CANS, TANKERS AND CONTAINERS

J. EKMAN *

Cans

General considerations

In many countries milk production units are small. With increasing industrialization, too, milk consumption tends to be greater in areas other than where it is produced. The problems of collection and transport of milk are thus of increasing importance in all dairying countries.

The purpose of milk collection is to move milk from the farms to the collection centres, or directly to the dairy plants, without any serious decline in milk quality in its widest sense—keeping quality, chemical composition, and the taste and flavour of the milk. When cans are used for milk collection, they may have to be delivered by the farmer to some spot from which they are picked up by the transport. At such pick-up points arrangements should be made to give the cans suitable protection from sunshine, dripping vegetation, and splashes from the road. The waiting period (especially on warm days) should not be too long. A good transport system therefore comprehends a transport timetable which will enable the producer to get his cans to the pick-up point at the most suitable time, and which will avoid delays in reception at the dairy plant when the transporters arrive with the milk. When transport covers any considerable distances it is in the interests of hygiene that the vehicles should be capable of fairly rapid speeds, and that they should be designed to be easily cleansed from road dirt and milk residues. In extreme climates it may be necessary to have covered transport to protect the milk from excessive temperatures; even a tarpaulin can be a valuable aid in this respect. If the transport carries other cargo besides the milk, it should not be loaded on to the same part of the vehicle, particularly if the additional freight is chemicals for the farms, or any other strong smelling or unclean load. In addition to avoiding the risk of contamination

* Technical Department, Swedish Dairies Association, Stockholm, Sweden.

of the contents of the cans, their external surfaces must be kept clean since they will be brought into the dairy plant on arrival.

As to bacteriological quality, the micro-organisms present in milk after milking should be prevented from increasing during transport, either by keeping pre-cooled milk at a low temperature in the transport can, or by cooling the milk in the vessel (if the transportation period is long enough). The insulation properties of the cans may differ according to whichever method is adopted. Contamination from a badly cleaned can or tank must not take place, nor should it be possible for any external contaminating material to enter the milk. This implies certain demands on the material and construction of the containers. Materials that can be given a smooth surface not easily scratched are to be preferred, and they must not be liable to severe corrosion by the cleaning agents necessary to dissolve milk residues or by sanitizers. The designer should bear in mind that every part of the container must be made available for mechanical cleaning and preferably also for inspection. Lids and junctions must fit, not only to avoid leakage but also to protect the contents.

Steps taken to improve the hygienic conditions of the milk involve chemical problems of milk quality. In many countries an oxidized flavour occurs, and among other causes copper and iron contamination of the milk should be mentioned. With improved milk hygiene, these metals should not be used in any surface in contact with the milk. For the same reason, and for the protection of the fat from lipolytic activity in raw milk, the design of cans or tankers should as far as possible prevent violent agitation of the milk or admixture of air with it during transport. Agitation may have some disadvantage also from the bacteriological point of view if bacterial clumps are broken up and spread throughout the bulk.

These conditions have an important bearing on milk quality and they should be fulfilled as far as possible. Obviously this may be done within several different collecting systems. However, milk production is an economic enterprise, and hygienic advice or injunctions that are unrealistic from the economic point of view will always give poor results.

Collection systems

Various systems of collection and transport of milk from the farm exist, and may be classified as follows:

(*a*) Collection and transport of cans or corresponding containers up to the size of about 50 litres or 10 gallons.

(*b*) Transportable bulk tanks used at the farm and taken to the dairy plant for emptying.

(*c*) Stationary farm bulk tanks used with transport tankers which pick up the milk at the farm. Tankers may also be equipped to collect, measure and sample milk from cans at the farm (" ambulant collection centres ").

(*d*) Mobile milking units—that is, transports equipped with milking utensils—in which the staff perform the milking and the milk is taken care of by the patrol.

(*e*) Plastic pipe-lines are used in some high areas for transporting milk down to the valleys.

The frequency of collection may vary rather widely because of climate and regional differences. The delivery of milk twice a day immediately after milking, and without any cooling, is practised in warm countries where it is difficult to cool milk on the farm; this system is also found in areas with small farms close to the collection centres or dairy plants. Such frequent transport involves a considerable labour, however, and a balance must be struck between labour costs and hygienic conditions.

Once-a-day collection is the common system in temperate dairy countries. The evening milk is kept overnight at the farm and is delivered, together with the morning milk, on the following day. In northern countries, where the weather is cold in winter and production is lower than in summertime, milk is collected every second day in areas with long distances between farms and dairies. Further, the system using refrigerated farm bulk tanks has been introduced in several countries; when farms are rather small collection can take place only every second or third day if the system is to bear the costs of this type of installation.

The organization and operation of different collecting systems is a question beyond the scope of this contribution, but as the factors influencing decisions in these matters have some bearing on conditions for milk hygiene, a brief account is given here.

The size of herds is of major importance to the collecting system. For small herds (by far the most common), big investments in cooling and storing equipment are impossible. The larger the herd, the more technical aids can be used. The transport costs per unit of milk depend on the distances and the amount of milk produced per farm—the "regional density" of milk. If there is little milk in a region the transport economy may be improved by collecting double the amount of milk every second day. This affords opportunity for good barn hygiene and the possibility of cooling the milk at the farms. The different uses to which the milk is put, marketing conditions and producers' prices are the factors that decide the quality of milk obtainable.

Cooling units on the farm

There are two main ways of cooling milk on the farm. The cheapest but not always available method is to use natural cold water or natural preserved ice; the other way, more expensive but more efficient, is by means of an energy-consuming cooling machine. The temperature of sub-soil water is only seldom below 8°C in summer and will not allow a milk temperature of below 10°C to be achieved. A refrigerator can—according to size—give any temperature down to zero, or can freeze the milk. Air is too poor a heat conductor to be used for efficient cooling. The cooling medium in contact with the surface next to the milk should be water or the expansion unit of the refrigerator.

The cooling procedure may take place in a special apparatus, either closed or open. The open-surface cooler is often used; the milk flows down over a ribbed tubular surface in the opposite direction to the water within the tubes. The tap-water passing through the cooler may be combined with a section containing iced water in the lower part of the apparatus. After cooling the milk is filled into the transport containers. Air infection from the surface cooler is negligible in an ordinary milk-room, but the cooler itself must be carefully cleaned; if the air of the room is liable to contamination, the cooler should have a cover. The use of open-air coolers, which involves some risk of contamination, is undesirable. Other possible sources of contamination during the cooling procedure are (1) seepage of cooling water into the milk when cans are immersed, and (2) at stirring of the milk to hasten cooling.

If no special cooling apparatus is used, the milk should be cooled in transport cans or in bulk tanks. Troughs of water, naturally cool or cooled by machine, may be used for immersion of the cans. A gentle agitation of the milk several times during the cooling procedure improves the heat exchange. Instead of troughs a spray or drip cooler can be used: the water flows down the outside of the can from a pored ring tube round the neck of the can. The most efficient types have an agitator in the milk, run by the water pressure. Tap-water or refrigerated water may be used. In farm bulk tanks the refrigerator is combined with the storage tank and allows the milk entering the tank at each milking to be cooled as well as stored at low temperature.

Before the temperatures of choice are discussed, it must be stressed that cooling is no substitute for primary hygiene at milking and during handling—it is a complement to it. When fresh from the udder the properties of milk allow only slight growth of the micro-organisms infecting it for about 2-4 hours—the bactericidal or adaptation phase. That period is prolonged if cooling takes place immediately after milking and this will give a better starting point for storage of the milk. If the milk is delivered to the dairy within that period, deep cooling is unnecessary: a temperature of about 15°C will do. If the milk is collected daily, but not within a few hours of milking, a temperature not over 10°-12°C is desirable. If collection occurs only every second day, adequate cooling below the temperatures mentioned (preferably below 4°C) is necessary to inhibit as far as possible the growth of the psychrophilic micro-organisms.

Transportation cans

Milk cans are always handled in a routine way, and a can that is easy to handle will also more probably be handled hygienically. The type of can is therefore of importance from this point of view. Standardization of milk cans has many advantages. If all cans are of the same size, handling in the dairy is easier; mechanical aids, such as transport chains, emptying machines and washing machines, work more efficiently; the lids are interchangeable; and transport vehicles can take a better payload (see Fig. 1). Moreover, manufacture in bulk of a uniform type of can will give a lower price per can.

FIG. 1
LOADING OF MILK-CHURNS ON TO LORRY

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Material used for cans

The material used for manufacture of milk cans should fulfil a number of requirements. It should have mechanical strength—the life of a can is not particularly protected—and it should be light-weight; it must withstand sudden and drastic changes in temperature (a can may pass in a minute from the cold of a winter's day to the heat of the steam sterilizer); it must be inert, and it should not transmit any flavours or toxic substances to the milk. It is preferable that the surface should be polished and remain so, since this improves washability. The material should not be such that water or any milk constituent will have a special tendency to adhere to it, since rapid drying after cleaning is an important feature. For cans in which milk is to be cooled by an external medium, the heat transfer capacity of the material is of importance for rapid cooling.

Tinned iron is the oldest and most common of the materials used in modern dairying. The state and age of cans in service varies greatly; the tin cover must be of good quality, be made of pure tin, and have a smooth, non-porous surface. The length of life for a tinned can is limited, even for those only in seasonal use. Rust tends to attack cans stored under not entirely suitable conditions more easily than cans in regular use. Tinned cans not in use should be thoroughly cleaned, dried, protected with grease or an anti-rust agent, and stored in a dry place. Corrosion has proved to be most active between 0° and 8°C. The advantages of tinned iron cans are comparative cheapness, and mechanical strength due to the iron content and the fact that the parts can be welded together at manufacture; their drawbacks are weight and susceptibility to rust.

Aluminium cans have come into general use during the past decades. In some countries they were held not to be strong enough for the heavy duty of a milk can. However, the properties of the alloys used and the construction and manufacturing technique has been considerably improved during the 1950's, and today it can be stated that light metal cans of first-class make stand up to the same tests as iron cans. An electrically oxidated surface is better than the original surface. Aluminium cans have good longevity provided that no cleaning agents containing pure alkali are used; modern cleansers containing metasilicate can be used without danger. Chlorine solutions should not be stronger than normally recommended—200 p.p.m. of active chlorine; weak nitric acid may be used for sterilizing aluminium cans. The material is somewhat elastic and bosses often disappear after some time.

Stainless steel is the best material for cans from the hygienic point of view. It is strong, easy to clean, and withstands many years of use. Cans of stainless steel are no heavier than those of tinned iron. Their main drawback is cost, as stainless steel is more expensive than other materials; however, distributed over years of use it is unlikely that the average cost of stainless steel cans is any greater than that of other types.

Plastic is also used for the manufacture of milk cans. There are numerous kinds and qualities of plastic with very different properties. At first, plastic cans were found to be not strong enough, their form was changed by the heat in the washing machine, and they transmitted flavours to the milk. However, improvements have been made, and today there are makes of plastic can which withstand the approval test by a good margin. The approved cans are strong owing to their elasticity, they are impervious to any chemicals used, and are easy to clean. They should, of course, be of a quality of plastic which involves no risk of contamination to the milk from the plastic material itself. They may become slightly scratched on the outside after some use, but this has not proved important in dairy hygiene. Their weight is very low—indeed it may be too low; in some cases empty cans are reported to have blown off the transport wagon! This difficulty may be overcome if the cans prove useful. Plastic cans have greater insulation than metal ones, and milk in plastic cans being cooled in troughs or by a spray-cooler needs considerably longer treatment with a greater flow of water to reach the desired temperature. On the other hand, cooled milk keeps cold longer in a plastic can when placed in warm surroundings. Perhaps the full situation with regard to plastic cans is not yet quite clear, but its further development should be followed with interest by dairy enterprises.

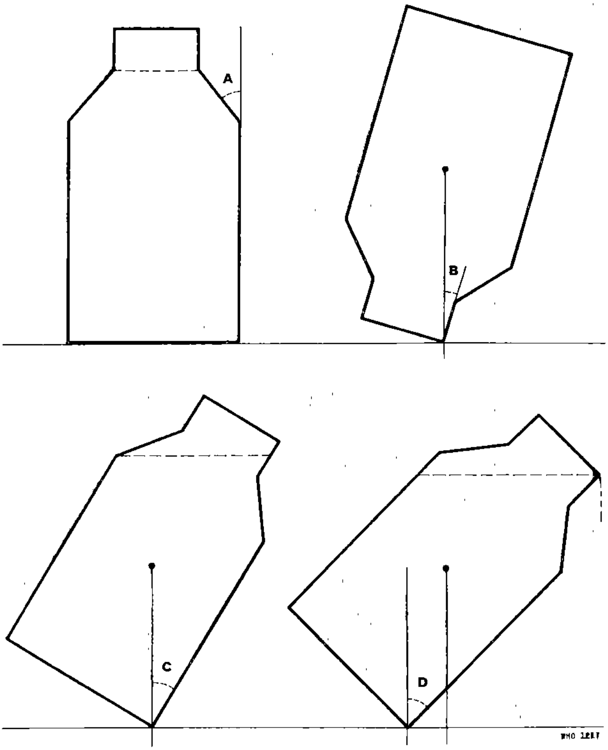
As an example of the weights of cans manufactured of different materials, the following figures for a 40-litre can are given: tinned iron and stainless steel—11-13 kg; aluminium alloy—5.5-6.0 kg; plastic—5.0-5.5 kg.

Design of milk cans

There is an ideal form for every detail of a milk can; however, the form of one detail may influence the properties of another part of the can, which should therefore be looked upon as a whole. When standardizing cans, for example, the height cannot be the same for all sizes, since the smallest cans would then be too narrow.

The position of the centre of gravity of the filled can in different situations is important for its convenient handling. At the farm and at loading, full cans are often rolled on the bottom hoop when they are moved. The angle of balance should not be too great, as this makes work inconvenient, nor should it be too small, or the can will risk accidental overturning. From the hygienic point of view, the angle at which milk spills from the full can is worth notice: it should not be less than the angle of balance, or milk will spill out from under the lid when the can is rolled. These angles, of course, are related to the height and diameter of the can, and also to the angle of the shoulders and the diameter of the neck (see Fig. 2). The angle of the shoulders should not be too great as a can with square shoulders is weakened as regards pressure from above, it drains slowly when tipped, and is difficult to clean and inspect. On the other hand, very steep shoulders give a wide neck which raises difficulties in fitting the lid, and it may be impossible to keep the diameter of the lid less than the diameter of the can, which is necessary if the can is to be lifted by the handles. Too small a neck diameter is likewise undesirable as regards the stability of the can when it is turned upside down in a washing machine, or when stored in an inverted position.

FIG. 2
DIAGRAM INDICATING ANGLES OF MILK CAN



A = Shoulder angle
B = Balance-point angle inverted
C = Balance-point angle full
D = Spill-point angle

To summarize, ideal standards for cans are as follows: angle of balance about 30°, spill-point angle more than 30°, shoulder angle less than 45°, and angle of balance inverted 15°-20° (all calculated from the vertical plane).

The handles of the cans must fit into the hands when gripped from outside or inside. A length of 10 cm is a minimum; the handle should be 4 cm from the edge of the lid on the inside, and preferably a similar distance from the periphery of the can on the outside. It should always be possible to grip the handle without risk of hurting the wrist against the lid or the fingers against the handles of neighbouring cans. It is unimportant whether the handle is riveted or welded to the body of the can, so long as the surface inside the point of connexion is smooth.

The lid must fit well into the neck There should be no danger of leakage during transport, nor should rain or dirt be allowed to come in contact with the inside of the can. The mushroom or umbrella lid carries off water best as it is smooth and has a clean edge. Some hold that the umbrella lid involves more labour because both hands are needed to lift it, while a lid with the handle set in a central concavity can be lifted with one hand. However—apart from the fact that there is no simultaneous task for the other hand—the cavity may collect dirt, the danger of which is partly overcome if the edge of the lid reaches 3-4 cm outside the neck. This should always be the case, but the edge should not reach the handles or the neighbouring cans, as was pointed out earlier. Thus the diameter of the can, that of the neck and the size of the edge of the lid bear a relationship to each other. The bottom ring must be very firmly fixed to the body of the can and provided with holes for water drainage when the can is in an inverted position.

Insulated cans

Insulated cans are sometimes used in warm countries. They are double-walled, and the intervening space is filled with cork, foam plastic or a similar light insulating material. However, it is always a problem to keep a closed space free from condensed water and to make the cans withstand the cleaning procedure. The insulation problem may be solved in a cheaper way by means of a light insulation hood which is placed over the can when the milk is chilled. When the milk is placed on a milk stand in the road to be collected by the transporter, the stand should preferably have a screen to protect the cans from direct sunshine. For the same reason the cans should be covered on the transporter both during the warm season, and during frost, as frozen milk is difficult to drain from the cans at the dairy.

Tankers [1]

Tankers are used to transport milk from farms provided with farm bulk tanks, or from collection centres to the dairy plants. Combined equipment also exists for picking up and measuring milk directly from transport cans for further transport by tanker. This combination may be a solution in areas where there are large and small producers on the same transport line and where farm bulk tanks are too expensive for small farms. If the tank incorporates a pump, hose, flow-meter and other utensils necessary for the collection of milk, the term " bulk milk pick-up tank " is often used.

It is often said that the bulk tank system improves milk quality—a statement which is too general: the quality of the milk put into the tank is still naturally of fundamental importance. Primary hygiene at milking must not be overlooked, whether or not a refrigerated tank is available. The low temperature in the tank will preserve the quality of a good milk, but it cannot improve unhygienic milk. The same is true of the tanker,

[1] See also chapter by Capstick, page 595.

and the well-known traditional hygienic practices for preserving milk quality must be adapted to the use of the tanker system. The milk in the tank must be safe for contamination from without; the edge of the manhole should be flanged upwards enough to prevent dripping into the tank when the lid is lifted. A special outer cover over the lid will protect it from dust and dirt from the road, and there must be some similar cover over any valve or hose connector through which the milk will pass during the operation. The opening of the valve on disconnection of the hose, or the opening of the hose when in place, should be closely sealed by a cap. On modern tankers, the dust cover over the valves and other utensils takes the form of a compartment with dustproof doors. When a good milk passes the valves without accident it should reach a clean tank. Hence, the tank should be easy to keep clean; and its material should be, for example, high-quality stainless steel (18 % chromium, 8 % nickel) which offers a hard polished surface withstanding chemicals and rust. Tanks can be made from aluminium alloys, which may be cheaper, although in the long run it is not certain that there is much difference in cost. It must also be remembered that a tanker can be used full-time and is handled by more highly trained staff than is necessary for cans. The cost of the tank itself is not the predominant factor, and there is no point in using material or equipment which is not of the best technical and hygienic standard. Large volumes of milk will pass through a tank, and the economic consequences of a failure are obviously much greater than with a can. Moreover, poor-quality material is more likely to become damaged and thus more difficult to clean. All inside weldings should be smooth and polished, as well as the rest of the surface; corners and edges should be rounded so that no residues can be overlooked. If the tank is not constructed to embody an automatic cleaning device, the size of the manhole and the height of the tank must permit a man to enter it for the purpose. All utensils, valves, pumps, the flow-meter of the pick-up tank, etc., should be of approved hygienic dairy type which can be disassembled for easy cleaning.

Another requirement for preserving milk quality is that the temperature be not considerably raised during transport. The bigger the volume of milk, the less is the ratio surface/mass and the less the heat exchange. The milk filled into the tanker is chilled, and it is usually not strictly necessary to envisage either a refrigerator or insulation. However, the tankers may be used under differing conditions, so that it is advisable for all permanent tankers to be constructed with an insulating layer of material such as cork, plastic foam or mineral wool, all efficient and cheap. The cost depends mainly on the necessary outer protection. This outer jacket can be made of aluminium, plastic or any other waterproof rigid material which is easy to clean. It is important that it should be well sealed against the entry of water or dirt. The bottom of the tank should not be forgotten, particularly if it is close to the engine, which may act as a heater.

For several reasons unpasteurized milk should be handled gently during transport. To avoid splitting of bacterial clumps, alteration of fat globules, with the attendant risk of lipolytic reactions, or admixture of air, which may give rise to oxidation problems, all unnecessary pumping, violent agitation and surging in the tank must be minimized. Thus it is often desirable to divide larger tanks by means of baffles, which should, however, allow cleaners to pass between the compartments.

FIG. 3
MILK TANKER

This tanker takes milk 240 miles (385 km) in a high-temperature, high-rainfall belt of tropical Queensland, Australia.

Reproduced by courtesy of Dr E. B. Rice, Director of Dairying, Department of Agriculture and Stock, Brisbane, Queensland, Australia

The general design of the tanker may be a technical problem more than a hygienic one. Nevertheless, many details of good design will also influence the hygienic aspects—efficient fastenings to ensure that the dust-proof doors are really shut, good lighting to prevent error when work is carried on during the hours of darkness, etc. Partitions between the pump motor and the pump and valves are useful in avoiding the risk of contamination with oil.

The tankers in present use include all forms, from free-standing insulated tanks placed on a truck, to streamlined sales-promoting and well-equipped pick-up tanks (see Fig. 3). The tendency is towards the latter type, as the extent of bulk collection makes it possible to have the trucks in use throughout the day.

Whether transport takes place in cans or in tankers, the fundamental problems of milk hygiene are the same. Cans can be handled by any driver but the tank handler must be a trained person capable of carrying out hygienic tests on the milk. The increase in temperature during transport is less in the tank than in the can. In one respect, however, there is a distinct difference between the systems; bad milk in one can will hardly influence the quality of the contents of the other cans, but bad milk put into a tanker will affect the whole bulk. Hence, the tank handler must be able to distinguish and reject bad milk. Experience, however, shows that in practice this presents little difficulty, and failures are rare.

This consideration of the two methods suggests that it is possible to arrange a good hygienic collecting system using either cans or tankers: the choice between them may be made mainly on the basis of economic and technical factors.