DAIRY PLANT

FIELDMAN, HAULER,

GRADER & TESTER'S

MANUAL

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PURPOSE

This publication is designed as a reference manual for fieldmen, haulers, graders, and testers. Knowledge of the problems encountered in the various areas of work may help promote cooperation in carrying out the important function served by each.

COMPOSITION OF MILK

To understand the problems which confront the fieldman, grader, and tester it is necessary to know the composition of milk. Below is a gross breakdown of major constituents and the approximate percentage in which they are found in milk:

Constituent	Percent
Water	87.0
Butterfat	4.0
Casein	2.8
Whey Proteins	0.7
Milk Sugar (Lactose)	4.8
Ash*	0.7
TOTAL	100.0

*Ash is the mineral matter which remains after charring.

TOTAL SOLIDS include everything except water. *Total protein* includes casein and whey proteins. The *solids not fat* are the constituents other than butterfat and water. Butterfat normally shows the greatest variation, protein content varies somewhat less, and lactose and minerals vary the least of all milk constituents. Changes in lactose content usually are compensated by changes in mineral content, i.e. increases in lactose will be followed by decreases in minerals and vice versa.

LAWS AND REGULATIONS

Grade "A" raw and pasteurized milk products are regulated under the Grade "A" Pasteurized Milk Ordinance, United States Department of Health and Human Services, Public Health Service, Federal Food and Drug Administration. Missouri adopts the Grade "A" Pasteurized Milk Ordinance and administers the program as such. Manufactured milk and manufactured dairy products are regulated under the Milk for Manufacturing Purposes and its Production and Processing, Recommended Requirements, United States Department of Agriculture, Agriculture Marketing Service, Dairy Programs. Missouri adopts the Milk for Manufacturing Purposes and its Production and Processing and administers the program as such.
Any person wishing to haul milk in bulk, or grade, sample, or test milk is required, by law, to obtain a license to perform this work.

All private, municipal, and industrial laboratory work must be done in compliance with grade "A raw milk standards and must be performed in laboratories certified by the regulatory authority

BACTERIOLOGY

Definition
Bacteria are small, one-celled plants. They range in size from 1/75,000 to 1/10,000 of an inch in diameter, from 1/25,000 to 1/10,000 of an inch in length. Each cell is capable of reproduction within itself.

Useful Action
Certain bacteria are used in manufacture of cultured dairy products and cheeses. They form desirable flavor compounds and change milk consistency.

Undesirable Action
Many bacteria cause spoilage of foods creating serious economic losses. Other bacteria, some of which may be carried in milk, can cause illness in man.

Appearance under the Microscope
Most bacteria encountered in the dairy industry will be rod-shape or round. Round bacteria are referred to as coccus (plural cocci). They are found singly or grouped characteristically:

1. Micrococcus – occur singly or in irregular groups
2. Staphylococcus – irregular, grape-like clusters.
3. Streptococcus – found in chains
4. Sarcina – occur as cubical packets of eight

Requirements of Bacterial Growth
Most conditions under which bacteria grow and multiply are similar to those needed for human survival. Bacteria must have:

WATER. Therefore, if milk handling and storage equipment is stored drained and dry, bacteria levels do not increase between milkings.

FOOD. Milk is an excellent source of many nutrients needed by bacteria. Removal of milk solids during cleaning helps starve them out.

OXYGEN. Some bacteria require oxygen (aerobes); others grow only in its absence (anaerobes). Still others are capable of living with or without oxygen (facultative).

FAVORABLE TEMPERATURE. All bacteria grow best at certain specific temperatures. However, these optimum temperatures differ among species. But no bacteria multiply at a maximum rate at temperatures below 40◦F. So cooling is an effective method for controlling growth.

FAVORABLE pH (acid or alkaline reaction). Bacteria grow best in solutions neither highly acid nor highly alkaline. Milk is slightly acid and favorable for their development.

Types of Bacteria in Milk
One way to classify bacteria is by temperature response. From this knowledge, insight can be obtained about their source and control.

1. THERMOPHILES are heat loving. They can grow even at pasteurization temperatures and readily multiply at 131ºF. Their growth range is 113ºF to 158ºF. You might find thermophilic bacteria in hot water lines or hot water storage tanks. Other sources are soil, bedding, and feeds. Thermophiles may be found in milk following pasteurization, thus contributing to "lab-pasteurized" counts.
2. THERMODURIC bacteria are literally durable to heat, thus thermo(heat)-durics. They survive pasteurization and are reported to producers in pasteurized counts, but do not grow at high temperatures. They cause milk to sour and decrease its shelf life. They are not associated with disease.
   Thermodurics can grow at temperatures between 45ºF and 104ºF. Their primary source is dirty equipment. Old, cracked inflations and milkstone deposits are common sources. During advanced lactation they may be found in the cow's udder.
   Most thermodurics are cocci. Thermodurics are usually a summer problem when warm temperatures permit rapid multiplication. They do not grow at cold temperatures. Clean equipment and cold storage conditions are necessary to control them.
3. MESPHILES grow best at temperatures between 68ºF and 104ºF.
4. PYSCHROPHILES can grow at relatively cold temperatures – even refrigeration temperatures. But they grow much slower at temperatures below 40ºF than at those above. Their best growth rate occurs between 68ºF and 86ºF.
   Off-flavors caused by psychrophiles are bitter, fruity, rancid, stale, and putrid. They also cause a physical defect – ropiness in milk.
   Psychrophiles have become more significant with the advent of bulk handling because milk is held on the farm longer. When contaminated with psychrophiles, opportunity for growth is present.
   Most milk quality tests do not detect psychrophiles because they grow slowly at incubation temperatures normally used for quality evaluation.
   Psychrophiles are found in water supplies. Their numbers increase in water storage tanks, recirculated cooling water, and in tank-type can coolers.
   Rinse water, when used on dairy equipment, should always be sanitized. Add 5 to 10 parts per million of chlorine. Or use an acid rinse. Keep equipment clean and milk rooms ventilated and dry.
   Psychrophiles are usually a raw milk problem. Pasteurization destroys psychrophiles and they get into finished products through post-pasteurization contamination.

Classification of Bacteria According to Reactions Produced

1. ACID PRODUCERS. Many bacteria ferment milk sugar (lactose) to form lactic acid. Most common of these is *Streptococcus lactis. S. lactis* is often used as a culture in the manufacture of various dairy products. It is found naturally occurring in raw milk.
   Lactobacillus species are used in some fermentation processes, but usually are not associated with raw milk quality problems.
   Many other rods and cocci produce acid.

2. ACID AND GAS PRODUCERS. Most notable among bacteria that produce both acid and gas from lactose are the coliform group (Aerobacter and Escherichia). Coliform bacteria have special significance to the dairy industry.
   In water, coliform imply potential contamination from sources known to carry disease. Coliform are present in the intestinal tract of humans and animals and their presences in water indicates possible contamination with fecal material. Disease bacteria originate from the same sources.
   In raw milk, the presence of coliform means either: (1) potential contamination from fecal material or (2) an extremely damaging case of mastitis.
   Major sources of coliform are dirty equipment and the cow's coat. They are present also in barn dust, on cereal grains and hay, and in polluted water.
   In pasteurized milk, the presence of coliform indicates post-pasteurization contamination. Some heat resistant strains have been isolated but their contribution to the coliform count in pasteurized products likely is negligible.
3. PROTEOLYTIC bacteria utilize protein in their growth. Off-flavors that result are bitter or putrid. Some proteolytics are psychrophilic (grow at cold temperatures) and originate in sources known to harbor psychrophiles.
   When equipment is scratched, cleaning and sanitation of the surface is difficult if not impossible. Scratches become a constant source of proteolytics.
   Some bacillus species (anaerobic spore-forming rods) can cause protein breakdown. Usually bacilli are not involved in spoilage problems because they do not grow at refrigeration temperatures. They may contribute to the proteolytic count, however. This means that mere presence of a proteolytic count is not conclusive evidence of a proteolytic problem.
   Clostridium species (anaerobic spore-forming rods) also can digest protein. These bacteria, too, are not usually implicated in off-flavor problems.
4. LIPOLYTIC bacteria can break down butter fat and produce rancid off-flavors (bitter with pungent odor). Most fat breakdown likely occurs as a result of naturally occurring lipase in milk (to be discussed later). In products stored for several days or longer, bacteria may contribute to rancid flavor development. Some lipolytics grow at cold temperatures and are, therefore, particularly undesireable contaminants.
5. SPORES. Some bacteria can form special structures which make them highly resistant to adverse conditions. One bacterial cell forms one spore. Spores resist the killing effect of heat, chemicals, light, and drying.
   Spores are often found in dust. Barns should not be swept just prior to milking.

DISEASES THAT MAY BE SPREAD BY MILK

Cow Disease That Can Be Spread To Man

1. BRUCELLOSIS (Bang's disease). This disease causes abortion in cows. The illness in man is called undulant fever.
   All milk for pasteurization, ultra pasteurization or aseptic processing and packaging shall be from herds under a brucellosis eradication program located in a Certified Brucellosis-Free Area or meet USDA requirements for a Certified Brucellosis-Free Herd. Missouri is a Brucellosis-Free state at publication.

2. Goat, sheep, or any other hooved mammal milk for pasteurization, ultra-pasteurization or aceptic processing and packaging, shall be from a herd or flock that has passed an annual whole herd or flock brucellosis test.
3. BOVINE TUBERCULOSIS. All milk for pasteurization, ultra-pasteurization or aceptic processing and packaging shall be from herds under a tuberculosis eradication program. Missouri is a Tuberculosis-Free state as of publication.
4. Q FEVER. This is a Rickettsia (Coxiella burnetii). The disease infects cows and is transmitted to man through raw milk.
5. CAMPYLOBACTER FETUS. This organism causes abortion in cattle and flu-like symptoms in humans.
6. YERSINIOSIS. *Yersinia enterocolitica* is the microbe that causes this disease. In humans, symptoms of the disease are similar to appendicitis.
7. OTHER INFECTIOUS AGENTS. Many organisms capable of producing abscesses can be spread from cow to man.

Diseases of Man That May Be Spread by Cows

Several disease agents common to man can be transmitted through contaminated milk. They are:

1. TYPHOID AND PARATYPHOID FEVERS (caused by salmonella). Milk must be contaminated with fecal material of an infected man or rodent.
2. SALMONELLA “FOOD POISON” DISEASES. Salmonellae produce a toxin when growing in man. They may be carried in milk. Typical food poisoning symptoms result about 30 hours after intake. This type of illness, though producing similar symptoms, differs from food poisoning caused by *Staphylococcus aureus*. With the latter, a toxin is produced while the organism is growing in a food environment outside man. Eating contaminated food then causes illness much faster.
   In recent years the salmonella problem has become more serious with more cases reported. Both raw milk and finished products can become contaminated with salmonellae; however, pasteurization kills all salmonellae.
   Salmonellae are commonly spread through contaminated feeds. Fowl, cattle, hogs, rodents, insects, humans, domestic pets, wild birds, and animals can serve as carriers. Eggs and egg products are also common sources of contamination, and salmonellae may be present in polluted water.
   Control methods involve:
   a. Strict sanitation.
   b. Positive pasteurization
   c. Prevention of post-pasteurization contamination.
   d. Separation of the milkhouse or milkroom from holding areas for farm animals, poultry, and from feed storage rooms.
   e. Cold storage of milk. Salmonellae can grow at temperatures between 50ºF and 120ºF.
   f. Good insect and rodent control
   g. Salmonella-free cows and milk handlers.
   h. Clean, properly sanitized water supplies.
3. SCARLET FEVER. Streptococcal infections cause scarlet fever.

4. SPETIC SORE THROAT. This is a streptococcal infection.
5. DIPHTHERIA, HUMAN TUBERCULOSIS, POLIOMYELITIS, and possibly other diseases. These may be spread through infected milk.
6. STAPHYLCOCCAL FOOD POISONING. *Staphylococcus aureus,* a bacteria that can cause mastitis, may produce a toxin (poison), if allowed to grow in milk. Although the bacteria are killed by pasteurization, the toxin remains stable and can cause illness.
    a. Conditions favoring growth of *S. aureus*: This organism grows at temperatures between 50ºF and 120ºF and multiplies slowly up to 60◦F. Unlike many bacteria *S. aureus* can grow in high concentrations of sugar or salt (45 percent solids, condensed milk, or up to 10 percent salt).
    b. Controlling growth of *S. aureus:* Staphylococcal mastitis is more prevalent since other competing mastitis organisms (streptococci) have been controlled by antibiotic treatment and because of the ability of staphylococci to develop antibiotic resistance. Therefore, to control staphylococcal infection on farms:
        i. Use mastitis control procedures.
        ii. Sanitize udders before milking.
        iii. Use strip cups, mastitis tests, and/or veterinary service
        iv. Keep equipment clean to prevent spread of the organism and stop growth of those that are present.
        v. Do not sell milk from cows having mastitis.
        vi. Keep milk cold!

Controlling Spread of All Milk Borne Diseases

1. Keep herd healthy. Segregate sick cows and discard their milk.
2. Allow only healthy individuals to work in dairy operations.
3. Keep premises and equipment clean.
4. Cool milk promptly and keep it cold.
5. Pasteurize milk quickly and prevent recontamination after pasteurization.

Killing Bacteria

Bacteria are killed by heat in the form of hot air, hot water, or steam. Effectiveness of kill depends upon time-temperature relationships. At higher temperatures, shorter periods of time are required to kill a given bacteria population.

Sterilization (total kill of all bacteria) requires a temperature of 250ºF for 20 minutes by steam heat. Pressure is required to get steam temperatures this high. This is a wet form of heat. Using dry heat, a temperature of 338ºF for at least one hour is necessary to bring about sterility.

Hot water treatment can be used. For immersion purposes a two-minute exposure at 170ºF is recommended; for flow-through sanitizing, 5 minutes at 170ºF. These are sanitizing treatments which may not necessarily bring about sterility.

Chemical sanitizers are effective bactericides. Sanitizers common to the dairy industry are chlorine, iodine, quaternary ammonium compounds, and acids.

Characteristics of sanitizers vary greatly depending upon their formulation. In general, chlorine sanitizers (hypochlorites) are inactivated by presence of organic matter.

Whenever milk, dirt, or manure gets into a chlorine sanitizer, chlorine is tied up and prevented from working. Prepare a fresh solution when this happens.
A chlorine solution exposed to air dissipates quite rapidly, especially at warm solution temperatures. Sanitizers should not be saved from one milking to the next.
Hypochlorites are fairly effective in hard water.
Iodine sanitizers (iodophors) may be slower acting than hypochlorites. They are quite stable, relatively noncorrosive, and nonchapping to skin. They are often used as udder wash.
Quaternary ammonium sanitizers may be adversely influenced by presence of water hardness compounds, although formulations may be prepared with water hardness control agents. They are generally effective against thermodurics, but less effective than chlorine sanitizers against some psychrophilic and coliform bacteria.
Effectiveness of acid sanitizers may be reduced by water hardness compounds unless acidity is taken to a fairly how level (pH 2.5-3.0). Acids do a good job of sanitizing. Some are used for udder washing.
Efficient and effective sanitization of equipment will result only if *the surface is clean and smooth!* A thin layer of milkstone can protect large numbers of bacteria from sanitizer action.
Factors related to sanitizer action are:

1. CONCENTRATION OF SANITIZER. Generally, stronger solutions kill more rapidly. Under no condition, however, should solutions stronger than those recommended on the label be used. Corrosion may result. Also, contamination of milk with sanitizers may cause off-flavors. In some cases, stronger solutions are *less* effective.
2. DURATION OF EXPOSURE. At label concentration, most sanitizers require about 2 minutes to kill practically all bacteria. On equipment surfaces quick dips are not adequate. The sanitizer must be in contact with every inch of surface to be sanitized for the specified time at any given concentration to be effective.
3. TEMPERATURE OF SOLUTION. Higher temperatures result in faster kill because heat destroys bacteria. Label directions on sanitizers should be followed strictly in this regard. Use of high temperatures when unnecessary can cause corrosion.
4. LEVEL OF BACTERIA POPULATION. The more bacteria present the longer exposure time required for effective sanitization. Clean surfaces, relatively free of bacteria, can be sanitized more efficiently.
5. PRESENCE OF SOIL RESIDUES. Only clean surfaces can be effectively sanitized.

Standards for Sanitizing with Hypochlorites and Iodine (1)

Hypochlorites:

Method of Application	Temperature Range	Minimum Available Chlorine Parts Per Million	Minimum Exposure Time – Minutes	Minimum Residual Chlorine after Exposure Parts Per Million
Circulation	75-90ºF	100	2	50
Spraying	75-90ºF	250	2	50
Fogging		400	2	50
Immersion	75-90ºF	100	2	50

Iodine:

Method of Application	Temperature Range	Minimum Available Chlorine Parts Per Million	Minimum Exposure Time – Minutes	Minimum Residual Chlorine after Exposure Parts Per Million
Circulation	50-70ºF	12	2	5
Spraying	50-70ºF	12	2	5
Fogging*		25	2	5
Immersion	50-70ºF	12	2	5

*Fogging not permitted with compounds containing foaming type wetting agents.

SOURCES OF HIGH BACTERIA COUNTS

The material presented thus far has been concerned with factors related to bacterial quality of milk. Tracking down sources of trouble requires observation of many different aspects of milk production. The following list of sources and causes of high bacteria counts and of abnormal milk is presented as a guide to troubleshooting problem farms.

I. Cow factors that may contribute to high bacteria counts:
   A. Mastitis
   B. Unclipped flanks and udders
   C. Late lactation milk. (Cows should be dried off 60 days before calving.)
   D. Colostrum – early lactation milk. (Milk should not be shipped until five days after calving.)
   E. Dirty teats and udders. (Sanitize teats and udders in warm sanitizer one to two minutes before attaching milking machine.)
   F. Systemic illness or other health problems. Unhealthy cows cause an increase in white blood cell count and other abnormal conditions within the milk.
   G. Mechanical injury of the teat or udder may result in bloody milk.

II. Milk Conditions
   A. Unclean habits of milker
   B. Unclean barn, stable, or milking parlor.
   C. Wet hand milking or stripping

III. Milking Equipment
   A. Conventional Milking (Bucket)
      i. Milker not *completely dismantled* and brush washed after *each milking.*
      ii. Use of rough, cracked, or porous materials (checked inflations), plugs in claws, gaskets, rubber or plastic milk hoses, and air hoses. Replace them and soak and brush clean daily. *Remove air plugs* in milker claw for cleaning.
      iii. Dirty milking machine pails and lids, especially the check valve and milk cock.
      iv. Dirty, sticky pulsators. (Clean them daily.)

v. Dirty vacuum lines of improperly designed and installed vacuum lines.
vi. Dirty carrying pails or open pails without lids (Dirt, dust, and extraneous material readily enter.)
vii. Equipment not stored properly. (It should be stored upside-down for good drainage and drying, preferably on a metal rack.)
viii. Incorrect use of detergents. (Follow label directions. Use cleaning compounds that are compatible with the water supply.)
ix. Unclean pails used in pour-in type water heater.
x. Polluted water supplies.
xi. Use of non-sanitized water in final rinse.
xii. Improper sanitation of equipment.
xiii. Lack of brushes, or brushes of the wrong size for cleaning holes and openings. (Use hard bristled brushes. Never use metal sponges. They scratch equipment surfaces.)
xiv. Inadequate hot water supply for washing and rinsing.

B. Pipeline Milking
i. Improperly installed lines. (Joints must be flush and lines pitched properly for clean-in-place systems. There can be no undrainable sags.)
ii. Worn inflations, gaskets, and milk hoses.
iii. Improper clean-in-place techniques – incorrect use of automatic washing devices and washing materials.
iv. Inadequate amounts of hot water and/or use of detergents which are incompatible with the water supply because of hardness, organic matter, or extreme acid or alkaline reaction.
v. Inadequate sanitization.

IV. Milk Cans and Lids
A. Improperly cleaned – can washer not functioning correctly; cans left dirty or wet.
B. Development of rust or dents or open seams.
C. Improper storage – not drained and completely dried.
D. Improper sanitization at the farm.

V. Bulk Tanks
A. Unclean interior, valves, lids, bridge, measuring stick.
B. Unsanitized or improperly sanitized.
C. Wrong vacuum attachment on vacuum tanks. (Use stainless steel line sloped away from lid toward a glass trap jar attached to vacuum line.)
D. Circulator or compressor not turned on at each milking.
E. Power failure.

VI. Cooling
   A. Low water level in can cooler. Be sure level is high as or higher than milk level in cans.
   B. Inadequate cooling. Milk temperature above 40°F
   C. Unsanitary hand agitation of milk in cans.
   D. Inadequate can cooling capacity
   E. Improper operation of bulk tank or can cooler.
   F. Plugged spray heads.
   G. Milk held more than two days on the farm.
   H. Improper ice water circulation.
      i. Clogged headers in spray tanks.
      ii. Failure in pump priming.
      iii. Failure of water circulator.

VII. Strip Cups
   A. Not used on every cow every milking.
   B. Foremilk not discarded (low fat, high bacteria count milk).
   C. Abnormal milk not noted.

VIII. Udder Washing
   A. Wash cloths not washed and sterilized after each use.
   B. Use of wash cloths on more than one cow. Preferably use *single service* disposable towels.
   C. Unclean or rusty pail for wash solution.
   D. Unclean wash water.
   E. No sanitizer in wash solutions.
      Note: Presence of dirt in sanitizer solutions may destroy their effectiveness.

IX. Milk Storage on Farm
   A. Milk not entirely removed from tank, thus making it impossible to wash the tank.
   B. Too small tank resulting in the use of unclean containers to store excess milk.

MASTITIS

Cows which show evidence of the secretion of abnormal milk in one or more quarters, based upon bacteriological, chemical, or physical examination, shall be milked last or with separate equipment; and the milk shall be discarded. Cows treated with, or cows which have consumed chemical, medicinal or radioactive agents which are capable of being secreted in the milk and which, in the judgment of the health authority, may be deleterious to human health, shall be milked last or with separate equipment, and the milk disposed of as the health authority may direct.

Changes in Milk Composition

Mastitis usually decreases the lactose and potassium and increases the sodium chloride in milk.

Because of the increased chloride, a chloride determination has been suggested to detect mastitis. However, cows with "normal" chloride content have frequently been noted suffering from mastitis, so chloride determination is not a very reliable method of diagnosing mastitis.

Mastitis causes an increase in some whey proteins and a decrease in casein. Casein level seldom varies until blood cell counts approach 1,000,000/ml. Normally the count runs less than 500,000/ml.

Fat tests may vary during a case of mastitis but the change is not consistent.

Solids-not-fat may decrease, but the extent of decrease depends upon how much the increases in whey protein compensate for the decreases in casein.

In general, it is difficult, if not impossible, to relate mastitis to a change in milk composition. Some pathogens cause very little udder damage.

Stages of Mastitis

1. ACUTE MASTITIS is easy to recognize. The udder is hard and hot, and stringy or watery milk is often produced. Milk production drops rapidly.

2. CHRONIC MASTITIS is a low-grade infection. Symptoms are difficult to recognize. Routine farm tests for mastitis are helpful in uncovering this problem. Though not readily observed, chronic mastitis does much damage to udders and is very costly is terms of losses in milk production.

3. SUBCLINICAL MASTITIS can be detected only by rather involved laboratory techniques. Disease bacteria are present but relatively inactive. They may flare up at any time into more serious stages of mastitis. Milk losses are not too great with subclinical mastitis, but recognition and treatment are desirable.

Agents Causing Mastitis

Over 20 different organisms including pathogenic yeasts, have been identified as causing mastitis. Bacteria most commonly associated with mastitis include four major groups:

1. STREPTOCOCCUS AGALACTIAE. These round bacteria occur in chains. They are spread easily during milking but, treatment is available to effectively control them. They live within the udder and are a herd problem.

2. OTHER STREPTOCOCCI. This group is present in the cow's environment at all times. They can live within or outside the udder and are a constant mastitis hazard although they account for fewer cases of mastitis than S. agalactiae.

3. STAPHYLOCOCCI. These bacteria are involved in more mastitis cases than perhaps any other group. They are much more common today than they were in years past. While Streptococci infections can be controlled reasonably well, their control prepares the way for Staphylococci infection. These bacteria often gain a foothold during periods of udder stress. Udder injury or repeated minor stresses as a result of poor milking practices permit them to develop within the udder. They are found both inside the udder and in the cow's environment.

4. BACILLI. This group is involved in a relatively small fraction of mastitis cases. They are present in the cow's surroundings. They do not respond well to treatment. Good sanitation is necessary to control them.

It is important to note that the majority of mastitis cases are chronic or subclinical. Although these are not readily apparent from visual observation or "feel" of the udder, losses in milk are great. A good mastitis control program is a must. Several considerations are important in mastitis control. None can be slighted without greatly increasing the possibility of mastitis occurring. Mastitis control requires:

A. Clean and sanitary milking equipment. Diseases such as mastitis are spread mechanically. A contaminated milking unit can spread mastitis to every cow milked with it.

B. Properly maintained equipment. To prevent stress on the udder, keep equipment in good repair.

C. Good milking techniques. Clean equipment which is in good repair will not control mastitis to any great extent if milking practices are poor. Cows must be prepared for milking. Wash udders in warm sanitizer solution. Get machines on within one or two minutes. Carefully observe units and get them off *as soon as cows are milked out. Don't* use more milking units than you can effectively handle.

D. Following milking use approved teats dip and apply to each teat.

TESTS FOR MASTITIS

Tests for mastitis can be grouped in two categories – those that may be used routinely and offer presumptive evidence of mastitis, and those used to isolate causative organisms. The latter involves culturing techniques and rather sophisticated procedures. They account for the high cost of detailed mastitis diagnosis and treatment. Several methods have been developed for routine testing. One of these screening methods must be run on each producer's grade "A" milk supply at the same frequency as for bacteria counts. The methods are as follows:

Whiteside Test

The Whiteside Test involves mixing 2 drops of 4 percent sodium hydroxide with 5 drops of milk on a glass plate, stirring for 20 seconds and noting the degree of coagulation. Negative samples appear similar to normal milk. Positive samples vary from a slight curdling to a thick sticky mass and are graded 1, 2, or 3 depending upon the extent of coagulation.

Whiteside Test reaction is thought to be due to the combined effects of calcium and white blood cells.

The Whiteside Test has been suggested for use on bulk milk for cheese making. Renetting time for negative Whiteside milk is about 7 minutes 40 seconds; for weakly positive milk, 8 minutes 40 seconds; and for strong positive, 10 minutes 20 seconds.

The Whiteside Test has been compared with the California Mastitis Test (CMT) on can milk. Whiteside Test showed a larger number of negative results on milk with a high cell counts. CMT yielded a larger number of positive tests on milk of low cell count.

Percent agreement between Whiteside results and actual bacterial examination has been found by one investigation to be: 89.2 percent for individual quarters, 82.0 percent for individual cows, and 65.2 percent for can samples.

A comparison of the cell count with Whiteside Test indicates the following general relationships:

1. Less than 80,000 cells/ml – 88 percent of Whiteside examinations can be expected to be *negative.*
2. 300,000 to 1,000,000 cells/ml – 38 percent of Whiteside Tests will be *negative.*
3. Over 1,000,000 cells/ml – 83 percent of Whiteside Tests show *positive* for mastitis.

California Mastitis Test

This test is performed by mixing equal amounts of CMT reagent and milk on a plastic paddle. Formation of a gel (thought to be a white blood cell-protein complex) is considered a positive reaction. The test reagent is a detergent. Several different detergents have been used with somewhat varying results.

CMT has been correlated with changes in milk yield of Holstein cows. Those cows having CMT's of trace, 1, 2, and 3 showed 6-, 10-, 16-, and 24.59- percent loss in milk yield respectively compared with cows having negative CMT's.

The following table indicates the relationship between CMT, catalase and chlorides on *quarter* milk samples. This relationship likely would be different on individual cow or herd milk samples:

CMT	% samples with reading over 40 by catalase test	Percent chlorides less than 0.11 percent
-	1.6	78.7
±	13.5	43.0
1	52.5	41.6
2	64.5	20.0
3	86.8	0

It should be noted that any attempt to correlate results of two or more different tests must take into account the kind of samples, whether quarter or individual cow, or herd milk, can or bulk. Relationships may vary between different types of samples.

In one experiment 2,428 can milk samples from 943 farms were analyzed by CMT, microscopic examination, and cultural tests. CMT detected 86.4 percent of samples showing positive by the latter two procedures. CMT also gave 29.8 percent false positive readings.

CMT may give false positive readings on milk from cows up to 3 or 4 days after calving. Also cows that are being milked once per day during late lactation will commonly show false positive reactions.

Some question concerning CMT reliability exists. Stability of milk to CMT possibly is influenced by bacterial action on milk. Factors associated with bacteria growth, therefore, may be the cause of false readings.

CMT is a helpful diagnostic tool, but may indicate positive reactions weeks after successful treatment because the cell count remains high.

A CMT reading of 2 or 3 on bulk milk generally indicates a serious mastitis problem.

Regulatory Control

Both grade “A” and manufacturing grade milk are regulated for presence of abnormal secretions. The milk is first screened for somatic cell count by California Mastitis test. Test readings require that a confirmatory test be made. Approved confirmatory methods include the Direct Microscopic Somatic Cell Count, Electronic Somatic Cell Counting, or the Optical Somatic Cell Count. At least four samples of raw milk must be taken and tested from each producer within every 6-month period. Whenever two of the last four consecutive confirmed somatic cell counts, made on samples taken on separate days, exceed 750,000 per ml (bovine) or 1,500,000 per ml (goat) or 1,000,000 per ml (sheep), a written notice is sent to the producer. At that point an additional sample must be taken within 21 days, but not before 3 days (during which the producer should take corrective action). If at any time the standard somatic cells per ml is exceeded on three of five tests, grade “A” permits may be suspended or other legal action taken. Manufacturing grade milk regulations for abnormal milk follow identically the grade “A” regulations.

STAINLESS STEEL….CARE AND USE

Although stainless steel resists corrosion, it is not completely stain-proof. Even within the group of alloys termed “stainless” corrosion resistance varies greatly. Use considerations frequently to determine the kind of stainless steel required, occasionally at the expense of stainless qualities.

Kinds of Stainless Steel

1. MARTENSITIC: chromium steels which can be hardened by heat. Characteristics – great load and shock strength, low corrosion resistance. Some uses – knives, blades, mill parts, nuts, and bolts. Typical member – Type 410.

2. FERRITIC: chromium steels having larger amounts of chromium than the martensitic; not appreciably hardened by heat. Some uses – ‘trim, molding, counters, and exteriors. Typical member – Type 430.

3. AUSTENTITIC: chromium-nickel alloys; not hardenable by heat. Characteristics – high degree of corrosion resistance. Some uses – suitable for product contact, such as milk processing and handling equipment. Typical member – 300 series stainless steels.

4. PRECIPITATION-HARDENABLE STAINLESS STEELS: of the different alloys in this group, the chromium-nickel-copper type probably has widest application in food processing. These are hardenable by heat. Characteristics – the copper is *not* extractable by food products or sanitizers (unlike “white metals”), and would not be a potential cause of oxidized flavor; it has good corrosion resistance and great strength, and is not subject to preferential corrosion in contact with 300 series, 18-8 type steels.

Some uses – shafts, pistons, bearings, bolts, and nuts. Typical member – 17-4-PH (Armco Steel Corporation designation).

The stainless steels probably most frequently used in the dairy industry are 300 series 18-8 types. The "300" is a type designation indicating certain characteristics; 18 refers to percent chromium, and 8 to percent nickel.

Surface finishes as classified arbitrarily by the steel industry are: Numbers 1, 2D, 2B, 3, 4, 6, 7, 8. The first three are unpolished, the others polished. Each category, though, includes a wide range of finishes. Characteristics of each finish include smoothness, sheen, color, and light reflectivity. To rate a given number, steels must be manufactured by certain procedures.

Corrosion of Stainless Steels

To be assured that stainless steel equipment you buy is of the quality and type desired, always refer to 3-A standards as established by the International Association of Milk, Food, and Environmental Sanitarians, the U.S. Public Health Service, and the Dairy Industry Committee.

Even the most corrosion-resistant stainless steels must be handled properly to insure long life. Factors influencing corrosion are:

1. IMPROPER USE OF CLEANERS AND SANITIZERS: Chemical agents that clean and sanitize dairy equipment vary in corrosiveness. Use them all strictly according to label instructions, with special attention to: (a) *quantity*, (b) *temperature* of solution, and (c) *duration* of exposure to equipment.

Some formulations of chlorine are among the most corrosive sanitizers in common use. Iodine compounds of similar formulation are also highly corrosive. Because these agents' corrosiveness increases with acidity, rinse all equipment before using an acid cleaner. After acid treatment, neutralize with an alkaline solution, followed by a hot water rinse. It is essential to prevent combined acid-sanitizer action on stainless steel.

On *clean* equipment, minimum amounts of sanitizer will effectively kill remaining bacteria. Equipment with even a very thin layer of milkstone or water hardness deposit cannot be sanitized adequately, even with excessive quantities of sanitizer.

Ordinary deposits on milk handling equipment frequently consist of chemical agents called "chlorides". They are highly corrosive. Deposits of these compounds can be prevented or greatly retarded by proper use of suitable cleaners.

Hard water is the source of several chemicals that cause corrosion. It may also destroy detergent action. Cleaners can be formulated to cope with water hardness to some extent. Shop around for the right cleaner for your water supply; or install a softening device, if necessary. *Keep equipment dry to slow corrosive action.*

2. ACTION OF UNLIKE METALS:

Corrosive conditions may be established when two different metals are in contact.

Do not use "white" metals with stainless steel or magnetic "400" series stainless steels with nonmagnetic "300" series. Construct clean-in-place lines from stainless steels of similar series.

Never use tops of bulk tanks or vats for tool storage. Prevent weld spatter from falling on stainless steel.

Again, this kind of corrosive action is accelerated by wet surfaces.

3. HARSH ABRASIVES:

When stainless steel is scratched, the protective influence of its natural (oxide) film is lost. When this occurs, stainless steel is unique in reacting like two dissimilar metals, as noted above. Pitting corrosion results.

Never use steel wool or metallic sponges to scrub stainless steel. Fiber brushes and sponges are adequate to remove dirt when equipment has been kept reasonable clean.

4. STRAY ELECTRIC CURRENTS:

Stray electric currents from improper or frayed wiring causes pitting corrosion. Good grounding is essential.

MILKING EQUIPMENT…CONSTRUCTION, MATERIALS, AND REPAIR

All multiuse containers, equipment, and utensils used in the handling, storage, or transportation of milk shall be made of smooth, nonabsorbent, corrosion-resistant, nontoxic materials, and shall be so constructed as to be easily cleaned. All containers, utensils, and equipment shall be in good repair. All milk pails used for milk handling and stripping shall be seamless and of the hooded type. Multiple-use woven material shall not be used for straining milk. All single-service articles shall have been manufactured, packaged, transported, stored, and handled in a sanitary manner. Articles intended for single-service use shall not be reused.

Milk contact surfaces and all multiuse containers, utensils, equipment, piping, and fittings must be constructed of one of the following:

1. Stainless steel of the A I S I 300 series.
2. Equally corrosion resistant, nontoxic metal
3. Heat resistant glass
4. Plastic or rubber and rubber-like materials which are relatively inert; resistant to scratching, scouring, decomposition, crazing, chipping, and distortion, under normal use conditions; are nontoxic, fat resistant, nonabsorbent, relatively insoluble; do not release component chemicals, or impart flavor or odor to the product; and which maintain their original properties under repeated use conditions.

MILKING EQUIPMENT….FUNCTION AND MAINTENANCE

Milking equipment must do a thorough and efficient job of milking. To do this you must have (1) adequate and steady vacuum and (2) steady pulsation. Following is a list of milk unit parts, their function and proper use.

Vacuum Pump

Vacuum pumps create the vacuum. Operate them according to manufacturer's instructions. Be sure the pump is large enough to handle the number of milker units *currently* being used. Maintain correct oil levels in the pump. Keep the belt in good condition and at proper tension.

The exhaust pipe should be as large as the exhaust opening on the pump. Smaller exhaust pipes reduce pump capacity.

Never locate pump next to feed bin or hay chute. They get dirty too quickly.

Sanitary Trap or Vacuum Reserve Tank

Two functions are served by this equipment: (1) It keeps line wash water or foreign material out of the pump and (2) provides some extra vacuum reserve.

Place this tank where it can be easily cleaned.

Vacuum Controller

As the name implies, this unit maintains vacuum at a constant level. It opens to admit air to prevent high vacuum. Whenever vacuum drops below a pre-determined level, it closes.

In new installations the vacuum controller is usually placed between the pump and first stallcock. If it is located at the far end of the line, plugging at the middle of the line could cause too much vacuum between the plug and pump.

Some have screened openings. Clean dust off the screen regularly to keep operation at full capacity.

Keep working part clean so that it operates freely.

You can usually tell when vacuum drops below the controller setting. Listen for the air hiss that occurs when the controller is open. Air should not be admitted for more than a few seconds at a time.

Vacuum Lines

One and one-quarter inch diameter vacuum lines are strongly recommended. They won’t plug as easy as smaller lines and they provide additional vacuum reserve. They are not much more expensive than three-quarter inch lines because stallcocks can be tapped directly into the line. Tees are not required. Most dairymen find less udder trouble with larger vacuum lines.

Slope the line one-quarter to one-half inch per 10 feet of line to permit moisture drainage. Clean the vacuum line at least once every three months or any time milk is drawn into it.

Stallcocks

Locate stallcocks on the side or upper part of the vacuum line – not on the bottom – to prevent plugging. *Keep them clean.*

You can check for leaks in stallcocks by listening for them when vacuum is drawn. Or, attach a vacuum gauge and determine if vacuum is present when the stallcock is shut.

Drain Valves

These are small metal spheres which fit into a socket when the pump is running and drop when the pump is shut off. Be sure they are closed when the pump is on.

Moisture should drain from these parts when the pump is not running. They should be located at low points in the line. Keep them clean so that they seal properly.

Pulsators

Pulsators alternate vacuum with vacuum release between the liner and metal shell. During vacuum release teats are massaged. In this way blood congestion and subsequent teat irritation is prevented.

Note manufacturer's recommendation. Some pulsators need oil; other should be kept dry.

Worn pulsators permit vacuum leakage. Some vacuum on the teats at all times causes irritations. Keep pulsators in good repair.

Pulsators should be kept clean to prevent stickiness which results in fluctuating pulsation and udder irritation.

Teat Cup Liners

Flabby, worn liners do a poor job of milking. Cracked or checked liners are a constant source of bacteria. Bacteria that are present in such cracks are particularly difficult to remove by regular cleaning procedures. Replace liners as soon as they are worn.

The milking machine must be kept in top operating condition. Only machines in good repair, correctly used, will reduce udder problems and milk efficiently.

PIPELINE MILKERS

Four types of material are used in pipeline installations: stainless steel, heat resistant glass, plastic and rubber, or rubber-like compounds. Plastics are used most often in step-saver units. The line is rolled out for use, then cleaned and re-rolled onto a drum for between-milking storage. Plastics should be approved for this purpose.

For glass and stainless steel, couplings should be of sanitary design and material to prevent corrosion and to maintain airtight seats.

Gaskets should be nonabsorbent, nontoxic, sanitary, and light colored. They should permit flush joints.

Inlet tees on pipelines must be of sanitary design, easily cleaned and drainable.

Installation of Pipelines

The Milking Machine Manufacturers Council of the Farm and Industrial Equipment Institute has established some minimum standards for CIP pipelines used on dairy farms. These are:

1. Make product contact surfaces at least #4 mill finish or equivalent to 150 grit or better obtained with non-contaminating abrasives.
2. Make welds or brazing as corrosion resistant as the parent material. The finish should be equivalent to #4 mill or 150 grit or better obtained with non-contaminating abrasives.
3. Hang CIP pipelines so that the entire length and all fittings remain in constant alignment and position when assembled.
4. Be sure support clamps for metal pipelines are of the same material as the line if no insulation is used between clamp and line. This will prevent electrolytic putting. Clamps should be constructed to allow for expansion and contraction of lines during variations in temperature.

5. Use self-positioning gaskets. Be sure gasket forms a flush interior joint.
6. Provide closures for milk nipples.
7. Make contact surfaces easily cleanable, self-draining, and removable for inspection.
8. Do not have a permanent connection between the water supply line and the CIP pipeline.
9. Slope the CIP line and return circulating line (if one is used) to assure self-drainage.
10. Have suitable tools for dismantling the pipeline for inspection purposes.
11. Use maximum lengths of piping where possible to minimize the number of joints.
12. Be sure milk pumps conform to 3-A Sanitary Standards for pumps. The pump should be easy to disassemble for cleaning and inspection. It should be self-draining.
13. Exteriors of pumps should be corrosion resistant or painted, and easily cleanable.
14. Milk contact surfaces should be easily cleanable, self-draining and readily removable for inspection. Exterior surfaces must be self-draining.
15. Parts which form the space between the motor and pump body must be constructed for easy accessibility and good draining.
16. Pumps should have smooth legs, rounded ends, and no exposed threads. Hollow legs must be sealed.
17. Minimum clearance between lowest part of the base and the floor must be no less than 2 inches for portable pumps, 4 inches for fixed pumps.
18. All milk contact surfaces should have smooth rounded corners and be accessible for cleaning.
19. Be sure there is a moisture trap in the vacuum line leading from the milk releaser or receiver. This line should not extend vertically for more than 12 inches including the elbow and should be detachable for inspection.
20. Use stainless steel, glass or equally corrosion resistant material for the vacuum line between the releaser or receiver and the trap. The inside diameter of this line should be 1-3/8 inch minimum and it should be included in the CIP system. During milking the line should drain toward the moisture trap.
21. Eliminate risers wherever possible. They may restrict the free flow of air which can interfere with milking vacuum.
22. Provide a moisture trap for any device used for admitting air and vacuum to the releaser.
23. The claw should be designed to permit thorough inspection when dismantled.
24. The pipeline system should be free of threads or open seams in all milk contact areas.
25. No milk passageway should be less than 5/16 inch inside diameter.
26. The milker lid and milk chamber should have smooth, easily cleanable surfaces.
27. The pulsator should be designed and constructed for easy removing and cleaning.

28. Milk tubes over 12 inches in length should not be less than ½ inch inside diameter, tubes less than 12 inches in length not less than 5/16 inch inside diameter.

MILKING PROCEDURE

Milking shall be done in the milking barn, stable, or parlor. The flanks, udders, bellies, and tails of all milking cows shall be free from visible dirt. All brushing shall be completed prior to milking. The udders and teats of all milking cows shall be cleaned and treated with a sanitizing solution just prior to the time of milking, and shall be relatively dry before milking. Wet hand milking is prohibited.
Surcingles, milk stools, and antikickers shall be kept clean and stored above the floor. Each pail or container of milk shall be transferred immediately from the milking barn, stable, or parlor to the milkhouse. No milk shall be strained, poured, transferred, or stored unless it is properly protected from contamination.
To produce clean milk of low bacteria count a well organized milking program is necessary. The following steps should be used routinely:

1. Keep the barn clean and dry. Provide fresh bedding for the cows. Sweep the barn *after* milking to keep dust down. Keep cows clipped around flanks and udders.
2. Sanitize milking equipment just prior to milking.
3. Wash and sanitize udder and teats before attaching milkers. Use single service paper towels. Throw them away after each cow is washed. This is essential in keeping bacteria counts low, preventing entrance of sediment, and for *proper milk let-down*
4. Use a strip cup. *Never* strip onto the floor. Presence of watery, flaky, or bloody milk is evidence of infection or udder injury. Do not add the strip-cup milk to the main supply because this milk is high in bacteria count.
5. Attach machines within 1 to 2 minutes following udder wash and stimulation. Delays cause decreases in production and longer milking time. Keep teat cups off the floor when attaching units to cows. This will keep the sediment down.
6. Watch milking carefully. Machine strip when milk stops flowing. Remove the unit as soon as cows are milked out. Otherwise udder problems are likely to develop. Treat each quarter individually.
7. Cool milk quickly.
8. Rinse and sanitize units between cows.
9. Rinse units in cool water immediately following milking.
10. Follow water rinse with a detergent rinse.
11. Dismantle and wash units in hot detergent solution.
12. Rinse in hot water.
13. Store units upside down to drain and dry. Some bacteria will be left on the equipment. They cannot multiply without water. Be sure equipment is *dry.* Large bacteria buildups can occur between milkings.

Milking Order

Cows with a history of mastitis or with an active case are sources of infection for clean cows. These cows should be milked last. The proper milking sequence is:

1. First-calf heifers free of mastitis

2. Older cows free of mastitis.
3. Cows with history of mastitis
4. Cows with active infection.

Milking Time

Fast milking is essential to control mastitis. Milking time can be readily checked. Multiply the number of milker units used by the number of minutes elapsing between attachment of the first unit and removal of the last at the end of milking. Divide this value by the number of cows milked. The value obtained includes both idle time of units as well as time required to transfer units between cows.

Example: With two units 24 cows are milked in 60 minutes. Average unit time per cow equals: ——

Some dairymen are able to keep their unit time as low as five minutes. Some causes of slow milking include:

1. Handling too many units.
2. Doing other chores during milking.
3. Inadequate preparation of cows for milk let-down.
4. Leaving milking units on after milk flow ceases.

CLEANING AND SANITIZING ON THE DAIRY FARM

The product-contact surfaces of all multiuse containers, equipment, and utensils used in the handling, storage, or transportation of milk shall be cleaned after each usage.

The product-contact surfaces of all multiuse containers, equipment, and utensils used in the handling, storage, or transportation of milk shall be sanitized before each usage.

All containers, utensils, and equipment used in the handling, storage, or transportation of milk, unless stored in sanitizing solutions, shall be stored to assure complete drainage, and shall be protected from contamination prior to use.

After sanitization, all containers, utensils, and equipment shall be handled in such manner as to prevent contamination of any product-contact surface.

Quality milk production is an investment in the future of dairying. And clean sanitary milking equipment is basic to the production of high quality milk. Requirements for proper cleaning vary according to type of equipment – let's look at each separately.

Metal Milker Unit Parts

Follow these steps when cleaning metal milker unit parts:

1. Immediately after milking, rinse equipment with luke-warm water. Don't let milk solids dry on equipment – they'll be more difficult to remove later.
2. Dismantle equipment. Wash in dairy cleaning solution prepared according to manufacturer's recommendations. Then wash equipment using proper size hard-bristled brushes or plastic sponges. Never use metal or even stainless steel sponges because they scratch surfaces.
3. Immediately after brush-washing, place all parts in second tank containing 5 gallons of cold water and an acid rinse made according to label instructions. This procedure

eliminates spotting and the need for special acid washes to remove milkstone. This step may be considered optional, but is essential where water hardness is above 15 grains.

4. Remove equipment from acid rinse and store *inverted*, *drained, and dry.* Bacteria cannot multiply on a dry surface.

5. Just prior to use, sanitize with a dairy sanitizer made according to manufacturer's instruction. *Drain well, but do not wipe.*

Note: If initial clean-up requires removal of milkstone, dismantle and soak in acid cleaner. Brush thoroughly. Complete cleaning using steps 1-4 above.

Inflations and Other Rubber Parts

Always use two sets of inflations, alternating a week of use with a week of "rest". Two sets treated in this manner outlive three sets used continuously.

For routine cleaning of rubber parts after milking, rinse with lukewarm water, wash with cleaning compound, and rinse with acid. Store parts dry.

During rest periods, wash and soak inflations in special compounds commercially prepared for this purpose. Rinse with tap water, then rinse with acid, and store them dry. Or, to assist in preserving life of rubber, store in lye or commercially prepared rubber cleaner and conditioner. Butterfat absorbed by rubber is removed in this process.

To prepare lye solution, use ½ pound of caustic to 5 gallons of water. Keep solution in a crock or stainless steel or plastic pail – OUT OF REACH OF CHILDREN!

After 7 days storage, remove inflations. Rinse them with water and wash in concentrated acid to neutralize them. They are then ready for use.

Vacuum Lines

Vacuum lines often are ignored as sources of milk contamination. But not only can lines contribute to production of poor quality milk, clogged lines cause vacuum changes that lead to mastitis. Clean vacuum lines at regular intervals or whenever an upset pail or broken inflation indicates that milk may have been drawn into the line.

1. Prepare solution of 4 ounces of caustic to 2 gallons of water. Use or prepare a quantity no greater than the volume of the trap or half the volume of the vacuum reserve tank. This precaution is necessary to prevent overflow of solution into the vacuum pump.

2. Draw solution through stanchion hose into the line, *starting at stallcock nearest the trap.* Draw 1 quart through each stallcock working away from trap; allow air to enter each time.

3. When finished, empty trap and discard solution. An extremely dirty line requires a second cleaning.

4. Draw 2 gallons of hot water through the line. Leave the stallcock open and vacuum pump running a while to dry the line.

Pipeline Milkers

Four mechanical methods are used to clean pipelines: (1) pressure or pump circulation, (2) vacuum circulating method, (3) vacuum flush system, and (4) vacuum-gravity.

The pressure system uses a pump to circulate the cleaning solutions. In vacuum circulation the vacuum pump draws cleaning solutions through the line with a return line completing the circuit.

Vacuum flush systems (sometimes referred to as reverse-vacuum) are designed for single runs of milk pipelines. No return line is used. Cleaning solutions are drawn to solution tanks at the “barn-end” of the line, the flow is reversed and a return run made to the milkhouse. This back and forth motion is repeated until the line is cleaned.

Vacuum-gravity systems are used for single runs of pipeline up to 50 feet long. No return pipe is used. The solution tank is placed at the barn end of the line. Vacuum draws the cleaning solution through the line and gravity returns it to the milkhouse.

Good cleaning requires proper control of circulation time, detergent concentration, solution temperature, water hardness, and air admission. No step can be slighted. Cleaning must begin immediately following milking.

Use only detergents or cleaners prepared specifically for pipelines. Requirements for cleaning are *different* from those for manual cleaning of milking machines. Stronger compounds with low foaming properties are essential. The detergent should be compatible with the water.

Follow label instructions on cleaner. The general procedure is to:

1. Preflush system immediately after milking with a large volume of lukewarm water. Flush until water appears clear.
2. Prepare cleaning solution. *Measure* amount of water needed. Be sure water is at the temperature specified on the label. Perhaps the most critical factor in cleaning pipelines is the temperature of the cleaning solution at the end of circulation. Without a booster heater, temperature drops during circulation and cleaning efficiency may be lowered. Factors contributing to a decrease in temperature are (1) length of line, (2) size of line, (3) velocity of wash solution, (4) length of wash cycle, (5) internal pipeline temperature, and (6) environmental temperature.
3. Circulate for the required length of time.
4. Rinse with large volume of tap water.
5. Prepare acid rinse and circulate. This step is optional, but is essential where water hardness is above 15 grains.
6. Drain well.
7. Within 1 hour before milking, sanitize the pipelines by circulating recommended strength of dairy sanitizer. Drain well.

The cleaning solution circulating unit including pump or vacuum washer, washing manifolds, and wash tanks must be made of stainless steel or other corrosion-resistant material.

Bulk Tanks

Bulk tanks may be cleaned either mechanically or manually but the job must be done *each time the tank is emptied*.

Manual cleaning requires a concentrated solution of bulk tank cleaner. For best results, prepare washing solution in a plastic bucket and place it inside the bulk tank. With a hard-bristled, long-handled brush, scrub the entire surface. Use an acid rinse to eliminate milkstone deposits.

Solution temperatures for bulk tank cleaning are usually held below 115°F.

For mechanical cleaning you must:

1. Rinse with cool water immediately after emptying (hauler usually performs this operation).
2. Prepare detergent solution according to directions.
3. Spray solution 10-15 minutes.
4. Drain and rinse thoroughly with tap water.
5. Finish with an acid rinse using *foamless* organic acid.
6. Drain well.
7. Sanitize just before using tank.

Plastic Tubing

Plastic tubing needs special care to keep it clear and free from discoloration.

Moisture absorption causes cloudiness. Drying, particularly in direct sunlight, returns plastic to normal transparency but conditions that permit moisture absorption soon cause the problem to reoccur. Always store plastic tubes in a drying position. Preferably, use mechanical forced air driers.

Red or pink discoloration is caused in several ways:

1. Water high in iron content – prevent this by using acid rinse after washing.
2. Improper use of iodine sanitizer – use only as directed.
3. Rubber migration – rubber in contact with plastic over an extended period of time migrates into the plastic.
4. Bacteria – prevent growth by good cleaning and sanitizing.

Other Considerations

Never use household detergents on dairy equipment – cleaning demands are different. Also, many household cleaners have odors or flavors that may be imparted to milk.

Minor variations in cleaning techniques from those listed here may be required depending upon the specific compound used. *Always read the label!*

COOLING OF MILK

Raw milk for pasteurization shall be cooled to 45°F. or less within 2 hours after milking.

Cooling milk quickly and keeping it cold is an essential feature in maintaining low bacteria counts. Or, looking at the other side of the coin, bacteria numbers increase very rapidly as temperature increases. The following table illustrates the point:

Increase in Bacteria Numbers in "Clean" Milk
Over a 12-hour period

Temperature	Increase
40°F	none
50°F	5-fold
60°F	15-fold
70°F	700-fold
80°F	3,000-fold

To better understand the potential for growth, consider generation time of bacteria. This is the time required for a single bacterial cell to divide and become two cells. At 90°F, cells can divide in approximately ½ hour. At this rate of multiplication, one cell can multiply to about 540,000,000 cells in *just 15 hours.* In other words, there is no time to delay in getting a defective cooler into proper functioning order. The generation time at various temperatures is

Temperature	Generation Time (hours)
90°F	½
70°F	1 ½
60°F	2 ¼
50°F	3
40°F	12
32°-35°F	36

For most effective control of bacterial numbers in raw milk, the temperature should be reduced to 40°F or less within 2 hours after milking and maintained at or near that temperature until delivered. This is especially critical for milk being shipped from dairy plants to distant markets, which may require an additional 2 days of transportation prior to reaching the point of processing. However, the Grade "A" Pasteurized Milk Ordinance requires only that milk be cooled to 50°F or less within 2 hours after milking and maintained at that temperature until delivered.

Even though bacteria numbers are kept down by cold temperatures, the total count reached in any given time will depend on the initial count, the temperature, and the conditions under which the milk was produced. The following table provides data indicating the relative influence of these various factors.

Effect of temperature on bacteria in milk produced under various conditions

Standard plate count (Bacteria numbers) per ml after:

Production Conditions	Storage Temperature	Fresh	24 hours	48 hours
1. Clean cows,	40ºF	4,295	4,138	4,566*
environment,	50ºF	4,295	13,961	127,727
and utensils	60ºF	4,295	1,587,333	33,011,111**
2. Clean cows,	40º	39,082	88,028	121,864
dirty environment,	50º	39,082	177,437	831, 615
and utensils	60ºF	39,082	4,461,111	99,120,000
3. Dirty cows,	40ºF	136,533	281,646	538,775
environment,	50ºF	136,533	1,170,546	13,662,115
and utensils	60ºF	136,533	24,673,571***	639,884,615

*Note: Bacteria count doesn't increase in clean milk held at low temperatures.
**Note: Bacteria count increases in clean milk when storage temperatures are too high.
***Note: Bacteria count increases to a high level in a short period of time even at refrigeration temperatures when bacteria come from dirty sources.

When milk is cooled in a bulk tank, the temperature of cold milk being held in the tank increases with the addition of warm fresh milk. If bacterial problems and rancidity problems are to avoided, this blend temperature should never go above 50°F. Be sure the bulk tank compressor capacity is large enough to do the job. All bulk milk tanks manufactured after January 2000 must include a working temperature recording device.

BULK HANDLING OF MILK

Every hauler is responsible for evaluating milk for off-flavor or odor, for presence of filth or abnormal secretions, for sampling milk for butterfat test, bacterial quality, and other quality checks. *This was and is a position of major responsibility*. And it explains why regulations were adopted requiring the hauler to be licensed by the state; that is, to show that he understands the nature of his position and is competent to perform it. A license once obtained, is issued for a period of 1 year, expiring on January 31 and must be renewed at that time. All haulers, including relief tank truck haulers, are required to have a license.

Guidelines can be established to assist a hauler in performing his work, but other factors – his appearance, clean clothing, and the condition of his truck are equally important. The milk hauler is a businessman, and all the elements that go into the success of any business must be a part of the hauler's way of life. The success of his business depends on it.

When installing bulk tanks on farms, be sure to calibrate the measuring devices accurately. After installation, tanks may settle out of tolerance and require recalibration. Here are some considerations to help do this job accurately:

Measuring Devices

Dipsticks are the most common measuring device for bulk milk. Some tanks are set on scales. Others use a surface gauge to measure the liquid inside the tank. This gauge has a plastic tube about 36 inches long with a scale graduated in thirty seconds of an inch. An electronic device senses the liquid surface.

Basic Considerations

Water, milk's major ingredient, is most dense at 39°F and therefore, weighs the most per unit of measure at that temperature. As temperature decreases from 39°F to 32°F water expands. On a 100-gallon tank this amounts to a 0.1 pint difference at 32°F compared to 39°F.

The same conditions exist as temperature increases above 39°F. At 50°F a 100-gallon tank reads about ¼ pint higher than at 39°F. These are small errors in comparison to other sources of error. Careless reading, dirty dipsticks, and residual milk losses can and do cause more significant variations in weight control.

Dipstick Measurements

Dipsticks are usually graduated in 1/16 or 1/32 inch subdivisions. Acceptable accuracy can be obtained if certain precautions are observed. Remember that stable positioning during installation is the basis of success.
Leveling procedures vary with different bulk tanks.

Some may have:

1. Punch or scribe marks inside the tank. Sometimes these are placed in each of the four corners.
2. Leveling areas on the outer top of tanks.
3. Built-in vertical and horizontal spirit or bubble levels.

Circular levels can be set and then fixed with lead and wire seals threaded in setscrews. These levels can be damaged.

When punch or scribe marks are used inside tanks, adjust legs until a prescribed amount of water touches all marks. You may have trouble seeing the water against the stainless steel surface; especially if marks are located deep inside the tank.

Leveling positions outside the tank are effective. Usually two scribe marks or pegs denote the leveling surface; proper positioning can be determined by placing a level between them. These marks are handy also for making routine checks at later dates.

Occasionally four punch marks will be placed at “capacity” level when initial calibration is made. Milk will flow out one or more of these holes if the tank settles out of tolerance. Subtle changes will not be detected.

Calibration of Tanks

A specially designed 5-gallon measuring can must be used. These can be obtained from petroleum equipment dealers at nominal cost. They are positive displacement cans which permit use of water at any temperature and can be read to 1 cubic inch. Inaccuracies arise only if water temperature varies significantly between dumping and reading. It is best to use water at a temperature close to that inside the tank.

Before dumping water a few requirements must be met:

1. Dipstick must be in a vertical fixed position.
2. Graduation marks and numerals must face away from tank wall.
3. Dipstick must not touch bottom of tank.
4. Maximum swing at the bottom of a dipstick which is 30 inches or less in length must not exceed ¾ inch; for 30 to 60-inch rods swing must not exceed 1 ¼ inch.
5. Dipstick must be absolutely clean. Greasy or oily rods allow products to creep higher. A film of moisture has the same effect. When the dipstick is clean, water droplets will not gather or spread anywhere on its surface.
6. Dipstick must be dry. Rods can be dried satisfactorily with paper towels. Rub briskly. Dust the stick with powdered Bon Ami from a cloth sac. Blow off excess to avoid high readings. Measurements made with water will then equal milk measurement at identical fill.

Pour precisely 5 gallons of water into tank using farm water supply. A funnel and pipe arrangement is usually used. Make reading after water comes to rest. All previous effort will be wasted if reading is not accurate. Have good lighting. Record reading. Do not record any indistinct or sloping or irregular measurements.

If any one reading is indistinct and you want to make a second attempt at the same fill, wash, dry, and redust stick before doing so. Never read from a previously wetted surface. Measurements should be recorded to the nearest graduation.

It is necessary to add 5-gallon increments until the tank is filled to capacity, recording after each dump. No section of the tank can be assumed to measure the same as another.

From this data a conversion chart can be prepared. Use 8.6 pounds per gallon as the weight of milk. Fill in weights for points between the measured 5-gallon recordings.

Once a tank has been positioned, leveled, and filled, it should be fixed to the floor. This will prevent accidental movement and discourage tampering. Rough a small area around legs and enclose each in a small amount of fast-drying cement.

Factory Prepared Calibration Charts

Many companies supply conversion charts with their bulk tanks. Nevertheless, each tank should be given an initial calibration study as previously described to assure accuracy. This means filling the tanks to capacity. Adding water to a single level and checking against the chart is not sufficient. If readings are consistently high or low, legs can be adjusted until volumes agree with chart figures.

TANKS DO GO OUT OF TOLERANCE.

When check weighings do not agree with farm receipts, tanks must be recalibrated. Until such time as an accurate metering device may become available, this requires use of the rather tedious 5-gallon unit procedure.

Making a success of a bulk milk operation is the job of producer, hauler, and processor. Accurate measurement of milk and effective sampling are keys to this success. If hauler and producer have a mutual understanding of problems involved, a healthy working relationship and fair treatment of all are assured.

Steps in Bulk Pickup

EQUIPMENT

1. Thermometer – Every milk hauler must have either a column or dial-type thermometer, easily readable, and with graduation intervals not exceeding 2°.

Initially, and at least once each 3-month period, check the thermometer for accuracy against a thermometer certified by the National Bureau of Standards, or one of equivalent accuracy.

2. Sampling Device – Common sampling equipment includes (1) metal dippers and (2) single-service or plastic sampling tubes. If a metal dipper is used, it should be equipped with a long handle and have a capacity of at least 10 ml.

Other devices are allowable providing aseptic sampling can be accomplished.

3. Sampling Device Carrier or Holder – Sampling equipment should be protected during and after sterilization. Metal cases, preferably stainless steel, are recommended for this purpose. Be sure the case itself is washed and sanitized daily. It can be a source of contamination.

4. Sample Containers (Sterile) – Several options are available, including (1) pre-sterilized, nontoxic plastic bags, (2) multi-use glass tubes with ground tops or molded tops assuring leak-proof closure, with nontoxic liners, and (3) evacuated sampling devices for collecting 10 ml portions.

On any container used, there must be a suitable place for sample identification.

5. Sample Case – The sample case must protect samples and assure maintenance of cold temperatures when properly iced. Use rigid metal or plastic construction with tight, insulated cover, and racks, compartments, or other means of protecting samples. Two-row racks provide good assurance of sample exposure to ice water, which is essential. All samples should be stored upright. Whatever style rack is used, ample space must be provided for ice. Sample temperature *must be maintained at* 32-40◦F. The rack should assure positioning so that sample necks are above water and samples cannot tip over or tilt so that ice water contamination is possible.

When sample cases are used as shipping cases, they should be equipped with tamper-proof sealing or locking device and be labeled “This Side Up” on top side.

AT THE PLANT

1. Before starting on route, check the sample case. Be sure it is well iced during summer months. Samples taken from a bulk tank must reflect the true condition of milk as it is received at the plant. The producer is not responsible for changes that take place in transit or during storage of samples prior to testing.

2. If you use a sampling dipper, be sure fresh sanitizer is present and of correct strength. Every precaution must be taken to prevent contaminating milk with sampling devices. Allow at least 30 seconds’ exposure in hypochlorite maintained at no less than 100 ppm. concentration, or equivalent strength sanitizer, as a sanitizing technique for sample dippers.

AT THE FARM

1. *Wash Hands* after bringing hose in through milkhouse port. Your hands constantly contact potential sources of undesirable contamination. While you work, transfer of bacteria from hands to milk is readily possible.

2. Check milk for abnormal odor, color, physical condition, or foreign matter. If some question concerning odor exists, warm a small sample to about 70°F. Any off-odor is more readily apparent at that temperature.

This is the only opportunity to assess milk quality before the tank load is mixed with other loads in the truck.

Dairymen should have a well-ventilated milkroom to make this task as easy as possible. Under the best possible conditions, odor evaluation is not easy. Barn odors mask off-odors of milk.

Do not sample frozen, partially frozen, lumpy, curdled, or churned milk, and do not accept milk with an off-odor, or milk containing floating extraneous matter.

Close lid immediately after making odor and visual evaluation. Open lids are sources of dust and fly contamination even as you work.

3. Check temperature of milk at all sampling locations and check level of tank. Milk temperature should be below 40ºF. Bacterial quality is directly related to holding temperature. A quick check can assure you that the compressor is operating normally. An upward trend in temperature can indicate potential refrigeration problems. By law, all bulk tanks must be equipped with accurate thermometers. However, the fieldman or hauler should carry a thermometer at all times for check purposes. At least *once each month*, check tank thermometer against a certified thermometer before insertion into milk.

Level must be determined to assure accurate measurement of milk. Tanks may settle out of level.

4. Before measuring, be sure milk is not surging. If you must shut off the agitator, wait at least 3 minutes for milk to quiet. On some tanks, a 10 minute wait may be necessary. This waiting period cannot be slighted. An over reading of many pounds results if milk is rippling when measuring stick is inserted.

5. Remove measuring stick. Wash thoroughly in *warm* water with *cleansing agent.* Dry thoroughly with a disposable tissue.

Milk creeps up on a dirty or wet measuring stick. If measuring stick is warm, air moisture will not condense on it. *Milkrooms must be equipped with hot and cold running water.*

6. Insert stick, remove, and read. Take reading only if milk line is absolutely flat. An irregular or sloped line indicates a dirty or moist stick or a lopsided tank level. The reading will be in error.

Good agreement between volume measurement of milk in bulk tanks and check weights of delivered milk in trucks can be obtained only by handling and reading measuring stick in the above manner.

7. Record reading and make conversion to weight by use of a conversion chart. Be sure charts have no printing errors. Producer's receipt should list stick measurement, pounds, odor, temperature, date, and time of pickup.

8. Start agitator and note time. At least 5 minutes of agitation are necessary to secure a representative milk sample. When milk level is very low or very high or agitation is not efficient, a longer duration is necessary.

Check installations initially to determine agitation efficiency. Take samples from four corners and center of tank. To meet 3-A standards, these should agree within 0.2 percent (2 points) by the Babcock test after 5 minutes' agitation.

9. Take sample. A 2 ounce sample is considered adequate for all test purposes. Identify each sample legibly with official number, label, or tag. At the first stop, take two samples, one for a plant temperature check upon arrival. Record time and date of sampling on this check sample.

If the sample is to be used for bacteria test, use sterile bottles and sampling technique. In the event the sterile container becomes contaminated, dispose of it and use another sterile container.

10. Place sample in refrigerated compartment immediately. Cold temperatures retard tendency to churn. Churned milk cannot be sampled accurately for butterfat testing.

Bacteria numbers and rancidity must not increase. Samples that arrive at the plant must represent the milk condition fairly. Be certain samples are held at temperatures between 32° and 40°F. If a dipper is used for sampling, store it in a sanitary container immersed in sanitizer of proper strength.

11. Pump all milk into truck.

12. Disconnect hose as soon as tank is emptied. With the hose unattached, rinsings do not get into the milk. Added water is adulteration. Rinse water may contain bacteria that can contaminate the load unless this precaution is observed. Quality tests cannot account for bacteria added after sampling!

13. Rinse tank and floor free of milk.

14. Before departing, be sure agitator is shut off and rear compartment in tank truck is closed.

Precautions

Always protect sterile sampling instruments from unnecessary exposure to contamination before and during use. To do this, it is advisable to carry sample dipper receptacle into the milkhouse.

Handle sterilized sample containers aseptically. If they are dropped, or laid on any surface, contamination may result. Always replace doubtful equipment with new sterile equipment.

When sampling dipper or sterile tubes are removed in preparation for sampling, rinse them twice in milk before transferring the sample. This will wash away residual sanitizer and any chance contamination that may be present.

If possible, sample containers should be pre-cooled before addition of sample to prevent warm up.

Do not fill sample containers more than ⅔ to ¾ full. This will facilitate sampling in the laboratory.

During transfer of milk sample, *do not hold container over the milk* inside the bulk tank.

Immediately after use, rinse sampling instruments in tap water.

The milk sample itself should be transferred to the refrigerated sample case immediately. Do not lay it down, or stuff it in a shirt pocket. Warm-up occurs very rapidly in a small sample of milk.

If the sample is above 40°F, use a cooling bath. Make a prompt delivery of all samples to the laboratory. To be legal, samples must be tested within 36 hours after collection.

WASHING TANK TRUCKS

In order that tank trucks are not a major source of milk contamination, they must be cleaned after each day's use, immediately after unloading the last load. Or, if a tank truck used for hauling manufacturing grade milk is used for grade "A" milk, the truck must be cleaned before any grade "A" milk is transferred to it.

Management Checks

For accounting purposes and for discovering routes in which losses are excessive, check-weighing is necessary. Increase accuracy of check-weighing by:

- Inspecting scales regularly.
- Balancing scales daily.
- Not weighing on snowy or rainy days.
- Not weighing in the open on a windy day.
- Waiting for tank to stop surging.
- Having a good man operating scales.
- Not inserting sticker until scale stops moving.

Check farm butterfat test against tank truck milk test – they should closely agree. This can be done as follows:

Farm	Test Percent		Milk Pounds		Butterfat Pounds
A	4.0	x	3,200	=	128.00
B	3.0	x	2,400	=	72.00
C	3.5	x	4,000	=	140.00
D	4.0	x	2,800	=	112.00
	Totals		12,400	=	452.00

Then —— = 3.6 percent average producer test. This should check closely with truck milk test.

Other Considerations

Occasionally, yellow flakes may be seen floating on the surface of bulk milk – these may be churned butterfat. High temperatures and excessive agitation can cause churning. Mastitis may result in unstable milk with possible appearance of yellowish particles that are not butterfat.

Considerable churning would have to occur before the butterfat test would be altered. To lower the test on 1,000 pounds of milk 1 point (0.1 percent) from 4.0 to 3.9 percent requires the loss of 1 pound of butterfat. It is doubtful that losses ever reach that magnitude.

KINDS OF MILK SAMPLES

Milk samples are the basis for milk purchase, for quality field work, and for regulatory control, and they require much laboratory time and expense. The total procurement program revolves around the sample.

No test, whether for bacteria or butterfat or any other quality factor, is any better than the sample tested. The sample *must* be representative. It must reflect conditions on the farm, at least to the extent possible in transit from the farm to the plant, and during storage at the plant prior to testing.

Fresh Milk Samples

Samples not treated with preservatives are considered “fresh”. Minimum sample size is 1 to 2 ounces.

Composite Samples

A composite sample is a sample made up of representative portions of milk collected and pooled together over a consecutive series of milk deliveries or pickups. Composite samples are usually built up during half-month intervals and may be referred to as 15 or 16 day composites. For regulatory purposes, composite samples must be held after testing for a period of 7 days, not including holidays.

The composite period should not exceed 16 days. For daily pickup, take at least a 10 ml sample and for every-other-day pickup, at least 20 ml.

A uniform sample size at each delivery is acceptable unless wide daily variations in butterfat test and weight occur. In such cases, use proportionate sampling. Increase sample size uniformly with increasing amounts of milk delivered.

Care of Composite Samples

Use a preservative to maintain samples in good condition during the composite period. The recommended preservative is potassium dichromate, especially where the Milko-Tester device is being used to analyze samples. Mercuric chloride (corrosive sublimate), while acceptable with the Babcock procedure, should not be used in laboratories using a Milko-Tester. When mercuric chloride is used as a preservative, one No. 2 tablet per 10-12 ounce composite will preserve milk samples over a 2-week interval under refrigeration. Each tablet should contain at least 0.25 grams and not more than 0.40 grams of mercuric chloride. Another compound sometimes used as preservative is formaldehyde (formalin).

In addition to using preservatives, other precautions are necessary to maintain samples:

1. Refrigerate samples between 35°F to 40°F to prevent churning.

2. Do not leave unrefrigerated for more than 1 hour per day during routine handling.

3. Prevent exposure to daylight. Strong light alters fat and makes redispersal difficult.

4. Minimize agitation. Daily agitation should suffice to distribute the added sample in the preservative. *Never* shake the composite when adding milk. Use a gentle rotary motion and avoid splashing on sides of bottle and stopper.

The "Universal" Sample

"Universal" is the name applied to a fresh sample taken each collection day, a sample which may be used for any and all purposes, i.e., bacterial or chemical analyses or butterfat testing. Simply put, the "universal" sample concept is: *one sample for every purpose.*

Here are some of the desirable features of this method of sample collection and handling:

1. Techniques are essentially the same as for butterfat sampling. The only major difference is use of sterile sample container. Precautions against contamination during sampling are necessary, but such precautions should be taken anyway.

2. A routine is established and does not vary from one collection to the next. Confusion arising from differences in sampling techniques for butterfat and quality test is eliminated.

3. Sampling programs designed around the butterfat test provide a check on adequacy of agitation. No other practical check is possible.

4. A sample is available at all times. It may be used for routine testing or rechecking. The latter usually necessitates a special trip to the farm, and the subsequent loss in time, labor, and expense. "Universal" samples also may be used by the regulatory agency in their control work.

5. Neither hauler nor producer is aware of the use, if any, to be made of any particular sample. Temptations are minimized. Consistent techniques are promoted.

6. Fresh milk may be tested for butterfat. In some markets, milk is now tested under a stratified random sampling program. That is, four samples of fresh milk are tested, with one sample selected at random from each of the four weeks in the month.

When a sample is available from every pickup, this can be a convenient method of operation.

7. A fresh sample is always available for flavor and odor evaluation if desired. Even though the supply of milk has already been committed, flavor and odor can be useful in pinpointing specific off-flavor problems.

In taking samples under aseptic (sterile) conditions, the sampling dipper is a prime source of contamination. Some markets have found it useful to require dipper storage on the farm. Under this system the hauler's job is simplified. He does not need to carry sampling utensils or sanitizing solutions in the tank truck. At the same time, the producer is made responsible for cleaning and sanitizing the dipper and for storing it in a sanitary manner. Dippers may be stored in sanitizing solutions or in the bulk tank proper. Only the producer is penalized of the dipper is not maintained in a sanitary condition. Dippers should be made of stainless steel and be easily cleanable. They should also be uniform in size.

Refrigeration of Samples

Samples may be considered properly refrigerated only when partly immersed in ice water, with an ice reserve. Anything less, especially in summer months, will allow warm-up. Both churning and bacterial increases can occur, assuming the milk was properly refrigerated on the farm. Sturdy, well-insulated sample boxes *abundantly iced* are a must. Regulatory authorities are now asking that a second sample of milk be taken at the first farm pickup, to be kept for a temperature check. A thermometer encased in a sample container is one way of providing temperature checks along the route and at the plant at time of delivery. Of course, all samples must be properly identified.

Abnormal Sampling

Do not sample either frozen or churned milk. Such milk may be accepted, but payment is made on the basis of the composite of *normal* samples only. In such cases, notify the producer promptly.

Ring Test Samples

Research shows that removing 1 ml. of milk from the composite during the 2-week collection period does not influence the fat test of the milk. Addition of proper amount of corrosive sublimate is essential to ring test. Excessive quantities of preservative (more than one No.2 tablet per 10 to 12 ounces of milk) may render milk useless for ring testing.

BARN AND MILKROOM CONSTRUCTION AND MAINTENANCE

A milking barn, stable, or parlor shall be provided on all dairy farms in which the milking herd shall be housed during milking time operations. The areas used for milking purposes shall (1) have floors constructed of concrete or equally impervious material; (2) have walls and ceilings which are smooth, painted, or finished in an approved manner, in good repair, ceiling dust-tight; (3) have separate stalls or pens for horses, calves, and bulls; (4) be provided with natural and/or artificial light, well distributed for *day and/or night milking; (5) provide sufficient air space and air circulation to prevent condensation and excessive odors; (6) not be overcrowded; and (7) have dust-tight covered boxes or bins, or separate storage facilities for ground, chopped, or concentrated feed.*

Milk quality is generally related to cleanliness of cows. In turn, cow cleanliness is related to the environment within which cows are pastured, held, and milked. Important among construction details and management practices are the following:

Stall Size

The minimum air space surrounding cows in stalls of stanchion barns should be 400 cubic feet. For large breeds a stall 6’3” x 4’6” is recommended as optimum for preventing teat injury. Overcrowding may also result in excessive odors.

Barn Lighting

Adequate light is an essential part of all working conditions. In the milking barn, the equivalent of ten foot candles of light is considered adequate, but always be sure enough light is available to make all working areas plainly visible.

Floors, Gutters, Feed Alleys, Maternity Pens

To assure good cleanability, all floors, including floors of maternity pens, all gutters and feed troughs must be constructed of concrete or other equally impervious material and graded to provide good drainage.

When maternity pens, calf pens, bull pens, or horse stalls are located in the milking barn, well-drained concrete floors are necessary, and such areas must be partitioned from the milking area of the barn.

Barn Walls and Ceilings, Doors and Windows

Various construction materials including wood, tile, concrete, cement, plaster, and brick are readily cleanable and dust-tight and make acceptable walls and ceilings of dairy barns. When feed is stored overhead, ceilings should be constructed to prevent sifting of dust and chaff into the milking barn, stable, or parlor. Hay openings must be fitted with dust-tight doors.

Where entry ways open directly into the milking barn, make doors tight fitting, and keep them closed. This will help prevent the circulation of dust and chaff into the milking area. For air circulation, curbed slotted air intakes are permitted along the haymow floor.

Barn Cleanliness

The interior shall be kept clean. Floors, walls, windows, pipelines, and equipment shall be free of filth and/or litter, and shall be clean. Swine and fowl shall be kept out of the milking barn.

A dairy barn must be kept clean and dry. Liming can be helpful in this respect, as well as use of other moisture-absorbing materials, but no treatment can replace regular daily cleaning of manure and dirt from barn. If gutter cleaners are used, they should be kept clean and in good repair.

Walls and ceilings should also be free of cobwebs and dust and should be whitewashed or painted as often as necessary to assure clean surfaces.

Cowyards

The cowyard shall be graded and drained and shall have not standing pools of water or accumulations of organic wastes: PROVIDED, That in loafing or cattle-housing areas, cow droppings and soiled bedding shall be removed, or clean bedding added at sufficiently frequent intervals to prevent the soiling of the cow's udder and flanks. Waste feed shall not be allowed to accumulate. Manure packs shall be properly drained and shall provide a reasonably firm footing. Swine shall be kept out of the cowyard.

Clean, dry cowyards are essential to keeping cows clean around flanks and udders. Grade "A" regulations include as cowyard, all cattle housing areas, loose housing facilities, pens, stables, resting barns, holding barns, loafing sheds, wandering sheds, and free stall housing. Manure packs must be solid to the footing of animals.

For the fieldman and/or inspector, it should be noted that muddy cowyards caused by recent rains are not considered in violation of the Grade "A" Pasteurized Milk Ordinance. However, cowyards should be reasonably free of cattle droppings.

Milkroom

A milkhouse or room of sufficient size shall be provided, in which the cooling, handling, and storing of milk and the washing, sanitizing, and storing of milk container and utensils shall be conducted.

The milkhouse shall be provided with a smooth floor constructed of concrete or equally impervious material graded to drain and maintained in good repair. Liquid waste shall be disposed of in a sanitary manner; all floor drains shall be accessible and shall be trapped if connected to a sanitary sewer system.

The walls and ceilings shall be constructed of smooth material, in good repair, well painted, or finished in an equally suitable manner.

The milkhouse shall have adequate natural and/or artificial light and be well ventilated.

The milkhouse shall be used for no other purpose than milkhouse operations; there shall be no direct opening into any barn, stable, or into a room used for domestic purposes: PROVIDED, That a direct opening between the milkhouse and milking barn, stable, or parlor is permitted when a tight-fitting, self-closing solid door(s) hinged to be single or double acting is provided.

Water under pressure shall be piped into the milkhouse.

The milkhouse shall be equipped with a two compartment wash vat and adequate hot water heating facilities.

When a transportation tank is used for the cooling and storage of milk on the dairy farm, such tank shall be provided with a suitable shelter for the receipt of milk. Such shelter shall be adjacent to, but not a part of, the milkroom and shall comply with the requirements of the milkroom with respect to construction, light, drainage, insect and rodent control, and general maintenance.

The floors, walls, ceilings, windows, tables, shelves, cabinets, wash vats, nonproduct contact surfaces of milk containers, utensils, and equipment, and other milkroom equipment shall be clean. Only articles directly related to milkroom activities *shall be permitted in the milkroom. The milkroom shall be free of trash, animals, and fowl.*

There shall be provided adequate hand-washing facilities, including running water, soap or detergent, and individual sanitary towels, in the milkhouse and in or convenient to the milking barn, stable, or parlor.

GENERAL CONSIDERATIONS

Location

If your milkhouse is to be attached to the barn, locate it on the clean side or end readily accessible to the roadway. A milkroom inside the barn is acceptable for both grade “A” and manufacturing grade milk. Locate it conveniently for the milk hauler.

Separation of Dairy Area

Swine and fowl carry diseases potentially dangerous to man; they must not enter a dairy barn, stable, milking parlor, or milkhouse. Exclude swine from the holding or bedded area in loose-housing systems. Confine horses, dry cows, calves, and bulls in stalls or pens that are kept clean and in good repair. Tight partitions between the dairy area and all other areas are essential.

Feed Storage

Restrict feed storage, grinding, and mixing to a section separated from the milking area and milkhouse by *dust tight partitions and doors.* Close off this section at all times except during feed transfer. Good venting to the outside reduces dust problems and explosion hazards. Equip hay chutes with hinged or sliding doors and keep them closed except when in use. Also place a door between the silo and milk area.

Approaches and Holding Area

You can produce low bacteria count, sediment free milk consistently only if your cows and milking area are clean. A concrete approach or ramp is recommended for all doorways and walks leading from the barn. This approach or ramp helps prevent injury to cows and reduces the amount of mud and manure tracked into the barn. Make it at least 8 feet longs and as wide as the door.

For *loose housing systems*, you must consider several other factors.

- Provide a concrete holding area where cows may assemble before milking. Slope it to drain away from the milking area. Allow 20 square feet per cow or 400 square feet for a 20 cow herd. For each additional cow add 10 square feet.
- Separate the holding area from the bedded area with a fence, plank, skirt, concrete block wall, or other similar structure. This separation prevents manure and straw from collecting in the holding area which must be kept clean and free from accumulated manure or liquids.
- Slope the holding area floor to form a ramp to the milking stall level. Or, if you prefer steps, make treads 16 to 24 inches deep with a rise of no more

than 8 inches. For outlet ramps, a slope no steeper than 1:4 (3 inches per foot to run) is recommended.

- Grade and drain the cowyard and feeding area and keep them free of standing pools and manure accumulations. A paved area of 100 square feet per cow is recommended. If you don't pave the entire lot, minimal paving should cover: (1) a 10-foot-wide strip in front of the loafing barn, running the entire length, and (2) at least 7 feet around the hay feeder.
- Whenever possible, slope the lot 2 to 4 feet per 100 feet (¼ to ½ inch per foot) away from loafing, holding, milking, and milk-handling areas.
- Install a watering tank or automatic waterer with heating device for winter. Do not install the waterer in the bedded area because wet and muddy conditions usually develop. Instead, place it on a *concrete* platform in an area protected from the wind and that may be opened to the inside of the barn during severe weather and to the outside during good weather.

MILKROOM DESIGN FOR STANCHION AND LOOSE-HOUSING INSTALLATIONS

Size

The milkroom is the area set aside for filtering, cooling, and storing milk and for cleaning and storing dairy utensils. The table shows the suggested floor area based on volume of milk production. The minimum recommended milkhouse size in 12 x14 feet. *Important*: In choosing milkroom dimensions, plan for herd expansion and/or conversion to bulk.

Bulk Tank Clearances

Clearances from walls or other equipment should be:

- Working side – 30 inches
- Outlet valve end – 36 inches
- Rear side – 30 inches
- Side opposite outlet valve – 30 inches

Provide a fixed, flytight, self-closing opening in an exterior wall for the milk conductor tube. Make this opening no less than 6 inches above the milkhouse floor or the outside loading platform – whichever is higher – and not less than 6 inches and not more than 8 inches square.

Floor Drains

Locate drains for easy cleaning and install deep water-sealed traps that can be thawed conveniently. To lessen danger of freezing and to permit ready draining without flooding the floor, locate drains near wash vats at least 1½ feet from outside walls. *Never locate drains under the bulk tank or milk outlet valve.*

Floor

Construct the floor of smooth, dense concrete or other impervious material. Slope it a minimum of ¼ inch per foot toward drains. Floors must be stable to insure year-round accuracy of milk measurements in bulk tanks.

Before pouring a milkhouse floor, remove topsoil and backfill with at least 8 inches of sand, gravel, or crushed rock. Install a 5-inch-thick concrete floor over this fill. To protect wall sheathing from excessive wetting, extend the concrete footing about 6 inches above the floor.

Interior Walls and Ceiling

The interior walls and ceiling should be of smooth, tight construction. Suggested materials include: matched lumber (shiplap or flooring), exterior plywood, asbestos board, or similar exterior materials on lumber backing; concrete block; or other masonry. The lower 4 feet of the wall must be waterproof or water resistant. Apply seal to this section to permit washing over an extended time.

Upper sections of walls and the ceilings must be sufficiently waterproof to permit cleaning as needed. Interior walls should be finished in a light color. Apply seal to all concrete blocks.

Insulation

Since insulation reduces your heating cost and helps insure proper ventilation, it should be used in all exposed outside walls. Frame construction should be double-walled with sheathing on inside and outside of studs. Use at least 1½ inches of insulation in both sidewalls and ceilings; 3½ inches is recommended in sidewalls and 4-6 inches in ceilings. Install a vapor seal between inside sheathing and studs to prevent moisture transfer inside building.

If you use single concrete block walls, fill them with insulation. Furring strips 2x2 inches, attached to the inside of the concrete block, are recommended. Fill spaces between blocks and inside sheathing with insulation.

You may also use a double 4 inch block wall; place 2½ inches of insulation between rows of blocks.

Ventilation

Adequate ventilation is needed in both summer and winter to minimize odors and moisture condensation on floors, walls, ceilings, and utensils. Fan ventilation with thermostatic control is recommended.

Outside fresh air inlets, with cross section area equal to 1 square foot per 750 cubic feet per minute (cfm) of fan capacity, are needed. Fan capacity expressed in cfm should equal one-sixth the cubic volume (length x height x width) of your milkhouse. For example, a 12 x 14 x 8 foot milkhouse requires a fan of 224 cfm capacity (12 x 14 x 8 x   = 224).

Heating

You should provide sufficient heat to prevent freezing.

Lighting

If windows are used, install them to allow for cross ventilation where possible. If glass blocks or similar materials are used, mechanical ventilation is necessary.

Install electric lights, with shallow reflectors, equal to 1 watt per square foot of floor area. In a bulk system, use one 150-watt bulb over and just beyond each end of the tank in addition to other lighting needed for proper cleaning. The Grade "A" Pasteurized Milk Ordinance requires a minimum of 20 foot candles of light in all working areas. Light may come either from natural or artificial sources.

Equipment

Milking equipment, preferably stainless steel must be durable and seamless. Milk cans also must be durable and seamless. Farm bulk tanks, milk pumps, pipelines, and fittings must meet 3A Sanitary Standards design, finish materials, and construction specifications.

Cleaning Facilities

Adequate hand-washing facilities shall be provided, including a lavatory fixture with running water, soap or detergent, and individual sanitary towels, in the milkhouse and in or convenient to the milking barn, stable, parlor, or flush toilet.

Hands shall be washed clean and dried with an individual sanitary towel immediately before milking, before performing any milkhouse function, and immediately after the interruption of any of these activities. Milkers and milk haulers shall wear clean outer garments while milking or handling milk, milk containers, utensils, or equipment.

Water under pressure is essential. Don't use hoses for washing the milkhouse and bulk tank for any other purpose. Store hoses on a rack close to the bulk tank. Install at least a 30 gallon automatic hot water heater (pressure type) in the milkhouse. It needs a thermostat and heating elements or units to maintain water at 140°F.

Provide extra hot water capacity and/or higher temperatures for clean-in-place (CIP) pipeline installations, off-peak heating, milkhouse heating, or other hot water uses in addition to normal cleaning. See the table for gallons of water required to fill 100 feet of pipeline:

Pipe Diameter (Inches)	Gallons (100 feet)
1	4.7
1½	9.2
2	16.3

If you use gas heaters, they should be properly vented.

Install two compartment sanitary wash and rinse vats. Each should be large enough to hold the largest can or utensil used. This requirement is necessary even when CIP systems are used.

Provide hand washing facilities including hot and cold running water, soap, and disposable towels.

Storage Cabinet

Provide a storage cabinet in which detergent, sanitizers, gaskets, brushes, etc., can be stored. But *do not* store insecticides, antibiotics, or medicinals inside the milkroom.

Screening

Effectively screen all openings during the fly season.

Doors

You must provide a door for any direct opening between the milkhouse or milkroom and the barn, stable, or milking parlor. Doors must be solid, tight fitting, and self-closing. A vestibule or breezeway is not required, but they may be built into the installation if desired.

The outer milkhouse door also must be tight and self-closing. If this door is hinged to swing inward, provide it with an outward opening screen door during the fly season.

Truck Approach

A properly graded and surfaced truck approach is necessary to prevent pooling of water. You may have to provide a concrete slab or asphalt surface. Also install adequate artificial light for loading after dark.

Hose Port

For bulk milk transfer, install a hose port fitted with a tight, self-closing door. Place it 6 or 8 inches above the floor of the milkroom.

WATER SUPPLIES

Water for milkhouse and milking operations shall be from a supply properly located, protected, and operated, and shall be easily accessible, adequate, and of a safe, sanitary quality.

Before installing new water or sewage facilities you should have local health or milk regulatory personnel approve your plans. The following general regulations normally apply:

Well Locations

Be sure your well site is not subject to flooding. Ground water is often contaminated and will pollute a clean water supply.

Slope grades down and away from the well. Prevent surface water accumulation for 50 feet in every direction around the well. No pump platform or pumproom floor should be located less than 2 feet above the highest known high water level of any nearby body of water.

Locate a new well at least 75 feet from cesspools or sewage leaching pits. Allow 50 feet between the well and a septic tank, outside toilet, manure pile, and unpaved feedlots where manure accumulates. No sewage disposal line should run within 10 feet (measured horizontally) of a well. If such a line runs more than 10 feet but less than 50 feet from a well, it must be cast iron and have leaded joints. All surface drainage must slope away from the well area. Provide a fill if natural drainage does not exist.

A sealed well casing must extend from at least 10 feet below ground surface to at least 6 inches above the well platform. Install a concrete slab, at least 4 feet square, around the well casing. Have the surface of the slab slope away from the well.

Wells dug into the ground are acceptable if properly located and constructed. A watertight outer lining of poured concrete must extend 10 feet below the surface and be attached to the well platform or pumproom floor with a watertight connection.

No pit or unfilled space may be within 10 feet (measured horizontally) of the well. This requirement does not apply to a residential basement which may be located closer to a driven or drilled water supply.

Pump Locations

Install a pneumatic pressure water system – don't install any pump or pumping equipment in a pit. An approved pitless unit placed in an insulated aboveground pumphouse is recommended. You may place the pressure tank of a pitless unit in the house basement or other similar location. But don't install the pump in a belowground room or pit off the house basement. And don't store other materials in an aboveground insulated pumphouse or other pump enclosure.

The base plate of a pump placed immediately over the well should form a watertight seal with the well casing.

Piping

You may use plastic (for cold water only), galvanized iron, or copper piping. If the pump is offset from the well, no suction pipe (all shallow well pumps and inlet pipes on jet pumps) should contact the earth. Install all such piping inside a watertight casing. In a two-pipe system, one inside the other, attach the outer pipe to the pressure side and the inner pipe to the suction of the pump.

Don't locate a water pipe within 10 feet (measured horizontally) of any sewer, drain, or other pipe that carries polluted water unless: (1) the bottom of the water pipeline is above the top of the sewer line, (2) the water line is placed on a solid shelf excavated to one side of the common trench, or (3) parts of the sewer line lying within 10 feet of the water line are of cast iron with leaded joints or the equivalent.

Water From Sources Other Than Wells

Obtain detailed plans for developing and using water supplies from springs, cisterns, or sources other than wells from your local health or milk regulatory personnel.

New Water Supplies and Contaminated Water Supplies

New water supplies or water which has been contaminated must be thoroughly disinfected before being used. Use a solution containing not less than 50 parts per million (ppm) available chlorine. This treatment may not be necessary with a flowing well or spring. To check effectiveness of chlorination, samples must be analyzed bacteriologically. Repeat disinfection, if necessary, until you obtain satisfactory results.

Disposal System

Every dairy farm shall be provided with one or more toilets, conveniently located and properly constructed, operated, and maintained in a sanitary manner. The waste shall be inaccessible to flies and shall not pollute the soil surface or contaminate any water supply.

Install a disposal system large enough to handle all wastes from the milkroom and milking parlor. Wastes from a toilet stool *must not* run into the disposal system for milkroom and parlor wastes. A solid, self-closing door may be used to separate a flush toilet from the milkhouse or milkroom. Louvered doors will not suffice. Remember, a separate disposal system is needed. A direct opening is not permitted if a privy system is used.

Milkroom and milking parlor wastes may be run into a common disposal system. This combined waste contains considerable fibrous material that does not readily break down. A settling chamber with a removable top for regular cleaning is recommended. Liquid wastes then may be run off in a disposable field or seepage pit.

Install all parts of the disposal system at least 3 feet below grade. A straw cover during winter helps protect against freezing.

OFF-FLAVORS IN MILK

Many different off-flavors occur in milk. Not all off-flavors are caused by bacteria. But the kinds of flavors produced by bacterial action are several and varied. Typical of these are sour, malty, putrid, bitter, and stale. Steps necessary to prevent bacterial entrance and growth in milk have already been discussed. (See Sources of High Bacteria Count-Page 10) Other off-flavor problems will now be reviewed.

Feed and Weed Flavors

Feeds and weeds cause the most common off-flavors in milk. Three factors help determine the presence and intensity of these flavors in milk: (1) the *kind* of feed the cow receives, (2) the amount received, and (3) the time between feeding and milking.

1. Kind of Feed – Very small amounts of some feeds can cause off-flavors in milk. Among the worst are legume silages.

2. Amount of Feed – Feed flavors become more pronounced as the quantity eaten increases.

3. Time lapse between feeding and milking – Feeding cows one hour before milking causes maximum feed flavor development. Cows should be fed at least five hours before milking. Some feeds such as legume silages, if fed in sufficient quantities, will produce feed flavors at the next milking even though they are fed immediately following milking.

Feeds causing off-flavors will be discussed individually to provide you with the information needed to handle your feed problems.

CORN SILAGE

1. Five pounds of corn silage fed 1 hour before milking cause only a slight off-flavor.

2. Ten pounds of corn silage fed 1 hour before milking produce a noticeable feed flavor, considered objectionable in market milk.

3. Eighteen pounds of corn silage fed 1 hour before milking produce intensive feed flavors.

Preventive Measures:

1. Feed corn silage in the manger after milking or in the stable yard after the cows have been milked.

2. If you must feed cows before milking, make it at least 5 hours in advance.

LEGUME SILAGE (SWEET CLOVER, ALFALFA, SOYBEAN)

1. As little as 5 pounds of legume silage fed 1 hour before milking will cause objectionable feed flavors.

2. When fed 1 hour *after* milking *no more* than *15 pounds* of this silage should be provided for each cow or undesirable flavors will be found in the milk at the next milking.

ALFALFA AND CLOVER HAY OR GREEN FEED

Alfalfa and clover are from the same plant family and have similar influence on milk flavor.

1. Fifteen pounds of alfalfa hay fed 2 hours before milking will cause definite feed flavors.

2. Thirty-four to forty pounds of green alfalfa fed 2 hours before milking will cause strong feed flavors.

EFFECT OF MIXING ROUGHAGE

There is no advantage in feeding roughages that do not impart a flavor along with those that do cause off-flavors. A given quantity of any feed that produces off-flavors will cause the same intensity of off-flavor development regardless of other feeds fed at the same time.

OTHER GREEN PASTURE FEEDS

1. Green barley, wild oats, and rye give definite flavors to milk when fed as complete feeds 2 hours before milking.

2. Cowpeas, corn, and foxtail produce less flavor for the quantity fed than barley, wild oats, or rye.

3. None of these feeds gives as much flavor to milk as do clover and alfalfa.

VEGETABLE BY-PRODUCTS

Cabbage

1. Fifteen pounds of cabbage fed 1 hour before milking produces off-flavors.

2. Increasing the amount from 15 up to 24 increases the intensity.

3. Twenty-five pounds of cabbage can be fed directly following milking without objectionable carry-over to the next milking.

Potatoes

Fifteen to thirty pounds of potatoes fed 1 hour before milking will produce only slight off-flavors, probably not noticeable to most consumers.

Apple Pomace

Milk may take up an apple flavor from apples store in the vicinity, and from feeding apples.

Turnips

1. Fifteen pounds of turnips fed 1 hour before milking may produce off-flavors.

2. Thirty pounds may be consumed directly after milking with little or no detrimental effect on flavor or odor.

OTHER PLANTS CAUSING ABNORMAL FLAVOR

1. Tarweed, bitterweed, mustard, wild radish, wild onions and garlic, ragweed, horseweed, peppergrass, yarrow, french or fanweed, ox-eye daisy, shepherd's-purse, docks, and leek all cause off-flavors.

2. These plants are generally consumed only when pastures are short.

3. It may be necessary to keep cows off such pasture to eliminate the off-flavors.

INFLUENCE OF CONCENTRATE FEEDS

The quantity of concentrate feeds generally provided at milking time is not sufficient to cause off-flavors and is considered to be an acceptable procedure. However, 7 pounds of rolled barley and dried beet pulp fed 1 or 2 hours before milking cause a slight feed flavor.

Acceptable concentrates include: wheat bran, coconut meal, soybean meal, wet brewers' grains, and mixed concentrates.

Summary

Feed flavors can be controlled by observing certain feeding schedules and by limiting the kind and amount of feed given to cows. In general, feeds given 5 hours before milking do not cause off-flavors. However, it is best to provide feed directly after milking and, if possible, remove cows from pasture 5 hours before milking (especially evening milking because cows tend to feed more heavily during the day).

The following feeds have only slight or no effect on the flavor of milk: sugar beets, dried beet pulp, soybeans, carrots, pumpkins, soybean hay, potatoes, mangoes, oats, rye, peas, corn (not corn silage), clover and grass, Timothy hay, most concentrates, and tankage.

Oxidized Flavors

Milk that has undergone an oxidation reaction will, in early stages, have a metallic or cardboard taste (sometimes referred to as cappy). As the reaction progresses the flavor becomes oily or tallowy. To some extent the type of flavor depends upon the particular compounds that are oxidized. Butterfat oxidation tends to produce the oily or tallowy flavors. Fat-like compounds called phospholipids yield the cappy flavor when oxidized. Approximately one-third of the phospholipids remain with the skim milk when whole milk is separated.

CAUSES OF OXIDIZED FLAVOR

Oxidized flavors in milk may be caused by:

1. Presence of oxygen. Milk is ordinarily saturated with air. Therefore, oxygen is readily available and the reaction will take place if other conditions are favorable.

Milk from which oxygen has been removed will not oxidize even in the presence of other causative agents.

2. Presence of some metals. Very small amounts of copper will cause oxidation. Iron may influence oxidation as well.

3. Presence of pro-oxidants – Sunlight and low pH (acidity) favor oxidation.

4. Presence of antioxidants – Milk contains some compounds that inhibit oxidation; some milk contain more than others. Antioxidant compounds may be increased in milk by heat treatments (170ºF and above, momentary heating).

Classifications of Milks According to Susceptibility to Oxidation

Milk from different cows, or the same cow or herd under different feeding programs, will vary widely in susceptibility to oxidation. Milks may be arbitrarily classified:

1. Spontaneous – develop oxidized flavor without added copper. This is generally a late winter, early spring problem. Prolonged feeding of dry rations may increase the tendency to oxidize. Green feed often reduces susceptibility.

2. Susceptible – will go oxidized upon addition of small amounts of cooper. Milks vary considerably in the minimum amount of copper required to produce a flavor in 2 or 3 days. In some cases 0.1 part per million is enough, in others ten times as much (1 part per million) is required.

3. Nonsusceptible – no flavor development in 2 or 3 days of storage at 40◦F. in the presence of 1 part per million of copper.

Methods of Controlling Oxidized Flavor Problems

Preventive measures should be used to control oxidation because no practical methods are available to eliminate the off-flavor once it is present.

Control procedures include:

1. Feeding green feed – access to green feed will help reduce milk susceptibility. Tocopherol or ethoxyquin added as feed supplement will significantly delay oxidation.

2. Elimination of copper-containing metals from processing lines. Bronze, brass, "white metal" and nickel silver contain copper. These metals *must not be used* for milk contact surfaces. Two problems arise: (1) copper is absorbed from the metal by the milk and (2) during clean-up and sanitization copper is picked up by solutions, transported through equipment (particularly for CIP operations), and coated on stainless steel equipment surfaces. The stainless steel then becomes a source of cooper contamination. Conditions favoring copper coating of stainless steel are:

a. Alkaline pH (6-10) pH 8-9 is worst. And presence of hypochlorites increases copper deposition.

b. Use of certain cleaners and sanitizers. In order of *decreasing* corrosiveness they are:

i. Sulfamic acid at 140°F
ii. Alkaline cleaners
iii. Iodine sanitizers at 77°F
iv. Hypochlorite at 140°F
v. Quaternary ammonium compounds

Because these agents are necessary for proper cleaning and sanitizing, the best approach is to replace all copper containing metals in farm milk handling equipment, processing lines, and equipment with stainless steel.

Where chronic oxidation problems exist, trouble can usually be traced to copper-containing metals on milk contact surfaces.

You can detect copper in metal by adding one drop of nitric acid to the metal. A bluish-green color develops if copper is present.

3. Frequent retinning of milk cans. Check cans in which milk is shipped. If any rust spots show, get them tinned. Rust is an oxide of iron, and iron can cause oxidation.

4. Homogenization of whole milk tends to inhibit oxidation.

5. Removal of air – this control procedure may be used in packaging dry milk products which contain fat. Nitrogen gassing of containers forces air out. Nitrogen does not cause oxidation. To some extent vacuum treatment may help but this is only temporary. Returning milk to atmospheric pressure conditions permits oxygen in the air to become re-absorbed in milk.

6. Heat treatment – At a temperature of 170°F or higher, antioxidants are formed. The extent of formation is a time-temperature function. Cooked flavors also occur but they tend to lessen with time. In fluid milk operations, a happy medium must be struck between cooked flavor levels and antioxidant formation.

7. Avoid exposure to sunlight.

Salty Flavor

Two conditions cause a salty flavor to appear in milk, late lactation and mastitis. If the majority of herd milk consists of late lactation and/or mastitic milk, a salty flavor will be evident. Increased salt content of milk – the same salt as used for table salt – causes this flavor

Sunlight Flavor

While sunlight flavor is not generally a raw milk problem, the fieldman should know that exposure of milk to sunlight creates an off-flavor. Usually sunlight flavor is classified along with oxidation. In fact sunlight may enhance oxidation. But a unique off-flavor may result, too. Usually, a burnt or cabbage-like flavor is found.

Factors related to sunlight flavor are:

1. Intensity of light – stronger light causes the off-flavors to appear faster. Only a few minutes in bright sunlight are needed. Longer exposure can cause it to develop even on cloudy days.

2. Length of exposure – the longer the exposure the more intense will be the off-flavor.

3. Nature of the milk – some milks are more susceptible than others.

4. Kind of container – paper containers and colored glass offer some protection

Rancidity

One of the most common off-flavors in the dairy industry is "slightly bitter". Although the cause may vary, hydrolytic rancidity must be considered a prime cause. Both farm and dairy plant problems may lead to its development. Once a bad flavor is present no processing treatment will eliminate it.

The word rancidity often causes confusion. Sometimes it is used to describe the oxidation defect. At other times the term is used to refer to hydrolytic rancidity. The two defects have one thing in common. They are both defects of butterfat. However, they are very much different in flavor characteristics, chemistry, and control procedures.

Figure 1. Diagram of a butterfat molecule.

```
                (B)
       -o-o-o-o-o-o-o-o-o-o-o-o-o-o-o-o-o
           (C)
[A]    -o-o-o-o
                       (D)
       -o-o-o-o-o-o-o-o-o-o-o-o-o
```

Figure 1 is a diagram of a single butterfat unit, a molecule. In chemists' terms A is glycerol and B, C, and D, the three chains, are fatty acids. These chains vary in length from 4 links to 20 or more. Their position on A (top, middle, or bottom) is not fixed from unit to unit (B may be located at middle or bottom and C at top or bottom, etc.). Both chain length and position alter characteristics of butterfat. Vast numbers of unique molecules are conceivable.

Under suitable conditions, one of which may be the presence of butterfat units of specific properties, a milk component call "lipase" may sever some of these chains. When a given number of short ones are released, the characteristic rancid flavor is detected. Because lipase is responsible for this breakdown, many persons refer to the defect as "lipase." Prevalence of the off-flavor during winter months has prompted some to term hydrolytic rancidity "wintry" off-flavor.

Conditions Favoring Rancidity Development

Several conditions result in rancidity development. These are termed "activations". Like an electric motor activates machinery, these treatments activate or cause the rancidity reaction to take place. They are:

1. Agitation and foaming.
2. Cooling to refrigeration temperatures, rewarming to 60°F to 90°F and recooling to refrigeration temperatures. This is called "temperature" activation.
3. Homogenization.
4. Mixing raw and homogenized-pasteurized milk.
5. Presence of excessive residual detergents and/or sanitizers.

Influence of Pasteurization

Pasteurization destroys lipase ability to break down butterfat. All treatments that cause rancidity require *raw* milk. Objectionable off-flavor developed before pasteurization but no further breakdown due to above factors occurs without raw milk contamination.

Some dairy products develop rancidity after pasteurization. In this case, bacterial contamination is usually responsible. These bacteria, called "lipolytics" secrete a lipase that breaks down butterfat the same as natural milk lipase.

Spontaneous Rancidity Development

Milk from some cows requires very little activation. Such milk is so susceptible that cooling alone causes rancidity. This kind of milk is not too common and few problems can be traced to this factor alone. In combination with other activations it may be significant.

Factors Related to Production of Susceptible Milk

Several conditions may stimulate production of milk highly susceptible even to milk activation treatments and/or “spontaneous” milk. These are:

1. Advanced lactation. Breeding schedules that allow most of the herd to come onto late lactation at the same time pose a potentially serious rancidity problem.

2. Mastitis

3. Dry winter feed. This is one reason why the defect often occurs in the winter. Milk from cows on pasture generally is less susceptible to rancidity.

4. “Heat” period may cause an increase in susceptibility, but this is of short duration.

5. *Any* illness that results in a sudden drop in production may be followed by rancidity problems.

Control Measures…Farm

Whether or not factors in items 1 through 5 above are present to promote rancidity development, controls must be continuously applied:

1. Use only inflations that are in good conditions. Cracks or holes permit entrance of air that can cause turbulence. Agitation and foaming result.

2. When installing pipeline milkers, keep the pipeline as close to the cows as possible. Air entering at the “claw” and bubbling up the milk hose may pose a problem. Pipeline far above cows require long hoses and allow agitation to take place over a longer period of time.

3. If “in-line” strainers are used, be sure joints on either side are airtight before milking. Lines “broken” at this point at each milking may not be properly tightened.

4. Keep pipeline joints on the vacuum side airtight. Any leak is a source of trouble.

5. Minimize the number of “risers” in the line. When milk is raised to a higher level, turbulence and foaming occur when the line is not filled with milk. Risers in a “full” line will not be serious sources of activation.

6. Do not operate pumps and releaser systems continuously if a full head of milk is not available at all times. Automatic control systems can be installed to activate pumps or releasers only when the milk jar is full. After the jar is emptied the pump and releaser automatically shut off.

7. Minimize or eliminate splash as milk enters cans or bulk tanks.

8. Keep milk cold. The most common cause of rancidity is agitation and foaming; the reaction progresses much faster at warm temperatures. Milk coming from a cow at body temperature is highly reactive. Quick cooling is essential.

9. Feed adequate amounts of good quality feed. Undernourished cows may produce susceptible milk.

10. Shut off vacuum while transferring milking machine to next cow. Keep sufficient vacuum to prevent milking machines from falling off cows.

Control Measures…Plant

1. Keep milk cold.

2. When separating milk at 80º to 90ºF avoid cooling cream and holding for long periods or holding cream at separation temperature. When cream is to be held prior to

pasteurization and churning, 120ºF holding temperature may be advisable if the holding time is short.

3. Carefully check flow sequence when pasteurizers are shut down for repair or lack of milk. Don't recycle raw milk. In market milk operations, prevent cycling homogenized-pasteurized milk into raw milk lines.

4. Never let pumps operate in a starved condition. Minimize raw milk pumping stations. Avoid "risers" in processing lines which may carry insufficient milk to fill the line.

5. Avoid air leaks in processing lines and equipment.

Characteristics of the Rancidity Reaction

When milk is activated, rancidity generally progresses to a level and then tapers off. If no further activation takes place, the established level remains. Additional treatment will cause further reaction and a new, higher plateau.

The rate of reaction depends on type of activation, temperature, and susceptibility of milk. Homogenization can cause detectable rancidity in a few seconds; agitation and foaming may cause an off-flavor in a few minutes or a couple days, depending on milk susceptibility and severity of agitation. Temperature activation and "spontaneous" rancidity usually require 12 hours or more for detectable rancidity levels to occur.

If a milk supply, previously activated, is nearly at a detectable rancidity level, further activation of any kind may cause off-flavor to develop quickly. The reaction must progress only for a short period of time before exceeding the critical level.

Chemical Flavors

Carelessness in use of detergents and sanitizers and other farm chemicals may result in their presence in milk. Excessive amounts cause off-flavors.

In whole milk, chlorine and iodine compounds may be detected at concentrations of 12 to 14 parts per million, in skim milk 6 to 8 parts per million. Strong solutions cause off-flavors at *lower* concentration than weak solutions. In other words, stock solutions from which weaker "use-strength" solutions are made will cause detectable off-flavors at lower levels of contamination than weak solutions.

Vapor from open sanitizer containers may condense on equipment surfaces. They form strong sanitizers which will cause off-flavors at low levels.

Keep Caps on Tight

Medications: Some udder and teat medicines contain a chemical called phenol. When phenol combines with chlorine or iodine sanitizers, extremely low concentrations of the end-product in milk causes an off-flavor. As little as 25 parts per *billion* is detectable.

Prevent chemical flavors by observing the following rules.

1. Use all cleaning and sanitizing chemicals at strength recommended on the label. Twice as much will not necessarily prove twice as effective.

2. Always drain lines before running milk through them.

3. Keep sanitizer containers tightly capped.

4. Avoid contamination of milk with ointments or salves containing phenols. Read the label. If the word "phenol" can be found, use extra care in handling the products.

CAUSES OF BUTTERFAT TEST VARIATIONS

Frequently the fieldman is called upon to explain the cause of a change in butterfat test. Minor variations may occur through inaccurate testing procedures in the plant. Farm factors can be involved and usually are much more significant. Some of these are listed below.

Daily Variations in Test of Individual Cows

Research has shown that butterfat tests vary considerably from day to day. Only one-fourth to one-third of most cows produce fairly uniform tests varying less than 1 percent.

In one disputed case an official testing agency noted a maximum of 1.2 percent change in fat test and 331 pounds in milk production by one herd on 2 consecutive days. Good herd management is essential to minimize daily variations in both fat test and production.

Breed Differences

Individual cows within a breed may vary greatly in butterfat output. In general, the fat content of milk of individual breeds increases in this order: Holstein, Ayrshire, Brown Swiss, Guernsey, and Jersey.

Stage of Lactation

Fat test decreases over the first 2 or 3 months after freshening and gradually increases during the remainder of lactation.

Cows calving in good flesh tend to produce milk of higher test than do cows calving in poor condition.

Greatest differences between the lowest and highest test during any one lactation period will be observed in cows averaging the *highest* test.

Season of the Year

Fat tests tend to increase during fall and winter and decrease during summer. Cows producing highest tests show greatest seasonal variations.

Temperature changes cause seasonal differences. An increase of 0.1 to 0.3 percent in test may occur with each 10ºF decrease in temperature and vice versa. This depends on the possible influence of any other factor or factors which cause tests to vary. Production of milk tends to follow a similar pattern.

Milking Interval and Time of Day

In general, shorter milking intervals result higher fat test and lower total yield of milk. For this reason, evening milk usually tests higher than morning milk.

Exercise

Moderate exercise (compared with no exercise) tends to increase fat content of milk.

Feeding

Cows must be fed adequate amounts of good quality feed if they are to produce to capacity. If cows are fed grain at levels yielding efficient production, feeding additional grain seldom changes butterfat test but may increase total milk production. Even good feeding practices will not guarantee higher tests because of influence of factors such as inheritance and milking practices.

Only accurate production records on cows can provide necessary information for breeding to advantage.

Feeding finely ground hay in substantial quantities or drastically reducing forage intake may lower the test.

Turning cows out on immature spring pasture will increase the volume of milk but lower fat tests. Making hay available at this time often will prevent extreme decreases in test.

Feeding cod liver oil may cause as much as 25 percent reduction in fat test.

Using large amounts of high-fat feeds will not substantially or necessarily increase tests.

Age of Cow

Fat tests tend to decrease gradually as a cow grows older, but over a lifetime this decrease may be no more than 0.2 percent.

Illness

Mastitis usually causes a temporary decrease in test. Other illnesses may cause a drop in volume and increase in test.

Milking Management

Milking management is by far the most important consideration in maintaining uniformly high fat and production figures.

1. Don't frighten or excite cows. Milk and fat yield will suffer.
2. Practice uniform milking procedures.
3. Prepare cows for milk letdown by washing udders in warm sanitizer solution. This step alone can save the milker up to 1 minute per cow in stripping time.
4. After preparing cows for milk letdown, attach milking machines without delay. (Delay of more than 1 to 2 minutes can cause both milk volume and fat to decrease.)
5. Complete milking within 3 to 5 minutes. This will help prevent mastitis.

Fat Test during Milking

As milking progresses the fat test increases sharply. "First milk" tests about 1 percent fat. This means you don't throw away much fat if a mastitis check is made with a strip cup. And if a mastitic condition is caught early, many dollars may be saved by quick treatment. Fat tests in stripper milk are high, usually ranging from 7 to 10 percent.

Other Farm Losses

Removal of topmilk for home consumption results in drastic decreases in test. One quart of cream testing 25-percent fat taken from a 10 gallon can of 4.0-percent milk lowers the test to 3.4 percent…..a six point drop.

Though it is obvious, calf and animal feeding must be considered as volume losses. Disputes between plant and farmer have occurred when this fact was forgotten.

"Heat" period may cause milk volume to decrease and fat test to go up.

Relation between Weight of Milk Delivered and Test

There is no consistent relationship between weight of milk delivered and the butterfat test of that milk. As one case in question, four consecutive deliveries of Jersey milk showed:

Day	Weight of milk pounds	Fat test percent
1	412	4.2
2	513	4.4
3	500	4.3
4	495	5.7

DHIA versus Plant Tests

DHIA testers are under direct order not to use results or take samples for check-testing plant tests. This practice can only result in misunderstanding and mutual distrust of those involved. In some cases the two tests will agree fairly well. In many they will not for one or more of the following reasons:

1. Plant results are obtained on composite samples prepared from all milk delivered. DHIA test is for 1 day's production only. Tests on composite samples may be slightly lower than tests on fresh milk. Use of the most accurate methods for determining fat levels indicates that Babcock test fat measurements are slightly *high*. Whether a fresh or composite sample is analyzed, results can be expected to range from 0.03 to 0.08 percent above actual fat test when the Babcock procedure is used.

2. Milking may be conducted with maximum efficiency and completeness on DHIA testing day. Cows may be milked out drier.

3. DHIA tests are not made on milk from cows that have been fresh fewer than 7 days.

4. Home use, calf feeding, and spillage will cause significant variation between DHIA and plant test.

5. Maximum values are reported by DHIA; subsequent handling of milk will most likely lower the test.

6. DHIA testers report results for test day and calculate production for the month. Plant tests are made on composites of all deliveries.

Any one of the factors which cause fat variations may influence the test on DHIA sampling day and cause differences between DHIA and plant test results.

Babcock Test

The Babcock test for butterfat, which the DHIA supervisor and dairy plant use, is accurate to plus or minus 0.1 percent (one point). Mismanagement of cows can cause decreases in test of 1.0 percent, 2.0 percent (10-20 points), or more.

Variations in Other Milk Constituents

There are minor variations in protein and solids-not-fat between different breeds of cows. To some extent protein and lactose levels are genetically independent of butterfat.

Underfeeding may reduce solids-not-fat to a slight extent. However, the amount of roughage fed does not have much influence on solids-not-fat milk.

Feeding may account for some variations in protein level. A low protein ration causes a slight reduction in protein in milk. Greater reduction is caused by low energy rations.

The mineral content of the feed has very little influence on mineral content of milk.

Season of the year causes changes in solid-not-fat in much the same pattern as occurs with butterfat. The variations are much smaller, thought, and considerably more irregular.

Proteins and minerals tend to decrease during summer months and increase during winter months. Lactose follows no seasonal trend.

Solids-not-fat tend to decrease slightly with age of the cow. Colostrum milk is higher in protein and mineral and lower in lactose than normal milk. Normal levels of theses constituents are usually reached within a few days after calving.

SEDIMENT

Consider the Following Points in Producing Sediment-Free Milk

1. PROVIDE dry approaches and holding areas for cows. This will reduce the amount of mud and manure tracked into the barn or milking parlor and help keep the cows clean. Paved areas are best. Allow 20 square feet of concrete per cow in the holding area or 400 square feet for a herd of up to 20 cows. For each cow over 20, add 10 square feet. Slope the holding area to drain away from the barn. Make the approach at lease 8 feet long and as wide as the door.
2. NEVER sweep the barn just prior to milk. Distribute dry feed at least 1 hour before milking or wait until after milking. This will reduce dust in the air.
3. KEEP cows clipped around flanks and udders. Long hair, besides being a source of sediment, holds dirt and manure which may find its way into milk.
4. WASH teats in warm sanitizer solution just prior to milking. If cows are quite dirty, the solution will have to be changed frequently; otherwise, you will be spreading dirt from cow to cow. Clean solutions also assure good bacterial killing power of sanitizers.
5. DRY teats with a towel. Use a separate towel (preferably a white, paper towel) for each row. The paper towel will remain clean after use if you have washed the cow properly.

6. APPLY milking machines with care, keeping the unit from sucking in bedding or dirt around the cow. If a unit falls off during milking, rinse off the dirt before reattaching it. Remember: a thimbleful of manure may add as many as 4 billion bacteria to milk.

7. MILK carefully. Avoid dirt or soil that collects on the bucket during milking. If you have a "transfer" or "stepsaver" pipeline system, be sure the transfer tank is kept covered.

8. FILTER or strain all milk into cans or bulk tank. Milk should be strained in the milkhouse or milkroom where dust in the air can be minimized. If you are doing a clean job of milking, *the filter pad will remain clean!* The purpose of straining is not to "clean" dirty milk. Rather, clean milk should be produced and the strainer used as an added safeguard. *Don't bang the strainer!*

9. PROTECT milking equipment from fly and dust contamination between milkings. Keep milkhouse windows closed during the dusty periods.

RESAZURIN TEST

One of the most common tests for evaluating bacterial quality of milk used for manufacturing purposes is the resazurin test. It is commonly referred to as a dye reduction test. The dye, which is added to milk, undergoes a chemical change called *reduction* when bacteria make certain changes in the milk. They dye changes color.

A dye reduction test estimates total number of *living* bacteria in the milk. Several factors influence the test. These factors do not lessen the usefulness of the test in a quality program. They are important to note for their significance in testing technique and evaluation of results. These factors are:

1. Kinds of bacteria present…reducing or non-reducing.
2. Numbers of bacteria present.
3. Stage of activity of the bacteria. The bacteria may be dormant if the milk has been cold or is old. It will take time for them to adjust to test conditions. In some samples bacteria may be growing actively and little or no adjustment occurs.
4. Body cells of the cow – All milk contains leucocytes (white blood cells); the average count runs between 70,000 and 100,000/ml. The leucocyte count in mastitic milk may reach 1,000,000/ml or more. The resazurin test can be used s an indication of mastitis. A quick color change initially followed by a lag period (consistently) is evidence of mastitis.

   A mastitic condition along with large numbers of bacteria (poor quality milk) will show only a quick color change to white.
5. Stage of lactation – The leucocyte count goes up in late lactation milk and is high in colostrums milk. This may influence the resazurin test.
6. Bacterial inhibitors - Extremely long reduction times should be suspect. Antibiotics or sanitizers may be present.
7. Oxygen incorporation – Vigorous agitation of samples incorporates oxygen and will delay the reduction.
8. Sunlight or other strong light – Exposure of the dye in milk or other solution causes it to fade.

9. Cream rise – The necessity for inverting tubes frequently is to prevent cream rise from influencing the test. As cream rises the bacteria are swept up and out of the reaction mixture. Samples rich in fat will influence the tests more severely.

10. Other reducing substances – Milk contains, to varying degrees, other compounds that can reduce the dye to some extent. These are called reducing agents.

11. Added copper – This will increase the reduction time to some extent.

12. Temperature – Only those bacteria that grow well at the temperature used will influence dye reduction. Psychrophiles, for example, may grow poorly at the standard temperature used in dye reduction tests.

Comparison of Resazurin Test to the Standard Plant Count

Resazurin times of 2¾, 2, and 0 hours are roughly equivalent to: less than 200,000, 200,000-1 million and greater than 1 million colonies respectively. High quality milk may show longer reduction time in winter than will summer milk of the same count. No seasonal influence should be noted on milks of lower grade.

STANDARD PLATE COUNT

The standard plate count is a method of determining numbers of bacteria by their growth on a culture medium. Visible colonies develop on the culture plates and are counted as such. Some factors which influence the standard plate count test are:

1. Colony development – Some colonies develop from individual bacterial cells, others from clumps of bacteria. It is not possible to distinguish between the two. They are both counted as “one” cell. Thus, the colony count is always less than the number of living cells present in the sample.
2. Unfavorable nutrient composition in the culture medium - Literally, it may not be a good food for some bacteria.
3. Unfavorable pH – A neutral pH is used. Yet, not all bacteria respond well in this environment.
4. Unfavorable oxygen level – Oxygen requirements of bacteria differ. One level is not suited to all types.
5. Unfavorable temperature – Not all bacteria grow at the temperature used in making the standard plate count test.
6. Age and stage of activity of cells.
7. Errors in measuring amount of sample, and errors in amount of water used in dilution blanks.
8. Counting errors.
9. Incomplete sterilization of equipment and/or solutions used in the test.
10. Improper sampling.

The standard plate count measures numbers of living cells. It is particularly well adapted for use on low count milk. It is commonly used for grading raw milk supplies for grade “A” use and for determining counts on pasteurized milk.

Estimating Thermophilic and Psychrophilic Bacteria by Standard Plant Procedure

The primary difference between thermophilic and psychrophilic bacteria and those that are counted by regular standard plate count is their range of growth temperatures. Thermophilics will grow well at temperatures higher than those used in the standard plate method and psychrophilics at lower temperatures.

To run a thermophilic test, incubate samples at 131ºF for two days. Psychrophiles may be estimated by incubating plates at 41ºF for seven days. Five days will give an indication of their presence, but longer time is better for more accurate results.

Evidence of psychrophiles can be obtained by incubating samples at the storage temperature used at the plant and making a direct microscopic count before and after incubation. An increase in bacteria numbers following incubation is evidence of psychrophiles.

The Plate Loop Method for Determining Bacterial Numbers

A modification of regular plating methods has been developed which offers faster plating possibilities.

The equipment consists of a syringe to which is attached a long platinum loop and a rubber hose. The syringe delivers 1 ml. every time it is depressed and the platinum loop is calibrated to deliver 0.001 ml. The end of the rubber hose is placed in sterile buffered water and is filled at intervals. Initially, the loop is flamed and then allowed to cool 15 seconds. Then, it is dipped in the sample and placed over the tempered agar plated and flushed off the loop with buffered water. The loop is not sterilized between samples, but is rinsed in the next sample before taking a loopful.

DIRECT MICROSCOPIC ANALYSIS

Direct counting of bacteria under the microscope can be used to estimate numbers. Like other methods there are factors which affect the use and evaluation of results. These include:

1. Both living and dead bacteria are counted.
2. Reasonably fast. A test can be run in 10-15 minutes.
3. Not a costly procedure.
4. Not good for examining low count milk, i.e., pasteurized milk or low-count raw milk.
5. Not all bacteria retain the same amount of stain. Some may be missed.
6. Variable distribution of bacteria on slides may cause inaccuracies.
7. Inaccuracy of measuring 0.01 ml quantities causes errors.
8. Difficulties in getting a representative sample may be encountered.
9. Perhaps the primary advantage of a microscopic procedure is that the shape of cells can be seen. This may be helpful in determining the cause of any problem.

At least four types of contamination are recognizable under a microscope.

1. Improperly cleaned equipment…The shape of the kind of bacteria in milk as it comes from the cow is usually small and round (micrococci). Dirty equipment will allow their growth and development. The presence of large numbers of small, round cells particularly if observed in clumps is evidence of dirty equipment.

2. Dusty or dirty equipment…The presence of large numbers of rod shaped bacteria indicates contamination from dust, soil, feed, manure, etc.

3. Improper cooling of milk…When milk is poorly cooled the bacteria will be found in pairs or short chains (S. lactis or S. cremoris). While in a stage of fast multiplication as would occur in warm milk, the bacteria divide and then remain associated with each other for a short time, thus short chains and pairs of round cells will be observed.

4. Mastitis...An increase in leucocyte count (large oval or irregular shaped cells) may precede evidence of bacterial infection. The appearance of long chains of round cells accompanies most mastitis cases. Grape-like clumps may be evidence of a staphylococcus infection.

Technically, the microscopic method is referred to as the Direct Microscopic Clump Count. First, the bacteria are stained to make them more visible. Then, under the microscope, they are magnified about 1,000 times. Clumps of bacteria are counted as one cell. Whenever individual bacterial cells are separated by less than the diameter of two cells, they are counted as one.

There are good and bad features in all milk quality tests. This, of course, is true of the microscopic procedure. One advantage the microscope offers is a picture of the types of bacteria in the milk. Sometimes, this picture can be used to help pinpoint the causes of high bacteria counts. Other times, production practices and problems are revealed. In addition, it is possible to detect mastitis and to determine the extent of infection. Also, certain mastitis-causing bacteria can be recognized. Although some of these indicators are crude at best, they can be helpful in a milk quality program. Let’s look at some examples of milk as it appears under the microscope:

Milk from Dirty Equipment and/or Dirty Cows

Bacteria in milk are usually round or rod-shaped. They occur individually or in clusters or chains. When milk is handled in dirty equipment, bacteria growing on the surface are often swept off in large clumps. The cells may be round or rod-shaped. Under the microscope they look like clumps.

Improperly Cooled Milk

If milk is not cooled quickly or if it is allowed to warm up during storage, bacteria will grow very rapidly. Their numbers will be great, and they will occur most likely in pairs or short chains. In bacterial growth, one bacterium splits into two. The two remain in close association with each other, thus, the presence of large numbers of pairs of cells. *Cool milk to 40°F or less within 2 hours! Keep it cold!*

Dusty or Dirty Environment

Bacteria associated with dust or manure is often rod-shaped. It is not unusual to find large numbers of these bacteria in milk produced in dirty or dusty milking areas or from dirty, unclipped cows. Feeding hay or sweeping barns just prior to or during milking will seed the air, making it difficult, if not impossible, to prevent contamination of the milk. Presence of large numbers of rod-shaped bacteria is evidence of such practices.

Mastitis Infections

Similar to the way in which bacteria are counted, the microscope can be used to detect body cells (somatic cells or white blood cells) found in milk of cows infected with mastitis. Microscopic examination is in fact one of the official methods used to verify findings of various screening tests.

The number of body cells is related to the seriousness of infection, and any bulk milk found to contain a million such cells or more can be considered to have come from a seriously infected herd. Other mastitis-causing bacteria cannot be recognized easily under the microscope.

Calculating the Microscopic Factor (MF)

Looking through a microscope, one views a round circle. This circle is called a "field". The area of this field determines the amount of milk which can be seen at any one time. Microscopes do vary in field size, and accurate counting can only be accomplished when the field size is known. Field size, number of fields in 1 , and amount of milk used, are the factors considered in calculating the Microscopic Factor (MF). The MF is calculated as follows:

1. Use a stage micrometer to determine the diameter (in millimeters) of one field under the oil immersion lens. The stage micrometer must be ruled in divisions of 0.1- and 0.01- millimeters.
2. Determine the area of the field by squaring the radius (r) and multiplying by 3.1416. The radius is one-half the diameter.
3. Convert the area of one field as measured in square millimeters to square centimeters, i.e., divide by 100.
4. Determine the number of fields in one square centimeter ($1 cm^2$), i.e. divide $1 cm^2$ by the area of one field (in cm^2) as determined in step 3.
5. Because the amount of milk used is 0.01 milliliters and it is spread over $1 cm^2$, determine the number of microscopic fields per milliliter by multiplying the number of fields (as determined in step 4) by 100.

The above calculations may be condensed into the following formula:

Microscopic Factor = ————

r^2 = radius times itself

The value thus derived is the number of microscopic fields/ml. of milk.

Sample calculation: Assume the field diameter (as measured with the stage micrometer) to be 0.146 millimeters (mm).

Then: radius = 0.146 ÷ 2 = 0.073
radius squared (r^2) = 0.073 x 0.073 = 0.005329

Then: —————— ——

Rounding off, the MF becomes 600,000

Calculating a Working Factor (WF)

If a constant number of fields are counted in routine work, a working factor may be calculated. The working factor is determined by dividing the microscopic factor by the number of fields counted. Then, estimated microscopic counts can be determined by multiplying the number of clumps of bacteria observed by the WF.

Sample calculations: Assume a MF of 600,000 and a constant of 20 fields examined. The working factor becomes:

Then, if a total of 40 clumps of bacteria were counted in 20 fields, the microscopic clump count would be 40 x 30,000 or 1,200,000.

TITRATABLE ACIDITY

Titratable acidity is sometimes used to measure milk quality. It is commonly used for grading cream. In this test the amount of acid or acid-like compounds is measured. There are two types of titratable acidity – apparent and developed. Fresh milk has an acid reaction. This is “apparent” acidity. The milk compounds and extent of acid reaction of these compounds which cause apparent acidity are:

Compound	Acidity Percent
1. Carbon Dioxide	.01 - .02
2. Citrates	.01
3. Proteins	.05 - .08
4. Phosphates	the remainder

“Developed” acidity is acidity which is caused by bacterial growth. Both apparent and developed acidity are expressed as *percent lactic acid.* The acid is present throughout the milk serum (skim portion). It is not associated with milk fat and does not rise with the cream.

The titratable acidity of milk from different breeds is:

Breed	Range	Average
Ayrshire	0.08 – 0.24	.16
Holstein	0.10 – 0.28	.16
Guernsey	0.12 – 0.30	.17
Jersey	0.10 – 0.24	.18

Titratable acidity has limited use in milk grading. It is true that an increase in acidity is evidence of bacterial growth. But considerable growth is needed before a detectable change in acidity takes place. Also, some bacteria do not produce much, if any, acid. Large numbers of such species can be present (very poor quality milk) and go undetected in an acid test.

Some factors which influence titratable acidity are:

1. Heat treatment – Very high heat causes acid formation in milk. Acidity is increased. Low heat expels gasses. Acidity is decreased.

2. Agitation – Moderate agitation removes gasses. The acidity will go down.

3. Vacuum treatment – Vacuum removes gasses. Acidity drops.

4. Fat test – The acids are in the serum. Increase in butterfat content, creams for example, reduces acidity.

5. Protein content of the milk – Note above that titratable acidity is influenced by protein content. The more protein present, the higher the apparent acidity. Over the years, protein content of milk has increased through breeding practices. This means that the average level of titratable acidity of *fresh* milk has increased. In any cow or herd milk of high protein level, expect a higher titratable acidity reading in the fresh milk, i.e. milk that has not increased significantly in bacterial count.

Making an Acidity Test on Milk

Equipment required for making a titratable acidity test is:

1. Automatic direct reading titration burette and reservoir
2. 9 ml. pipette
3. White cup

The reagents used are N/10 sodium hydroxide (the titrating solution) and 1% phenolphthalein (the indicator) in alcohol.

The procedure is as follows:

1. Add 0.5 ml. phenolphthalein to cup
2. Add 9 ml. of milk
3. Add N/10 sodium hydroxide until a faint, persistent pink color is obtained. This pink color should disappear in 15-20 seconds due to absorption of carbon dioxide from the air.
4. Read percent acid directly*

*If an automatic burette is not present, a 25 ml. burette may be used. Using 9 ml. of milk, divide burette reading by 10 to obtain percent lactic acid.

Making an Acidity Test on Cream

Cream must be weighed because of variations in weight per unit volume with differences in fat content. Pipettes will not deliver the same weight of cream if fat test varies.

1. Weigh 9 grams of cream directly into cup, balanced against 9 gram counterpoise on cream scales.
2. Proceed according to directions for milk acidity determination.

CHEMICAL CONTAMINATION PROBLEMS

Many different chemicals are used around the dairy farm. Pesticides (insect and pest killers), herbicides (weed killers), antibiotics and other drugs can find their way into milk if proper precautions are not taken. Milk contaminated with these compounds is considered adulterated and cannot be marketed.

Use of Pesticides

Emphasis should be placed on effective screening of windows and doors, clean surroundings, and efficient manure disposal as the primary means for controlling flies and insects. The need for pesticides should be cut to a bare minimum. When pesticides are used extra precautions are essential.

ALWAYS READ THE LABEL! All the information needed can be found on the label. Take note of (1) where the compound can be used, (2) how much to use, (3) when to use, (4) method of application (whether as a dust, spray, or bait), and (5) special warnings, i.e. exceptions to its use, handling dangers, and container disposal problems.

On most dairy farms use of chemical insect killers falls into three areas of application, the cows, the barn, and the milkhouse. The label provides this information. *Follow directions carefully!*

Some compounds must be applied as a dry dust. Others can be used as a spray. It is important to note these special considerations.

Weed and insect killers for pasture and forage crops pose another problem. Milk, from cows grazing in contaminated pastures or being fed contaminated forage, picks up the chemicals. Cows can graze or feed immediately after application of some chemicals. Other chemicals require a waiting period before grazing or cutting. The chemicals may disappear from standing crops, but persist in cut crops. Chemicals should be applied only on days when the wind is not blowing. The neighboring farm or other crops on the same farm can become contaminated by drift.

Because of the possibility of accidental contamination, never store pesticides inside the milkroom.

Use of Antibiotics and Other Drugs

Some persons have an acute sensitivity to antibiotics and other drugs. Even in bulk operations where the milk is diluted many fold, contamination from one producer's supply can be dangerous. Antibiotics get into milk by the following routes:

1. Direct injection into the udder – If one quarter is treated, other quarters become contaminated. The chemicals are carried by the bloodstream.

2. Intramuscular injection – If a cow is given a "shot" of antibiotic, the milk will become contaminated.

3. Through feed – Antibiotics are sometimes used as feed additives. In some cases low concentrations are acceptable. Nonetheless, the feed is one method by which drugs get into milk.

Tests	Properties being measured	Components included	Critical factors
Ether Extraction (e.g. Mojonnier or Roese-Gottlieb)	Components soluble in ether and insoluble in dilute alkali	True fats (triglycerides) Phospholipids Some fatty acids Fat soluble vitamins Cholesterol "Impurities?"	Weighing techniques decanting off ether layer
"Sulfuric acid	Components lighter than	True fats	Strength and

methods" (i.e. Babcock and Gerber)	and insoluble in strong solution	Some fatty acids and vitamins Impurities (water, curd, etc.?)	amount of acid temperature control, centrifugal force.
Detergent methods (e.g. Schain, DPS, and TeSa)	Components lighter than and insoluble in detergent solution	True fats Some fatty acids, vitamins, and phospholipids Impurities (water, curd, etc.?)	Temperature control particularly during digestion, mixing of reagent with milk
"Milko-tester"	Light transmission through fat globule suspension. (Depends on number of globules)	All components that exist as insoluble globules in versene suspension	Size of fat globules, calibration of instrument
Infra-red testing devices	Infra-red absorption (Depends on number of fat molecules)	True fat Phospholipids	Calibration of instrument, size of fat globule

Read the Label

The label will state the necessary withholding time, usually three days, though it may be longer. The holding period is related to dosage. While 500,000 units of drug may clear the milk in 72 hours, a large dose may not.

All milk should be withheld from treated cows at least 72 hours – unless the label specifically states that the drug will clear the cow (at the recommended dose) in a shorter time.

Tests for Antibiotics

A number of methods find use as means of detecting antibiotic residues in milk. Grade "A" requirements make necessary the use of a disc assay procedure using *Bacillus subtilis* as test organism in producer milk. Commingled milk at the plant must be tested by the *Sarcina lutea* Cylinder Plate method. Provisions are made for use of equivalent tests in both cases. The former method achieves a sensitivity of about 0.05 unit of penicillin per ml of milk. The latter test can reach to 0.00625 unit of penicillin per ml of milk. In all antibiotic tests, sensitivity depends on the organism used in the test. Several new tests have been developed using *Bacillus stearothermophilus* var. *calidolactis* (or other strains of this organism). In all such methods, lack of growth of the test organism is used as evidence of presence of antibiotic or other inhibitor(s). The Delvotest P utilizes a purplish dye and *absence* of color change as indicative of positive reading. The test is considered sensitive to 0.002 unit of penicillin per ml. The Difco Disc Assay method, using *stearothermophilus,* achieves essentially the same sensitivity but in a disc assay type procedure. Disc assay methods involve use of lintine disc, which is dipped in milk and then placed on a culture plate previously seeded with the test organism. A clear zone (a zone of no bacterial growth) appears around samples positive for presence of antibiotics.

MILKFAT TESTING

Accurate, precise testing of milk fat is a job of unequaled importance to all dairy operations. As long as milk is purchased on a butterfat basis, and as long as fat has monetary value, both equitable treatment of producer and processor, and dairy plant efficiency rest on the individual performing the milk fat test.

Two factors are essential in any testing program. These are accuracy and precision. The accuracy (of any test) must be related to some standard: in dairy work is usually the Mojonnier test. Accuracy, then, would concern the ability of test and tester to agree with the Mojonnier standard, or some other selected standard. Precision, on the other hand, refers to the reproducibility of the test, or how well two or more tests on the same sample agree with each other. Confusion can be avoided if these two words are clearly understood. Secondly, it is necessary to understand that different fat tests actually measure different milk components. When tests are compared, this fact must be taken into account. The table on the previous page outlines the properties, components, and critical factors involved in several common milk fat test procedures.

BABCOCK TEST FOR FAT IN MILK

The following information describes the equipment, reagents, and test procedures for making a Babcock test.

In order to understand why the Babcock test must be run exactingly it is necessary to know the basis for the test:

First, it is a test based on weight. The reading is a percentage value based on weight, not volume. Yet a device for measuring volume (pipette) is used for sampling – and an 18 gram sample is delivered when properly pipetted. With the topmost surface of the milk adjusted to the graduated mark on the suction tube, and when the last drop is blown out, 17.45 ml of sample is discharged. Since the average specific gravity of milk is 1.032 the *weight* of sample will be 1.032 x 17.45 = 18 grams.

The test is read directly. To make this possible the test bottle is calibrated so that each 1% division contains 0.18 grams of fat at 135° F (thus the need for tempering samples).

Sulfuric Acid

The sulfuric acid must have a specific gravity of 1.82 – 1.83. Specific gravity is a way to express strength of the acid. USE ACID WITH EXTREME CARE! Severe burns occur upon contact.

The temperature of the acid should be below 68°F otherwise charring may occur.

Principles of the Babcock Test

1. The sulfuric acid digests all the milk solids except fat, thus freeing the fat.
2. The acid generates heat.
3. The acid increases the specific gravity of the nonfat portion of the acid-milk mixture. This increases the tendency of fat to separate out.
4. The acid makes the mixture more fluid (reduces the viscosity) which also aids in separation.

5. The centrifuge (tester) throws the heavier acid-serum mixture to the bottom and the butterfat, being lighter, collects in the neck of the bottle.

Equipment

1. Standard 8-percent, 18-gram, 6-inch test bottle.
2. Standard milk pipette, calibrated to contain 17.6 ml water at 68°F, with a grooved rubber gasket allowing for venting of test bottle during discharge of sample.
3. Acid measure. Graduated cylinder or other approved measuring device calibrated to deliver 17.5 ml sulfuric acid.
4. Centrifuge or tester. Must be heated to 130° to 140°F during operation and be equipped with a thermometer. An automatic temperature control is recommended. The centrifuge must be mechanically driven, vibration-free, and operate at following speeds:

Wheel diameter inches	Minimum rpm
14	909
16	848
18	800
20	759
22	724
24	693

Wheel diameter means distance between the inside bottom of opposite cups measured through the center of rotation when cups are horizontally extended. Speeds should not exceed required minimum by more than 40 rpm.

5. A speed indicator (tachometer) permanently attached to the centrifuge is desirable.
6. An accurate timer with audible alarm.
7. Reading device for measuring fat column. Use sharp needle-pointed dividers or calipers. A mechanical reading device with a constant source of indirect light, a magnifying lens, and a heated platform for the test bottle is strongly recommended.
8. Water bath for test bottles, with a thermometer and a device (preferably automatic) to maintain uniform water temperature between 130° and 140°F.
9. Water bath for warming fresh and composite milk samples to 100°F; with thermometer and a heater thermostatically controlled for 110°F maximum.

Reagents

1. Sulfuric acid with a specific gravity of 1.84 at 68°F.
2. Soft or distilled oil-free water. Treat hard water either by boiling or adding 4 to 5 mls sulfuric acid per quart just prior to use. Hard water (carbonates) cause bubbles in the fat column.

Testing Procedures

PREPARATION OF MILK SAMPLE FOR PIPETTING

1. Warm the fresh milk samples and composites to 100°F in a water bath. Final temperatures should not exceed 100°F. Do not mix milk until sample has reached

100°F. Never hold warmed sample more than 30 minutes before mixing and sampling. Water bath temperature should not exceed 110°F when samples are inserted.

2. Reincorporate any cream adhering to sides of bottle or stopper with the contents by gently rotating or stirring. Use a special rubber disc (policemen) to dislodge adhering cream if necessary. Mix the sample within 30 minutes after reaching 100°F by pouring it into another clean, dry container and back into the original at least twice. If the composite bottle is not over two-thirds full, mix the sample by holding it horizontally and rocking it back and forth 6 times through a distance of 6 inches within 3 seconds, being careful to avoid churning.

3. Pipette immediately after mixing.

PIPETTING

1. Immerse the tip of the 17.6 ml milk pipette to about one-half the depth of the milk.

2. Fill pipette, remove milk adhering to the outside of the delivery tube, and then adjust the topmost surface of the milk to the graduated mark on the suction tube.

3. Insert entire delivery tube in neck of the test bottle and release contents.

4. When pipette has drained for 10 to 15 seconds after free flow stops, blow out the last drops.

ADDING ACID TO MILK

1. Milk in test bottles should be between 50° to 70°F before acid is added.

2. The sulfuric acid should be between 50° to 68°F. Approximately 17.5 ml is required.

3. Hold test bottle at an approximately 45° angle and add acid slowly all at one time, washing all traces of milk into the bulb.

4. Start mixing milk and acid gently by rotating test bottle (directed away from the body) until curd disappears. Continue mixing vigorously for at least 30 seconds more. (A mechanical mixing device is recommended when several tests are run at once.)

5. The bottles should be placed in a heated centrifuge and centrifuged immediately after mixing milk and acid, to avoid excessive cooling.

CENTRIFUGING PROCEDURE

1. Place samples in centrifuge preheated and maintained at 130° to 140°F and whirl for 5 minutes after proper speed is reached. Use a timer.

2. Add soft water (at 140° to 150°F) until bulb of bottle is filled.

3. Whirl for 2 minutes after centrifuge is up to speed.

4. Add soft water (at 140° to 150°F) to bring fat column within the graduated portion. At time of reading, the entire fat column must be within the graduated portion of the test bottle.

5. Whirl for 1 minute after centrifuge is up to speed.

6. Transfer bottles to water bath at 130° to 140°F (preferably 135°F) and hold for at least 5 minutes before reading. Keep water level slightly above the tops of the fat columns of all test bottles.

READING THE TESTS

1. Remove test bottle from bath, wipe, and with dividers immediately measure that fat column in its entirety, from the bottom of the lower meniscus to the top of the upper meniscus. Avoid hooking dividers in graduation marks. Do this by making initial measurements from side or rear of bottle. Hold test bottles vertically at eye level in front

of a constant source of indirect artificial light when reading. An acceptable mechanical reading device is recommended (see EQUIPMENT, item 7).

2. Report results to the nearest 0.1 percent. (Value of smallest unit of graduation – sometimes called “one point”.)

3. Reject all tests in which the fat column is milky or shows curd or charred matter, or in which reading is indistinct due to foam or a poorly formed meniscus. Repeat such tests, adjusting amount of acid added.

4. Record each test immediately.

Sampling Procedure

MILK IN CANS

Start with mixing disc at bottom of can, pull up along near side and push down far side, being careful to incorporate cream adhering to shoulder. Mix thoroughly before sampling.

MILK IN WEIGH TANKS

Never assume that the dumping process will mix milk adequately. Errors as high as 2 percent in fat test can result. Tanks of proper design minimize or eliminate need for further agitation. If the weigh tank does not mix the milk adequately, alternative procedures can be used:

1. Mount an electrically driven agitator on the weigh tank and operate it continuously during receiving.

2. Install baffle plates in the weigh tank.

3. Use air agitation. All air should be filtered for this purpose. Take the sample halfway between center and end of the tank.

Check weigh tanks periodically for sampling accuracy. Check all new installations prior to use.

MILK IN BULK TANKS

Bulk tanks must comply with 3-A standards which require agitators capable of complete mixing in not more than 5 minutes. Bulk milk is considered completely mixed when fat determinations on samples from different tank levels and at extreme distances from the agitator do not vary more than ±0.1 percent. Ice samples during transit from farm to plant. Never carry the composite, as such, in the truck.

BABCOCK TEST FOR FAT IN CREAM

Use essentially the same technique for sampling cream as for sampling milk. Cream is thicker, however, and samples should be poured back and forth about 5 times. Then, proceed as follows:

1. Weigh 9 grams into 50 percent cream test bottle. (Cream is weighed rather than pipetted because it varies greatly in specific gravity at different butterfat percentages.)
2. Add 8-12 ml acid, mix to get chocolate brown color.
3. Add 5-10 ml soft water.
4. Whirl 5 minutes.
5. Add 140°F water to float fat into neck.
6. Whirl 1 minute.

7. Temper 5 minutes at 135°-140°F
8. Add glymol (4-5 drops) and read. Glymol flattens the meniscus and allows more accurate readings.

Legal cream test bottles come in the following sizes:

1. 18 gm, 9 inch, bulb capacity not less than 45 cc
2. 9 gm, 6 inch, bulb capacity not less than 45 cc
3. 9 gm, 9 inch, bulb capacity not less than 45 cc

Causes of Error in the Babcock Test

The more important causes of inaccuracies in the Babcock test are as follows:

1. Improper mixing of sample.
2. Careless measuring of sample and acid.
3. Pipetting milk which is either too warm or too cold.
4. Slow blending of acid with milk, having acid too warm, or using too strong an acid with milk, causing charring.
5. Having acid too cold, using too weak an acid, or insufficient mixing of acid with milk, causing curd to appear in fat column.
6. Excessive delay in mixing acid and milk, and between time of mixing and centrifuging.
7. Incorrect speed of centrifuge.
8. Over or under-timing.
9. Variations in temperature of tester.
10. Hard water or dirty water added to samples.
11. Improper water-bath temperature.
12. Improper light source for reading test.
13. Errors in reading fat column.
14. Dirty or inaccurate glassware.
15. Operator fatigue or incompetence.
16. Dishonesty.

The influence of some of these causes of error on test results is shown in the following table:

Errors in fat accounting which may result from milk testing procedures.

	Babcock Test	
Testing Procedure	**Percentage too high**	**Percentage too low**
Babcock test vs. ether extract	(0.05-0.07)	….
Tester operated too long (38 min.)	0.09	…..
Reading tests when too hot (175°-180°F)	0.05	…..
Speed of centrifuge too high (200 rpm above normal)	0.02	….
Composite test vs. daily test	…	0.02
Water bath temperature too low (120°F)	…	0.03
Water bath not deep enough	….	0.03
Tester operated too short a period (4.5 min)	….	0.07
Speed of centrifuge (20-in.) too low (200 rpm below normal)	…	0.11

Inaccuracy of test bottles	?	?
Holding temp. of composite samples (58°-80°F)	**….**	0.04-0.08

USE OF THE MILKO-TESTER

Calibration

The procedure for calibrating the Milko-Tester according to Shipe in A.O.A.C. is:

1. Test in triplicate 20 representative milk samples ranging from 3 to 6 percent fat by 15.029 or 15.031 and the Milko-Tester (15.029 and 15.031 are A.O.A.C. designations for the Roese-Gottlieb and Babcock methods respectively. In other words, you could use either method in calibrating the Milko-Tester).

2. Calculate the average for each sample by each method to the nearest 0.01 percent.

3. Calculate the standard deviation of the difference, S_D, as follows:

$$S_D = ((D^2) - (D)^2 /N) / (N - 1)$$

Where D = average of results by 15.029 or 15.031 on sample minus the average of Milko-Tester results on the same sample, e.g. $(B_1 + B_2 + B_3) / 3 – (M_1 + M_2 + M_3) / 3$ (where B = reading by the Babcock method (or Roese-Gottlieb), and M = reading by the Milko-Tester).

Where N = number of samples tested (if the specification of 20 samples tested is exceeded, include all samples tested in the calculations except those for which an error in 1 or more determinations can be proven.

Operation

The following is a guide for operation of the Milko-Tester as an official method of testing butterfat. It is a condensation of information found in the operator's manual of the manufacturer. The material is intended as a guide for routine, day-to-day analysis. For more detail, consult the manual per se.

The foregoing discussion assumes that the Milko-Tester has been properly calibrated. Units should be calibrated when installed. Thereafter, accuracy and precision checks must be made every 10,000 samples. Recalibration is necessary whenever:

1. The 10,000 sample check fails.

2. The following parts are replaced, rebuilt, or adjusted: diluents syringe, syringe check valve, separation valve, pipette, cuvette, photocell, photolamp, stabilizer, or homogenizer.

3. For the Mark II, 20,000 samples have been run through the equipment, or at least every 6 months. The 20,000 sample calibration is required because of the necessity to overhaul the homogenizer at that stage. If 6 months elapse before the 20,000 sample limit is reached, the unit must be recalibrated, no matter how many samples have been analyzed. The Mark III model can perform up to 60,000 analyzes before recalibration.

Start-Up Procedure

1. Check meter reading (fat test scale) with power disconnected. The meter must read 9.2 percent exactly. If it does not, adjust the Milko-Tester by means of the screw located in the center part of the meter.

2. Allow the unit to warm up (plugged in and turned on) for 40 minutes or more before making the first test. (This is necessary only if the Milko-Tester is turned off at the end of a day's use.)

3. Inspect intake filter. Be sure it is unclogged (free of dirt, milk solids, etc.).

4. Force air out of diluent syringe (push in the plunger and let it return to normal setting). Through window in top of unit note whether or not all air bubbles have been expelled.

5. Check diluent level in bottle. Be sure there is enough liquid for proper operation.

6. "Zero" the unit on diluent. That is, make a reading on diluent only. Indicator should read 0. If it does not, make appropriate adjustment.

7. Check the rubber valve at the inlet of the diluent syringe as follows. Remove the diluent tube and filter from the diluent bottle. Hold the filter so that it can be observed and slowly depress the diluent syringe. If valve is functioning properly, no diluent will come back through the filter. If diluent does return through the filter, replace valve and recheck.

Sampling Preparation

1. Warm milk samples to 100°F in a water bath. Final temperature should not exceed 100°F. Do not mix milk until samples have reached 100°F. Never hold warmed samples more than 30 minutes before mixing and sampling. Water bath temperature should not exceed 100°F when samples are inserted.

2. If cream adheres to the sample container, reincorporate it by gently swirling or stirring. When necessary, a rubber disc (policeman) may be used to dislodge adhering cream.

3. Mix sample within 30 minutes after reaching 100°F. Mixing procedure may vary with type of sample container, although not necessarily. In glass containers (or in Whirl Paks if desired) mix milk by pouring into a dry container and back into the original at least twice. Or, mix by rocking the sample back and forth 6 times over a distance of 6 inches. An air space is essential for this method of mixing. Always be careful to avoid churning.

4. Test the sample immediately after mixing.

Testing Procedure

1. Place well-mixed samples under the sample pickup tube.
2. Start homogenizer (push "start" button). A yellow light will come on.
3. After yellow light goes out, wait 3 seconds.
4. Depress funnel slide plunger to its full travel; hold it in.
5. Depress diluent syringe plunger to its full travel and release.
6. Gently allow funnel slide plunger to return to its original position.
7. Remove sample. Wipe off intake.

8. Take the reading from the meter immediately after the needle comes to rest. Be sure to align the needle with its mirror image to the rear. Read the nearest 0.1 percent (one point).

Daily Maintenance

After samples have been run and it will be more than 5 minutes to the next sample, cycle distilled water through the homogenizer. Do this two times. Flush the cuvette (diluent) twice, and return the needle to zero.

At the end of the day: (1) repeat above, (2) clean the collecting funnel, stirrer, and all other parts in that area, and (3) clean up any milk spilled during the day.

Weekly Maintenance

Once each week, clean the Milko-Tester as follows:

1. Mix 2 ounces of milkstone remover with 2 ounces of distilled water and draw this mixture into the unit through the sample tube. Allow to stand in the unit for 15 to 20 minutes, and then flush 3 times with distilled water.

2. Draw diluent into unit by placing a diluent bottle under sample pickup tube. Allow to stand 15 minutes. Cycle the homogenizer twice using distilled water. Flush cuvette as indicated under "Daily Maintenance" above.

3. Clean or replace sample filter mesh. It may be cleaned by immersion in nitric acid. This will remove organic sediment that has accumulated.

4. Clean collecting tube (below the milk pipette outlet) of encrusted sample. Rinse chips through outlet line.

Weekly, But at Least Every 2,000 Samples

1. Check water level in water bath. Add distilled water if needed.

2. Lubricate funnel slide rails, push-buttons for funnel slide and diluent dispensing syringe, homogenizer bearing, eccentric of gear motor, bearing and slide rail which supports the bearing.

3. Check pilot lamps. Replace if necessary.

4. Check shift value. This is read through the small round window on the left side cover.

5. Check diluent bottle for contamination; replace if necessary. Also check diluent screen, and replace if necessary.

6. Check diluent syringe. If deposits are observed on the inside of the syringe (usually it will appear as white ring near the end of the piston), remove the unit, disassemble, and clean.

Record Keeping

It will be necessary for the Milko-Tester user to have records available at all times for both personal needs and those of the State Milk Board in carrying out routine inspection work. For this purpose, keep: (1) a calibration record and (2) a daily operational record.

The calibration record should include date, reason for calibration, and calibration data (all analyses made on all samples, both high and low fat, the average of the triplicate analyses, and all calibrations).

Daily records should include: (1) date, (2) number of samples run, (3) accuracy checks, (4) shift value checks, (5) standardization data, (6) parts replaced, if any, (7) weekly cleaning program on the day set aside for this task, (8) name of operator, and (9) other data deemed necessary to the upkeep and accurate operation of the unit as desired by the operator.

Regulatory Requirements

1. The Milko-Tester shall be operated and maintained according to the manufacturer's operation manual, which shall be available at all times in conjunction with the instrument.

2. All dairy plants utilizing a Milko-Tester shall assign a qualified licensed person to supervise the operation and maintenance of the instrument.

3. A permanent written record of all repairs, calibrations, check tests, and number of samples tested shall be kept on file.

4. Samples used for calibration shall include samples in the butterfat ranges of 3-4 percent and 5-6 percent.

5. Check tests shall be performed daily prior to using the instrument and thereafter during operation, as often as necessary to maintain accurate tests.

6. Potassium dichromate, not more than 1 percent by weight of the sample, must be used as a preservative if a preserved sample is used for testing. Other preservatives produced and available after the adoption of Regulation Agr. 1540 may be used providing they are approved by the Commissioner.

7. It is the responsibility of the assigned Milko-Tester operator to determine that the Milko-Tester is operating correctly. If at any time he/she believes the results obtained are biased, all further testing with the defective machine shall cease until the unit has been adjusted, repaired, and recalibrated.

8. The individual running the standard method used to calibrate the electronic tester shall hold a currently valid testing license.

Other Official Tests

Both the Gerber and Mojonnier tests are official procedures in Missouri. The Mojonnier test requires special equipment and uses an analytical (very sensitive) balance for weighing samples. It is usually considered to be the standard upon which other tests are compared. However, it is rather tedious and time consuming and does not lend itself to routine work involving large numbers of samples. The Gerber test does not have these disadvantages and is nearly as versatile, although possible somewhat less precise. The Gerber test does lend itself well to large numbers of samples and is sufficiently versatile to make it a very useful procedure for market milk operations. Special test bottles and a Gerber centrifuge are required. The test requires slightly less time to run than the Babcock test.

The procedure for making a Gerber test is as follows:

1. Warm samples to 100°F and hold 5 minutes. Be sure sample is well mixed before pipetting.

2. Using 11 ml pipette, add 11 ml of milk to test bottle. (Pipette is full when top meniscus of milk coincides with graduation line.) After free flow stops, wait 3 seconds and blow out last drop.

3. Incline rack 20° off horizontal.

4. Holding bottle at 45° angle, slowly add 10 ml of sulfuric acid previously cooled to 50°F.

5. Return bottle to rack, positioning it to maintain vertical plane of stem to insure complete milk displacement.

6. Add 1 ml of isoamyl alcohol.

7. Insert lock stopper. Exert pressure firmly to secure seating.

8. Hold with stopper end up and shake until curd is digested. Then shake an additional 10-15 seconds.

9. Hold bottles at stopper and neck (because of heat) and invert not less than 4 times. This should mix in all “trapped” acid. Keep bottles at 45° angel.

10. Place bottles in centrifuge – stopper toward outside.

11. Whirl 4 minutes.

12. Temper 5 minutes at 140°F.

13. Remove bottles individually. Fit stopper on key on reader stand. Apply gentle pressure to bring bottom of fat column to coincide with nearest whole percent.

14. Read graduation at top of the fat column at the bottom of the shallow meniscus. Read to nearest 0.05 percent graduation.

15. Subtract bottom “whole percent reading” from top reading to get percent butterfat.

Relationship between Fat and Solids-Not-Fat

Don’t expect high solids-not-fat content in milk of low fat test. On the average, milk testing low in fat also will test low in solids-not-fat. For each 1.0 percent drop in fat test, you might expect a 0.4 percent drop in solids-not-fat and vice versa. This relationship is not consistent enough to permit accurate calculation of solids-not-fat from fat measurements. But it does tell you what to expect. Milk testing 3.5 percent fat will ordinarily have between 8.4 and 8.5 percent solids-not-fat. You would neither expect 3.5 percent test milk to have 8.7 or 8.8 percent solids-not-fat nor 8.2 or 8.3 percent solids-not-fat. Individual cow samples might show such odd relationships, but less so in herd milk – and even less so in mixed herd milks.

MILK PROTEIN

Protein content of milk averages about 3.2 percent in the United States. Of this amount, about 2.5 percent is casein and 0.7 percent is whey proteins. At a level of 3.5 percent milkfat, protein content, which follows generally the pattern for butterfat, becomes about 3.1 percent. Factors that tend to cause changes in milkfat level tend also, and in similar fashion, to alter protein content. The level of protein falls as lactation progresses; it also decreases during spring and summer, but increases in fall and winter. Ability to produce protein is determined by genetic factors. Breed differences occur just as they do in milkfat production. Average protein content of milk, of different breeds, ranges close to the following: Holstein (3.3), Ayrshire (3.4), Guernsey (3.6), Brown Swiss (3.7), and Jersey (4.0). To increase the percentage of protein in milk, dairymen must breed for increases in protein yield, not percentage, in order to prevent a decrease in total milk yield. The same breeding philosophy holds for other milk components.

Generally speaking, mastitis causes an increase in total protein content of milk, but casein content goes down. The gain in protein takes place in the whey protein fraction. Because cheese consists only of casein as protein component, yield of cheese suffers with an increase in severity of mastitis.

Test for Milk Protein and Solids-Not-Fat

Because proteins consist of amino acids and because amino acids contain nitrogen, a reference procedure for determining protein content has been developed around an analysis for nitrogen. It is called the Kjeldahl method. This is the reference procedure for all routine methods of determining protein content. To convert a reading of nitrogen content to protein, a factor must be used. This factor varies to some extent for different proteins. The reason lies in the varying amino acid composition (thus nitrogen level) in various proteins. The factor for milk protein is 6.38. Take the nitrogen content of milk and multiply that value by 6.38 and you get protein content. At least this is how the test calculation usually is made. Milk, however, contains some components other than protein that also contain nitrogen. Collectively, these are termed non-protein nitrogen (NPN). Milk averages about 5 percent NPN. Therefore “true” protein content, as measured by the Kjeldahl method, must consider NPN. To derive a true protein level requires that NPN be deducted from total nitrogen before applying the factor above.

The above considerations are important because the Kjeldahl method is the reference against which routine protein testing methods are standardized. Any “error” in the Kjeldahl procedure is automatically built into routine procedures. The major error that occurs centers on NPN, a component that varies seasonally, by breed, and protein content of feed. Higher levels of protein in feed yield somewhat higher NPN levels in milk.

Two different kinds of methods are most frequently used in routine analysis of milk for protein content. The first is referred to as dye-binding methods; the second is infra-red analysis. Two different dyes are applied in the former methods, and two test methods are thereby distinguished. One dye is amido black, the other orange g. In both dye-binding procedures, excess dye is added to milk. The dye is attracted to and binds to protein. The dye/protein complex is precipitated out of solution and the residual dye is accounted for by light absorbance measurement. The amount of residual dye is inversely proportional to the amount of protein. Different proteins do have differing capacities to bind dye, and this fact must be considered in making measurements of different proteins or ratios of proteins in a given food system. For example, the dye-binding capacity of whey proteins is 20 percent higher than whole milk protein. The dye-binding capacity of casein is 5 percent lower than whole milk protein. In the amido black method, caution must be taken to recalibrate the equipment when new dye is purchased. Purity of the dye varies from one lot to another.

Infra-red equipment allows for measurement of fat, protein, lactose, solids-not-fat, or total solids all on the same piece of equipment. A number of different models of infra-red units are used in milk analysis. All are based on the principle that different chemical bonds absorb more or less infra-red light of specific wave lengths. Because chemical bonds vary by milk component, infra-red absorbance (or reflectance) can be used as a means of quantifying the amount of each.

Evaluating Different Test Methods

A routine test procedure is evaluated by three criteria: (1) the degree to which the method agrees with a reference test, (2) the precision with which the method is able to repeat itself on the same sample, and (3) the degree to which test results between laboratories and obtained by different technicians agree with each other. Respectively, these three criteria are termed accuracy, repeatability, and reproducibility.

FREEZING POINT DETERMINATION AND ADDED WATER

The most precise measure of adulteration of milk with water is freezing point of milk. Freezing point depends on dissolved substances. In milk, lactose and mineral salts lower the freezing point slightly below that of water.

Freezing point of milk is its most constant property. Within the udder, increases in lactose are always compensated for by decreases in mineral salts and vice versa, thus stabilizing the freezing point.

Addition of water causes a rise in freezing point. This increase can be measured with great precision. Amount of added water can be readily calculated. In some few instances water is added intentionally. Far more often water gets into milk because of failure of the dairyman to adequately drain lines or pumps, milk jars, or bulk tanks. The problem is generally more serious in pipeline installations. Water used to "chase" last milk through the pipeline or out of the bulk tank also can add significant amounts.

Origin of Present Freezing Point Base

Extent of water adulteration is gauged by the degree to which freezing point of a milk sample varies from the natural freezing point of a given milk supply. Most often the "natural" freezing point is taken as an average value for any given pooled supply of market milk. One study found the average for the United States to be -0.540°H (H in this case stands for Hortvet, the name of the scientist who first devised a standard test for freezing point). Although natural variations in freezing point do exist, statistical analysis shows that milk of 99 percent of the United States cow population falls somewhere within the range of -0.560°H and -0.525°H. The latter (the higher figure) has become the legal standard over the years. What it says, in effect, is that only very rarely (1 in 100 times or less) will an unadulterated (natural) milk supply be found to have a freezing point above this level. Putting it differently, any milk showing a freezing point above -0.525°H almost certainly has been adulterated with water, whether accidentally – as often is the case – or intentionally.

Development of a Working Standard

The legal standard is an upper freezing point base, a base considerably higher than anticipated in average milk supplies. As such, it serves as a legal basis, but it really doesn't serve as a very good "working" standard. That is, considerable water could be added to the average milk supply before the legal standard is exceeded. Take the national average cited above as an example. The question is how much water could be added to such milk before the freezing point would exceed the legal upper base.

The calculations are:

$$0.540 - 0.525 = 0.015$$
$$0.015 \div 0.540 \times 100 = 2.8\%$$

The answer is 2.8%. Using precise figures and not rounding off, the percentage in reality is 2.9. Nearly 3 percent of water can be added to average milk supplies before the legal standard is exceeded. This is a considerable amount and a costly amount to haul or to process out of milk at today's high energy costs. Thus a "working" standard appears desirable. Such a standard placed at some level below the legal base, should ideally make worthwhile a field visit to the farm yet avoid unnecessary visits. It is possible, again by statistical means, to determine what this "working factor" should be for any level of probability of finding a problem of added water. A factor can be set, for example, that ensures that 2 out of 3 field visits will result in positive finding of adulteration, thus allowing analysis and corrective action to be taken. This freezing point value is given as one standard deviation above the average. The standard deviation determined in the national survey of R. W. Henningson was found to be -0.00676°H. Deducting that value from the average (-0.5404) gives a working base of -0.534°H. This value could be lowered slightly to account for test variability. Where the average freezing point of unadulterated milk is -0.540°H, a reasonable working factor would appear to be -0.535°H.

Degrees Hortvet vs. Degrees Centigrade

The Hortvet standard has been used for many years in the dairy industry. It is in fact used interchangeably with degrees centigrade, which is an error. Cryoscopes often are calibrated in degrees Hortvet and results are reported in degrees centigrade. The original error, which has since led to use of this unconventional temperature standard, was made at a time when methods for determining freezing point simply were not precise. That is no longer the case, and it would appear desirable to convert now to the more universal standard, i.e. centigrade. This is not difficult to do. The same salt standards are used in the calibration of cryoscopes. The devices simply are set at equivalent centigrade values, rather than at Hortvet values. Readings are then made directly in degrees centigrade.

Or, degrees Hortvet can be converted to centigrade using the formula:

Conversely, the formula for converting centigrade to Hortvet is:

Some comparisons of Hortvet and centigrade reading follow:

Degrees Hortvet	Degrees Centigrade
-0.422*	-0.4080
-0.544	-0.526
-0.540	-0.522
-0.537	-0.519
-0.530*	-0.5125
-0.525	-0.508
-0.621*	-0.6002

*Based on known amounts of salt in water. Salt levels are 6.892, 8.692, and 10.200 grams per 1,000 grams of water for the -0.422, -0.530, and -0.621 Hortvet measures, respectively.

Calculating Added Water

Most cryoscopes provide for direct reading of added water using some standard value as a base. Over the years a 3 percent tolerance also has been provided. The AOAC standard uses as an average freezing point the value -0.546°H. Using 3 percent tolerance, the figure becomes -0.530°H. Percentage of water added can then be calculated in 2 different ways:

1.

In the above example, -0.530 becomes the expected freezing point. Other values may be more precise for any given producer or milk plant.

2. If water addition is calculated on a weight basis, the formula becomes:

In this example, T.S. means total solids.

Causing of Variations in Freeze Point

Minor variations in freezing point occur. Several different factors are involved:

1. Seasonal variations - Some change in freezing point occur throughout the year. You might expect slightly lower values in the spring than in winter. This has been attributed to changes in feed and temperature.
2. Feed – Starvation diets, shifts from low to high carbohydrate feed, and other ration changes cause freezing point variations.
3. Breed – Ayrshire herds appear to have the highest average milk freezing point. Slight differences may be found between other breeds.
4. Morning versus evening milk – Morning milk has been found to be approximately 0.002°C higher than evening milk.
5. Acidity development – One of the more important causes of freezing point changes is souring. Freezing point is lowered and will compensate for water addition.

6. Mercuric chloride – Addition of preservative will decrease freezing point. Composite samples should not be tested without use of suitable correction values. The correction factor will vary according to concentration of preservative.
7. Freezing – Milk that has been frozen will have a slightly higher freezing point.
8. Vacuum treatment – Removal of gases from milk will tend to raise the freezing point.