INVESTIGATION OF SILICONE APPLICATIONS TO THE DAIRY INDUSTRY

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INVESTIGATION OF SILICONE APPLICATIONS TO THE DAIRY INDUSTRY

BY

VICTOR A. JONES

AN ABSTRACT

Submitted to the College of Agriculture
Michigan State University of Agriculture and
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MASTER OF SCIENCE

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ABSTRACT VICTOR A. JONES

The application of various silicone antifoam agents and release agents to the dairy industry was investigated in laboratory and dairy plant tests. Foams frequently present problems in the processing of dairy products, especially in filling operations, vacuum condensing, and reconstitution of dry milks.

The effectiveness of Antifoams A, B, and AF Emulsion at various concentrations and temperatures in breaking down the foams of reconstituted nonfat milk, skim milk, and homogenized milk was studied in two types of laboratory tests. In the first test foam was produced by mechanically agitating test tubes of milk treated with antifoam agents and observing the foam breakdown time. Concentrated antifoam agents were sprayed on milk foams in the second test, and the time required for the foam to dissipate was determined. Antifoam AF Emulsion was tested in a commercial can filling operation, and the effect of Antifoams A, B, and AF Emulsion on the whipping properties of cream was investigated.

Antifoams B, and AF Emulsion were not detected by flavor or appearance when used at concentrations of 500 and 170 ppm respectively. Antifoam A spray left an objectionable film on the milk surface but Antifoam A did not impart an off-flavor when used in milk at the rate of 50 ppm. Each of the antifoam agents was relatively ineffective in breaking down foams of reconstituted nonfat milk, skim milk, and homogenized milk at 32°F but became increasingly effective at 60, 90, and 120°F. At 120°F they were very effective. When used at the same level of active antifoam concentration, Antifoam AF Emulsion appeared to be more effective than Antifoams A or B. Antifoam AF Emulsion reduced the time required to fill a ten-gallon can with homogenized milk at 40°F from approximately 34 seconds to 32 seconds when used at the rate of 27.5 ppm. The whipping properties of cream did not appear to be significantly impaired by 250, 1000 or 340 ppm of Antifoams A, B, or AF Emulsion respectively.

Silicone Antifoams A, B, and AF Emulsion appear to have limited applications in the processing of dairy products. Because of the many factors which influence their effectiveness, these antifoam agents should be tested under the conditions in which they will be employed to determine the practicality of their use.

Silicone release agents including Slipicone, 200 Fluids of 100 centistoke and 1000 centistoke viscosity, Z-4141, and silicone resins were tested for their ability to improve appearance, to prevent product adhesion, and to reduce the total operating labor required in cleaning operations in a milk plant. Silicones were applied to glass slides which were washed in a mechanical washing apparatus, to aluminum wall paneling, and to stainless steel dairy plant equipment including pasteurizing vats, cheese vat, butter churn, spray dryer, and table top. The silicones did not seem to improve appearance or ease of cleaning of equipment or paneling in these tests. The results of product adhesion tests indicated that Slipicone did not prevent butter from sticking in the churn, and inconclusive results concerning nonfat milk powder adhesion were obtained on silicone resin treated plates in a spray dryer.

The results of investigations with silicone release agents suggest limited if any practical applications of Slipicone, 200 Fluids, silicone resins, and Z-4141 in improving cleanability or appearance of stainless steel equipment or aluminum paneling.

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TABLE OF CONTENTS

INTRODUCTION

Silicon and oxygen, the basic materials from which silicones are formed, constitute three-fourths of the earth's crust (20). The commercial development of silicones was not realized, however, until wartime demand stimulated their production in 1943 (26). Since the war, industry has been fast in recognizing the usefulness of silicones in improving efficiency of operation or quality of products. Silicones have been used for a variety of purposes including antifoamants, lubricants, release agents, water repellents, dielectrics, and numerous other tasks.

The silicones are chemical polymers which may be produced as fluids, greases, resins or rubbers by varying their molecular structure (31). The properties of the silicones with which this paper will be primarily concerned include antifoam, water repellent, and anti-stick or release properties.

Manufacturing processes in the dairy plant are frequently slowed by foams, and increased efficiencies could be realized if foams could be eliminated or reduced. Some of the major problems with foams occur in filling operations, including vats, bottles and cans; vacuum condensing operations; vat pasteurization; reconstitution of dry milks; separation; and clarification. In the Michigan State University Dairy Plant filling of 10-gallon cans could be accomplished in one-third of the time and at colder temperatures if foam could be eliminated on homogenized milk. In considering the control of foam in dairy products, the definite relationship between the physico-chemical properties which cause foaming and the various activities at the fat globule interface should be kept in mind (12)(15). Destroying the ability to foam may influence churning of butter, whipping of cream, and overrun attainment in ice cream.

Cleaning operations in the milk plant require between 25% and 30% of the total operating labor (7). If the water resistant or release agent properties of silicones could be utilized to keep dairy products from sticking or in a beneficial way cause the equipment and containers to clean more easily, tremendous savings could be made.

This study was designed to determine the effect of various silicones in controlling foam and improving cleanability in dairy plant operations.

LITERATURE REVIEW

Numerous applications have been suggested for silicones in the dairy industry. Little research data have been published to verify or disprove these potential uses, however. This literature review is divided into three sections: (1) Suggested Applications, (2) Types and Properties of Silicones Used in This Research Project, and (3) Toxicity and Legal Limitations of Silicones.

Suggested Applications of Silicones in the Dairy Industry

Antifoam Agents. Ross (33) states that silicones are, perhaps, the most versatile of all the antifoaming agents. Todd (44)(45)(46) suggests the use of silicone defoamers in the dairy industry to increase production, decrease processing time, upgrade quality of products, and permit the saving of product sometimes lost as foam in the agitation, mixing, and pumping of dairy products. His suggestions included foam control in the production, processing and evaporating of skim milk and cottage cheese whey; in dairy confection mixes which are molded and frozen on stick handles; in detergent cleaning solutions; and in recirculating cooling brine systems. One dairy (10) found that a silicone defoamer, Dow Corning Antifoam AF Emulsion, promptly eliminated or reduced to a minimum the foam formed in the processing of Fudgsicle mix.

Methods of applying the antifoam agents vary with the type of agent used, but include the following (44)(45)(46):

1. Coat the sides of processing equipment above the normal liquid level.
2. Apply to wire mesh suspended above the foaming system.
3. Coat inside of filling nozzles.
4. Disperse in dry ingredients and add to foaming systems.
5. Add directly or dilute with water and add to foaming system.

<u>Release Agents and Lubricants for Processing</u>. Listed below are some of the uses for the silicone release agents which have been suggested by Todd (44)(45)(46):

1. Apply to processing equipment to prevent burn-on or build-up of product and to make the surface easier to clean.
2. Treat paper used for wrapping or containers to prevent sticking of product.
3. Apply to hot irons for release in heat sealing plastic films or to prevent build-up on heat sealing bars.
4. Lubricate valves used for high temperature operations.
5. Use as a lubricant for installing tubes or hose on metal pipe.

6. Use silicone rubber on conveyor belts to release hot or cold products.

Schulz, Kock and Siegfried (39) found that a silicone coated stainless steel surface kept Emmental cheese curd from adhering as tenaciously as to uncoated stainless steel. Sapp and Hedrick (38) concluded that pan glaze applied to novelty molds for ice cream bars did not aid in the release of the frozen bars.

Maintenance. Rupprecht and Crosby (36) state that motors rewound with silicone (Class H) insulation are more resistant to heat and water than motors rewound with any other class of insulation. The capacity of a motor may be increased by as much as 50% by rewinding with a silicone insulation, and the life expectancy of the motor is greatly increased when exposed to high ambient temperatures, overloads or moisture. The ability of silicone insulation to resist water could be especially helpful in dairies since a large volume of water is used in cleaning and rinsing equipment.

Silicone paints are suggested for boilers, exhaust stacks and steam lines (11)(18). Silicone paints withstand high temperatures (up to 1000°F) and moisture and require a minimum of maintenance.

Other maintenance uses mentioned for the silicones include gasket or seal material which is heat stable, odorless, and resistant to oil; lubrication for bearings operating at high temperatures or in the presence of moisture;

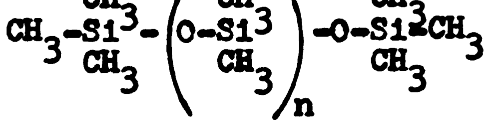
and finishes for the exterior of masonry buildings to prevent efflorescence, stain, and water penetration, but allow the material to breathe (5)(11)(26)(44)(45)(46).

Miscellaneous Uses. Silicone coating of glass bottles reduces scratching and breakage and gives the bottle a brighter and glossier appearance (1)(9)(44)(45)(46). The silicone is sprayed on the outside of the bottle between the washer and filler. Moisture, even from normal air, adsorbed by surface abrasion weakens the glass (1). The strength of glass is partially rejuvenated by the adsorption of silicone in the abrasion. The silicone is hydrophobic and so repells the water.

Todd (44)(45)(46) suggests water repellent fabrics and shoes treated with silicones for dairy plant employees, but he does not consider the treated shoes a substitute for boots. He also mentions silicone hand creams for protection from water borne irritants to help combat problems of skin irritation in the food industry.

Types and Properties of Silicones Used in This Research Project

Dimethyl Silicone Fluids. Dimethyl silicone fluids, known in chemical literature as dimethyl siloxane polymers or dimethyl polysiloxanes, have the chemical formula (6) (26):



$$CH_3-\underset{CH_3}{\overset{CH_3}{Si}}-\left(O-\underset{CH_3}{\overset{CH_3}{Si}}\right)_n-O-\underset{CH_3}{\overset{CH_3}{Si}}-CH_3$$

McGregor (22) states that these products are available from the General Electric Company as "G. E. Silicone Oils" in a wide range of viscosisties. They are water white fluids which are very stable to heat and oxidation and have a more nearly constant viscosity over a wide temperature range than any other liquid (6).

The dimethyl silicones are useful in the following tasks where the properties mentioned are particularly important for accuracy, constant performance, minimum maintenance or long life (6):

1. As damping fluids - heat, oxidation and mechanical shear resistant, and constant viscosity over wide temperature ranges.
2. As instrument fluids - low freezing and high flash points, constant viscosity, and low vapor pressure.
3. As hydraulic fluids - constant viscosity over a wide temperature span, low freezing, high flash points, high autoignition temperature, and resistant to heat and shear breakdown.
4. As liquid dielectrics - superior dielectric to most other liquids, heat and oxidation resistant, constant viscosity and dielectric properties with temperature changes, and water repellent.
5. As lubricants - heat and oxidation stability, constant viscosity over wide temperature ranges, high flash and low freezing points.
6. As release agents - heat stable, oxidation resistant, non volatile, readily wet mold surfaces, forms

no carbonaceous deposit.

7. As water repellent - heat stable, high surface resistivity.
8. As polishing agent - readily wet surfaces, lubricant for hard surfaces, water repellent, stable at high and low temperatures, nonvolatile, and resistant to oxidation and weathering.
9. As coating and impregnant in pump packings - water repellent, resistant to a variety of chemicals, and stable to heat.
10. As an additive - antifoamant in many non-aqueous systems, increased temperature stability and resistance to abrasion and weathering when added to synthetic rubbers.

<u>Antifoam Agents</u>. Silicone antifoam agents are compounds made by adding a few percent of a finely divided silica to a high poylmer dimethyl silicone (26). The compounds retain the heat resistance, low freezing point, low volatility, and dielectric properties of the dimethyl silicones, and they gain antifoam properties in some aqueous systems. The silicone antifoamers accomplish their mission by breaking down the foam bubbles after they are formed. The 100% silicone compound used in this research project was Dow Corning Antifoam A. A similar product, Antifoam 81066, is available from the General Electric Company (33).

Antifoam emulsions are also available which are combinations of 100% silicone compound with an emulsifying agent (41). Dow Corning Antifoam AF Emulsion is a stable dispersion of 30% Dow Corning Antifoam A and emulsifying agents commonly used in the food industry (2). The AF Emulsion has the consistency of thick cream and is white in color. Dow Corning Antifoam B is 10% Dow Corning Antifoam A with food grade emulsifiers (8). It is free flowing, readily dispersible in aqueous solutions and exceptionally stable on dilution.

Slipicone. Slipicone is a release agent silicone compound available from the Dow Corning Corporation (4). It is heat stable, resistant to oxidation, and does not break down to leave a carbonaceous residue. It is not irritating to the skin and is safe to use in sealing packages containing food.

Z-4141. This product is a glass protectant produced by the Dow Corning Corporation. It is water repellent when applied in a thin film to glass (3). It also protects the glass from scratches and reduces breakage. Similar material is available from General Electric Company as SM-70 Emulsion (9). Syl-Gard 17 is glass protectant manufactured by Dow Corning especially for use by dairies (3).

Toxicity and Legal Limitations of Silicones

Dimethyl Silicone Fluids. Rowe, et al (34), found that no discernible ill effects resulted when test animals were fed up to 2% of their body weight of the dimethyl silicone fluids. McGregor (26) states that there are no cases on record of any permanent physiologial disturbances of persons handling methyl, mixed methyl, and phenyl polysiloxanes in research, production, or use.

Antifoam Agents. Toxicological studies on rats and guinea pigs by Rowe, Spencer and Bass (34) gave the first indication that the defoamers were non-toxic. In a two year feeding test with rats, they found that concentrations of 3,000 ppm had no adverse effect on rats (35). In reference to Dow Corning Antifoam A, Lehman (24) representing the U. S. Food and Drug Administration reported in 1950 that: "The toxicological data which have been submitted appear to show that the material is relatively non-toxic by oral administration. We have seen no reason to object to its use to suppress foaming when the quantity employed does not exceed 10 ppm." At present up to 10 ppm of Antifoam A are permitted in processing of food without standards of identity (2)(5). Food grade emulsifying agents are used in manufacturing Antifoam AF Emulsion and its use is permitted up to 34 ppm in nonstandard food products. Antifoam B is a newer product containing food grade emulsifiers which has not yet been approved by the Food and Drug Administration.

Slipicone. If slipicone is to be used in contact with food, it should be applied in a film sufficiently thin that the food will not pick up over 10 ppm of slipicone (4).

Z-4141. This material should not be used in contact with food products (3). Only the exterior of containers should be treated. A downdraft over a spraying operation is recommended to ensure no spray drifts into the containers. The Z-4141 container label warns against prolonged breathing of vapor or repeated skin contact.

EXPERIMENTAL PROCEDURE

Silicone Antifoam Agents

The antifoam properties of Dow Corning Antifoam A, Antifoam AF Emulsion, and Antifoam B were tested with skim milk, homogenized milk with approximately 3.5% butterfat, and reconstituted 9% nonfat milk from the Michigan State University Dairy Plant at 32, 60, 90, and 120°F.

Preliminary investigations were made to determine a satisfactory method of producing foam in these products and methods for measuring the quantity and stability of the foam. The preliminary investigations included the four methods described below.

Test tubes, 2 x 20 cm, containing 25 ml of reconstituted nonfat milk and 300 ml kjeldahl flasks, containing 300 ml of reconstituted nonfat milk, were hand shaken. The height of foam was measured immediately, and 1, 2, and 5 minutes following agitation of the milk. The time for foam to breakdown completely was also determined. Hand shaking was unsatisfactory because of the difficulty of duplicating results.

Foam production with a Waring Blendor and with an ADMI Solubility Index Mixer were attempted with 100, 200, 300, and 400 ml of reconstituted nonfat milk with agitation periods of 10, 30, and 60 seconds. The Waring Blendor was operated at both slow and fast speeds. The foam volume was measured immediately and 1 and 5 minutes following agitation. Foam produced by this means was very stable and did not seem to respond similarly to foams produced in commercial processing operations.

Fifty milliliters of milk was allowed to drain from a burette into a 100 ml graduate. Investigations were conducted with reconstituted nonfat milk, skim milk, and homogenized milk. The foam formed by this method was measured immediately and at 1, 2, and 5 minutes. Although results could be duplicated, this method was slow, required cleaning of the burette between different types of milk, and required a large number of graduates.

Foam was also produced by bubbling air through 50 ml of milk in a 100 ml graduate. The air was introduced into the milk by a glass tube with a small opening in the end inserted into the milk. The volume of foam and milk at 15, 30, 45, and 60 seconds or the time for the foam to reach the 100 ml level or the top of the graduate was determined. Whether volume or time measurements were used depended upon the volume and speed of foam production. Transfer of antifoam agent by the glass rod was possible by this method unless the tube was thoroughly cleaned after each test. Control of the air temperature was another obstacle to this method.

<u>Laboratory Investigation of Antifoam Agents Dispersed in Milk</u>. Mechanical agitation of test tubes was the most suitable method for producing foam in the laboratory.

Twenty five ml of milk was placed in 2 x 20 cm test tubes and the tubes were stoppered. The test tubes were mechanically agitated for 30 seconds in a horizontal position with the length of the test tube parallel to the direction of agitation. The agitator moved the tubes through a distance of 1½ inches at the rate of 275 times per minute. Temperature of the milk was controlled by placing the test tubes in a water bath for the 60, 90, and 120°F tests. The 32°F test was conducted in a refrigerated cooler. The effectiveness of the antifoam agent was determined by measuring the time for the foam to break down to the point where any part of the surface of the milk was visible. In cases where the foam did not break down within a given time, the height of the foam at the specified time was recorded.

Antifoams A, B, and AF Emulsion were selected for this experiment because they represented the commercially available silicone antifoam agents. As was indicated in the literature review Antifoam A was the active antifoam component of each of the three types of antifoam agents used in this investigation. The Food and Drug Administration permit the use of 10 ppm Antifoam A in foods without standards of identity. The Antifoam A content of Antifoam AF Emulsion was used by the Food and Drug Administration in setting the level at which Antifoam AF Emulsion may be used in food without standards of identity. Therefore, the Antifoam A concentration was used as the basis for comparing the types of antifoam agents. To avoid confusion in discussing the antifoam agents, Antifoam A concentration is frequently expressed as ppm of "active antifoam". The terms "Antifoam A" and "active antifoam" are used synonymously for purposes of clarity within this paper.

Dow Corning Antifoam A was diluted in toluene to give 0.1, 0.2, 0.4, and 1.0% solutions. Toluene was the most readily available of the solvents suggested by the manufacturer. Test tubes were filled with the solution; the solution was poured off; and the test tubes were permitted to dry. In preliminary investigations test tubes and stoppers were weighed immediately before the solution was added and immediately after it was poured off. These weights indicated that the test tubes contained about 0.125 mg of Antifoam A when the 0.1% solution was used; 0.250 mg for 0.2%, 0.50 mg for 0.4% and 1.25 mg for 1.0% solutions. These quantities of Antifoam A were equivalent to 5, 10, 20, and 50 ppm of active antifoam respectively in 25 ml of milk.

Dow Corning Antifoam AF Emulsion was diluted to 8.5% by dispersing in distilled water for the tests at 32°F. This diluted Antifoam AF Emulsion was then added to the milk as follows: 1 drop in 125 ml of milk to give approximately a 34 ppm concentration; 2 drops in 125 ml to give 68 ppm, 4 drops in 125 ml to give 136 ppm; and 1 drop in 25 ml to give 170 ppm. For the tests at 60, 90, and 120°F the Antifoam AF Emulsion was diluted to 0.85% by dispersing in distilled water. One drop of this dispersion in 25 ml of milk was approximately 17 ppm; 2 drops, 34 ppm; 4 drops, 68 ppm;

and 10 drops, 170 ppm. In all tests the diluted Antifoam AF Emulsion was used within three hours of its preparation.

Dow Corning Antifoam B was diluted to 2.5% by dispersing in distilled water for all tests. One drop of the dispersion in 25 ml of milk was approximately 50 ppm; 2 drops, 100 ppm; 4 drops, 200 ppm and 10 drops, 500 ppm. The diluted Antifoam B was used within three hours of its preparation.

Reconstituted nonfat milk, skim milk, and homogenized milk samples were treated with 0, 5, 10, 20, and 50 ppm active antifoam in the form of Antifoams A, B, and AF Emulsion for tests at 60, 90, and 120°F. At 32°F samples of reconstituted nonfat milk, skim milk, and homogenized milk were treated with 0, 5, 10, 20, and 50 ppm active antifoam in Antifoams A and B and with 0, 10, 20, 40, and 50 ppm active antifoam in Antifoam AF Emulsion. Five replicate samples of reconstituted milk and skim milk were tested at 32, 60, 90, and 120°F, and five replicate samples of homogenized milk were tested at 32 and 120°F. Only duplicate samples of homogenized milk were tested at 60°F, and only duplicate samples of untreated homogenized milk were tested at 90°F because the foam breakdown times for untreated homogenized milk at these temperatures were 10 seconds or less.

The signs < and > were used in recording the foam breakdown time or height of foam to show that the value was less than or greater than the value indicated. The reasons for the use of these symbols fall into three categories. First, no attempt was made to accurately measure foam breakdown times of less than 5 seconds. Times of less than 5 seconds were recorded as <0:05. Second, when the foam did not breakdown within 1 hour, the foam height was measured at a specified time following agitation of the test tubes. This time was not the same for all trials, and so an exact average could not be calculated. In cases of this nature the signs < or > were used to give the best indication of the foam height or breakdown time.

Third, in a few tests the exact time of foam breakdown had passed before the observation was made. This occurred in less than 2% of the trials. When this happened, the foam breakdown time was recorded as less than the time when the observation was made (<).

Samples with each type of silicone antifoam agent and each concentration of antifoam agent were checked immediately and at 1, 3, 7, and 15 days for flavor and other detrimental characteristics.

Effect of Antifoam Sprays on Milk Foams. The effectiveness of Antifoams A, B, and AF Emulsion in dissipating foams of reconstituted nonfat milk, skim milk, and homogenized milk was investigated. Milk, foam, and air temperature were maintained at 32°F by conducting the experiment in a refrigerated cooler. Foam was produced by beating 300 to 500 ml of milk with a Dormeyer Electric Mixer. The foam produced in this manner was not always of uniform bubble size and density, however. The milk foam was transferred into four 250 ml glass beakers with a tablespoon to give as uniform samples as possible.

Antifoams B and AF Emulsion were diluted with one and two parts of water respectively. The dilutions were sprayed onto the milk foam with a perfume atomizer. Antifoam A was dispensed from a commercial pressurized spray container. Two trials were made with homogenized milk and skim milk with each type of antifoam agent. Two reconstituted nonfat milk trials were conducted with Antifoams B and AF Emulsion and one trial was conducted with Antifoam A. The effectiveness of the antifoam agents was determined by measuring the cm of foam and milk at time intervals of 1, 2, and 5 minutes depending upon the stability of the foam.

Antifoam AF Emulsion Test in a Commercial Can Filling Operation. Antifoam AF Emulsion was tested for its effectiveness in reducing foam in the Barrett air operated can filler in the Michigan State University Dairy. The foam produced in filling a ten-gallon can was collected from the foam vent. This foam normally would have returned to the surge tank of the can filler. Observations were made on the time required for the first foam to come through the vent, time required to fill the can with milk, and the volume of foam. Foam volume was measured as the height of foam in a stainless steel container 8 inches in diameter and 10 inches high. Approximately 600 gallons of homogenized milk was collected in a cold storage tank. About 250 gallons of this milk at 41°F flowed by gravity through the can filler as a control. The surge tank of the can filler was emptied. To the remaining 280 gallons of milk, was added 30 g of Antifoam AF Emulsion which was thoroughly dispersed in 2 gallons of control milk and then added to the storage tank. The storage tank agitator was allowed to operate for 5 minutes before the experiment was continued. The Antifoam AF Emulsion concentration in milk was calculated to be about 27.5 ppm. The treated milk was run through the can filler. Twenty gallons of control milk and treated milk were allowed to flow through the can filler before data was collected, and the data collected when the surge tank was not full was omitted.

Influence of Antifoam Agents on the Whipping Properties of Cream. The effect of silicones on the whipping time, volume, body, stability, and flavor of whipped cream was checked by adding Antifoams A, B, and AF Emulsion to 200 ml of whipping cream at the rates of 250, 1000, and 340 ppm respectively. The cream tested 34.4% butterfat and was whipped with an electric beater for 2 minutes at 50°F. Immediately after whipping the treated samples were compared with two control samples for volume, body, and flavor. A second comparison was made after holding the samples for 2 hours. Body and stability of the whipped cream were checked by visual observation.

Silicone Release Agents

Laboratory Cleanability Test Using a Mechanical Washing Apparatus. The mechanical washing apparatus described by Jensen (21) was used to wash glass slides coated with various silicones. Dow Corning products, Slipicone, Z-4141, 100 centistoke 200 Fluid, and 1000 centistoke 200 Fluid, were coated on 1 11/16 x 2 3/8 inch, double strength, B type glass slides. Slipicone was wiped on the glass slides, and the excess was removed with a clean cheese cloth. Slides were immersed in a 1:500 dilution of Z-4141 in distilled water, removed and allowed to drain, dry and cure for 24 hours. The 100 centistoke and 1000 centistoke 200 Fluids were diluted to 5% by dissolving in toluene. The glass slides were immersed in this solution, removed and permitted to drain and dry.

Duplicate slides with each type of silicone release agent treatment and control slides with no treatment were immersed in homogenized milk at room temperature. The slides were removed from the milk and placed in a metal rack at about a 45 degree angle and permitted to drain and dry for 15 minutes.

A 0.1% detergent solution was prepared by using All Purpose Cleaner No. 7 manufactured by E. F. Drew and Company, Inc. and tap water. The temperature of this solution was maintained at 120°F. The slides were soaked in this solution and then propelled in Jensen's washing apparatus at the rate of 52 oscillations per minute. The length of soaking and washing periods is given hereafter. Following the wash period the slides were immersed in distilled water to rinse, immediately removed and allowed to dry in the draining rack mentioned above.

A light transmission reading was determined for each slide by placing it in a Cenco-Sheard-Sanford Photolometer with approximately a 0.45 mm slit and a 450 millimicron filter which was 0.45 mm thick. The slit opening had to be adjusted slightly during the test to maintain a reading of 100 for a clean, untreated glass slide. Four readings were obtained for each slide, and these were averaged.

Soiling the glass slides, soaking, washing, rinsing, and photolometer readings as described above were repeated 15 times. The first set of five slides, including a control and one slide with each type of silicone treatment, was soaked in the detergent solution for 1 minute and washed for 1 minute for the first through the fourth trials; in the fifth and sixth trials the slides were soaked for 30 seconds and washed for 30 seconds; and for the seventh through the fifteenth trials the slides were soaked for 15 seconds and washed for 10 oscillations of the washing apparatus. The second set of slides were soaked for 1 minute and washed for 1 minute for the first and second trials; soaked for 30 seconds and washed 30 seconds, for trials three and four; and soaked 15 seconds and oscillated 10 times in the washing solution for the fifth through the fifteenth trials. The soak period and washing time were shortened during the test to permit the photolometer reading to be reduced below 100.

Laboratory Investigation of Milk Powder Adhesion. Slipicone was coated on the outside surfaces of 500 ml stainless steel beakers and 300 ml glass beakers. The beakers were buffed to remove as much silicone as possible. The beakers were placed in a plastic bag containing a small quantity of nonfat dry milk and the sack was manipulated to produce a dust. Upon removal from the sack the beakers were observed for thickness of dry milk film, and ease of removing the dry milk with an air blast or brush.

Effect of Release Agents on Dairy Plant Paneling and Equipment. Silicones were coated on eight areas of aluminum wall paneling and nine pieces of equipment in the MSU Dairy Plant as outlined below. The treated areas were checked for adhesion of soiling product, ease of cleaning, and general appearance including the ability to flush clean, and dry to a bright appearance. Before the silicone was applied, the area was cleaned with trichloroethane. Slipicone was sprayed on the area, and the excess was removed with a cloth. The 200 Fluids of 100 and 1000 centistokes viscosity were dissolved in toluene to give concentrations of 0.2, 1, 2.5, and 10%. The solution was wiped on the area with a cloth and allowed to dry. It is routine procedure to apply mineral oil to the exterior of stainless steel equipment in the Michigan State University Dairy after each cleaning to improve the appearance. Observations were made to determine if Slipicone or the 200

Fluids applied to equipment was a semi-permanent coating which would not require application after each cleaning.

Aluminum Wall Paneling. The 100 and 1000 centistokes 200 Fluids in 1, 2, 5, and 10% concentrations were applied to aluminum wall and overhead paneling. Twelve areas were included in the investigation including two untreated control areas, two mineral oil coated control areas, and one area with each concentration of 100 or 1000 centistoke 200 Fluid. Each treated area was approximately 2 x 9 feet. About 5 feet of the length was vertical wall paneling and the remaining 4 feet was horizontal overhead paneling. The appearance of the silicone treated areas was compared with control areas at 1 week intervals for 10 weeks by visual observation. The ease of cleaning was checked about 3 months after the silicone treatment by manually cleaning the areas and observing the ease of soil removal.

Stainless Steel Table Top. A 3 x 5 foot stainless steel table top was divided into ten 12 x 18 inch areas. Duplicate areas were coated with 0.2, 1, and 5% solutions of 1000 centistoke 200 Fluid and four areas were left as controls. After the table was used in the normal routine work of the pilot laboratory, observations were made on the ease of cleaning and the appearance of each area each day for 1 week following the silicone treatment. The third day after the silicone treatment, about 1 pint of reconstituted nonfat milk was poured onto the table and allowed to dry. Observations were made on the ease of manual cleaning and resulting appearance.

Cheese Vat. Slipicone and a 10% solution of 100 and 1000 centistoke 200 Fluid were applied to three 2 x 3 foot areas on the inside walls of a Meyer-Blanke 400 gallon Nu-Vat. Cheddar cheese was made in the vat. Visual observations were made on the ease of cleaning the vat by a manual washing procedure.

Stainless Steel Pasteurizing Vats. Slipicone and 5% solutions of 100 and 1000 centistoke 200 Fluid were applied to six areas on the exterior surfaces of three stainless steel circular vats of various sizes in the dairy plant. Each area was approximately 3 square feet. The surfaces were checked for appearance each day for 3 days following the silicone treatment.

Roller Dryer. Approximately one-half of each of the drums of a Buflovak Laboratory Vacuum Double Drum Dryer was coated with a 5% solution of 1000 centistoke 200 Fluid. Observations were made on the ease of removal of a film of nonfat dry milk immediately after the silicone application.

Spray Dryer. The Dow Corning Corporation coated 6 x 8 inch stainless steel plates with silicone resins, containing both methyl and phenyl groups, and designated in this experiment as 12-1, 12-2, 12-3, 12-4, 12-5, and 12-6. These plates were suspended from the baffle plate in the exhaust end of the Rogers Dryer in the MSU Dairy Plant. The plates were in a vertical position perpendicular to the air flow. The nonfat dry milk build-up, ease of brushing powder from the plates, and appearance were compared to a control plate which received the same treatment except that it was not coated with silicone. The plates were placed in the dryer for four trial periods. In trials No. 1 and No. 2 the dryer was operated for about 9 hours. Trials No. 3 and 4 covered 2 and 3 nine-hour days of dryer operation respectively. The plates were washed manually with a general purpose cleaner between each test.

Butter Churn. A standard (No. 4) finish stainless steel plate 8 x 24 inches was coated with Slipicone. The plate was attached to one of the shelves in a 600-pound stainless steel Gosselin butter churn. Observations were made on the adhesion of butter to the coated plate during and following the churning process. Slipicone was also applied to two portions of the sandblasted interior surface of the churn. Approximately 2 square feet of the drum and 1 square foot of a shelf was coated with the Slipicone. Visual observations were made on the adhesion of butter and ease of cleaning.

Sanitary Valves. Slipicone and a 10% solution of 1000 centistoke 200 Fluid were applied to three-way stainless steel valve plugs and valve seats. The Slipicone was sprayed on to the valve and then spread with a cloth to a thin coating. Observations were made on the lubricating value and permanence of the silicone coating during use and the influence of the usual manual washing procedure.

EXPERIMENTAL RESULTS

Silicone Antifoam Agents

Laboratory Investigation of Antifoam Agents Dispersed in Milk. The foam breakdown times for reconstituted 9% nonfat milk, skim milk, and homogenized milk treated with silicone Antifoams A, B, and AF Emulsion, are presented in Tables 1 to 3. The results regarding the stability of milk foam on reconstituted nonfat dry milk at 32, 60, 90 and 120°F are given in Table 1. The same information is given for skim milk and homogenized milk in Tables 2 and 3 respectively. The values in these tables represent the average of five replicate samples except for homogenized milk at 60 and 90°F. Because the foam breakdown time for untreated homogenized milk at the 60 and 90°F temperatures was 10 seconds or less, only duplicate samples were tested. The original data from which the foam breakdown times were calculated are recorded in Tables 10 to 20 of the Appendix.

In most cases the reason for the use of the symbols $<$ and $>$ in Tables 1, 2, and 3 can be determined by referring to the original data in Appendix Tables 10 to 20. The use of the symbols in the Appendix is explained in the Experimental Procedure.

A foam breakdown time of 60 minutes was determined for one of the reconstituted milk samples at 60°F with 20 ppm of active antifoam in the form of Antifoam AF Emulsion.

The other four samples had foam breakdown times of 26, 39, 43 and 60 seconds. Since the 60 minute foam breakdown time was completely out of line with the other results, and far in excess of the foam breakdown time for one-fourth this concentration of Antifoam AF Emulsion, this value was not included in Table 11 of the appendix nor in the calculation of the average value shown in Table 1, Figure 1 or Figure 4.

The average foam breakdown times are presented in graphical form in Figures 1 to 6. Figures 1 to 3 show the relative effectiveness of the three antifoam agents used in this experiment. Figures 4 to 6 depict the same data to show the affect of temperature on the effectiveness of the antifoam agents. The data was plotted as if the < and > signs did not exist.

The results presented in the tables and graphs contain four variables: type of milk, type of silicone, concentration of silicone, and temperature. The effect of each of these variables will be reported.

Types of Milk. The foam of untreated reconstituted nonfat milk was more stable at 32, 60, and 90°F than untreated skim milk or homogenized milk foams. Homogenized milk foam was more persistent at 32°F than skim milk foam, but the reverse was true at 60 and 90°F. At 120°F the foam lasted for more than 1 hour on all three types of milk.

Type of Silicone Antifoam Agents. Figures 1 to 3 show the relative effectiveness of Antifoams A, B, and AF

Emulsion in reducing foam breakdown time. In general when the silicone antifoam agents were used at a rate to provide the same concentration of active antifoam in the milk, Antifoam AF Emulsion was equally or more effective than Antifoam B, and Antifoam B was equally or more effective than Antifoam A. Reconstituted nonfat milk and skim milk at 32 and 60°F were exceptions to this general trend. In these cases Antifoam A was equally or more effective than Antifoam B.

Concentration of Silicone Antifoam Agents. Increasing the concentration of antifoam agents reduced the foam breakdown time in most cases. Exceptions were in skim milk with Antifoams B and A at 32 and 90°F respectively, and in homogenized milk with Antifoam A at 32, 60, 90, and 120°F, Antifoam B at 32 and 60°F, and Antifoam AF Emulsion at 60°F. In each case the increase in foam breakdown time was small.

Influence of Temperature on Silicone Antifoam Agent Effectiveness. Antifoams A, B, and AF Emulsion were most effective in preventing or dissipating foams on reconstituted nonfat milk, skim milk, and homogenized milk at 120°F and least effective at 32°F. The antifoam agents appeared to be slightly more effective at 90 than at 60°F. At 120°F all of the milk samples which were not treated with a silicone antifoam agent had foam lasting for more than 1 hour. Five ppm of active antifoam in the form of either Antifoams B or AF Emulsion destroyed the foam within 25 seconds at 120°F. Antifoam A coated on the test tube walls greatly decreased the foam breakdown time when used at the rate of 5 ppm of active antifoam.

At 90°F untreated skim milk foam dissipated within 7 minutes, but untreated reconstituted nonfat milk foam persisted for more than 60 minutes. Reconstituted nonfat milk foam required 10, 20, and 50 ppm of active antifoam in Antifoams AF Emulsion, B, and A respectively to reduce the foam breakdown time to less than 1 minute. Five, 10, and 20 ppm of active antifoam in the form of Antifoams AF Emulsion, B, and A respectively were required to reduce the foam breakdown time of skim milk to less than 1 minute. Homogenized milk foam dissipated in less than 10 seconds at 90°F and so no attempt was made to determine the effect of silicone antifoam agents.

At 60°F the foam breakdown time for reconstituted nonfat milk was reduced from more than 60 minutes to less than 4 minutes by using 5 ppm active antifoam in the form of Antifoam AF Emulsion, but 50 ppm in the form of Antifoam A or B were required. Each antifoam agent was more effective at 60°F than at 32°F when tested with the reconstituted nonfat milk. Untreated skim milk at 60°F had a foam breakdown time of 2 minutes. The antifoam agents reduced this time, but even 50 ppm active antifoam in Antifoams A, B or AF Emulsion did not dissipate the foam in less than 30 seconds. Untreated homogenized milk foam remained for only 10 seconds at 60°F. The antifoam treatment at this temperature did not appear to be significant. The data seems to suggest a trend toward slightly increased foam breakdown times when silicone antifoam agents are used on homogenized milk at 60°F.

The foam of reconstituted nonfat milk at 32°F persisted for more than 60 minutes when the milk was treated with 10 ppm of active antifoam in Antifoams A, B, or AF Emulsion. The foam breakdown times for untreated skim milk and homogenized milk were approximately 5 and 18 minutes respectively. Treatment with 10 ppm of active antifoam in Antifoams A, B or AF Emulsion did not appreciably reduce the foam breakdown time. Even 50 ppm of active antifoam in Antifoams A or B or 40 ppm in Antifoam AF Emulsion did not have any appreciable effect on the foam breakdown time. Fifty ppm of active antifoam in Antifoam AF Emulsion gave a substantial reduction in the foam breakdown time, however.

Effect of Silicone Antifoam Agents on Flavor. Antifoams A, B, and AF Emulsion could not be detected in reconstituted nonfat milk, skim milk or homogenized milk by flavor, odor or appearance during the 15 days following their addition. When Antifoam A was applied to test tubes in a toluene solution, the toluene was detected as causing an off-flavor of the milk.

Reduced Ability of Antifoam Agents to Destroy Foam Upon Repeated Agitation. A number of observations were made concerning the loss of ability of Antifoams A, B, and AF Emulsion to breakdown the foam of reconstituted nonfat

TABLE 1

Effect of temperature and antifoam agent concentration on the foam breakdown time of reconstituted nonfat milk[a]

Temp (°F)	Active anti-foam (ppm)	Antifoam AF Emulsion		Antifoam B		Antifoam A	
		Foam[b] (cm)	Time (min:sec)	Foam[b] (cm)	Time (min:sec)	Foam[b] (cm)	Time (min:sec)
32	0	2.2	180:00	2.2	180:00	2.2	180:00
32	5	---	-------	1.4	180:00	1.1	110:00
32	10	0.0	73:36	1.8	180:00	0.9	85:00
32	20	.0	23:56	1.4	180:00	.6	60:00
32	40	.0	23:16	---	-------	---	-------
32	50	.0	1:16	1.4	180:000	.0	>16:24 <19:36
60	0	>1.7	60:00	>1.7	60:00	>1.7	60:00
60	5	.0	2:39	>1.2	60:00	.0	>39:00
60	10	.0	1:56	>1.0	60:00	.0	21:11
60	20	.0	0:42	>0.3	60:00	.0	<6:19
60	50	.0	:32	.0	3:25	.0	1:06
90	0	1.0	60:00	1.0	60:00	1.0	60:00
90	5	.0	1:52	.0	>60:00	.0	>25:00
90	10	.0	:43	.0	15:59	.0	>37:00
90	20	.0	:28	.0	0:34	.0	1:29
90	50	.0	:14	.0	< :05	.0	0:29
120	0	1.4	60:00	1.4	60:00	1.4	60:00
120	5	.0	:24	.0	:25	.0	8:02
120	10	.0	:13	.0	:09	.0	:50
120	20	.0	:08	.0	< :05	.0	:26
120	50	.0	< :05	.0	< :05	.0	:18

[a] Each value represents the average of five trials.

[b] If the foam did not breakdown within one hour, the foam height was measured in cm at the time specified.

TABLE 2

Effect of temperature and antifoam agent concentration on the foam breakdown time of skim milk[a]

Temp (oF)	Active anti-foam (ppm)	Antifoam AF Emulsion		Antifoam B		Antifoam A	
		Foam[b] (cm)	Time (min:sec)	Foam[b] (cm)	Time (min:sec)	Foam[b] (cm)	Time (min:sec)
32	0	0.0	5:16	0.0	5:16	0.0	5:16
32	5	——	——	.0	5:10	.0	5:10
32	10	.0	4:52	.0	<6:08	.0	4:24
32	20	.0	3:08	.0	4:28	.0	3:38
32	40	.0	2:48	——	——	——	——
32	50	.0	0:54	.0	4:26	.0	3:16
60	0	.0	1:58	.0	1:58	.0	1:58
60	5	.0	< :56	.0	<1:42	.0	<1:47
60	10	.0	:52	.0	1:31	.0	1:14
60	20	.0	:23	.0	0:42	.0	0:58
60	50	.0	:27	.0	:25	.0	:32
90	0	.0	7:00	.0	7:00	.0	7:00
90	5	.0	:35	.0	<1:39	.0	2:38
90	10	.0	:23	.0	:34	.0	4:26
90	20	.0	:08	.0	:07	.0	1:01
90	50	.0	< :05	.0	< :05	.0	:11
120	0	1.5	60:00	1.5	60:00	1.5	60:00
120	5	.0	:25	.0	< :18	.0	5:11
120	10	.0	:09	.0	< :06	.0	:15
120	20	.0	< :05	.0	< :05	.0	:10
120	50	.0	< :05	.0	< :05	.0	:08

[a] Each value represents the average of five trials.

[b] If the foam did not breakdown within one hour, the foam height was measured in cm at the time specified.

TABLE 3

Effect of temperature and antifoam agent concentration on the foam breakdown time of homogenized milk[a]

Temp (°F)	Active anti-foam (ppm)	Antifoam AF Emulsion		Antifoam B		Antifoam A	
		Foam[b] (cm)	Time (min:sec)	Foam[b] (cm)	Time (min:sec)	Foam[b] (cm)	Time (min:sec)
32	0	0.0	17:38	0.0	17:38	0.0	17:38
32	5	---	-----	.0	18:48	.0	15:46
32	10	.0	15:28	.0	18:56	.0	18:08
32	20	.0	15:06	.0	18:56	.0	12:52
32	40	.0	11:02	---	-----	---	-----
32	50	.0	1:42	.0	18:30	.0	10:16
60	0	.0	0:10	.0	0:10	.0	0:10
60	5	.0	:12	.0	< :10	.0	:15
60	10	.0	:10	.0	:16	.0	:14
60	20	.0	:10	.0	:07	.0	:13
60	50	.0	:07	.0	:08	.0	:10
90	0	.0	< :10	.0	< :10	.0	< :10
120	0	.7	60:00	.7	60:00	.7	60:00
120	5	.0	:23	.0	< :21	.0	1:05
120	10	.0	:12	.0	:06	.0	:34
120	20	.0	< :06	.0	< :05	.0	:37
120	50	.0	< :05	.0	< :05	.0	< :05

[a] Values for 32 and 120°F represent the average of five trials. Values for 60 and 90°F represent the average of duplicate trials.

[b] If the foam did not breakdown within one hour, the foam height was measured in cm at the time specified.

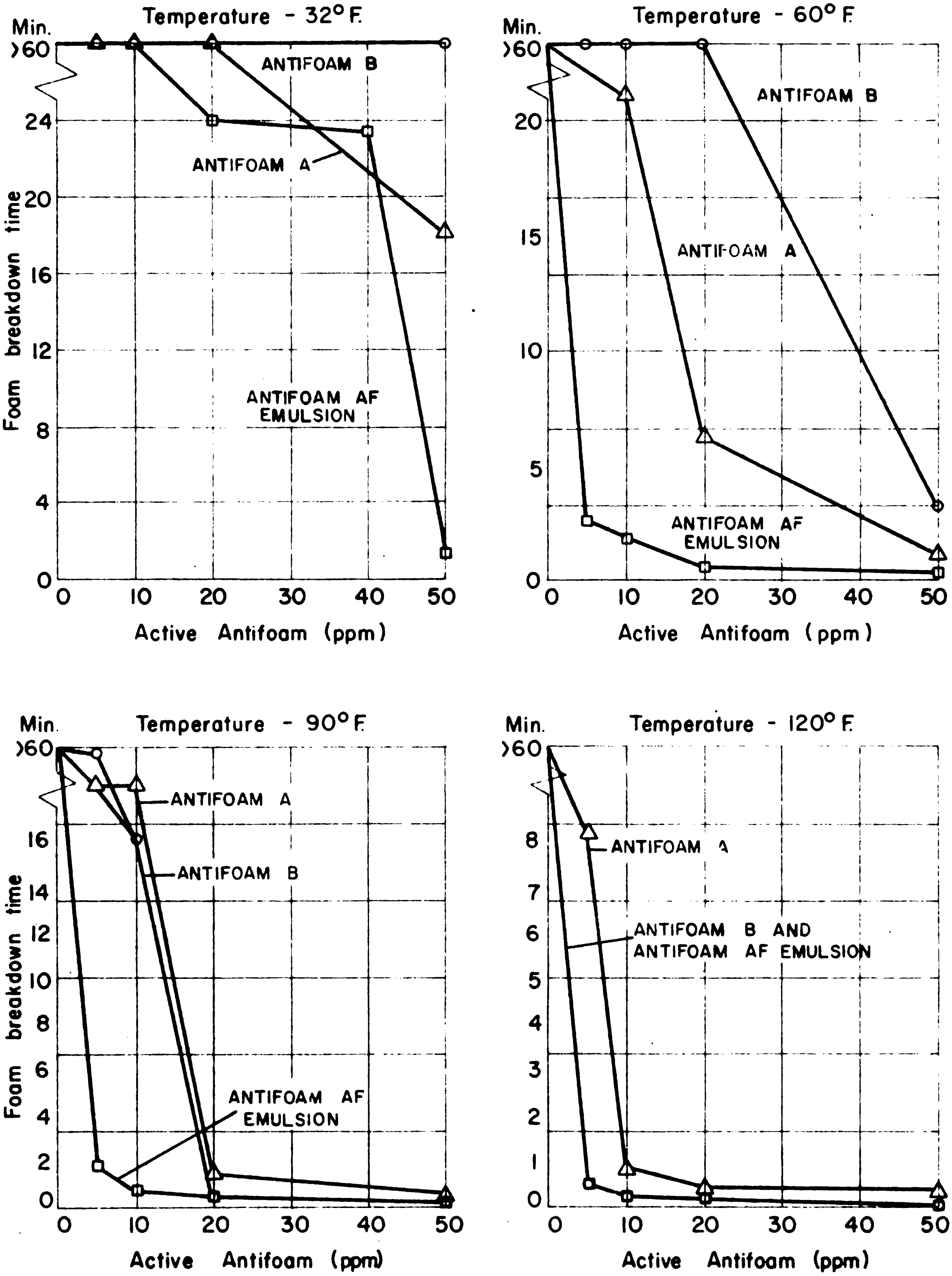
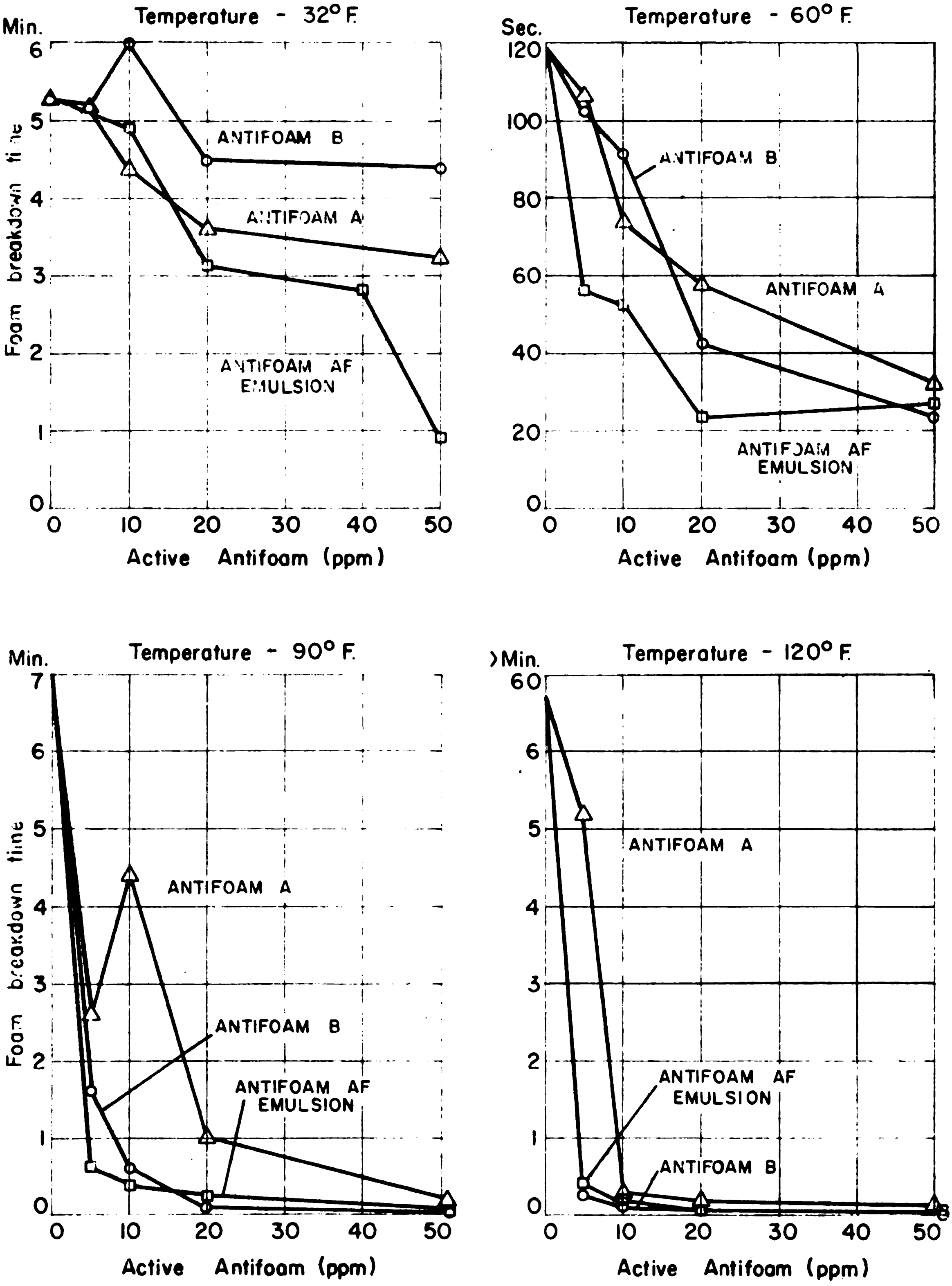


Figure 1. Effect of silicone antifoam agents on reconstituted nonfat milk foam breakdown time.



Temperature - 32° F

Temperature - 60° F

Temperature - 90° F

Temperature - 120° F

Figure 2. Effect of silicone antifoam agents on skim milk foam breakdown time.

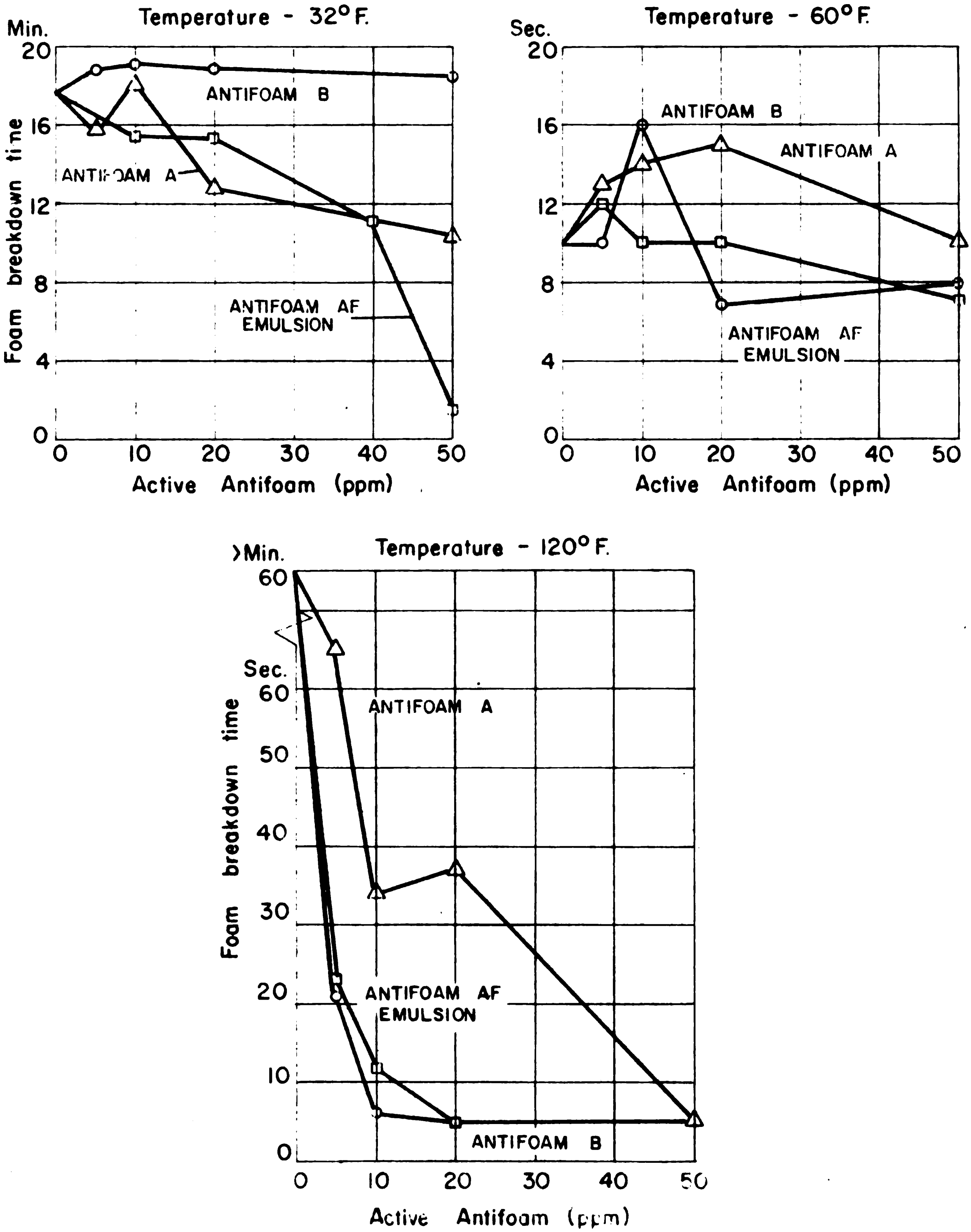


Figure 3. Effect of silicone antifoam agents on homogenized milk foam breakdown time.

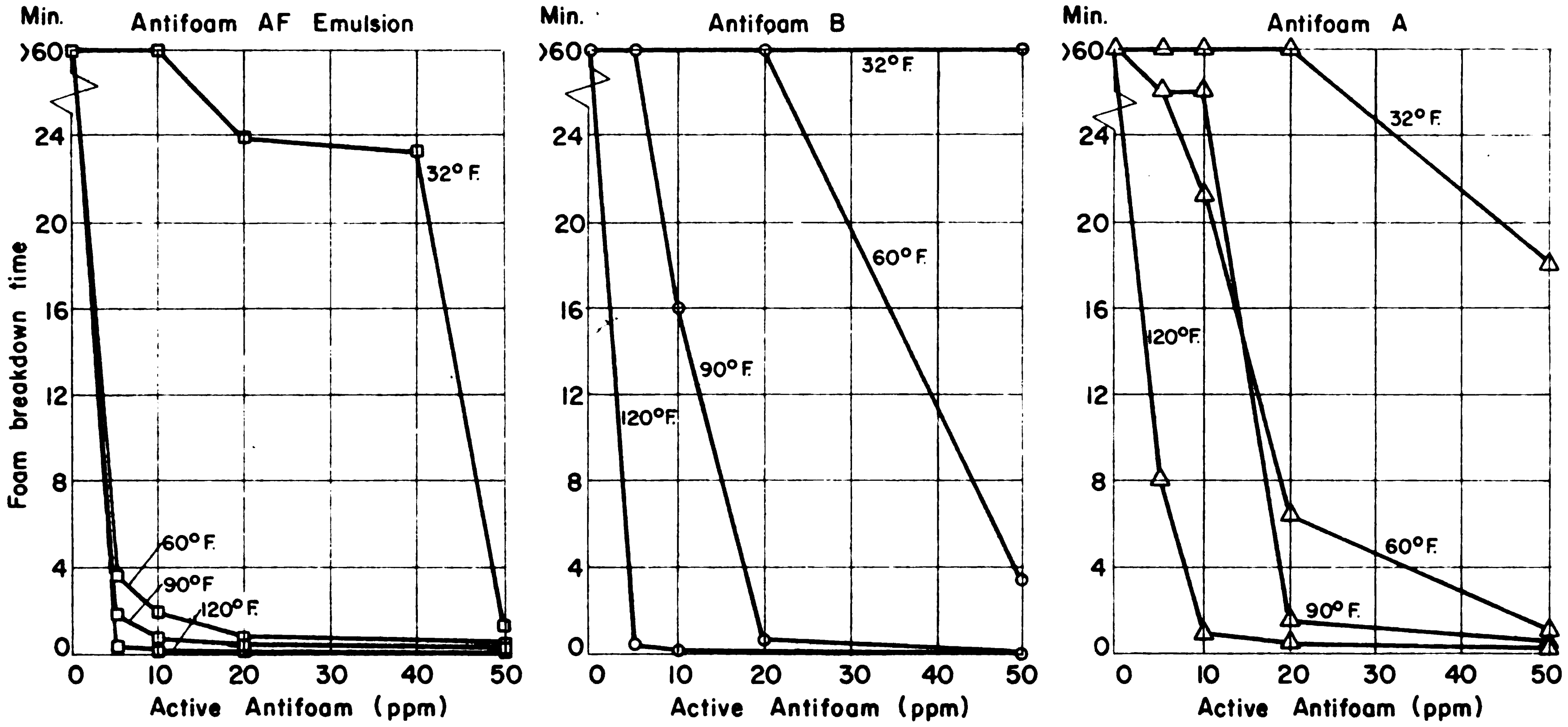


Figure 4. The influence of temperature on the effectiveness of silicone antifoam agents on reconstituted nonfat milk foam breakdown time.

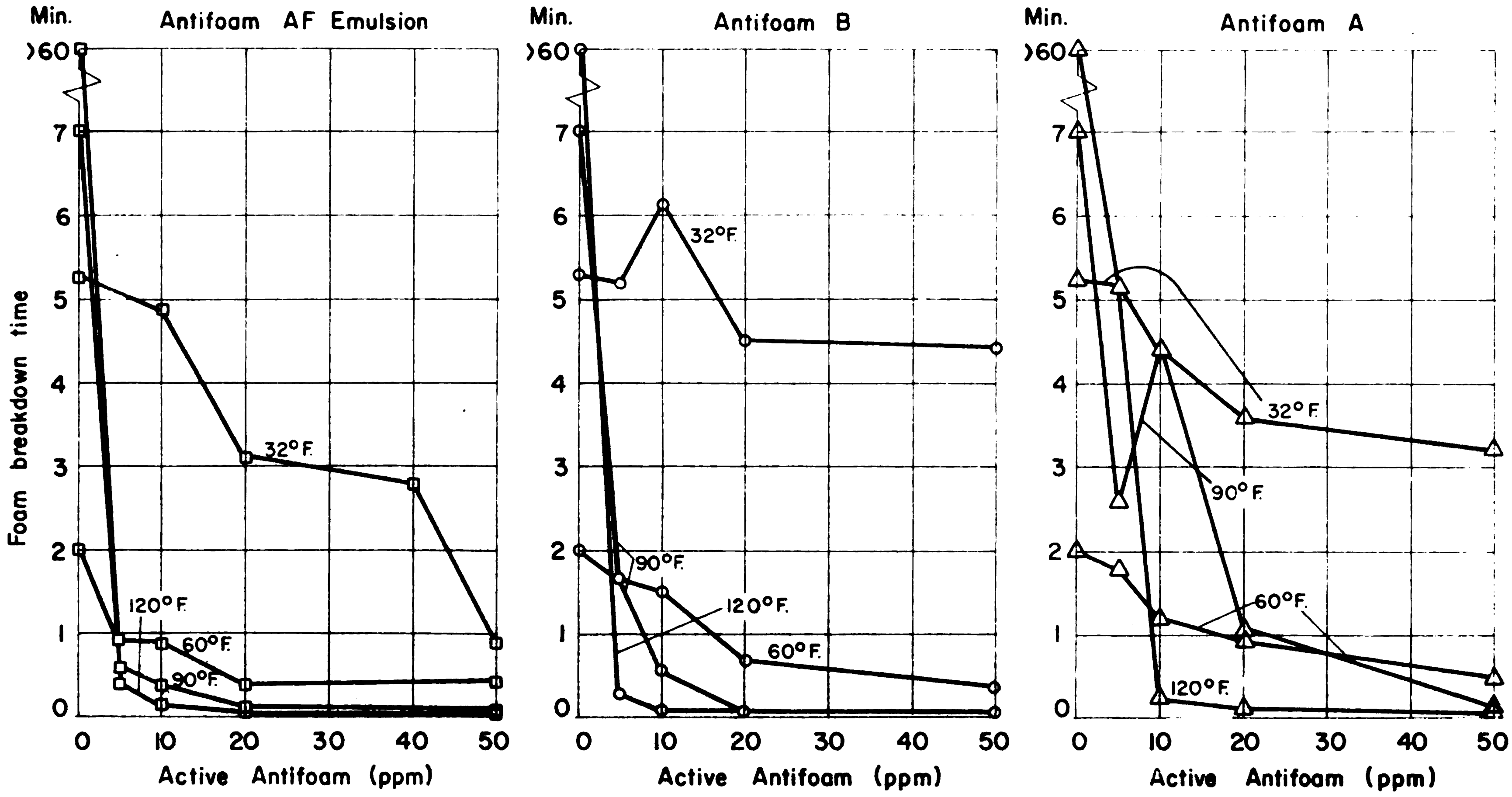


Figure 5. The influence of temperature on the effectiveness of silicone antifoam agents on skim milk foam breakdown time.

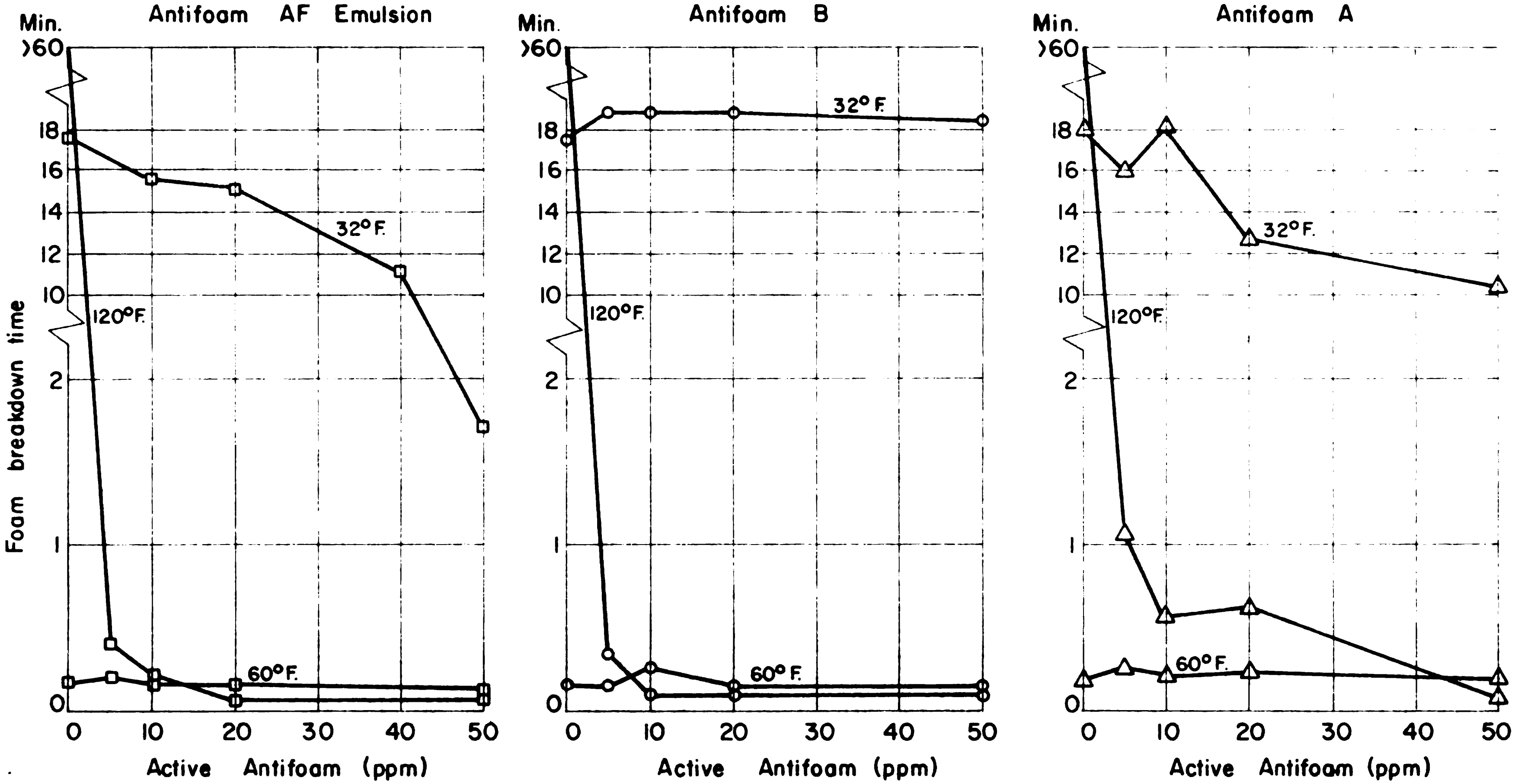


Figure 6. The influence of temperature on the effectiveness of silicone antifoam agents on homogenized milk foam breakdown time.

milk, skim milk, and homogenized milk at 60, 90, and 120°F. The foam breakdown time increased each time agitation of a treated milk sample was repeated after the foam produced by the previous agitation disappeared when the foam breakdown time was less than 5 minutes. No attempt was made to determine foam breakdown times greater than 5 minutes. The increase in foam breakdown time upon repeated agitation appeared to vary with a number of factors. Further tests are necessary to determine more precisely the extent of loss of antifoam properties as related to temperature, type of antifoam agent, concentration of antifoam agent, type of milk, etc.

Effect of Antifoam Sprays on Milk Foams. The quantity of 33% Antifoam AF Emulsion dilution delivered by one rapid depression of the atomizer bulb was approximately 2.1 mg. This was equivalent to 0.7 mg of actual Antifoam AF Emulsion. Approximately 3.4 mg of 50% Antifoam B dilution was delivered by one rapid depression of the atomizer bulb. This was equivalent to 1.7 mg of actual Antifoam B. Approximately 70 mg of Antifoam A was dispensed in 1 second by the pressurized spray container. A rapid depression and release of the spray container valve delivered approximately 22 mg of Antifoam A.

Measuring from the table top the 250 ml beaker was 8.5 cm high. The milk level when the foam had dissipated was approximately 1.5 cm for all samples of milk. The height

TABLE 4

Effect of silicone antifoam agent sprays on reconstituted nonfat milk foam

Time (min)	Height of milk and foam (cm)							
	1st trial				2nd trial			
	Antifoam AF Emulsion (mg)				Antifoam AF Emulsion (mg)			
	0	3.5	7.0	14	0	3.5	7.0	14
1	8.5	8.0	7.2	6.8	8.5	8.0	7.8	7.7
2	8.5	7.2	6.7	6.1	8.5	7.7	7.5	7.3
3	8.5	6.7	6.0	5.3	8.5	7.5	7.2	7.1
4	8.5	6.3	5.5	4.5	8.5	7.4	7.0	6.7
5	8.5	5.5	5.0	3.5	8.5	7.3	6.8	6.5
6	8.5	5.3	4.5	3.0	8.5	7.3	6.5	6.1
7	8.5	5.0	4.0	2.5	8.5	7.1	6.3	5.7
8	8.5	5.0	4.0	2.2	8.5	7.0	6.0	5.2
9	8.5	4.5	4.0	2.0	8.5	6.5	5.5	5.0
10	8.5	4.0	3.5	1.9	8.5	6.0	5.3	4.5
15	8.5	3.0	3.3	1.8	8.5	5.5	4.5	3.5
20	8.5	2.5	2.0	---	8.5	4.5	3.5	3.0
25	8.5	2.0	1.8		8.5	4.2	3.3	2.5
30	8.5	---	---		8.5	4.0	3.0	2.2

TABLE 4 (Continued)

Time (min)	Height of milk and foam (cm)							
	1st trial				2nd trial			
	Antifoam B (mg)				Antifoam B (mg)			
	0	8.5	17	34	0	8.5	17	34
1	8.5	8.2	8.0	7.8	8.5	8.0	8.0	8.0
2	8.5	8.1	7.9	7.8				
3	8.5	8.1	7.9	7.7	8.5	7.8	7.8	7.7
4	8.5	7.9	7.7	7.5				
5	8.5	7.8	7.6	7.0	8.5	7.8	7.7	7.5
6	8.5	7.8	7.5	6.5				
7	8.5	7.7	7.4	6.2				
10	8.5	7.0	6.0	5.0	8.5	7.3	6.9	5.9
15	8.5	6.7	5.5	4.2	8.5	6.0	5.7	4.5
20	8.5	5.7	5.0	3.5	8.5	5.5	5.0	3.5
25	8.5	5.0	4.5	3.0	8.5	5.3	4.8	3.3
30	8.5	4.5	3.5	2.5	8.5	5.2	4.7	3.1

	Antifoam A (mg)			
	0	22	44	70
1	8.5	8.0	7.9	7.8
3	8.5	7.7	7.5	7.4
5	8.5	7.3	7.1	6.9
10	8.5	6.4	6.0	5.8
15	8.5	5.0	4.8	4.7
20	8.5	4.5	4.0	4.0
25	8.5	4.0	3.5	3.5
30	8.5	3.0	3.8	2.8

TABLE 5

Effect of silicone antifoam agent sprays on skim milk foam

Time (min)	Height of milk and foam (cm)							
	1st trial				2nd trial			
	Antifoam AF Emulsion (mg)				Antifoam AF Emulsion (mg)			
	0	2.1	7.0	14	0	2.1	7.0	14
1	8.5	8.0	7.0	6.5	8.5	7.7	7.0	6.5
2	8.0	7.2	5.5	3.5	8.0	6.5	5.5	4.5
3	7.0	6.5	4.5	2.0	6.7	5.5	3.5	2.5
4	5.5	4.7	2.3	—	5.5	4.0	2.0	2.0
5	4.5	3.0	—		4.5	2.5	—	—
6	2.5	2.0			2.5	2.0		
7	2.0	—			2.0	—		
	Antifoam B (mg)				Antifoam B (mg)			
	0	8.5	17	34	0	8.5	17	34
1	8.0	7.8	7.8	7.7	8.5	8.2	8.1	8.1
2	7.7	7.5	7.2	6.9	8.5	7.9	7.5	7.3
3	6.9	6.5	6.2	5.7	8.2	7.1	6.9	6.5
4	5.7	5.3	5.1	4.5	7.3	6.5	5.9	5.5
5	4.5	4.0	3.7	3.1	6.5	5.5	5.0	4.5
6	2.5	2.1	2.0	1.8	5.0	4.5	3.5	3.0
7	2.0	1.9	1.8	—	4.0	3.5	2.7	2.0
8	1.8	—	—		2.7	2.3	2.0	—
9	—				2.0	1.9	—	
10					1.8	—		
	Antifoam A (mg)				Antifoam A (mg)			
	0	70	140	350	0	22	70	140
1	8.1	7.7	7.7	7.6	8.0	7.7	7.7	7.6
2	7.9	7.0	7.0	7.0	7.7	6.7	6.7	6.5
3	7.5	6.2	6.2	6.4	6.9	5.5	5.5	5.3
4	7.0	5.0	5.2	5.0	5.2	4.5	4.3	4.1
5	6.0	4.3	4.3	4.5	4.5	3.3	3.1	3.0
6	5.5	3.2	3.5	3.5	2.5	2.0	2.0	2.0
7	4.0	2.3	2.5	2.5	2.0	—	—	—
8	3.0	—	2.0	2.0	—			
9	2.3		—	—				

TABLE 6

Effect of silicone antifoam agent sprays on homogenized milk foam

Time (min)	Height of milk and foam (cm)							
	1st trial				2nd trial			
	Antifoam AF Emulsion (mg)				Antifoam AF Emulsion (mg)			
	0	7.0	14		0	0.7	3.5	7.0
1					8.0	7.7	7.3	6.9
2	8.0	5.5	4.5		7.7	7.3	6.5	5.5
3	6.0	4.5	2.0		5.9	5.5	5.0	3.5
4	3.0	2.0	—		3.5	3.0	2.5	2.0
5	1.8	—			2.6	2.5	2.0	—
6	—				2.0	2.0	—	
	Antifoam B (mg)				Antifoam B (mg)			
	0	8.5	17	34	0	8.5	17	34
1	8.2	8.0	7.8	7.5	8.5	8.2	8.2	8.2
2	7.5	6.8	7.0	7.2	8.3	8.2	8.1	8.0
3	6.5	6.0	5.5	5.3	8.0	7.8	7.8	7.5
4	4.2	4.0	3.5	3.0	7.0	6.8	6.8	6.5
5	2.5	2.5	2.3	2.1	5.0	5.0	5.0	5.0
6	2.1	2.0	1.9	1.9	4.0	4.0	4.0	4.0
7	2.0	1.9	—	—	2.5	2.5	2.5	2.5
8	—	—			2.0	2.0	2.0	2.0
	Antifoam A (mg)				Antifoam A (mg)			
	0	70	140	350	00	70	140	350
1					8.5	7.7	7.5	7.5
2	8.0	7.5	7.5	7.5	8.0	6.7	7.4	7.2
3	6.7	6.2	6.1	6.1	7.0	6.1	5.5	5.5
4	4.5	4.2	4.5	4.5	5.7	4.5	4.0	3.5
5	3.2	2.8	3.1	2.5	4.5	3.0	2.3	2.3
6	2.0	2.0	2.0	2.0	2.5	2.0	—	—
7	—	—	—	—	2.0	—		

of foam and milk at 1, 2, or 5 minute intervals is presented in Tables 4 to 6. The effect of Antifoams A, B, and AF Emulsion sprays on reconstituted nonfat milk is given in Table 4. The same information for skim milk and homogenized milk is shown in Tables 5 and 6.

Antifoam agent sprays appeared to reduce the foams of homogenized milk, skim milk, and reconstituted nonfat milk at relatively slow rates at 32°F. Twenty minutes was required for the foam of reconstituted nonfat milk to completely dissipate with the most effective of the antifoam sprays (14 mg of Antifoam AF Emulsion). The most effective antifoam spray on skim milk and homogenized milk was also 14 mg of Antifoam AF Emulsion. This treatment reduced the skim milk foam in approximately 4 minutes as compared with 8 minutes for a control sample. The homogenized milk foam sprayed with 14 mg of Antifoam AF Emulsion was dissipated in about 3 minutes compared with 8 minutes for a control sample. Antifoam A was the least effective considering the high level at which it was used, and this antifoam agent left an objectionable film on the surface of the milk.

Antifoam AF Emulsion Test in a Commercial Can Filling Operation. The data obtained in filling 10-gallon cans with homogenized milk is presented in Appendix Table 21. The data for the 23 cans of control milk and the data for the 21 cans of milk treated with 27.5 ppm of Antifoam AF Emulsion were averaged. The average time for the first foam to come through the foam vent was 7.87 and 7.86 seconds respectively for control and treated milk. The time for the cans to fill was 33.7 and 31.7 seconds for control and treated milk. The corresponding volumes of foam as measured by the height of foam in an 8 inch diameter, 10 inch high container were 7.3 inches and 6.1 inches. The temperature of the treated milk was 40°F as compared with 41°F for the control milk.

Influence of Antifoam Agents on the Whipping Properties of Cream. The results of whipping tests with silicone antifoam agent treated cream are presented in Table 7.

TABLE 7

Influence of silicone antifoam agents on the whipping properties of cream.

Treatment	Volume after whipping (ml)	Body of whipped cream	
		Immediate	After 2 hrs
Control	400	very firm	firm
340 ppm Antifoam AF Emulsion	400	firm	firm
1000 ppm Antifoam B	400	firm	firm
250 ppm Antifoam A	400	firm	firm
Control	400	very firm	firm

The 200 ml control and treated samples of cream each whipped to approximately 400 ml of whipped cream. Two control samples each gave very firm bodied whipped cream in the 2 minute whipping time. The three samples treated with 250, 1000 and 340 ppm of Antifoams A, B, and AF Emulsion respectively appeared to be slightly less firm bodied after the 2 minute whipping time. The difference did not seem to be enough to be of practical significance, however. Two hours after whipping no difference was apparent in the firmness of body of the treated or control samples. The antifoam agents could not be detected by an off-flavor in any of the five samples.

Silicone Release Agents

Laboratory Cleanability Test Using a Mechanical Washing Apparatus. The photolometer reading for each set of slides coated with various silicones is presented graphically in Figure 7. The photolometer reading for Slipicone treated glass slides before soiling was 102 compared with 100 for the control, 200 Fluid, and Z-4141 coated slides. The higher photolometer reading for Slipicone treated slides was evident even after soiling and washing. After the first soiling and washing trial, the Slipicone treated slides appeared to be the most soiled by visual observation although they gave the most light transmission. By the fifteenth trial the Slipicone coated slides appeared to be the cleanest and showed the highest light transmission of any of the slides.

Milk did not wet the surface of any of the treated slides until about the tenth trial. Thereafter only the Slipicone treated slides repelled the milk. The control slides had a more uniform soil during the first four trials because the milk wet the glass surface. From the fifth to the tenth trials the control slides repelled the milk, but after the tenth trial, the milk again wetted the surface and the control slides soiled more uniformly. Since the treated slides and the untreated slides were all immersed in the same milk, the untreated slides could have picked up enough silicone from the treated slides to repell milk. To check this, a group of three untreated slides were retested in uncontaminated milk to prevent possible silicone pickup. These slides did not exhibit the repelling effect toward milk, and their light transmission percentage was reduced to less than 90 in seven trials. The original control slides gave light transmission readings of 98 or more after seven trials.

A number of slides showed increases in photolometer readings above their original value during the first 10 trials. None of the slides appeared to be as clean following soiling and washing as the unsoiled slide used for adjusting the photolometer.

After the 15th trial each slide was soaked in a general purpose detergent solution and washed with a cloth. The silicone coating was removed, at least to the extent that the slide did not repell water, without difficulty from

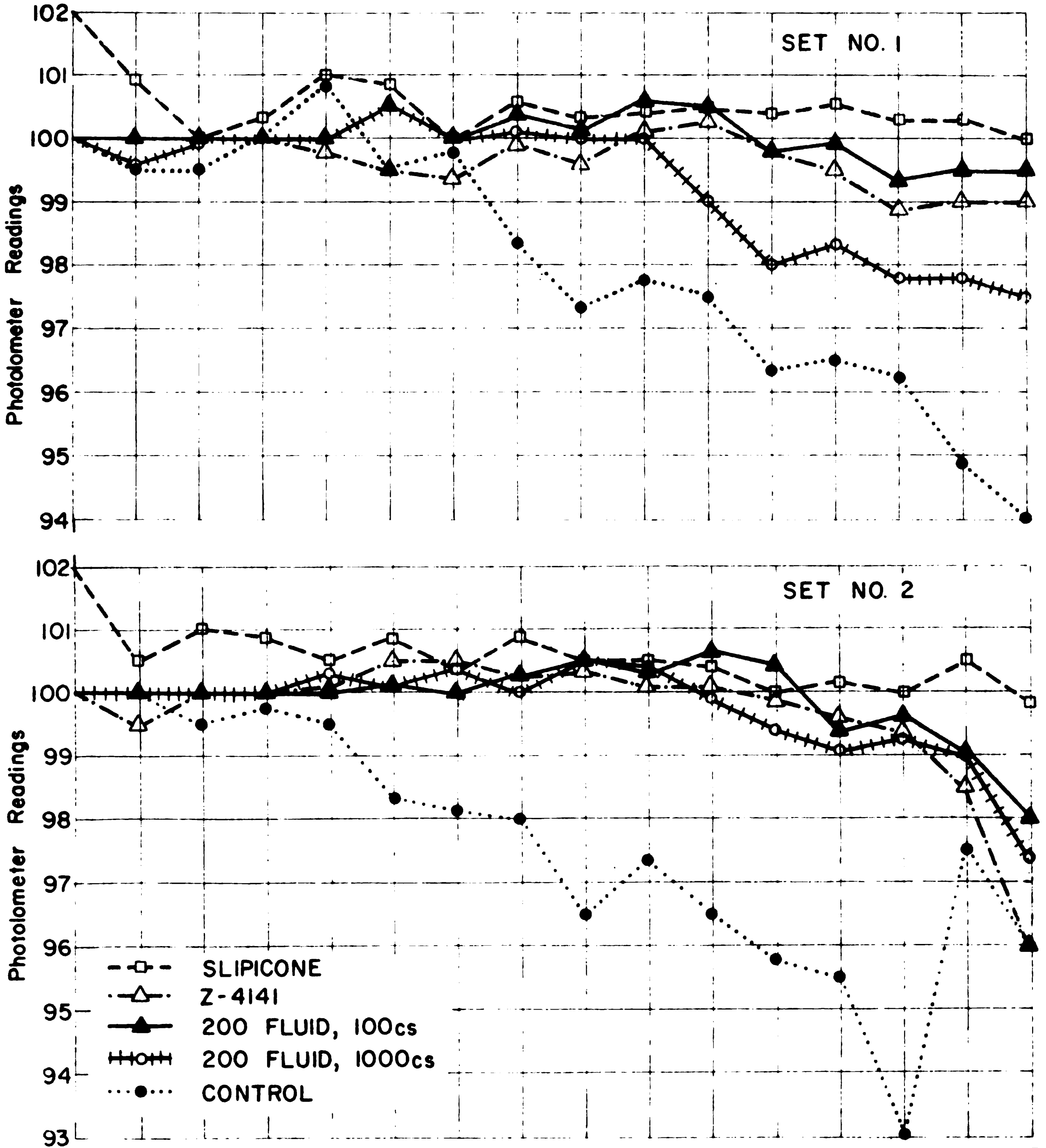


Figure 7. Photolometer readings for silicone treated slides after succesive soiling and washing trials.

each of the slides except those coated with Z-4141. Considerable scrubbing did not remove the Z-4141.

Laboratory Investigation of Milk Powder Adhesion. Not enough of the Slipicone could be buffed from the treated areas of glass or stainless steel beakers to prevent adhesion of dry milk to the surface. In four tests each with glass and stainless steel beakers, the control area was readily discernable because less powder adhered to the untreated surface. Removal of the powder by air blast or brush was easier from the control areas than from the treated areas.

Effect of Release Agents on Dairy Plant Paneling and Equipment. The results of the cleanability, appearance, and product adhesion tests will be reported in the following subheadings.

Aluminum Wall Paneling. The appearance of aluminum wall paneling in the MSU Dairy did not appear to be improved by coating with any of the trial concentrations of 200 Fluids at any time during the 3 months period following their application when compared with either the untreated or mineral oil coated controls. Soil tended to show slightly more on the silicone treated areas than on either type of control areas, especially during the first few weeks of the test. When the panel was washed, no difference was evident in the ease of cleaning or appearance following cleaning.

Stainless Steel Table. The silicone treated areas on the stainless steel table could be distinguished by close scrutiny from the control areas only after the first day of use. The appearance ratings at the end of the first day were good, good plus, very good, and excellent for the areas treated with 0, 0.2, 1.0, and 5.0% 1000 centistoke 200 Fluid respectively. At no other time in the 1 week test period following the application of silicone was any difference in appearance discernable. Water spots were more apparent on the silicone treated areas of the table when water was allowed to dry on the table immediately after the application of silicone. Differences in ease of cleaning were not evident at any time during the test period.

Cheese Vat. In one trial no distinction could be made in ease of cleaning the three Slipicone or 200 Fluid coated areas of the stainless steel cheese vat lining after making cheddar cheese.

Stainless Steel Pasteurizing Vat. Neither appearance nor ease of cleaning appeared to be improved by coating six areas on stainless steel vats in the MSU Dairy with Slipicone or 5% solutions of 200 Fluids. The silicone treated areas did not appear as bright as the other portions of the vats which received the routine mineral oil coating after cleaning.

Roller Dryer. The 5% solution of 1000 centistoke 200

Fluid was applied to rolls of the roller dryer at a time when adhesion of dry milk film to the rolls was a problem. In this one test silicone treatment did not appear to improve the ease of removal of the dry milk film. In fact no difference was observed.

Spray Dryer. The effectiveness of silicones in preventing build-up of powder or facilitating the removal of nonfat milk from stainless steel plates in the spray dryer was inconclusive. In four tests the difference in nonfat dry milk build-up on the various plates was discernable by visual observation in test No. 3 only. The rating of nonfat dry milk build up for test No. 3 is given in Table 8. Each value is the average of ratings from each side of the plate, the highest numbers indicating the most build-up. The ratings indicate the approximate percent of metal surface covered with powder as determined by visual observation. The nonfat dry milk build-up was greater on all of the plates in this test than in any of the other tests.

Comparative ratings for the ease of manually removing nonfat dry milk from the plates with a brush are presented in Table 9. The ratings range from 2.0 to 8.0. A 2.0 was indicative of easy removal and 8.0 was very difficult removal.

In test No. 2 there was less nonfat dry milk build-up than in any other test. The film was most difficult to remove from the control plate in tests No. 1, 3, and 4, but it was easiest to remove from the control plate in test No.

TABLE 8

Build-up of nonfat dry milk on silicone resin treated stainless steel plates in a dryer

Treatment[a]	Rating[b]
Control	70
12-1	55
12-2	55
12-3	50
12-4	50
12-5	45
12-6	50

[a] The silicone resins, which contained both methyl and phenyl groups, were identified only by code numbers 12-1, 12-2, 12-3, 12-4, 12-5, and 12-6 by Dow Corning Corp.

[b] Approximate percent of surface covered with powder.

TABLE 9

Ease of removal of nonfat dry milk from stainless steel plates coated with silicone resins and mounted in a spray dryer

Silicone resin coating[a]	Powder removal rating[b]			
	Trial number			
	1	2	3	4
Control	5.0	2.0	8.0	5.5
12-1	3.0	3.0	6.0	4.0
12-2	3.5	3.0	5.0	4.5
12-3	2.5	3.5	2.5	4.0
12-4	2.5	3.0	3.0	4.5
12-5	2.0	3.0	2.0	4.5
12-6	2.5	4.5	3.0	5.0

[a] The silicone resins, which contained both methyl and phenyl groups, were identified only by code numbers 12-1, 12-2, 12-3, 12-4, 12-5, and 12-6 by Dow Corning Corp.

[b] Large numbers indicate more difficult removal.

2.

Butter Churn. No benefit could be detected from applying Slipicone to either the No. 4 finish stainless steel plate or to the shelf or wall sandblasted surface areas inside of the butter churn. The butter adhered to the total area of the Slipicone coated stainless steel plate and had to be scraped from the plate. No benefit could be determined in the Slipicone treated areas on the sandblasted surfase as far as either adhesion of butter or ease of cleaning were concerned when compared with the untreated areas.

Sanitary Valve. In one test two sanitary valves coated with Slipicone and two coated with 200 Fluid appeared to operate satisfactorily until they were washed. Following the wash, however, another application was required to cause them to operate smoothly again.

DISCUSSION

Silicone Antifoam Agents

Laboratory Investigation of Antifoam Agents Dispersed in Milk. The major factors influencing the foaming properties of milk and the affect of silicone antifoam agents on milk and its foam breakdown time will be discussed under the following sub headings: Type of Milk, Type of Silicone, Concentration of Silicone, Influence of Temperature, Affect on Flavor, and Reduced Ability of Antifoam Agents to Destroy Foam Upon Repeated Agitation.

Type of Milk. The foam of reconstituted nonfat milk was considerably more stable at 32, 60, 90, and 120°F than skim milk or homogenized milk. The skim milk and reconstituted milk were from the same source, the MSU Dairy, and the only difference in processing was the heat treatment involved in condensing and drying. Previous workers have published data which tends to show that heat treatments of milk, at least up to an optimum point, increase the stability of milk foams (13)(23)(47). Heat treatment is the most logical basis upon which the difference in foam breakdown times of reconstituted nonfat milk and skim milk could be explained.

By measuring the percentage increase in volume of a whipped sample of milk, Sanmann and Ruehe (37) found that homogenization increased considerably the foaming ability of whole milk at 40 and 80°F, but increased only slightly the foaming ability of skim milk at the same temperatures. Foam volume and foam stability are not necessarily correlated, but an increased volume of foam on homogenized milk at 32°F might be at least a partial explanation of the greater foam breakdown time of homogenized milk than skim milk. The same reasoning would lead to the conclusion that homogenized milk foam should have a greater foam breakdown time at 60 and 90°F than skim milk foam. The reverse was true in this experiment. Leviton and Leighton (25) found the antifoam properties of milk fat depend upon their ability to spread on water. Previously King (22) had shown that the ability of fat to spread on water increases as the temperature increases. This may account for the decreased stability of homogenized milk foam at 60 and 90°F as compared with skim milk foam since there are more fat globules in homogenized milk to establish weak points in the foam lamella.

Type of Silicone Antifoam Agent. There were considerable variations in the effectiveness of the three antifoam agents at some temperatures even though corresponding concentrations of active antifoam agent were used. Explanation for this variation centers around the emulsifying agents and the accuracy of the procedure. Antifoam A is without emulsifier and Antifoams B and AF Emulsion have different emulsifiers. The emulsifying agent could influence the effectiveness of the active antifoam agent.

The concentration of Antifoam A was calculated on the basis of the total quantity of active antifoam coated on the inside walls of the test tube. For calculating purposes, all of the antifoam agent was assumed to be dispersed in milk. The portion of antifoam agent which may have adhered to the test tube and thus did not contribute to the defoaming process was not considered. The procedure used in coating the test tube could also be a source of error in determining the exact quantity of antifoam agent in the milk. Even in the case of maximum concentration only 1.25 mg of antifoam agent was calculated to be in the milk. The Antifoam A concentration could more accurately be discussed as a given percentage of Antifoam A dissolved in toluene and coated on the test tube. This gives no basis for comparison with Antifoams B and AF Emulsion, however.

Difficulty was encountered in getting a uniform dilute emulsion of Antifoam AF Emulsion to add to the milk samples. This was especially true at 32 and 60°F. Although every attempt was made to obtain uniform emulsions, there remains the possibility that the portion of diluted Antifoam AF Emulsion added to the milk sample could have been more concentrated, thus making the AF Emulsion appear more effective than Antifoam B.

Concentration of Silicone Antifoam Agent. The recommendation of the manufacturer and previous applications of silicone antifoam agents to other products would lead one to expect the increased effectiveness obtained by using greater concentrations of antifoam agent. Of the two exceptions to this trend in skim milk, the one at 32°F is probably explained by Table 16 of the Appendix. The foam breakdown time was plotted as 6:08 minutes when it was actually less than this time but the exact time was not determined. No explanation is apparent for the second exception with Antifoam A at 90°F.

Although several exceptions seem to exist with homogenized milk, close examination of Figure 3 or Figure 6 show the exceptions for milk at 60°F or above were a maximum of 7 seconds. At 32°F where each of the antifoam agents was relatively ineffective, the maximum exception was 2.5 minutes. This variation is probably within the scope of error one might expect from the experimental procedure.

Influence of Temperature on the Effectiveness of Silicone Antifoam Agents. Temperature has been recognized as one of the major factors governing foaming properties of milk for a number of years (23)(30)(37)(40). Foam volume and foam stability have been shown to be at a minimum on skim milk and milk containing less than 5% butterfat at approximately 80°F to 90°F. Above and below this temperature the foam volume and foam stability increase. The stability increases more when the temperature is increased from the minimum foaming temperature than when the temperature is decreased. Studies have been conducted concerning the substance or substances causing milk to foam (12)(15)(16)(17)(19)(25)(28)(30)(40)(41)(42)(43) and a number of theories have been suggested to explain the influences of temperature on the foaming properties of milk (12)(14)(15)(16)(25)(29)(32). Although the foaming substance is generally regarded as a protein, the exact cause of foaming and reasons for the effect of temperature are as yet unsolved. Until more is known concerning these factors, little can be definitely stated about the cause of the increasing effectiveness of silicone antifoam agents with increasing temperatures from 32 to 120°F. The following factors are considered possibilities which might help explain the influence of temperature.

First, Milk foam films are known to be thinner at higher temperatures (32). It would seem logical that an antifoam agent would be more effective in breaking down a thin film than a thicker one. It is also known that milk foam stability increases with increases in temperature above the minimum foaming temperature (23)(37). The relationship of increased stability to possible increased effectiveness of antifoam agent on thin films remains a question.

Second, if the foaming agent in milk at low temperatures is different than the foaming agent in milk at high temperatures as suggested by El-Rafey and Richardson (16), silicone antifoam agents could conceiveably be more effective in one type of foaming system than another.

Third, the spreading coefficient of an antifoam agent is influenced by the surface tension of the foaming liquid. Ross (33) gave the following relationship:

$$S = \gamma_F - \gamma_{D_1F_1} - \gamma_D$$

where S = spreading coefficient, γ_F = surface tension of foaming liquid, $\gamma_{F_1D_1}$ = interfacial tension at antifoam agent foaming liquid interface, and γ_D = surface tension of antifoam agent. Newlander (27) states that an increase in milk temperature lowers the milk surface tension markedly. If the other factors remained constant, a decrease in milk surface tension would increase the spreading coefficient of the antifoam agent and thus increase its effectiveness. Temperature may also affect the interfacial tension or the surface tension of the antifoam agent such that the spreading coefficent may be increased.

Effect of Silicone Antifoam Agents on the Flavor of Milk. Since the active antifoam agent in each of the silicones tested is a chemically inert, tasteless, odorless product, the only possible source of taste or flavor would be the emulsifier. The emulsifier used in Antifoam AF Emulsion is a commonly used food grade emulsifier (2). Antifoam B is a newer product which also was designed for use in food processing operations. It was therefore, not surprising that the antifoam agents could not be detected in the low concentrations employed.

Reduced Ability of Antifoam Agents to Destroy Foam upon Repeated Agitation. The fact that silicone antifoam agents tend to lose effectiveness in breaking down foam upon repeated agitation of milk leads the writer to conjecture that the antifoam agent may spread on other interfaces than the milk/air interface and thus prevent its functioning as an antifoam agent.

Effect of Antifoam Sprays on Milk Foams. Explanation for the slow rate of foam breakdown of concentrated sprays of silicone antifoam agents rests on a statement by Ross (33). The high interfacial tension of silicone antifoam agents hampers the ease of dispersion of the antifoam agent so that droplets of the antifoam agent do not readily get to the films between the bubbles.

Antifoam AF Emulsion Test in a Commercial Can Filler Operation. Since the antifoam agents were found to be relatively ineffective at low temperatures in the laboratory experiments on homogenized milk, the inability of 27.5 ppm of Antifoam AF Emulsion to appreciably reduce the foam problem in the can filler was predictable.

Influence of Antifoam Agents on the Whipping Properties of Cream. Richardson and El-Rafey (30) showed that two types of foam may exist on milks of varying fat content. Milks above 7.5% fat content exhibited a predominately phospholipid-protein type of foam as compared with a protein type foam for lower fat content milks. Apparently the silicone antifoam agents are more effective in breaking down the foam of the protein type than of the phospholipid type foam of whipping cream.

The foam film of phospholipid type foam is thicker than that of protein type foam. The antifoam agents may be more effective in breaking down protein type foam because of its thinner walls. The thick walls of phospholipid type foam may hinder the establishment of weak points in the foam film of whipped cream.

Silicone Release Agents

Laboratory Cleanability Test Using a Mechanical Washing Apparatus. It would appear that the repelling agent properties of each of the silicones tested tended to improve the cleanability of the glass slides in the laboratory experiment with the mechanical washing apparatus. The wash was designed to remove only part of the soil so that a measurement of the soil left could be determined by photolometer readings. Since each silicone coating except Z-4141 was not difficult to remove with a cloth and detergent solution, the writer speculates that much of the effectiveness of the silicones would be lost by the thorough washing procedures employed in dairy plant operations. The Z-4141 silicone is made especially for glass containers and is not recommended for use on other materials and so its use in the dairy would be limited.

Effect of Release Agents on Dairy Plant Paneling and Equipment. About the same results were experienced on each type of equipment on which silicone was used to improve appearance and/or cleanability, and so they will be discussed together. The improvement in cleanability evidenced in the laboratory experiment with glass slides was not detectable when silicones were applied to dairy plant equipment. Two reasons can be offered as explanation: (1) Silicones may be more effective release agents on the smooth glass surfaces than on rougher stainless steel or aluminum or (2) the difference in cleanability may be so slight that it is not detectable in the manual cleaning procedure.

Because of its repelling properties, the silicone coated surfaces in some cases actually showed soil more than uncoated surfaces. The soil tended to concentrate in spots which were more evident than if the soil was more uniformly spread over the surface.

Spray Dryer. The heavier build-up of nonfat dry milk in trials No. 1, 2, and 4 may indicate that the powder was not completely dry when it reached the metal surfaces. If this were so, the brief information available on the effectiveness of silicone resins in preventing milk powder build-up in the spray dryer indicates that a silicone resin coating might be desirable in an experimental dryer or in a dryer in which there was a possibility of some of the nonfat milk not being completely dry when it reached metal surfaces. Heavy powder build-up was considerably easier to remove from the silicone coated plates than from control plates.

SUMMARY AND CONCLUSIONS

Investigations were conducted with three antifoam agents and four release agent type silicones in some dairy plant operations. Each of the silicones tested was a Dow Corning Corporation product.

Silicone Antifoam Agents

The effect of Antifoam A, Antifoam B, and Antifoam AF Emulsion on the foaming properties of milk and cream was studied in the laboratory and in one dairy plant test. In general, the results of this experiment can be summarized as follows.

1. When used at the same level of active antifoam concentration, Antifoam AF Emulsion was equally or more effective in breaking down foams of reconstituted nonfat milk, skim milk and homogenized milk than Antifoam B, and Antifoam B was equally or more effective than Antifoam A.
2. Foam breakdown times varied inversely with the concentration of antifoam agent.
3. Each of the Antifoam agents was relatively ineffective in breaking down reconstituted nonfat milk, skim milk, and homogenized milk foams at 32°F but became increasingly effective at 60, 90 and 120°F. At 120°F they were very effective.

4. Antifoam Agents A, B, and AF Emulsion at concentrations up to 50, 500, and 170 ppm respectively could not be detected by appearance, flavor, or taste. The toluene in which Antifoam A was dissolved was detected by an off flavor, however, and Antifoam A sprayed on foams left an objectionable film on the surface of the milk.
5. The foam dissipating ability of the antifoam agents in milk appeared to be reduced upon repeated agitation of the milk.
6. Sprays of antifoam agents were slow in breaking down reconstituted nonfat milk, skim milk and homogenized milk foams at 32°F.
7. Concentrations of 250 ppm Antifoam A, 340 ppm Antifoam AF Emulsion, or 1000 ppm Antifoam B did not adversely affect whipping time, stability, or flavor of whipped cream.

Because of the many factors which affect the foaming of milk, such as temperature, constituents, concentration, heat treatment, viscosity, homogenization, surface tension, agitation, etc., prediction of the effectiveness of a given concentration of a particular antifoam agent is extremely difficult if not impossible. These results lead to the conclusion that silicone antifoam agents may have limited applications in the processing of dairy products. Because of the variation in effectiveness, silicone antifoam agents should be tested under the conditions in which they will be employed to determine the practicality of their use.

Silicone Release Agents

The role of silicone release agents, including Slipicone, 100 centistoke 200 Fluid, 1000 centistoke 200 Fluid, silicone resins, and Z-4141, in relation to the appearance, cleanability, and adhesion of dairy products to stainless steel equipment, aluminum paneling, and glass slides was briefly investigated. A summary of the results follows:

1. Slipicone, 200 Fluids, and Z-4141 coated on glass slides improved the ease of cleaning if the silicone was not removed by a previous cleaning.
2. Slipicone and the 200 Fluids were removed at least to the extent that they did not repell water after a thorough wash with a general purpose detergent.
3. Not enough Slipicone could be removed from glass or stainless steel to prevent an increased adhesion of nonfat dry milk.
4. Slipicone and the 200 Fluids did not appear to improve ease of cleaning or appearance of stainless steel table top, cheese vat, or pasteurizing vats, butter churn or aluminum paneling.
5. Silicone resins appeared to improve the ease of removal of nonfat dry milk build-up on stainless steel surfaces in a spray dryer when the build-up was heavy. The ease of removal was not improved when there was very little build-up.

6. Slipicone coated on a No. 4 finish stainless steel plate did not prevent adhesion of butter during the churning process.

The results of investigations with silicone release type agents suggest limited if any practical application in improving cleanability or appearance of stainless steel dairy plant equipment or aluminum wall paneling. Ease of removing nonfat dry milk from silicone resin coated stainless steel plates in a spray dryer during three trials indicates that further investigation of this aspect of silicone applications would be desirable.

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APPENDIX

TABLE 10

Effect of type and concentration of silicone antifoam agents on the foam breakdown time of reconstituted nonfat milk at 32°F

Antifoam AF Emulsion

Trial No.	Active antifoam (ppm)									
	0		10		20		40		50	
	Foam[a] (cm)	Time (min: sec)	Foam[a] (cm)	Time (min: sec)	Foam[a] (cm)	Time (min: sec)	Foam[a] (cm)	Time (min: sec)	Foam[a] (cm)	Time (min: sec)
1	1.8-	180:00	0.0-	48:00	0.0-	6:50	0.0-	19:20	0.0-	0:42
2	2.0-	180:00	.0-	60:00	.0-	12:10	.0-	19:20	.0-	1:10
3	2.0-	180:00	.0-	80:00	.0-	28:00	.0-	19:40	.0-	1:20
4	2.3-	180:00	.0-	90:00	.0-	31:20	.0-	21:50	.0-	1:30
5	2.7-	180:00	.0-	90:00	.0-	41:20	.0-	37:00	.0-	1:40
Ave.	2.2-	180:00	.0-	73:36	.0-	23:56	.0-	23:16	.0-	1:16

Antifoam B

	Active antifoam (ppm)				
	0	5	10	20	50
1	1.8-180:00	0.5-180:00	0.9-180:00	0.8-180:00	0.9-180:00
2	2.0-180:00	1.1-180:00	1.1-180:00	1.2-180:00	1.2-180:00
3	2.0-180:00	1.6-180:00	1.9-180:00	1.3-180:00	1.3-180:00
4	2.3-180:00	1.8-180:00	2.2-180:00	1.5-180:00	1.7-180:00
5	2.7-180:00	2.1-180:00	2.7-180:00	1.8-180:00	1.7-180:00
Ave.	2.2-180:00	1.4-180:00	1.8-180:00	1.4-180:00	1.4-180:00

Antifoam A

1	1.8-180:00	0.7-110:00	0.8- 85:00	0.3- 60:00	0.0- 5:30
2	2.0-180:00	1.0-110:00	.8- 85:00	.5- 60:00	.0- 13:50
3	2.0-180:00	1.0-110:00	.8- 85:00	.6- 60:00	.0- 15:20
4	2.3-180:00	1.1-110:00	.9- 85:00	.7- 60:00	.0-<31:40
5	2.7-180:00	1.6-110:00	1.3- 85:00	.7- 60:00	.0- 31:40
Ave.	2.2-180:00	1.1-110:00	.9- 85:00	.6- 60:00	.0->16:34 <19:36

[a] If the foam did not breakdown within one hour, the foam height was measured in cm at the time specified.

TABLE 11

Effect of type and concentration of silicone antifoam agents on the foam breakdown time of reconstituted nonfat milk at 60°F

Trial No.	Active antifoam (ppm)									
	0		5		10		20		50	
	Foam[a] (cm)	Time (min: sec)	Foam[a] (cm)	Time (min: sec)	Foam[a] (cm)	Time (min: sec)	Foam[a] (cm)	Time (min: sec)	Foam[a] (cm)	Time (min: sec)
Antifoam AF Emulsion										
1	0.6-	60:00	0.0-	0:24	0.0-	0:25	0.0-	0:26	0.0-	0:15
2	.8-	60:00	.0-	:23	.0-	:35	.0-	:39	.0-	:15
3	.9-	60:00	.0-	:38	.0-	:41	.0-	:43	.0-	:17
4	2.0-	120:00	.0-	5:10	.0-	4:00	.0-	1:00	.0-	:25
5	4.0-	120:00	.0-	6:30	.0-	4:00	---	----	.0-	1:30
Ave.	>1.7-	60:00	.0-	2:39	.0-	1:56	.0-	:42	.0-	:32
Antifoam B										
1	0.6-	60:00	0.8-	60:00	0.0-	110:00	0.0-	105:00	0.0-	0:20
2	.8-	60:00	.9-	60:00	.8-	60:00	.0-	120:00	.0-	:20
3	.9-	60:00	1.0-	60:00	.8-	60:00	.4-	60:00	.0-	:25
4	2.0-	120:00	1.5-	120:00	.9-	60:00	.5-	60:00	.0-	7:30
5	4.0-	120:00	1.8-	120:00	2.7-	120:00	.6-	60:00	.0-	8:30
Ave.	>1.7-	60:00	>1.2-	60:00	>1.1-	60:00	>.3-	60:00	.0-	3:25
Antifoam A										
1	0.6-	60:00	0.0-	14:30	0.0-	3:05	0.0-	0:35	0.0-	0:20
2	.8-	60:00	.0-	30:00	.0-	14:00	.0-	<1:30	.0-	:25
3	.9-	60:00	.0-	30:00	.0-	21:50	.0-	1:51	.0-	:40
4	2.0-	120:00	.6-	60:00	.0-	32:30	.0-	8:00	.0-	3:00
5	2.4-	120:00	1.0-	60:00	.0-	34:30	.0-	19:40	---	----
Ave.	>1.7-	60:00	.0-	>39:00	.0-	21:11	.0-	<6:19	.0-	1:06

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[a] If the foam did not breakdown within one hour, the foam height was measured in cm at the time specified.

TABLE 12

Effect of type and concentration of silicone antifoam agents on the foam breakdown time of reconstituted nonfat milk at 90°F

	Antifoam AF Emulsion									
	Active antifoam (ppm)									
	0		5		10		20		50	
Trial No.	Foam[a] (cm)	Time (min: sec)	Foam[a] (cm)	Time (min: sec)	Foam[a] (cm)	Time (min: sec)	Foam[a] (cm)	Time (min: sec)	Foam[a] (cm)	Time (min: sec)
1	0.7-	60:00	0.0-	0:25	0.0-	0:22	0.0-	0:17	0.0-	0:04
2	.9-	60:00	.0-	:29	.0-	:30	.0-	:25	.0-	:05
3	1.0-	60:00	.0-	1:30	.0-	:43	.0-	:27	.0-	:08
4	1.2-	60:00	.0-	2:30	.0-	:48	.0-	:30	.0-	:20
5	1.4-	60:00	.0-	4:25	.0-	1:10	.0-	:40	.0-	:35
Ave.	1.0-	60:00	.0-	1:52	.0-	:43	.0-	:28	.0-	:14
	Antifoam B									
1	0.7-	60:00	0.0-	50:30	0.0-	1:30	0.0-	0:10	0.0-	<0:05
2	.9-	60:00	.0-	53:30	.0-	5:30	.0-	:10	.0-	<:05
3	1.0-	60:00	.6-	60:00	.0-	6:20	.0-	:10	.0-	<:05
4	1.2-	60:00	.6-	60:00	.0-	30:50	.0-	:50	.0-	<:05
5	1.4-	60:00	---	------	.0-	34:45	.0-	1:30	.0-	:08
Ave.	1.0-	60:00	.0-	>60:00	.0-	15:59	.0-	:34	.0-	<:05
	Antifoam A									
1	0.7-	60:00	0.0-	3:15	0.0-	17:00	0.0-	1:20	0.0-	0:13
2	.9-	60:00	.0-	7:15	.0-	24:00	.0-	1:30	.0-	:17
3	1.0-	60:00	.0-	26:00	.0-	24:30	.0-	1:30	.0-	:19
4	1.2-	60:00	.0-	27:00	.5-	60:00	.0-	1:35	.0-	:25
5	1.4-	60:00	.9-	60:00	.5-	60:00	---	----	.0-	1:10
Ave.	1.0-	60:00	.0-	>25:00	.0-	>37:00	.0-	1:29	.0-	:29

[a] If the foam did not breakdwon within one hour, the foam height was measured in cm at the time specified.

TABLE 13

Effect of type and concentration of silicone antifoam agents on the foam breakdown time of reconstituted nonfat milk at 120°F

Trial No.	Active antifoam (ppm)									
	0		5		10		20		50	
	Foam[a] (cm)	Time (min: sec)	Foam[a] (cm)	Time (min: sec)	Foam[a] (cm)	Time (min: sec)	Foam[a] (cm)	Time (min: sec)	Foam[a] (cm)	Time (min: sec)
Antifoam AF Emulsion										
1	0.5-	60:00	0.0-	0:17	0.0-	0:11	0.0-	<0:05	0.0-	<0:05
2	1.4-	60:00	.0-	:17	.0-	:12	.0-	:07	.0-	<:05
3	1.5-	60:00	.0-	:28	.0-	:12	.0-	:07	.0-	<:05
4	1.5-	60:00	.0-	:30	.0-	:13	.0-	:08	.0-	<:05
5	1.9-	60:00	.0-	:30	.0-	:15	.0-	:11	.0-	<:05
Ave.	1.4-	60:00	.0-	:24	.0-	:13	.0-	:08	.0-	<:05
Antifoam B										
1	0.5-	60:00	0.0-	0:12	0.0-	0:08	0.0-	<0:05	0.0-	<0:05
2	1.4-	60:00	.0-	:25	.0-	:08	.0-	<:05	.0-	<:05
3	1.5-	60:00	.0-	:30	.0-	:09	.0-	<:05	.0-	<:05
4	1.5-	60:00	.0-	:30	.0-	:09	.0-	<:05	.0-	<:05
5	1.9-	60:00	.0-	:30	.0-	:10	.0-	<:05	.0-	<:05
Ave.	1.4-	60:00	.0-	:25	.0-	:09	.0-	<:05	.0-	<:05
Antifoam A										
1	0.5-	60:00	0.0-	1:55	0.0-	0:23	0.0-	0:10	0.0-	0:11
2	1.4-	60:00	.0-	3:30	.0-	:25	.0-	:18	.0-	:14
3	1.5-	60:00	.0-	4:00	.0-	:35	.0-	:25	.0-	:15
4	1.5-	60:00	.0-	13:15	.0-	1:15	.0-	:30	.0-	:17
5	1.9-	60:00	.0-	17:30	.0-	1:30	.0-	:45	.0-	:35
Ave.	1.4-	60:00	.0-	8:02	.0-	:50	.0-	:26	.0-	:18

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[a] If the foam did not breakdown within one hour, the foam height was measured in cm at the time specified.

TABLE 14

Effect of type and concentration of silicone antifoam agents on the foam breakdown time of skim milk at 32°F

Antifoam AF Emulsion

Trial No.	Active antifoam (ppm)									
	0		10		20		40		50	
	Foam[a] (cm)	Time (min: sec)	Foam[a] (cm)	Time (min: sec)	Foam[a] (cm)	Time (min: sec)	Foam[a] (cm)	Time (min: sec)	Foam[a] (cm)	Time (min: sec)
1	0.0-	4:50	0.0-	4:20	0.0-	2:30	0.0-	2:10	0.0-	0:30
2	.0-	5:00	.0-	4:40	.0-	2:40	.0-	2:30	.0-	:40
3	.0-	5:30	.0-	4:50	.0-	2:40	.0-	2:50	.0-	1:00
4	.0-	5:30	.0-	5:10	.0-	3:40	.0-	3:00	.0-	1:10
5	.0-	5:30	.0-	5:20	.0-	4:10	.0-	3:30	.0-	1:10
Ave.	.0-	5:16	.0-	4:52	.0-	3:08	.0-	2:48	.0-	:54

Antifoam B

	Active antifoam (ppm)									
	0		5		10		20		50	
1	0.0-	4:50	0.0-	4:40	0.0-	5:20	0.0-	3:50	0.0-	4:00
2	.0-	5:00	.0-	5:00	.0-	5:50	.0-	4:00	.0-	4:20
3	.0-	5:30	.0-	5:10	.0-	<6:10	.0-	4:30	.0-	4:20
4	.0-	5:30	.0-	5:20	.0-	<6:10	.0-	5:00	.0-	4:40
5	.0-	5:30	.0-	5:40	.0-	<7:10	.0-	5:00	.0-	4:50
Ave.	.0-	5:16	.0-	5:10	.0-	<6:08	.0-	4:28	.0-	4:26

Antifoam A

1	0.0-	4:50	0.0-	4:20	0.0-	3:50	0.0-	3:10	0.0-	2:10
2	.0-	5:00	.0-	5:00	.0-	4:20	.0-	3:40	.0-	3:10
3	.0-	5:30	.0-	5:20	.0-	4:20	.0-	3:40	.0-	3:40
4	.0-	5:30	.0-	5:20	.0-	4:30	.0-	3:40	.0-	3:40
5	.0-	5:30	.0-	5:50	.0-	5:00	.0-	4:00	.0-	3:40
Ave.	.0-	5:16	.0-	5:10	.0-	4:24	.0-	3:38	.0-	3:16

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[a] If the foam did not breakdown within one hour, the foam height was measured in cm at the time specified.

TABLE 15

Effect of type and concentration of silicone antifoam agents on the foam breakdown time of skim milk at 60°F

Antifoam AF Emulsion										
	Active antifoam (ppm)									
Trial No.	0		5		10		20		50	
	Foam[a] (cm)	Time (min: sec)	Foam[a] (cm)	Time (min: sec)	Foam[a] (cm)	Time (min: sec)	Foam[a] (cm)	Time (min: sec)	Foam[a] (cm)	Time (min: sec)
1	0.0-	1:30	0.0-	0:25	0.0-	0:24	0.0-	0:16	0.0-	0:10
2	.0-	2:00	.0-	:25	.0-	:25	.0-	:20	.0-	:10
3	.0-	2:00	.0-	:29	.0-	:35	.0-	:21	.0-	:13
4	.0-	2:10	.0-	1:00	.0-	1:00	.0-	:25	.0-	:20
5	.0-	2:10	.0-	<2:20	.0-	1:55	.0-	:35	.0-	1:20
Ave.	.0-	1:58	.0-	<:56	.0-	:52	.0-	:23	.0-	:27
Antifoam B										
1	0.0-	1:30	0.0-	1:30	0.0-	0:40	0.0-	0:30	0.0-	0:15
2	.0-	2:00	.0-	1:30	.0-	1:10	.0-	:40	.0-	:20
3	.0-	2:00	.0-	1:40	.0-	1:15	.0-	:45	.0-	:25
4	.0-	2:10	.0-	1:50	.0-	2:00	.0-	:45	.0-	:30
5	.0-	2:10	.0-	<2:00	.0-	2:30	.0-	:50	.0-	:35
Ave.	.0-	1:58	.0-	<1:42	.0-	1:31	.0-	:42	.0-	:25
Antifoam A										
1	0.0-	1:30	0.0-	<1:30	0.0-	0:39	0.0-	0:36	0.0-	0:10
2	.0-	2:00	.0-	1:33	.0-	:48	.0-	:45	.0-	:17
3	.0-	2:00	.0-	1:42	.0-	1:05	.0-	1:00	.0-	:22
4	.0-	2:10	.0-	1:50	.0-	1:39	.0-	1:30	.0-	:30
5	.0-	2:10	.0-	2:20	.0-	2:00	---	---	.0-	1:20
Ave.	.0-	1:58	.0-	<1:47	.0-	1:14	.0-	:58	.0-	:32

[a] If the foam did not breakdown within one hour, the foam height was measured in cm at the time specified.

TABLE 16

Effect of type and concentration of silicone antifoam agents on the foam breakdown time of skim milk at 90°F

Trial No.	Active antifoam (ppm)									
	0		5		10		20		50	
	Foam[a] (cm)	Time (min: sec)	Foam[a] (cm)	Time (min: sec)	Foam[a] (cm)	Time (min: sec)	Foam[a] (cm)	Time (min: sec)	Foam[a] (cm)	Time (min: sec)
	Antifoam AF Emulsion									
1	0.0-	6:30	0.0-	0:18	0.0-	0:15	0.0-	0:07	0.0-	<0:05
2	.0-	6:30	.0-	:29	.0-	:19	.0-	:07	.0-	<:05
3	.0-	6:30	.0-	:35	.0-	:24	.0-	:07	.0-	<:05
4	.0-	7:15	.0-	:38	.0-	:25	.0-	:09	.0-	<:05
5	.0-	8:15	.0-	:55	.0-	:33	.0-	:11	.0-	:05
Ave.	.0-	7:00	.0-	:35	.0-	:23	.0-	:08	.0-	<:05
	Antifoam B									
1	0.0-	6:30	0.0-	1:15	0.0-	0:15	0.0-	<0:05	0.0-	<0:05
2	.0-	6:30	.0-	<1:45	.0-	:27	.0-	<:05	.0-	<:05
3	.0-	6:30	.0-	1:45	.0-	:30	.0-	<:05	.0-	<:05
4	.0-	7:15	.0-	1:50	.0-	:50	.0-	:10	.0-	<:05
5	.0-	8:15	---	----	.0-	:50	.0-	:10	.0-	<:05
Ave.	.0-	7:00	.0-	<1:39	.0-	:34	.0-	<:07	.0-	<:05
	Antifoam A									
1	0.0-	6:30	0.0-	0:59	0.0-	0:57	0.0-	0:20	0.0-	0:07
2	.0-	6:30	.0-	1:18	.0-	1:30	.0-	:50	.0-	:09
3	.0-	6:30	.0-	1:30	.0-	3:15	.0-	1:25	.0-	:10
4	.0-	7:15	.0-	3:30	.0-	7:30	.0-	1:30	.0-	:11
5	.0-	8:15	.0-	6:00	.0-	9:00	---	----	.0-	:20
Ave.	.0-	7:00	.0-	2:38	.0-	4:26	.0-	1:01	.0-	:11

[a] If the foam did not breakdown within one hour, the foam height was measured in cm at the time specified.

TABLE 17

Effect of type and concentration of silicone antifoam agents on the foam breakdown time of skim milk at 120°F

Trial No.	Active antifoam (ppm)									
	0		5		10		20		50	
	Foam[a] (cm)	Time (min: sec)	Foam[a] (cm)	Time (min: sec)	Foam[a] (cm)	Time (min: sec)	Foam[a] (cm)	Time (min: sec)	Foam[a] (cm)	Time (min: sec)
Antifoam AF Emulsion										
1	0.9-	60:00	0.0-	0:06	0.0-	0:07	0.0-	<0:05	0.0-	<0:05
2	.9-	60:00	.0-	:08	.0-	:08	.0-	<:05	.0-	<:05
3	1.8-	60:00	.0-	:10	.0-	:10	.0-	<:05	.0-	<:05
4	1.8-	60:00	.0-	:11	.0-	:10	.0-	<:05	.0-	<:05
5	1.9-	60:00	.0-	1:30	.0-	:10	.0-	:07	.0-	<:05
Ave.	1.5-	60:00	.0-	:25	.0-	:09	.0-	<:05	.0-	<:05
Antifoam B										
1	0.9-	60:00	0.0-	0:10	0.0-	<0:05	0.0-	<0:05	0.0-	<0:05
2	.9-	60:00	.0-	:13	.0-	:05	.0-	<:05	.0-	<:05
3	1.8-	60:00	.0-	:15	.0-	:07	.0-	<:05	.0-	<:05
4	1.8-	60:00	.0-	:25	.0-	:07	.0-	<:05	.0-	<:05
5	1.9-	60:00	.0-	<:30	.0-	:08	.0-	<:05	.0-	<:05
Ave.	1.5-	60:00	.0-	<:18	.0-	<:06	.0-	<:05	.0-	<:05
Antifoam A										
1	0.9-	60:00	0.0-	0:20	0.0-	0:08	0.0-	<0:05	0.0-	0:05
2	.9-	60:00	.0-	:40	.0-	:10	.0-	:07	.0-	:08
3	1.8-	60:00	.0-	5:30	.0-	:16	.0-	:10	.0-	:08
4	1.8-	60:00	.0-	6:30	.0-	:21	.0-	:10	.0-	:10
5	1.9-	60:00	.0-	12:55	.0-	:22	.0-	:20	.0-	:11
Ave.	1.5-	60:00	.0-	5:11	.0-	:15	.0-	:10	.0-	:08

[a] If the foam did not breakdown within one hour, the foam height was measured in cm at the time specified.

TABLE 18

Effect of type and concentration of silicone antifoam agents on the foam breakdown time of homogenized milk at 32°F

	Antifoam AF Emulsion									
	Active Antifoam (ppm)									
Trial No.	0		10		20		40		50	
	Foam[a] (cm)	Time (min: sec)	Foam[a] (cm)	Time (min: sec)	Foam[a] (cm)	Time (min: sec)	Foam[a] (cm)	Time (min: sec)	Foam[a] (cm)	Time (min: sec)
1	0.0-	16:30	0.0-	14:50	0.0-	8:10	0.0-	8:00	0.0-	1:20
2	.0-	17:00	.0-	15:00	.0-	15:20	.0-	8:50	.0-	1:30
3	.0-	18:00	.0-	15:40	.0-	16:40	.0-	13:00	.0-	1:40
4	.0-	18:10	.0-	15:50	.0-	17:40	.0-	14:20	.0-	1:50
5	.0-	18:30	.0-	16:00	.0-	17:40	.0-	16:20	.0-	2:10
Ave.	.0-	17:38	.0-	15:28	.0-	15:06	.0-	11:02	.0-	1:42
	Antifoam B									
	Active antifoam (ppm)									
	0		5		10		20		50	
1	0.0-	16:30	0.0-	17:20	0.0-	16:20	0.0-	17:10	0.0-	17:50
2	.0-	17:00	.0-	18:30	.0-	17:40	.0-	18:00	.0-	18:10
3	.0-	18:00	.0-	18:50	.0-	18:50	.0-	19:10	.0-	18:30
4	.0-	18:10	.0-	18:50	.0-	20:10	.0-	19:40	.0-	18:50
5	.0-	18:30	.0-	20:30	.0-	21:40	.0-	20:40	.0-	19:10
Ave.	.0-	17:38	.0-	18:48	.0-	18:56	.0-	18:56	.0-	18:30
	Antifoam A									
1	0.0-	16:30	0.0-	14:00	0.0-	16:00	0.0-	9:20	0.0-	5:10
2	.0-	17:00	.0-	14:40	.0-	18:10	.0-	11:20	.0-	10:00
3	.0-	18:00	.0-	15:20	.0-	18:20	.0-	12:40	.0-	11:10
4	.0-	18:10	.0-	16:00	.0-	18:40	.0-	14:30	.0-	12:00
5	.0-	18:30	.0-	18:50	.0-	19:30	.0-	16:30	.0-	13:00
Ave.	.0-	17:38	.0-	15:46	.0-	18:08	.0-	12:52	.0-	10:16

[a] If the foam did not breakdown within one hour, the foam height was measured in cm at the time specified.

TABLE 19

Effect of type and concentration of silicone antifoam agents on the foam breakdown time of homogenized milk at 60°F

Trial No.	Active antifoam (ppm) 0		5		10		20		50	
	Foam[a] (cm)	Time (min: sec)	Foam[a] (cm)	Time (min: sec)	Foam[a] (cm)	Time (min: sec)	Foam[a] (cm)	Time (min: sec)	Foam[a] (cm)	Time (min: sec)
Antifoam AF Emulsion										
1	0.0-	0:10	0.0-	0:12	0.0-	0:10	0.0-	0:10	0.0-	0:06
2	.0-	:10	.0-	:12	———	———	.0-	:10	.0-	:07
Ave.	.0-	:10	.0-	:12	.0-	:10	.0-	:10	.0-	:07
Antifoam B										
1	0.0-	0:10	0.0-	<0:10	0.0-	0:15	0.0-	0:06	0.0-	0:07
2	.0-	:10	.0-	:10	.0-	:17	.0-	:08	.0-	:08
Ave.	.0-	:10	.0-	<:10	.0-	:16	.0-	:07	.0-	:08
Antifoam A										
1	0.0-	0:10	0.0-	0:14	0.0-	0:13	0.0-	0:12	0.0-	0:09
2	.0-	:10	.0-	:15	.0-	:14	.0-	:14	.0-	:11
Ave.	.0-	:10	.0-	:15	.0-	:14	.0-	:13	.0-	:10

[a] If the foam did not breakdown within one hour, the foam height was measured in cm at the time specified.

TABLE 20

Effect of type and concentration of silicone antifoam agents on the foam breakdown time of homogenized milk at 120°F

Antifoam AF Emulsion

Active antifoam (ppm)

Trial No.	0		5		10		20		50	
	Foam[a] (cm)	Time (min: sec)	Foam[a] (cm)	Time (min: sec)	Foam[a] (cm)	Time (min: sec)	Foam[a] (cm)	Time (min: sec)	Foam[a] (cm)	Time (min: sec)
1	0.6-	60:00	0.0-	0:07	0.0-	0:07	0.0-	<0:05	0.0-	<0:05
2	.6-	60:00	.0-	:07	.0-	:07	.0-	<:05	.0-	<:05
3	.8-	60:00	.0-	:08	.0-	:08	.0-	<:05	.0-	<:05
4	.8-	60:00	.0-	:20	.0-	:10	.0-	<:05	.0-	<:05
5	.9-	60:00	.0-	1:15	.0-	:30	.0-	:11	.0-	<:05
Ave.	.7-	60:00	.0-	:23	.0-	:12	.0-	<:06	.0-	<:05
Antifoam B										
1	0.6-	60:00	0.0-	0:09	0.0-	<0:05	0.0-	<0:05	0.0-	<0:05
2	.6-	60:00	.0-	:17	.0-	:05	.0-	<:05	.0-	<:05
3	.8-	60:00	.0-	:20	.0-	:05	.0-	<:05	.0-	<:05
4	.8-	60:00	.0-	<:30	.0-	:08	.0-	<:05	.0-	<:05
5	.9-	60:00	.0-	:30	.0-	:09	---	---	.0-	<:05
Ave.	.7-	60:00	.0-	<:21	.0-	:06	.0-	<:05	.0-	<:05
Antifoam A										
1	0.6-	60:00	0.0-	0:06	0.0-	0:05	0.0-	<0:05	0.0-	<0:05
2	.6-	60:00	.0-	:10	.0-	:05	.0-	<:05	.0-	<:05
3	.8-	60:00	.0-	:35	.0-	:35	.0-	:40	---	---
4	.8-	60:00	.0-	1:38	.0-	:55	.0-	:50	---	---
5	.9-	60:00	.0-	2:55	.0-	1:10	.0-	1:30	---	---
Ave.	.7-	60:00	.0-	1:05	.0-	:34	.0-	:37	.0-	<:05

[a] If the foam did not breakdown within one hour, the foam height was measured in cm at the time specified.

TABLE 21

Effect of Antifoam AF Emulsion on homogenized milk foam produced in a commercial 10-gallon can filling operation

Can No.	Control milk			Milk treated with 27.5 ppm Antifoam AF Emulsion		
	Time for 1st foam (sec)	Can filling time (sec)	Foam height (inches)	Time for 1st foam (sec)	Can Filling time (sec)	Foam height (inches)
1	7.0	32	7.5	7.5	30	6.0
2	8.0	33	7.3	8.0	30	6.0
3	8.0	33	7.2	7.5	31	6.0
4	8.0	34	7.5	8.0	30	6.0
5	8.0	33	7.5	7.5	31	6.0
6	7.5	34	7.3	7.5	30	6.0
7	8.0	34	7.4	8.0	31	6.0
8	8.0	34	7.2	8.0	31	6.0
9	8.0	34	7.3	8.0	32	6.0
10	8.0	35	7.3	7.5	31	6.0
11	8.0	35	7.5	8.0	31	6.0
12	8.0	34	7.3	8.0	32	6.0
13	8.0	34	7.4	8.0	32	6.0
14	8.0	33	7.2	8.0	31	6.0
15	8.0	34	7.4	8.0	32	6.2
16	8.0	33	7.3	8.0	33	6.5
17	8.0	34	7.3	8.0	33	6.0
18	8.0	33	7.2	7.5	34	6.3
19	8.0	34	7.3	8.0	33	6.0
20	7.0	33	6.8	8.0	33	6.0
21	8.0	33	7.2	8.0	34	6.0
22	8.0	34	7.2			
23	8.0	34	7.3			
Ave.	7.87	33.7	7.3	7.86	31.7	6.1

TABLE 22

Photolometer readings of glass slide Set No. 1 after successive soil and wash trials

Trial No.	Photolometer readings				
	Slipicone	Z-4141	200 Fluid 100 cs	200 Fluid 1000 cs	Control
1	100.8	100.0	100.0	99.6	99.5
2	100.1	100.0	100.0	99.9	99.5
3	100.3	100.0	100.0	100.0	100.0
4	101.0	99.8	100.0	100.0	100.9
5	100.8	99.5	100.5	100.5	99.6
6	100.0	99.4	100.0	100.0	99.8
7	100.6	99.9	100.4	100.1	98.4
8	100.3	99.6	100.3	100.0	97.4
9	100.4	100.1	100.6	100.0	97.8
10	100.5	100.3	100.5	99.0	97.5
11	100.4	99.8	99.8	98.0	96.4
12	100.6	99.5	99.9	98.4	96.5
13	100.3	98.9	99.3	97.8	96.3
14	100.3	99.0	99.5	97.8	94.9
15	100.0	99.0	99.5	97.5	94.0

TABLE 23

Photolometer readings of glass slide Set No. 2 after successive soil and wash trials

Trial No.	Photolometer readings				
	Slipicone	Z-4141	200 Fluid 100 cs	200 Fluid 1000 cs	Control
1	100.5	99.5	100.0	100.0	100.0
2	101.0	100.0	100.0	100.0	99.5
3	100.8	100.0	100.0	100.0	99.8
4	100.5	100.1	100.0	100.3	99.5
5	100.8	100.5	100.1	100.1	98.4
6	100.4	100.5	100.0	100.4	98.1
7	100.8	100.3	100.3	100.0	98.0
8	100.5	100.4	100.5	100.5	96.5
9	100.5	100.1	100.3	100.4	97.4
10	100.4	100.1	100.6	99.9	96.5
11	100.0	99.9	100.4	99.4	95.8
12	100.1	99.6	99.4	99.1	95.5
13	100.0	99.4	99.6	99.3	93.0
14	100.5	98.5	99.1	99.0	97.5
15	99.8	96.0	98.0	97.4	96.0