM	2		99.0	36.54	85,883	0.0174	0.0073	5.4	6.31	0.43	0.86	
		Filterable PM	3		99.2	37.17	87,233	0.0155	0.0064	4.8	6.31	0.38	0.76	
									gr/DSCF		Average	0.38	0.76	B
		Cond. Inorg. PM	1	EPA 5	97.5	36.06	86,068	0.0004	0.00017	0.13	6.31	0.010	0.020	
		Cond. Inorg. PM	2		99.0	36.54	85,883	0.0011	0.00046	0.34	6.31	0.027	0.054	
		Cond. Inorg. PM	3		99.2	37.17	87,233	0.0012	0.00050	0.37	6.31	0.029	0.059	
									gr/DSCF		Average	0.022	0.044	B
		Cond. Org. PM	1	EPA 5	97.5	36.06	86,068	0	0.0	0.0	6.31	0.0	0.0	
		Cond. Org. PM	2		99.0	36.54	85,883	0	0.0	0.0	6.31	0.0	0.0	
		Cond. Org. PM	3		99.2	37.17	87,233	0	0.0	0.0	6.31	0.0	0.0	
									%		Average	0.0	0.0	NR
		CO2	1	Orsat	NA	NA	86,068	NA	0.50	2,950	6.31	240	470	
		CO2	2		NA	NA	85,883	NA	0.40	2,360	6.31	190	370	
		CO2	3		NA	NA	87,233	NA	0.50	3,000	6.31	240	480	
											Average	220	440	B

Basis for rating: Average process rate for whole test; condensible organic PM < blank concentration
Problems noted: Run 3- problems maintaining spray pattern, plugging in the dry powder receiver; does not appear to have influenced test results.
Other notes:

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
RESEARCH TRIANGLE PARK, NC 27711

APR 9 1997

OFFICE OF
AIR QUALITY PLANNING
AND STANDARDS

Mr. Joe Brehm
Wisconsin DNR
Post Office Box 7921
101 S Webster Street
Madison, Wisconsin 537007-7921

Dear Mr. Brehm:

Enclosed for your review is a draft version of Section 9.6.1, Natural and Processed Cheese, that we proposed to publish in AP-42, Compilation of Air Pollutant Emission Factors.

As you probably know, AP-42 is widely used by the U. S. Environmental Protection Agency, State and local air pollutant agencies, and industry to develop emission estimates for particular sources when source specific data are not available. It is increasingly used in a variety of air quality management applications, including inventories, modeling, new source review, and operating permits. However, it is important that information published in AP-42 has as sound a technical basis as possible.

In order to meet our deadlines, we would appreciate receiving any comments you may have no later than May 15, 1997, which allows approximately 6 weeks for your review.

If you have more recent data or information which can be included in this section, please submit it on the same schedule. We will make every effort to review and include it in the section.

Please direct reviews, comments, and questions you may have to me. My address is, U. S. Environmental Protection Agency, Emission Factor and Inventory Group (MD-14), Research Triangle Park, North Carolina 27711. My telephone number is (919) 541-5371.

Thank you in advance for your participation in this review.

Sincerely,

Dallas W. Safriet
Environmental Engineer
Emission Factor and Inventory Group

Enclosure

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
RESEARCH TRIANGLE PARK, NC 27711

OFFICE OF
AIR QUALITY PLANNING
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Mr. Thomas Gallagher
United Dairy Industry Association
10225 West Higgins Road
Suite 900
Rosemont, Illinois 60018-5616

Dear Mr. Gallagher:

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Emission Factor and Inventory Group

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UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
RESEARCH TRIANGLE PARK, NC 27711

OFFICE OF
AIR QUALITY PLANNING
AND STANDARDS

Ms. Maureen Killough
American Cheese Society
1523 Judah Street
San Francisco, California 94122

Dear Ms. Killough:

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Mr. David Todd
California Air Resources Board
2020 L Street
Post Office Box 2815
Sacramento, California 95814

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Dallas W. Safriet
Environmental Engineer
Emission Factor and Inventory Group

Enclosure

SECTION 9.6.1, NATURAL AND PROCESSED CHEESE

Draft Report Reviewers

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