THE USE OF PLASTICS IN THE DAIRY INDUSTRY

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Phenomenal progress of plastics in the last ten years has exerted considerable influence on patterns of manufacturing, buying and selling in all industries. One has only to glance around the home, the plant, in the stores, in transportation equipment, and in all facets of everyday living to see the tremendous impact that plastic materials have had and how they have introduced trends almost to the brink of revolutionary change. Excluding the use of plastics in consumer items and soft goods, this same trend can be seen in the industrial adaptation of plastics, not in place of standard materials of construction, but as materials in their own right or in conjunction with steel, wood, glass, paper, textiles, etc. The transition of thought from plastics as "substitutes" to their stature strictly on their own merit has finally been accomplished — not through propaganda nor advertising but through acceptance and performance by the most exacting of all tests, those of the consumer. This path has not been easy nor has it been credited with success in all ventures. The age old theory of supply and demand and natural selection, has drawn to the wayside many materials and ideas which in some areas of industrial use, still remain to plague the overall progress of plastics. These midadventures and false starts are normal and quite necessary to the development of any approved product.

It is now increasingly evident that the use of plastic materials in the dairy industry is inevitable. The use of plastics in the form of molded shapes, films and foils in food packaging has contributed greatly to hastening the exploration and development of plastics in contact with dairy products. The background gained in food packaging supplied the necessary impetus, particularly with respect to testing of materials and ingredients that are non-toxic or lacking in those properties which contaminate food products. The advantages of non-toxicity in contact with a wide variety of foodstuffs, clarity, light weight, sealability, adaptability of raw materials, have accounted for the progress made in this field.

In the majority of food packaging problems, however, there is a distinction which sets it apart from problems involved in the dairy industry as we are considering here — that of single versus multiple use. Single use containers, foils and films based on certain types of plastics are considered in much the same manner in the packaging of dairy products as in other foods or products that are ingested. However, the immediate and impending problem of using plastics in contact with dairy products, is not the packaging of the product for distribution but rather its use as a component part of the processing of raw or finished dairy products, which defines it as multiple use. The entire theme of this paper then, will deal with the consideration of plastic materials in processing equipment, subjected to multiple use.

PLANNING FOR UTILIZATION OF PLASTICS
IN THE DAIRY INDUSTRY

The preponderance of stainless steel and glass used in and around dairy process equipment suggests that the performance and background of these materials serve as guide and comparison for the performance of new materials — not in the sense of a substitute

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1Presented at the 44th Annual Meeting of the INTERNATIONAL ASSOCIATION OF MILK AND FOOD SANITARIANS, INC., at Louisville, Kentucky, October 7-10, 1957.
but as an objective to attain by utilizing the virtues of new materials and subsequently obtain improvements or at the minimum, equality of performance. The pattern of experience with metals and glass then shapes the direction of establishing standards for plastics, realizing that performance, not the individual physical or chemical properties, is to be judged. (In some aspects of this comparison, it may rightly appear to be an invalid conclusion, but confined to serving as a guide, it then becomes a reasonable comparison.)

To establish a program of investigation of plastic materials which will provide sound technical data directed explicitly toward the real problem of the use of plastics in dairy equipment, creates many complications due to the nature of the problem, the diversity of materials to be considered, and the necessity of soliciting assistance from many manufacturers scattered throughout the country. Being cognizant of the fact that the ideal is never attained, the following steps are offered, directed toward the future acceptance of plastic materials:

1. **Orientation**
   To provide meetings and conferences whereby the dairy and plastic industries and their representatives can formulate a common area of operation, each educating the other in the pertinent details of the application, and to finally discuss ways and means for resolving the problem.

2. **Organization**
   To establish a pattern of cooperation through central committee action, such a committee to be made up of representatives of the associations and controlling bodies, to insure full recognition of every facet of the problem.

3. **Implementation**
   The collection of data and its review by committee action, leading up to formulating tentative procedures for evaluation.

4. **Correlation**
   The collection of data based upon the tests according to tentative procedures agreed upon and their review.

5. **Classification**
   To devise a system of classification of the various plastics, based upon their salient properties, to serve as a selection guide for the many different applications and requirements of use, and to further serve as identification of the plastic material to insure its proper use and inspection.

6. **Standardization**
   The drafting of a tentative standard for plastic materials, with provision for periodic review, change, or addition. The Plastics Task Committee, composed of representatives of the plastic materials manufacturers and fabricators, the Dairy Industry Supply Association, public health officials, sanitarians and dairy users, as well as observers from associated organizations has, ever since its inception, attempted to follow the above procedures, with steps 1 and 2 accomplished and step 3 scheduled for the very near future.

### Classification of Plastics

A general background of plastics, their properties and classifications, is necessary in order to continue the discussion. For the sake of brevity, the best that can be done at present will be to deal with generalized classifications, reverting to more detail only to the extent that the detail is important to the case at hand. With this in mind, we recognize that much will remain to be explained and that considerable freedom of interpretation should be tolerated.

Plastics are divided into two general types, thermosetting and thermoplastic. The first, identified as "thermosetting or thermosets", achieve their usefulness by virtue of the fact that the nature of their composition and manner of manufacturing results in a substance that can be formed into various shapes with the application of heat and pressure to varying degrees and will convert, cure, or "set" to an insoluble, malleable material by means of a chemical reaction. Thermosets are characterized by their hardness, heat resistance, strength, insolubility and chemical resistance. They are normally colored or opaque, and available in varying degrees of strength and hardness but are restricted in the latitude of certain properties such as flexibility, clarity and densities, the latter being largely a function of the inert filler used to impart processing properties, physical characteristics, and lowering of overall costs.

The second general type is termed "thermoplastics", whose differentiation involves in the main, the fact that no chemical curing or setting takes place when formed to the desired shape by heat or pressure. Thermoplastics may change in shape by applying heat and pressure repeatedly — analogous to paraffin wax, which can be formed, remelted, formed, remelted, etc. without chemical reaction, the process involving a change in physical state. Thermoplastics are characterized by their latitude of property variations within a given material to produce objects that are heat temperature susceptible — that is, their physical properties and to a degree their chemical properties,
are likewise subject to variation as the temperature increases. Contrasting this property to thermosets, it can be readily seen that the one single and important delineation is temperature resistance. Additionally, another important difference to be taken into account, is the fact that chemical curing agents are necessary to initiate and complete the curing of a thermoset and are contained within the plastic in its raw, uncured, unformed condition. These curing agents are chemically reactive at the curing temperature and as such, catalyze or react with the raw plastic to the extent that their final physical properties are obtained when the forming process is complete. It is difficult if not impossible to be absolutely sure that the entire amount of curing agent is consumed and no longer available in the plastic to be subsequently leached or extracted from it when placed in different liquid environments. Also, the nature of the curing agents is such that they present a problem in their effect on the extraction rate, contribution of organic and inorganic impurities, and toxicity when in contact with products such as milk. Conversely, thermoplastic materials are relatively free of such an objection — due to their chemical nature and the fact that their ability to be formed into various shapes, does not rely upon a chemical change and thus, they contain no curing agents as in the thermosets. This is not to say, that there are no thermosets which could be used in contact with a food or beverage. There are special types of thermosets, whose background of study and use is extensive and known to present little or no hazard under the conditions for which they were intended. The latter statement is a key to the use of thermosets — thorough exploration and study to prove beyond a reasonable doubt that the disadvantage of the thermosetting material is safe for the intended use. A good example of such materials are those plastics used in the molding of plastic dinnerware and utensils, having satisfactory properties under variable yet stringent environments.

Departing from the original objective of generalized and brief descriptions of plastics, there exists one detail that bears explanation in order that subsequent references are clarified. In connection with the term plastics, polymer and compound will appear. The difference between the two has a bearing on any description of materials that would be used in applications involving dairy product contact. The term polymer is restricted to low to high molecular weight resins in their pure form, with no ingredients added other than those which are necessary to its production or containing ingredients that are present in trace amounts, advertently or inadvertently. Materials such as polyethylene, polystyrene and acrylic plastics could be classified in this category. These materials may be used to fabricate useful articles directly from the polymer, without additional ingredients being added by the fabricator. The term compound is accepted generally to describe a plastic to which has been purposely added one or more ingredients to modify its properties for specific applications. In this case, a polymer would have been purchased by the fabricator, the necessary ingredients combined and processed to produce a compound, which is in turn fabricated into a product. Basic manufacturers not only produce polymers but may also produce compounds which are supplied to fabricators.

Properties of Plastics

With this brief background on plastics, our attention can now be directed toward the properties that plastic materials should exhibit in order to qualify for applications in the dairy industry, in processing equipment where it will be subjected to multiple use. The primary property obviously would be its non-toxicity or perhaps a better definition, its safety, and the non-adulteration of the food product by means of leaching extraction or degradation in both a quantitative and qualitative sense. Second to safety would be the chemical resistance to reagents and environments to which it will be exposed in use. This property not only infers stability of the plastic throughout its useful life but also its resistance to chemical change which would influence its ability to resist imparting harmful substances to the food product. The third, and most important from a mechanical standpoint are the physical properties such as strength, impact resistance, resistance to physical change when exposed to the temperature variations, both high and low, surface finish of the part to insure smoothness and ease of cleaning, resistance to abrasion, color or clarity where required, and dimensional stability. Any comparison of thermoplastic versus thermosetting plastics by means of these qualifications brings into clear focus their predominant differences — as to safety of use, both require considerable study before acceptance but the probability of acceptance is in favor of the thermoplastics. As to chemical resistance, the majority of thermosetting materials have good to excellent ratings, whereas specific types of thermoplastics not only equal those of the thermosets but in many cases exceed the requirement. Physical characteristics are subject to a wide degree of variation, being virtually unlimited in scope as to choice of materials, compromised only to the extent that certain properties in given applications are paramount to others. As mentioned before, the heat resistance of thermosetting plastics versus the temperature susceptibility of thermoplastics is many times the determining factor.
An impression might be gained that thermoplastics would not be suitable for process equipment if the part contacts hot water, steam, or varying temperatures, because of their susceptibility to change in physical properties at elevated temperatures. In the thermoplastics, as to range of softening point or upper limit of temperature susceptibility, variations from 175°F to as high as 475°F may be observed. Thus it may be seen that there are materials in the thermoplastic class that may be used at elevated temperatures and it is largely a choice of other physical properties that permit their selection and use in order to take advantage of their superior properties.

**Types of Plastics**

Currently there exist several basic plastics which appear to be most logical in the choice for immediate use and acceptance. Their background and experience in food packaging over the past four to six years, the extent of their technical development and refinement, have influenced this conclusion. Each will be discussed in a general fashion, directing all comments specifically to dairy applications.

Nylon, chemically identified as a polyamide resin, is thermoplastic and normally recognized by the layman as a material used in textiles, hosiery and other soft goods; yet few are aware of the fact that it enjoys wide acceptance in industrial applications. Nylon is available from a number of manufacturers in the form of a polymer and a compound, in many grades, colors, and flow properties. It may be obtained as a powder, pellet, sheeting, rods, tubes, solution coatings, and filaments, ready for forming by the fabricator. In these many forms products made from nylon enjoy wide usage in industrial fields for reasons of their physical properties, dimensional stability, resistance to wear, and their general durability. Being a thermoplastic, it has favorable chemical characteristics and resists chemical attack to a high degree. Nylon lends itself, like other plastics, to the usual processing methods. It is quite well adapted to machining, a technique that is recommended for special shapes where the number of parts required initially is restricted. Its properties as to molding make it an excellent choice for large volume applications. The present disadvantage of nylon for dairy applications is no doubt due to a lack of specific experience and background. Water absorption up until recently has been in question by regulatory authorities when used as a food contact surface but this problem is being solved satisfactorily. It should be emphasized, however, that only specific grades of nylon have been submitted to the rigorous tests required for approval. Under no circumstances will any clearance be given all materials and grades identified as nylon, the problem is and must be much more specific as to the grade, composition, properties, and the adequacy of testing. Nylon is normally a hard, impact-resistant material and may be recommended for applications where abrasion, erosion, and impact strength are factors in design.

The acrylics have had considerable background and study and as such many successful adaptations of the acrylic resins have been proven in food and drug packaging, surgical implants, dental techniques, etc. It also is available in powder, pellet, rod, tube, and sheet form as well as in latex and soluble types for protective coatings and adhesives. Unlike nylon, the acrylics may be molded, extruded, and machined. Wherever clarity and surface conditions must be maintained, however, it is questionable as to whether the acrylics will maintain these properties indefinitely when subjected to stringent cleaning and brushing in constant contact with harsh cleaning chemicals. It suggests itself however, for applications involving the need for glass-like clarity and in situations where the sanitizing procedures are not severe.

The fluorocarbon resins are slightly opaque in thin sections to opaque in thick sections, having a waxy surface. These materials are processed by the usual techniques of molding and extruding, with the exception that they require much higher forming temperatures and in some types, specific attention is required as to pressures and times of forming by sintering and annealing. Their unusually high resistance to chemicals of all types and their resistance to elevated temperatures are factors which solve many industrial problems. However, their high material cost and the special techniques and equipment required in fabricating must be considered, particularly in relation to the economics of the dairy application in mind.

Polyethylene is quite familiar to everyone in the form of packaging film and the disposable squeeze bottle. It is a unique material that is especially suited to food packaging wherever the physical properties of the natural material can be tolerated and there is no condition of elevated temperature to encounter. Recent developments in high density types have increased the range of temperature resistance and the successful application of polyethylene in dairy applications will no doubt be considered on the basis of the newer developments rather than the adaptions of the low density polyethylene used in commercial packaging today. Polyethylene in thick sections is semi-flexible to semi-rigid, and like other thermoplastics, may be colored to any desired degree.

The vinyl resins are available in rigid, semi-rigid, and flexible types, clear to opaque as desired, with a
wide variety of properties and in practically every physical form for fabrication or use. Of all the plastics to be considered in process equipment, the vinyls offer the widest range of possibilities as to their physical, chemical, and processing advantages. Vinlys have certain disadvantages however — limits in temperature resistance, cold flow under compression, and the fact that all vinyl plastics are compounded, must be taken into account. The use of vinyl resins in compounded form in food packaging has been largely an evaluation of the compounding ingredients rather than the basic resin, which is known to be completely nontoxic. Therefore, every change of physical property and chemical resistance which may result from varying the compounding ingredients, must be thoroughly evaluated.

Obviously there are many other plastics that may now or in the very near future qualify but it must be kept in mind that the first requirement in the selection of a plastic is based upon prior investigation and review by regulatory authorities as to its use in contact with foods and beverages. Many of the new plastics have not been thoroughly tested in this regard simply because they have not as yet been directed toward food packaging problems in their initial development and until this data has been accumulated and reviewed, the choice of plastics for use in the milk industry will be initially limited.

After having selected the material, no evaluation is complete without consideration of the manner and the cost of forming and fabricating. This is particularly true in preliminary applications for dairy process equipment where the number of parts will be few in number, diversified in shape, and the cost of fabricating them will be high as contrasted to their future large volume use. Some plastics lend themselves to all types of forming, whereas advantages of others are more prominent in or restricted to special methods. It can be safely stated that each part, each use, and each plastic will of necessity be judged on its own particular merits of fabricating rather than relying on a selection of a common fabricating method for all plastics. In short, methods of fabricating and producing plastic parts are as important to the successful use of the material as is the process of selecting the material itself. For that reason a discussion of fabricating methods for plastics is in order.

FABRICATING METHODS

The most common method of forming a plastic part is by molding — compression, transfer, and injection molding. In all three cases, however, a mold properly designed and constructed must be developed in order to produce the first piece. Mold cost is an important factor which must be considered in relation to the number of parts required and the speed in which the parts are to be made. Mold costs increase as one considers compression molding, transfer molding and finally into injection molding, which produces the largest number of parts at the lowest cost, but with a high initial mold cost. If the volume of the part justifies the expenditure, injection molding is recommended. In the case of thermosetting resins, both injection and compression molding are used for large volume production, machining the shape from pre-formed blanks is normally adapted to limited production or the development of design and evaluation of performance. This method is commonly used throughout industrial applications where mold costs cannot be justified and the material or the design lends itself to such a method. To produce a thin sheet for example, for food packaging, the plastic material is calendered but in the case of multiple use applications, calendering of thin sheets is of very little importance. Calendering is of importance when the plastic in heavier gauges is formed into large articles by a process of vacuum forming. Here the calendered sheet is placed over the mold cavity, heated and then pulled into the cavity by vacuum, followed by cooling in place. This method is ideal for large shapes such as covers for process equipment but is limited to those materials that are stiff or require no internal or external support. Not all plastics lend themselves to vacuum forming. The process of continuous extrusion is restricted normally to compounded thermoplastic resins and this method affords continuous lengths in various cross sectional shapes. Another common form of fabricating using certain types of thermosetting materials, is accomplished by casting the liquid uncured resin into an appropriate mold followed by curing in place and removal of the part from the mold. It is doubtful as to whether this technique will have very much application for parts used in dairy process equipment. Since plastics can be dissolved in various solvents and since certain plastics are liquid in raw polymer form, we should consider the process of applying thin coatings to metallic parts in order to provide a barrier and avoid corrosion. This technique is resorted to only in cases where occasional contact with chemicals and sanitizing agents is encountered. No general rule can be used as a guide to follow in the selection of materials and fabricating methods for each and every part that would be considered in dairy equipment, as one is very much dependent upon the other.

SPECIAL REQUIREMENTS FOR USE OF PLASTICS IN THE DAIRY INDUSTRY

There are peculiarities in the use of plastics in dairy
equipment as compared to similar uses in the packaging and processing of other foods. In processing equipment wherein the plastics will be subjected to multiple use, the problems are quite similar, in that the plastic part will be subjected to many different environments and required to be cleaned and sanitized at regular intervals. However, there are differences in the manner in which the equipment is sanitized and the schedules of cleaning are somewhat different, being more severe in dairy use than those normally encountered in the processing of foods. It is well known that the sanitizing procedures used throughout the dairy industry cover a wide variety of chemicals, concentrations, times and temperatures, and it behooves the plastic to have an inherent ability to withstand all of these conditions to a high degree. Repeated sanitizing three and four times a day, followed by stringent inspection, place a great deal of the burden on the design and the type of material from which a given part would be made. This is one of the requirements of dairy applications that determine the superiority of materials and eliminate a number of plastics that under normal circumstances would have been considered adequate. Another peculiar requirement in the handling of milk and milk products is in the fact that sanitary design is required in practically all parts. There are no aspects of sanitary design which cannot be met by practically all of the plastic materials suitable for use. However, it is part of the design problem to provide surfaces which will be smooth and which will retain their smoothness throughout use in order to insure that the part does not contaminate the milk product by virtue of an improperly formed surface or one which will change in use. Milk and the products of milk are extremely complex substances. The nature of the resin base of plastics and their compounding are likewise complex. The marriage of two complex systems resulting in satisfactory performance and use necessitates a great deal of study and selection in order to insure their future growth. Another peculiarity of dairy use lies in the fact that repeated inspection of stainless steel parts is required, and those responsible for the inspection are well aware of what stainless steel is, what it looks like, what it should do, and how it reacts. If that part should be produced from a plastic material, it then requires as much information as to identification and performance as in stainless steel to insure that the inspection procedure is adequate.

**ADVANTAGES OF PLASTICS FOR MILK PROCESSING EQUIPMENT**

A question has been repeatedly asked as to why use a plastic as a component part of dairy processing equipment when the background of steel, glass, and porcelain enamels are adequate to serve the purpose. This question can be approached from several standpoints but by far the most important is the fact that progress in any direction will meet with certain resistance and the quality of the product which is being developed attains its stature by meeting the resistance and overcoming it. In that fashion the developments of today become the accepted standards of tomorrow. Plastics offer many advantages, among the more important being light weight, possibilities of clarity or color, the fact that there are multiple choices to be made of many materials to do a given job better, a lower cost of the material as well as the fabrication, an advantage for the future in the fact that plastics provide a favorable replacement factor as to their performance versus cost. By this is meant the possibility of low cost plastic parts being used for a period of time approaching the termination of usefulness, at which time the part may be thrown away and replaced by a new part. The fact that plastics are non-metallic in construction avoids metal corrosion. The raw materials from which plastics are made are virtually unlimited as to supply and normally are not influenced by fluctuating conditions such as has been experienced in the past with metals containing alloying ingredients in short supply or sensitive to economic variations.

The possibilities of tailor-making plastics and their subsequent wide scope of modification to improve basic properties is likewise an advantage, provided that the requirements and the volume of use are thoroughly defined before specific products are engineered and produced. There are advantages to be gained in the use of a plastic material based upon the nature of surfaces of a plastic as compared to metallic surfaces. These advantages largely deal with the wetting action or the absence of wetting action and the fact that plastic surfaces in being chemically resistant, retain their surface smoothness in many different environments. The property of impact resistance is important to expensive parts in that the part is not fragile, does not abrade nor gouge easily, and maintains its integrity when exposed to a variety of chemicals or mechanical treatments. Part of the advantage of impact resistance lies also in the fact that plastics can be varied in their hardness from very soft flexible materials up to extremely hard and rigid materials, thus providing the design engineer with latitude of choice contingent upon the functions and the manner in which the part may be handled, not confined to equipment of today but for improved design of the future.
Problems Relative to Successful Applications

The introduction of any new material naturally will create problems. It would be well to recognize in advance typical problems that could arise that would have a bearing on the successful application of plastics under the adage of "being fore-warned is being armed". The following recommendations are made on the basis of past experience under similar circumstances and should be taken into account by each and every equipment manufacturer who is interested in design and construction of equipment utilizing plastics. Not only should care be taken in the selection of the material on the basis of thorough testing, but also a great deal of attention should be given the selection of the processor as to the background, capabilities, and facilities to develop, test, and produce a material, specifically for the given requirement. This statement is made because of the fact that the name plastic still has, in business circles, a fascinating and romantic ring, indicative of a large, profitable, fast turnover market. The widespread acceptability of plastics and their relative newness have attracted a large number of businesses from the small limited shop to the large corporation, each serving a particular need from a local business up to international distribution. Selecting a fabricator with sufficient technical background, as well as facilities to service the product, is one that should be given thorough study before embarking on any given program. This is not to say that the small plastics organizations are inadequate nor incapable of supplying plastic parts - the nature and scope of their business precludes the overhead of technical personnel or equipment which is necessary to thoroughly evaluate a material, a process, or a design. Many fabricators are not familiar with the detailed problems that exist in the adaptation of specialty plastics when used in contact with foods. There is also the possibility that after describing the general type of plastic to be used, a substitute material may be offered at a lower cost, with short cuts in quality, control, and care in manufacturing which could lead to serious difficulties, particularly in the application of materials subject to sanitizing procedures and ultimate contact with foods. This is part of the problem of suitable indentification and of actual specifications. It is especially a problem in thermoplastics where second grade material can be reprocessed and formed into a prime product to lower the cost but at the same time, possibly contaminate the product. The fact that thermoplastics can be used over and over again, changed in color, changed in hardness, etc. may cause difficulty in the control of the quality of the materials supplied to the dairy industry by fabricators who are interested in obtaining the business at lower cost, generally at the expense of the ultimate consumer. As plastics are introduced into the dairy industry, there can be many misapplications if specifications or standards are not available. Under these circumstances, it is quite obvious that such misapplications will darken the reputation of plastics in general and certain materials specifically. It is for this reason that a standard for plastics is so important to the proper development and progress of plastics, their selection, their processing, and their quality control. The problem of identifying the type, grade, manufacturer, part number, and intended use is most important to insure its approval for use in the field by the authorities. Without such identification or grading, many substitutes could appear, many problems could arise, and the progress of plastics will be seriously impeded.

A Look to the Future

Finally, we should look into the future as best we can to predict the role that plastics may play affecting the progress and the efficiency of processing equipment that will most surely be developed. As a product contact surface, it is reasonable to assume that the present day plastics, when fully tested in light of the requirements of the dairy industry, will be used in increasing amounts in the next five years. This period should prove the material and will give confidence to the manufacturers of equipment when the advantages as well as disadvantages of plastics are fully known. It is quite reasonable to assume that new materials will be always appearing to solve new problems and improve standard products, the basis of their development being the fact that each and every material has its own special set of virtues. Eventually, based on the use of plastics in a product contact surface a great deal of attention will be given the use of plastic as a material of construction for equipment where the surface does not contact the food, replacing in full standard materials such as steel, glass, alloys, rubber, porcelain and paint. Without the difficulties of toxicity, problems of leaching and extraction, and dealing with those cases where plastics have the necessary physical properties and appearance, it can be predicted that many flat areas, supports, framework, moving parts, valves, driving mechanisms, and many other parts will be made from plastic to insure longer life, lighter weight, and lower costs. The case of fabrication and the possibilities of economics in design and replacement will improve the performance and the initial cost of the process equipment of the future. These developments cannot be realized unless there is established and maintained a close liaison between the dairy equipment fabricator.
and the plastic materials manufacturer and fabricator. This can be accomplished first by a recognition of mutual problems, fostering areas of agreement where standards can be established, sharing of experiences with a motivation of improvement, and the desire to initiate and continue sound product development programs. Realizing that the magnitude of the problem and the intricacies involved will not permit the attainment of such an ideal situation, patience, fairness, and good chemical and engineering common sense can stimulate and produce dividends for both the dairy and the plastic industry.