pure STRATEGIES

Sources of Phthalates in Dairy Farm Equipment

Prepared for Environmental Health Strategy Center & The Coalition for Safer Food Processing & Packaging

March 20, 2018

Table of contents

Executive Summary 1
I. Introduction 3
II. Potential Sources of Phthalate in Milk from Farm Equipment 5
III. Test Results for Equipment 15
IV. Information from Dairy Equipment Suppliers 20
V. Findings 23
VI. Next Steps 25
Appendix I: Phthalate Test Results 27
Appendix II: Communication on Glitex 181 PVC Tubing 37
Appendix III: Companies Providing Flexible Tubing to Food Industry 39

Executive Summary

While the evidence of adverse health effects of ortho-phthalate plasticizers has resulted in a prohibition of the use of most phthalates in food contact materials for fatty foods, including dairy, in the EU, U.S. FDA has not imposed any similar restrictions. Testing of commercial dairy products has demonstrated the presence of phthalates – particularly in those products with higher fat content and subject to greater processing. Studies, especially in Belgium, have shown that while later steps in product preparation can contribute significantly to the levels of phthalates in products, significant phthalate levels are often present already in the raw milk from dairy farms. This study is one part of a broader effort to understand the sources of phthalates at dairies and to develop strategies to eliminate those sources.

This report focuses on the equipment on dairy farms that can contribute to the presence of phthalates in raw milk. For the equipment that is likely to have the highest potential impact on the presence of phthalates in the milk, it also considers current and potential contributions of dairy equipment suppliers in mitigating the problem.

The first focus of the study was on testing a few samples from common equipment at dairies that could potentially lead to the presence of phthalates in the raw milk. Since phthalate-plasticization of PVC and synthetic rubber hoses and teat cup liners has been widely available in the past, the expectation was that even a small number of samples might provide information on the patterns of continued use. Out of 20 samples including 6 hoses, 2 teat liners, gaskets, and other materials, one teat liner contained significant phthalates.

To supplement the test results, the study gathered additional information from dairy-supply companies and views of dairy experts on the extent of continued use. The combined result of these efforts demonstrated that, while there is clearly movement among major suppliers (especially those with roots in the EU) to transition to phthalate-free equipment, there is significant continuing use. The extent of the transition is not clear; views of dairy experts ranged from seeing very little movement away from phthalates to feeling that there are some significant changes in the offerings of a significant number of suppliers.

Major findings of the report include:

- The combination of test results and company product reviews demonstrate that some suppliers continue to use phthalates to plasticize both PVC and synthetic rubber dairy equipment.
- A substantial range of alternatives to PVC or rubber equipment plasticized with phthalates is currently available in the market for dairy farm equipment.

- There is also evidence that some suppliers either no longer offer products plasticized with phthalates or at least provide phthalate-free alternatives. But there is very little evidence so far about how great an impact this increased availability of phthalate-free equipment has had on dairy farm equipment choices.
- The motivation for suppliers to develop replacements for phthalate-plasticized materials has not, up to this point, come from dairy farmers – who are concerned with equipment functionality and cost, and often not aware of the significance of phthalates.
- Increased equipment durability is a potential competitive advantage for suppliers and an incentive for change for the farmer. The fairly short lifecycle of traditional equipment provides an opportunity for relatively rapid change if the right business incentives are in place.
- Understanding of current equipment use and opportunities for accelerating change could be enhanced by a study focused on current offerings of phthalate and non-phthalate equipment by a significant segment of the larger suppliers. The study could also assess supplier plans for phasing out of any currently available phthalate-plasticized equipment. Supplier sensitivity on the issue appears substantial; both leaders and laggards could be recognized.

I. Introduction

Evidence from several studies has demonstrated that some proportion of the phthalates[1] found in the final dairy products purchased by consumers may already be present in the raw milk from the dairy farms.[2] This report is part of a larger project to identify sources of phthalates in dairy products, and to alter the primary choices of materials or process steps that are currently resulting in phthalates in dairy products. The focus of this report is on potential sources of phthalates in equipment used at the dairy farm that could contribute to the presence of phthalates in raw milk from dairies. The report includes:

- Review of information from a variety of sources to identify types of equipment most likely to lead to the presence of phthalates in raw milk.
- Testing of a limited number of samples from common equipment at the dairy that could come into contact with the raw milk.
- Information from some dairy equipment manufacturers on use of phthalates to provide the needed flexibility for equipment such as milk hoses on the dairy farm, as well as indications of changes by those manufacturers with respect to their dependence on phthalates as a primary means to provide the needed product flexibility.

Other steps in the production of dairy products may be a source of phthalates in the final products – e.g., phthalates from food contact materials in the packaging or processing for milk, cream or cheeses or other dairy products.[3] In addition, since phthalates are lipophilic, concentrations of the phthalates increase in the fattier end products (e.g.,

[1] Throughout this report, the term "phthalates" will be used in place of "ortho-phthalates." Ortho-phthalates is the family of chemicals that are of concern in dairy (and other food) supplies, and commonly referred to just as 'phthalates.' Terephthalates, a family of structurally similar chemicals with a far lower hazard profile, are sometimes used as replacements for ortho-phthalates as plasticizers, including in equipment such as milk hoses on dairy farms.

[2] Fierens T, Van Holderbeke M, Willems H, De Henauw S, Sioen I. Phthalates in Belgian cow's milk and the role of feed and other contamination pathways at farm level. Food Chem Toxicol. 2012 Aug;50(8):2945-53. https://www.ncbi.nlm.nih.gov/pubmed/22659009
Fierens T, Van Holderbeke M, Willems H, De Henauw S, Sioen I. Transfer of eight phthalates through the milk chain--a case study. Environ Int. 2013 Jan;51:1-7. https://www.ncbi.nlm.nih.gov/pubmed/23138015
Cao, X. Phthalate Esters in Foods: Sources, Occurrence, and Analytical Methods. Comprehensive Reviews in Food Science and Food Safety. 2010 9: 21-43. http://onlinelibrary.wiley.com/doi/10.1111/j.1541-4337.2009.00093.x/full
Castle L, Gilbert J, Eklund T. Migration of plasticizer from poly(vinyl chloride) milk tubing. Food Addit Contam. 1990 Sep-Oct;7(5):591-6. https://www.ncbi.nlm.nih.gov/pubmed/2253803
Fierens, Tine, Isabelle Sioen, Stefaan De Henauw, et al. "Phthalate Contamination in the Milk Chain." *Visie, Gezondheidswinst En Toekomst : Book of Abstracts*. 2010. 57–57. https://www.wiv-isp.be/aph/pdf/APH68_S63.pdf
Van Holderbeke M, Geerts L, Vanermen G, Servaes K, Sioen I, De Henauw S, Fierens T. Determination of contamination pathways of phthalates in food products sold on the Belgian market. Environ Res. 2014 Oct;134:345-52. https://www.sciencedirect.com/science/article/pii/S0013935114002722?via%3Dihub

[3] For example, two enforcement campaigns by Scandinavian government agencies found violations of EU phthalate restrictions for food contact materials in 23% and 39% of conveyor belts, plastic tubes, lids and gloves– all due to PVC plastics. Petersen, Jens Højslev, and Lisbeth Krüger Jensen. "Phthalates in soft PVC products used in food production equipment and in other food contact materials on the Danish and the Nordic Market 2013-2014." *International Journal of Food Contamination* 3.1 (2016): 3. (https://foodcontaminationjournal.springeropen.com/articles/10.1186/s40550-016-0026-6)

cheeses and cream). But while later steps in production may add to the phthalate concentrations in the ultimate products, phthalates in raw milk from the dairy remain a source of the phthalates in the final dairy products.

The following sections include:

- Overview of potential sources of phthalates in raw milk.
- Test results for samples of materials from dairy farm equipment.
- Information on phthalate-free offerings or initiatives by dairy equipment suppliers
- Summary of findings and potential next steps.

II. Potential Farm Equipment Sources of Phthalates in raw milk

Opportunities for reducing phthalates in raw milk resulting from dairy farm equipment focus on flexible plastic or rubber equipment that could be plasticized with phthalates. The most likely sources are equipment that comes into direct contact with the raw milk from the cow, such as milk hoses or inflations/teat cup liners. Other potential sources include:

- Equipment with potential indirect contact with the milk, such as sources of iodine or other disinfectants/cleaners, or plastic brushes used for cleaning cows' udders in more automated systems.
- Equipment that comes into contact with cows' silage or other feed, though this requires some evidence of how phthalate from such sources would be metabolized by the cow and passed into the milk.

1. Equipment with direct contact with raw milk from the cow

The following sections review tests of equipment, information from dairy equipment suppliers and perspectives of dairy experts on each of these categories of equipment. The major emphasis is on the equipment that seems to have the greatest likelihood of contributing to the presence of phthalates in raw milk. Figure 1 shows the equipment in the automated milking systems that moves the milk from the cow to the bulk tank that stores the milk until transferred to transport.[4]

The most important parts in the diagram for potential migration of phthalates into the raw milk are the liner (see Figure 2), the short milk tube and the long milk tube. During the milking process, four teat cups attach to the cow's teats; the liner (or inflation) of the teat cup pulsates to create the flow of milk. Only the liner (rubber, silicone or soft plastic)[5] touches the cow's teat during the milking process. The milk then passes into the claw, and from there into the long milk tube (or milk hose). The hose – rubber, silicone or plastic (usually PVC) --runs from a few feet to as much as a dozen feet before it connects to stainless steel pipes.[6] Gaskets occur throughout the system, starting with the claw. While some of the joints in the pipe will be welded, there will be a substantial number of gaskets and o-rings. The gaskets are generally made from rubber – often nitrile rubber.[7]

---

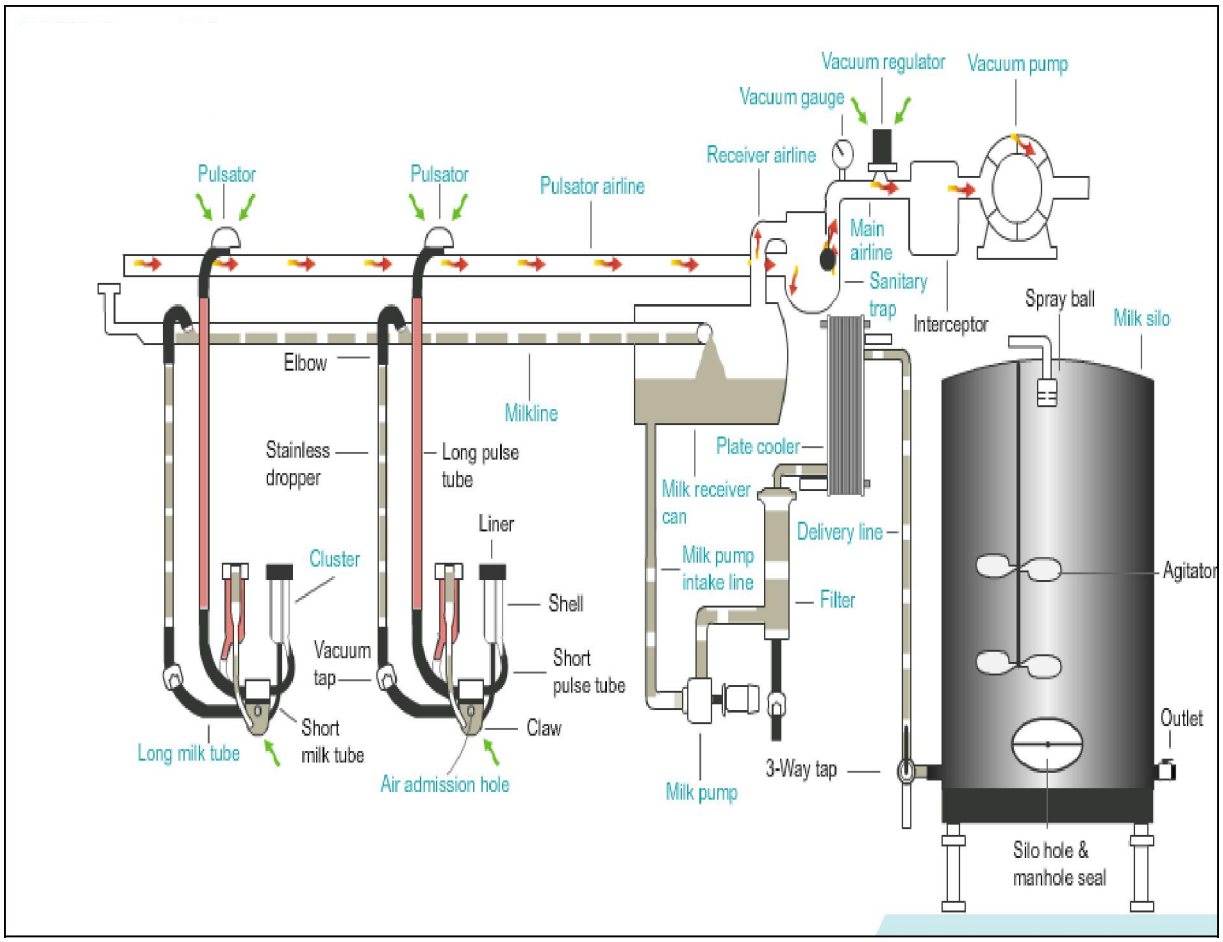
[4] The diagram in Figure 1 is from DairyNZ, "The Milking Plant," (https://www.dairynz.co.nz/milking/the-milking-plant/)

[5] A specific reference to plastic for liners identified during the review was by DairyFlo, a New Zealand company, which advertises that its liners last three times longer than rubber liners. The plastic is identified as a thermoplastic urethane and is plasticizer free. It is not clear if DairyFlo products are currently available in the US, though DairyFlo is applying for international patents. http://www.dairyflo.co.nz/faqs/

[6] Information from Tonya Schoenfuss, Associate Professor Dairy Products Technology & Associate Director, Midwest Dairy Foods Research Center, University of Minnesota (emails 11/30/17 & 12/10/17; phone interview 12/1/17).

[7] Tonya Schoenfuss, phone interview 12/1/17; Rick Kersbergen, University of Maine Cooperative Extension, phone interview 11/8/17

Figure 1: Milking Equipment

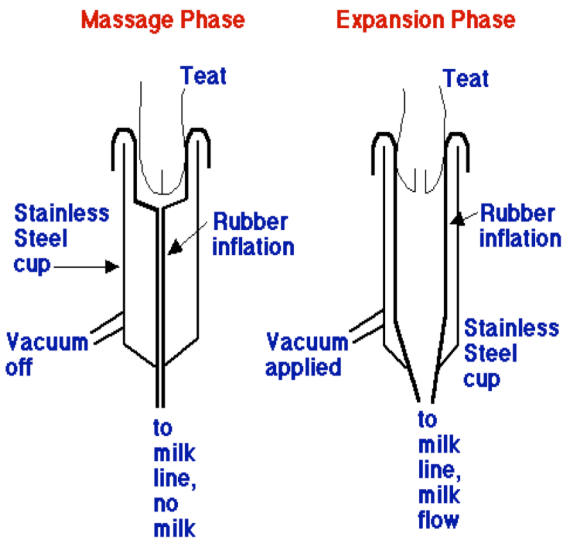


After the milk flows into the stainless steel pipe, it passes through both a filter and a plate cooler before entering the bulk tank. The filter (which might be nonwoven fabric or more permanent meshes)[8] screens out solids such as dirt, hair or manure. The filter is placed before the plate cooler both to protect the cooler from the solids and to allow milk fats to pass through the filter while the milk is still warm (since, once cooled, milk fats could solidify and be filtered out of the milk).

[8] According to a DeLaval report on filters, there are two types of filters – disposable filters, made of non-woven fabrics (e.g., polyester, cotton, cellulose, viscose) for use in just a single milking session, and permanent filters made of mesh stainless steel or hard plastic screens, with the former predominating. "Nearly all the raw milk produced on farms is filtered by disposable milk filters" (p. 25). DeLaval, "Efficient Milk Filtration" http://www.delaval.ch/ImageVaultFiles/id_26182/cf_5/53570972BR_Filter-handbook.PDF

The plate cooler reduces the temperature of the milk for storage in the bulk tank. Like the stainless steel pipe gaskets, the gaskets in the plates of the plate cooler are generally synthetic rubber.[9]

Figure 2: Teat Cup & Inflation/Liner[10]



The bulk tank is the last stop for the raw milk on the farm before it is pumped into a truck for transport to a dairy for processing. Once again, there are gaskets and seals that are typically of rubber construction.

Performance requirements

The most common materials for liners and hoses until recently included synthetic rubber and PVC for hoses, and synthetic rubbers for inflations – both of which could be plasticized with phthalates. The market is changing, and an increasing range of alternatives is available on the market, including both PVC and synthetic rubbers with non-phthalate plasticizers and alternative materials that require very little or no plasticizing, such as silicones or advanced synthetic rubbers. Views vary on how extensive the actual change in use has been. But there is general agreement among those contacted for this report that dairy farmers base their choices on functionality and cost – that concern about phthalates is still limited (or as one dairy owner captured the view, "probably it is the cheapest cost for the functionality you need"). So while on-line catalogs sometimes include "phthalate-free" statements, dairy farmers focus on how new or alternative materials improve performance.[11]

Both the inflation/liner and milk hose must be flexible and durable. Materials must be resistant to heat of the raw milk (at about 100 degrees Fahrenheit) and to the alkaline and acid rinses used for regularly cleaning the hoses to avoid material or microbial buildup inside the hose. In addition, they must meet FDA requirements for food contact materials and 3-A Sanitary Standards for multiple use plastic or rubber materials.[12a]

[9] See, for example, https://hambydairysupply.com/stainless-steel-plate-with-nitrile-gasket-for-t4-koolway-mueller-surge-plate-cooler/

[10] Courtesy of Professor H. Douglas Goff, Dairy Science and Technology Education Series, University of Guelph, Canada. https://www.uoguelph.ca/foodscience/book-page/automatic-milking

[11] Interviews with Rick Kersbergen, University of Maine Cooperative Extension (11/8/17); Douglas Reinemann, Associate Dean for Extension and Outreach, College of Agricultural and Life Sciences, University of Wisconsin (12/1/17); Tonya Schoenfuss, Associate Professor Dairy Products Technology & Associate Director, Midwest Dairy Foods Research Center, University of Minnesota (emails 11/30/17 & 12/10/17; phone interview 12/1/17); Gabe Clark, Founder and Director at CSR Consultancy (11/16/17).

[12a] 3A Sanitary Standards for Multiple-Use Plastic Materials, # 20-27. Available for purchase at https://www.techstreet.com/standards/3a-20-27?product_id=1800159

Liners (see Figure 2) need to meet performance goals that include fitting tightly enough on a range of teat sizes and shapes to be airtight, being comfortable for the cow, and meeting a range of technical needs to facilitate full milking of the cow. A particular challenge for the liner is that the material needs to remain resilient, without propagating cracks that could harm the teat, while pulsing (inside the teat cup shell) on the cow's teat at a rate in the range of 45-60 pulses per minute.[12]

In addition to being resistant to chemical cleaning rinses, hoses must remain flexible within a wide range of air temperatures that can vary substantially depending on geography and time of year. Potential material issues for milk hoses are that the interior of the hose becomes rigid or cracked from the chemical rinses, that the hose becomes inflexible in cold weather, or that the hose generally loses flexibility due to leaching of the phthalates. (The last of those changes is an anticipated length-of-life factor for the hose; the first two are perceived as product failures). In addition, the hoses should be relatively easy to handle, so that factors like weight or ease of cleaning can be significant.[13]

Materials

EU prohibitions on the use of most phthalates in food contact materials for fatty foods, including dairy, have led to the development of a wide range of non-phthalate alternatives for all of the direct contact materials in hoses, phthalates and gaskets.[14] While these restrictions are now mandatory in the EU, adoption in the absence of regulations in the U.S. has been slow. Among the most-used materials, both PVC and synthetic rubber materials may have high levels of phthalates, although there are non-phthalate alternatives commercially available for both.

PVC

PVC plasticized with phthalates has provided a functional, relatively inexpensive type of milk hose at dairy farms.[15] In addition to low cost, benefits include relatively light weight, durability and flexibility through a wide temperature range.

---

[12] Department of Animal Sciences, University of Illinois, "Milking Machine" (http://ansci.illinois.edu/static/ansc438/Mastitis/milkmachine.html). Microscopic studies show that inflations that still appear undamaged may still be deteriorating fairly quickly. (Rick Kersbergen, University of Maine Cooperative Extension, 11/8/17).

[13] Tonya Schoenfuss, Associate Professor Dairy Products Technology & Associate Director, Midwest Dairy Foods Research Center, University of Minnesota (emails 11/30/17 & 12/10/17; phone interview 12/1/17). Douglas Reinemann, Associate Dean for Extension and Outreach, College of Agricultural and Life Sciences, University of Wisconsin (12/1/17)

[14] For inflations, no specific use of PVC was identified, though there were catalog listings for "plastic" inflations. Without more information it's hard to be certain whether or not a "plastic" is PVC, but that seems less likely than that the rubber-like properties that are valuable for an inflation might be realized through use of a thermoplastic elastomer that has some plastic and rubber components. For example, see Dairy Flo's Leading the Change to Plastic, http://www.dairyflo.co.nz/why-choose-dairyflo-products/

[15] Experts at different geographic locations stated, with equal certainty, that PVC milk hoses or rubber milk hoses were the preferred choices at dairy farms, so there may be regional differences or differences in sizes of dairies that affect choices between the two. Personal communications.

Without additives, PVC is rigid. To ensure continued flexibility and avoid cracking or breaking in cold weather, PVC hoses require increasing levels of plasticizers at colder temperatures. For DEHP, typical formulations use 30% to 40% DEHP by weight, and provide cold weather flexibility down to -40 to -50 degrees centigrade.[16] But the hose gradually degrades and becomes less flexible because the phthalate plasticizers are not chemically bound to the PVC polymer. DEHP or other phthalate plasticizers migrate out of the PVC into the raw milk passing through the hoses. Both the heat (about 100 degrees F) and fat content (since phthalates are lipophilic) can accelerate that migration. The high percentage of phthalates in the PVC makes this a potential major source for phthalates leaching into the raw milk.

Alternatives to PVC with DEHP or other phthalate plasticizers are becoming more widely available for dairy equipment. These alternatives include both blends of PVC with other polymers (which may reduce requirements for plasticizers) and use of non-phthalate plasticizers. [17] While dozens of plasticizers have been developed for both general or specialized use, plasticizers identified in milk hoses are constrained by the particular performance requirements and cost constraints of dairy farms. One common alternative plasticizer is DOTP, a terephthalate.[18] While DOTP (also called DEHT) shares many of the same plasticizing characteristics as DEHP, it shares fewer of DEHP's hazardous properties (although data gaps remain).[19] Other plasticizers – identified either from tests results (Table 1 below) or from information provided by companies (Table 6 below) – include adipates (e.g., DEHA) and additives identified only as 'bio-based.' Some bio-based plasticizers may be used as secondary plasticizers, providing additional flexibility in combination with primary plasticizers (which may be the case with the glycerin triacetate found in two of the products).[20]

Rubber

While a few inflations or milk hoses may still be made with natural rubber, most rubber products are now made with synthetic rubber. Synthetic rubbers found in the tested samples, for example, included EPDM, nitrile rubber, and rubbers based on ABS and polystyrene/polypropylene. While rubber may be plasticized for processing or flexibility, plasticizing may be achieved with petroleum oils rather than phthalates or other alternatives. But phthalates still are used in some rubbers used in dairy farm materials.

[16] Handbook of Vinyl Formulating (John Wiley & Sons, 2008, 2nd edition), edited by Richard F. Grossman, pp. 181182.
[17] Specific information on alternatives is often unavailable due to proprietary restrictions.
[18] Some companies label their plasticizers as 'terephthalates,' without specifying the specific chemical.
[19] The hazard profiles of DEHT and DEHP can be found at https://www.pharosproject.net/material/show/2004682 and https://www.pharosproject.net/material/show/2086424.
[20] Studies indicate potentially problematic hazard issues for DEHA, while glycerin triacetate has a favorable hazard profile. See https://www.pharosproject.net/material/show/2007649 and https://www.pharosproject.net/material/show/2004452. On secondary plasticizers, see Kirk-Othmer, Concise Encyclopedia of Chemical Technology (4th edition, Wiley Interscience Publication, 1999), p. 1578.

While not found in the milk hose samples, phthalates were identified in one of the rubber inflations (see Table 2 below). Without more comprehensive testing, there is no way to know what proportion of rubber hoses, inflations or gaskets are plasticized with phthalates. Depending on the specific synthetic rubber, and whether a phthalate plasticizer is used only for processing or for providing product flexibility, phthalate concentration in the rubber may range from as little as 1% to as much as 16%.[21] The phthalate level found in the tested inflation exceeded 10%. These levels, while lower than in PVC, still provide significant opportunity for migration into the warm raw milk.

But not all synthetic rubbers require plasticizers. Some copolymer combinations provide inherent plasticizing without additional plasticizing additives. A few are advertised as "plasticizer free." Since the particular chemical combinations are often proprietary, there is no way in such cases to know what polymers are involved except through testing.

Silicone

Silicone is widely available for use in milk hoses, inflations and gaskets and, since it is inherently flexible, requires no plasticizers.[22] Silicone products have greater durability than the alternatives, which reduces labor time required for equipment changes. But they also are subject to abrasion, and cracks beginning on the outside can propagate through the hose or can create rough edges or cracks in inflations that can irritate teats – both of which can reduce the general durability advantage.[23]

Silicone products are significantly more expensive, at least in the short term, which can be an important barrier to changing to silicone from either plastic or rubber. But, at least in some cases, the long-term costs might be similar or lower due to the greater durability of silicone products.[24]

---

[21] Kirk-Othmer, pp. 1580-1581, 1768-1769; Additives for Plastics Handbook by John Murphy (2nd edition, Elsevier Advanced Technology, 2001), pp. 231-233; Rubber Compounding Ingredients: Need, Theory and Innovation, Part II by C. Hepburn (Smithers Rapra Technology, 1997).

[22] The word 'rubber' is used broadly, and may be applied to silicone, as well as to some thermoplastic elastomers that include non-rubber polymers. The use in this report reflects the distinctions generally made on dairy distributor and supplier sites, which treat silicones as a separate class.

[23] Interview with Douglas Reinemann, Associate Dean for Extension and Outreach, College of Agricultural and Life Sciences, University of Wisconsin (12/1/17). Another issue that was raised by one company representative and appeared on some sites is that milk fat can both stick to the walls of silicone hoses and migrate through the silicone to form lumps of fat on the outside of the hose. This apparently depends on the specific formulation of the silicone material; it may also be resolved by two layers of different materials in the hose. (Personal communication)

[24] See "Consider material, value, performance when choosing liners," by Nathan Brown, DeLaval Solution Manager for liners and tubes, Progressive Dairyman, (12/11/2015) https://www.progressivedairy.com/topics/management/consider-material-value-performance-when-choosing-liners . While it appears generally to be the case that silicone products are more expensive on distributor sites, it is difficult to estimate the difference. A representative of one company that sells silicone products noted that, considering the greater durability of silicone, the difference is quite small,

2. *Equipment with no direct contact with raw milk from the cow*

Once milk enters the milking system through the inflations, there should be no contact between the milk and equipment on the farm other than that summarized above. Still, the fact that some levels of phthalates have been found after hand-milking of cows[25] raises questions about other possible sources.

As noted above, there are some potential equipment sources to consider that do not involve direct contact with the raw milk after the cow has been milked:

- Phthalate contamination from equipment involved in cleaning, including application of disinfectants to cows' udders prior to milking.
- Contamination of cows' feed with phthalates by equipment used in storing or preparing the feed.

Cleaning and Disinfection

Cleaning of cows' udders and application of disinfectants is done before milking to reduce risk of bacterial contamination of the milk or of mastitis for the cows and to stimulate oxytocin release that results in more rapid and complete milking of the cow.[26] Equipment that could be considered as possible sources of phthalates include:

- Dip cups used by workers at the dairy to apply the disinfectant solution to the teats. The applicator portion of the cup is rigid, though in some a bottom portion of the container is flexible.
- In partially or fully automated systems there may also be:
    - Hose through which the disinfectant from the container is transferred to be sprayed on the teats.
    - Spraying device, possibly also containing a rotating brush to aid in cleaning the teats.
- Containers, at least if they are plastic, that contain the iodine (or other disinfectant solution).

The potential for this equipment to be a source of phthalates depends on both the materials and potential phthalate content of the equipment and the likelihood that, if phthalates were present, they would remain as residues on the teats after application of water or a disinfectant solution.

---

while a representative from a company making PVC products estimated the difference to be as high as five-to-one. (Personal communications)

[25] Fierens, Tine, et al. "Phthalates in Belgian cow's milk and the role of feed and other contamination pathways at farm level." *Food and chemical toxicology* 50.8 (2012): 2945-2953. https://www.ncbi.nlm.nih.gov/pubmed/22659009

[26] Interview with Rick Kersbergen, University of Maine Cooperative Extension (11/8/17); interview with Gabe Clark, Founder and Director at CSR Consultancy (11/16/17); Department of Animal Sciences, University of Illinois, "Milking Process" (http://ansci.illinois.edu/static/ansc438/Mastitis/milkprocess.html).

With respect to the equipment, the most likely potential source of phthalates would appear to be any hose conveying the solution, since the hose could presumably be of any of the materials used in milk hoses. The plastic containers with the iodine solution would be hard plastic, so less likely to contain any plasticizers that could contaminate the disinfectant solution. With respect to the dip cup, even those with a flexible base have limited time of contact with the solution – even assuming some might be PVC with phthalates. Spraying devices are made with hard, not flexible, plastic. While there could be other materials, both GEA and DeLaval state that the bristles in their teat cleaning systems are made of nylon,[27] which would not generally be expected to be plasticized with phthalates.[28]

Finally, some of those involved with dairies noted that the cleaning and preparation for milking requires drying the teats after cleaning. This is usually done with either with a powered drying system, or with single-use paper. In combination, they viewed this equipment as a less likely source of phthalates than the equipment involved in milking and transferring the raw milk to the bulk tank.[29]

In spite of these caveats, the potential for phthalates from equipment used for cleaning and disinfection can't be set aside. If, for example, phthalates were to be present in the antiseptic solution and the drying step were not adequate, residual phthalates could be on the teat during the milking process.[30] To determine this possibility would require testing phthalate levels in the iodine solution applied from equipment (whether hoses, applicators or the original container) made from material that tests show to include phthalates.

Phthalates from Feed

Feed for cows consists of fresh forage from pastures and of silage (mostly grown and stored on-site) and concentrate (purchased high carbohydrate, fat, protein and vitamin mixes imported to the farm).[31] All three provide potential sources of phthalates in the feed – whether from environmental sources affecting the pasture, from preparation of the concentrate mix (predominately offsite) or preparation or storage of the silage. In terms of equipment/materials used at the dairy, migration of phthalates from equipment to silage is the principal concern.

---

[27] https://www.gea.com/en/products/cow-brush-e-brush-and-m-brush.jsp; https://www.delaval.com/en-us/our-solutions/cow-comfort/cow-brushes/delaval-mini-swinging-brush-msb/

[28] "The high degree of crystallinity in nylon means that plasticization can occur only at very low levels. Plasticizers are used in nylon but are usually sulfonamide-based since these are generally more compatible than phthalates. These plasticizers help improve the processing of the nylon." "Plasticizers" in Encyclopedia of Polymer Science and Technology, V.3, p. 519.

[29] Interview with Rick Kersbergen, University of Maine Cooperative Extension (11/8/17); interview with Gabe Clark, Founder and Director at CSR Consultancy (11/16/17)

[30] Time pressures during this step could, in some instances, be a contributing factor.

[31] Alberta Milk, "What do dairy cows eat?" https://albertamilk.com/ask-dairy-farmer/what-do-dairy-cows-eat/

Previous studies provide evidence that phthalates in a cow's feed may pass through the cow into the cow's milk. The extent or limitations of this process require additional study, as recommended by Fierens *et al* (2012). In the most extensive research effort thus far, the authors noted that some phthalates to which cows were exposed through feed (DMP, DEP, DnBP, DCHP, DnOP) did not result in phthalates in the raw milk, while for others (DiBP, DEHP) the phthalates were found in the milk.[32]

They reported on a case at one farm where silage the cows consumed contained phthalates, in spite of there being no detectable phthalates present in soil, water or pasture. Subsequent testing of the cows' milk after manual milking demonstrated the presence of DiBP in the milk. The authors concluded:

> ...silage is almost certainly contaminated with DiBP due to migration from contact materials such as cling films, sails or sealants used during production, mixing or during storage at the farm.[33]

Figure 3: Silage Bale[34]

The most likely sources for phthalates in silage due to farm equipment would be either the wraps of bales of silage (Figure 3) or the covers over silage bunkers (Figure 4). Bales provide protection for relatively small amounts silage. Review of silage wraps available through on-line sites indicate that the most common material is some form of polyethylene – often described as made from 'premium grade polyethylene resins,'[35] or simply as superior to 'conventional' polyethylene.[36]

Figure 4: Silage Bunker[37]

For larger farming operations, silage may be stored in large silage bunkers such as that in Figure 4. The tires on top of the cover over the bunker are used as weights to keep the cover sealed. As in the case of the silage wrap, a common material is polyethylene. FarmTec, for example, describes its covers UV-resistant knitted polyethylene that will last for years.[38]

---

[32] Fierens, Tine, et al. "Phthalates in Belgian cow's milk and the role of feed and other contamination pathways at farm level." *Food and chemical toxicology* 50.8 (2012): 2945-2953. (https://www.ncbi.nlm.nih.gov/pubmed/22659009)

[33] *Ibid.* There's no way to know what silage wrap or cover was used on the Belgian farm.

[34] Picture from the University of New Hampshire Cooperative Extension https://extension.unh.edu/blog/utilizing-undf-dairy-cow-diets

[35] Blue Lake Plastics, http://www.bluelakeplastics.com/ag-silage-bags-and-sheeting.php; Farm Plastic Supply, https://farmplasticsupply.com/bunker-covers

[36] Blue Lake Plastics, http://www.bluelakeplastics.com/ag-silage-bags-and-sheeting.php; Farm Plastic Supply, https://farmplasticsupply.com/bunker-covers

[37] Picture © Werner Willmann / Wikimedia Commons / CC-BY-SA-3.0 / GFDL

[38] FarmTec, https://www.farmtek.com/farm/supplies/prod1;ft_hay_feed_storage;pg109200.html ; Farm Plastic Supply, https://farmplasticsupply.com/bunker-covers; Global Plastic Sheeting, https://www.globalplasticsheeting.com/ag-liners---covers

Since polyethylene is inherently flexible, it seems improbable that phthalates would be used in the formulation.[39] There are, however, numerous sites offering silage wraps or bunker covers that specify use of plastics, but with no information on exactly what the materials are, and the likely use of multiple plastics was confirmed during an interview.[39]

Testing of crumb rubber from recycled tires used on children's playgrounds and rubberized surfaces for sporting events has found phthalates in the rubber, among a number of hazardous chemicals. While a range of other plasticizers are used in tires, older tires used on bunkers could contain phthalates. While the rubber in whole tires has less exposed surface than the crushed rubber, it is a potential source of phthalates that should be tested – both in terms of the presence of phthalates in the tires and the potential rate of leaching.[40]

Two dairy experts found it more likely that any phthalates could come from wraps than from the larger bunkers. One noted that the depth of bunkers can be anywhere from ten to thirty or more feet, and that it was unlikely that phthalates, if present in the cover of a bunker, could penetrate through more than the very top layers of the silage. Both also noted the complexity of resolving the source of a particular, given the multiple potential sources of feed or environmental contamination.[41]

Assessing the linkages of phthalates in milk from the cow with either particular materials in equipment that contacts feed or with other sources of phthalates was beyond the scope of this study. Such a study would need to connect specific measures of phthalate contamination of feed with sources in the materials used to store silage. That would provide a positive basis for distinguishing between equipment and general environmental sources of phthalate contamination of the feed.

---

[39] A review of polyethylene in The Handbook of Plasticizers notes potential uses of phthalates and other plasticizers in polyethylene. All of the references in the section on polyethylene, however are based on patents rather than actual applications, so it's not clear how applicable it would be to the uses of polyethylene covers for silage. George Wypych, editor, Handbook of Plasticizers, ChemTec Publishing (2004), http://61.188.205.38:8081/hxgcx/hcjs/UploadFiles/pdf/%E6%96%87%E7%8C%AE%E5%BA%93/%E6%A8%A1%E5%9D%973%E5%90%88%E6%88%90%E6%9D%90%E6%96%99%E5%8A%A9%E5%89%82/Handbook%20of%20Plasticizers%20-%20G.%20Wypych%20(Chemtec,%202004)%20W W.pdf. Global Plastic Sheeting, https://www.globalplasticsheeting.com/ag-liners---covers; Zuidervaart, https://www.globalplasticsheeting.com/ag-liners---covers; Farm Plastic Supply, https://farmplasticsupply.com/bunker-covers?product_id=275; interview with Rick Kersbergen, University of Maine Cooperative Extension (11/8/17).

[40] Llompart, Maria, et al. "Hazardous organic chemicals in rubber recycled tire playgrounds and pavers." *Chemosphere* 90.2 (2013): 423-431. https://www.ncbi.nlm.nih.gov/pubmed/22921644; Miles Moore, "Industry defends use of crumb rubber in artificial surfaces," RubberNews.com. http://www.rubbernews.com/article/20141027/NEWS/310209997?template=printart

[41] Interview with Douglas Reinemann, Associate Dean for Extension and Outreach, College of Agricultural and Life Sciences, University of Wisconsin (12/1/17); interview with Rick Kersbergen, University of Maine Cooperative Extension (11/8/17).

III. Test Results for Equipment

Dairy farms, and the equipment used on those farms, are highly diverse. As any review of equipment available at on-line sites for distributors and suppliers demonstrates, there is a wide range of available alternatives for any dairy equipment. For this report, we gathered a small sampling of flexible equipment components and tested them for presence of phthalates. The samples were identified and selected from those available through on-line distributors.

Materials for testing were selected from the following:

- Milk hoses
- Teat cup liners/inflations
- Gaskets/o-rings in milking equipment and connections
- Teat dip cups and other equipment for cleaning/disinfectant solutions
- Silage wrap

The materials were selected to provide some insights on the presence of phthalates in dairy equipment and the use of alternative polymers and plasticizers. The emphasis for testing was on materials from equipment that has direct contact with raw milk from the cow. It is both the likeliest major source of phthalates in milk due to farm equipment, and a contributing cause of phthalates in milk where changes could most readily and quickly be made. The tests of materials reviewed in this section include sixteen samples from equipment that directly contacts the raw milk (9 from hoses, 2 from inflations, 4 gaskets, 1 filter), 3 from equipment involved in application of disinfectant/cleaning of the cows' teats before milking (1 hose, 2 dip cups) and one piece of silage wrap.[42]

Test Results for Hoses

Samples of nine milk hoses from on-line dairy supply distributors were tested for phthalates. The goal was to find any indications of phthalates in those milk hoses that could potentially result in presence of phthalates in the raw milk. The sample included a mix of different materials – including some that were labeled (accurately, the tests demonstrated) "phthalate-free." As the results in the following table demonstrate, none of these samples contained phthalates (although phthalates were found in one of the inflation samples – see below).

[42] All the samples except the silage wrap were purchased from distributors. The piece of silage wrap was provided from a farm.

Table 1: Test for Phthalates: Milk Hoses[43]

Product Name	Company or Distributor[44]	Material Result from FTIR	Solvent Extraction FTIR result
DairyFlow High Performance Milk and Dairy Transfer Tubing	TBL	Polystyrene copolymer (e.g. polystyrene/ethylene-butylene)	Mineral oil
Black Rubber Milk Tubing 9/16 in I.D 1 ft	GEA	Poly(isoprene) or EPDM rubber; kaolin	Mineral oil; Santoflex 13
Black Rubber Milk Tubing 5/8 in I.D w/o stripe 1 ft	GEA	Poly(isoprene) or EPDM rubber; kaolin	Mineral oil; Santoflex 13
1.5 inch I.D. Tigerflex Milk Hose/Tubing	Kuriyama	PVC; DOTP	DOTP
3/4 ID Milk hose/tubing per foot	Saint Gobain	PVC; glycerin triacetate	Glycerin triacetate ("triacetin")
5/8 ID Silicone Milk Hose/Tubing	Hamby Dairy Supply	Polydimethylsiloxane (PDMS, a silicone)	Polydimethylsiloxane
5/8 ID Surge Milk Hose/Tubing	GEA	PVC	Glycerin triacetate ("triacetin")
Clear PVC tubing 1/2in ID x 3/4in OD food grade, 100ft/roll	Nelson Jameson	PVC; DOTP	DOTP
CSC200 Cleargard PVC clear helix, 2in suction hose, food grade, 100ft/roll	Saint Gobain	PVC; DOTP	DOTP

While the tests of sample milk hoses did not find any phthalates, they do shed light on some of the alternatives to phthalate-plasticized PVC available for milk hoses.

- First, the five PVC milk hoses are plasticized with two different non-phthalate plasticizers – DOTP and glycerin triacetate. DOTP (or DEHT), a terephthalate, has performance properties very similar to DEHP, but without the endocrine disruption, developmental and other hazard characteristics of DEHP. Glycerin triacetate is approved by both the EU and FDA for food contact uses.[45]
- In addition, three other polymers are used in these hoses. One of the hoses is silicone and requires no additional plasticizer. The other two are synthetic rubber – one based

[43] All tests were carried out by, or at the direction of, the Ecology Center in An Arbor, Michigan. The complete test results for all products tested, as well as a description of the testing methodology, are in Appendix I. Links to the equipment at the sites from which the products were purchased are included in that Appendix.

[44] Where possible, the companies manufacturing the hoses (TBL, Kuriyama, Saint Gobain), or other equipment in subsequent tables, are identified. This includes hoses that are part of major direct equipment sales and services for dairies (e.g., GEA). Otherwise the distributors (Hamby Dairy Supply, Nelson Jameson) are listed. Based on separate information from an interview (see below), it is possible that the GEA hoses are manufactured by Saint Gobain.

[45] http://www.eastman.com/Literature_Center/T/TT141.pdf

on acrylonitrile/butadiene/styrene or polystyrene, the other EPDM. All of the synthetic rubber hoses contain mineral oil, which may be a processing aid or a plasticizer.

Test results for inflations/liners

Two types of inflations were tested for phthalates. Both were made from synthetic rubber based on acrylonitrile/butadiene/styrene. One included the plasticizer DEHA, an adipate. The other used a combination of phthalates exceeding 10% by weight of the material.

Table 2: Test for Phthalates: Inflations[46]

Product Name	Company or Distributor	Material Result from FTIR	Solvent Extraction FTIR result	GC/MS Results
Westfalia original 086, set of 4	GEA	Acrylonitrile; polystyrene; polybutadiene; SiO2; carbon black	Adipate; Santoflex 13	DEHA substantially present; DOTP trace
NuPulse Cow Inflations (4) OEM parts	Hamby Dairy Supply	Acrylonitrile; polystyrene; polybutadiene; SiO2; carbon black	Ortho-phthalate	Phthalates: DIDP 9.06%, DINP 1.11%; Adipates: DEHA trace

Even though the tests only involved two samples, they demonstrated two important concerns about potential contamination of milk by phthalates at dairy farms.

- The one piece of equipment with direct contact with the cow's teats during milking can be a source of phthalate contamination. It is possible that the action of the inflation during milking may promote leaching.
- PVC products are not the only source of concern for phthalate contamination. Even though the percent by weight of phthalates in the NuPulse inflation is lower than what would be expected in PVC, it is substantial.

Test results for filters and gaskets

Gaskets and inflations are in continuous contact with the raw milk in the claws, pipes, plate coolers and bulk tanks, though the contact is more limited than for hoses and inflations. While the raw milk is hot initially, it is cool by the time it reaches the bulk tank, so heat would play a smaller role in leaching. While there would be little concern for silicone gaskets, rubber gaskets appear to be by far the most common. The need for plasticization would seem likely to be lower, but phthalates could be present in rubber products.

[46] The complete test results for all products tested are in Appendix I. Links to the equipment at the sites from which the products were purchased are included on that table.

Table 3: Test for Phthalates: Filter & Gaskets[47]

Product Name	Company or Distributor	Material Result from FTIR	Solvent Extraction FTIR result
Schwartz Filter-Clean Tuffy 4 9/16" milk filter	Tuffy	polyester + a styrene acrylic polymer	Inconclusive; no evidence of phthalate
1.5 Surge Gasket for stainless steel pipeline	Hamby	Acrylonitrile; polybutadiene; talc	DOTP
Gasket for BouMatic barrel claw	Boumatic	Inconclusive polymer (may be EPDM); calcium carbonate; silica	mineral oil; silica
Window Gasket for Westfalia Bio-Milker	GEA	Inconclusive due to carbon black distortion of spectrum	Inconclusive. No evidence of phthalates
212 O-ring FDA EPDM Black	Nelson-Jameson	Inconclusive due to carbon black distortion of spectrum	mineral oil; other components. Inconclusive. No evidence of phthalates

Even with the uncertain polymer readings, a useful result is that one of the gaskets is plasticized with DOTP. While DOTP is a non-phthalate, it is a common substitute for DEHP, suggesting the potential for phthalates in gaskets.

The filter is a polyester, which is a common description of material for disposable filters (most common in milking systems) available from distributors. As discussed above, permanent filters are likely to be stainless steel or hard plastic mesh.[48] Filters appear to be a less likely source of phthalate contamination.

Test results for cleaning & disinfection equipment

Since the most likely sources of phthalates would be the hose for automated disinfectant application systems or any flexible component for hand-held applicators, tests were run on two hand-held applicators and one hose.

[47] The complete test results for all products tested are in Appendix I. Links to the equipment at the sites from which the products were purchased are included on that table.
[48] DeLaval, "Efficient Milk Filtration" http://www.delaval.ch/ImageVaultFiles/id_26182/cf_5/53570972BR_Filter-handbook.PDF

Table 4: Test for Phthalates: Cleaning & Disinfection[49]

Product Name	Company or Distributor	Material Result from FTIR	Solvent Extraction FTIR result
Replacement bottle for Ambic Dip Cups	Ambic	Polyethylene	nothing extracted.
Replacement bottle for Hamby & RJB Dip Cups	Ambic	Polyethylene	nothing extracted.
Clear tubing for ambic teat sprayer ATS410	Ambic	PVC + DOTP	DOTP

The results confirm the potential for hoses with phthalates. In this case, the plasticizer is DOTP, a common alternative/substitute for phthalate plasticizers. But it does indicate the potential for phthalate plasticization of the hose used in automated disinfectant application.

Test result for silage wrap

One piece of used silage wrap was acquired from a dairy farm. No samples of bunker covers were obtained for testing.

Table 5: Test for Phthalates: Silage Wrap

Product Name	Company or Distributor	Material Result from FTIR	Solvent Extraction FTIR result
Silage Wrap Sample	No information	polyethylene + poly(isobutene)	nothing extracted.

This test did not indicate any source of phthalates. Because of the complexity of potential sources of phthalates in feed, a research design focusing first on instances of phthalates in samples from hand-milked cows, and then testing potential equipment (as well as other) sources might be more effective in establishing linkages.[50]

[49] The complete test results for all products tested are in Appendix I. Links to the equipment at the sites from which the products were purchased are included on that table.

[50] While the Belgian study is suggestive, the lack of any testing of, or information on, the materials used makes it difficult to know what type of equipment might have been used, or how to apply the results more broadly. Fierens, Tine, et al. "Phthalates in Belgian cow's milk and the role of feed and other contamination pathways at farm level." *Food and chemical toxicology* 50.8 (2012): 2945-2953. https://www.ncbi.nlm.nih.gov/pubmed/22659009

IV. Information from Dairy Equipment Suppliers

Websites and/or contacted companies manufacturing and/or selling hose and inflation equipment for dairies provided information to supplement the tests. While not intended as a comprehensive survey of what types of material are on the market, it does provide some additional insight into potential sources of phthalates in equipment, and perspectives on prevalence of hoses and inflations plasticized with phthalates. The table below provides a summary of some relevant information about use of phthalates and alternatives. All of these companies manufacture and/or sell a wide variety of products; the table below includes only those that, on the basis of website information or personal communications, appeared most germane with respect to use of phthalates as plasticizers.

Table 6: Companies Manufacturing/Providing Milk Hoses/Inflations[51]

Companies	Material information
Saint-Gobain[52]	• Major international firm with operations in U.S.; businesses include developing and manufacturing high performance materials. • Manufactures milk hoses used by several dairy equipment companies. • Principal milk hose products Tygon-M-34-R (thermoplastic PVC blended with other polymers, *non-phthalate plasticizer*) and Tygon II silicone tubing (*no plasticizer*).[53] • Tygon M-34-R was reformulated in 2012 to eliminate phthalates. • Patents list a large number of possible plasticizers for thermoplastic elastomers, including bio-based & terephthalates[54]
GEA[55]	• International technology and food equipment and services company based in Germany. Comprehensive provider of equipment and services to U.S. dairy industry.

[51] In addition to the companies included in the table, two additional companies were identified with plans to enter the U.S. market with non-phthalate hoses: Terraflex, an Israeli firm with a PVC hose with DOTP plasticizer (email from Batsheva Lerner, International Sales Manager, 1/23/18) and UdderOne, which already manufactures and sells a urethane-based inflation (http://udderone.com)

[52] Phone interview (2/12/18) and email (2/7/18), Jessica Kenepp, Associate Sales Engineer, Saint Gobain; https://www.processsystems.saint-gobain.com/applications/raw-milk-collection; http://www.tygons3tubing.com/Transflow-S3-M-34-R-Tubing.pdf; https://www.processsystems.saint-gobain.com/news/silicone-vs-epdm-rubber-tubing-does-it-make-difference-milk-processing-applications.

[53] There are several different variants of these tubes with different names (e.g., Transflow S3 M-34-R silicone tubing)

[54] Patent #9,416,267; "Blend composition, flexible tubing material and method of making the blend," http://patft.uspto.gov/netacgi/nph-Parser?Sect1=PTO2&Sect2=HITOFF&p=1&u=%2Fnetahtml%2FPTO%2Fsearch-bool.html&r=1&f=G&l=50&co1=AND&d=PTXT&s1=9416267.PN.&OS=PN/9416267&RS=PN/9416267

[55] Phone conversation with Chad Carlson, GEA (2/12/18); https://www.gea.com/en/productgroups/milking-systems/index.jsp; https://www.gea.com/en/productgroups/farm-equipment/index.jsp; https://www.gea.com/en/products/gea-liner-overview.jsp;

	• Milk hoses and inflations/liners provided both as part of/replacements for complete dairy systems and for separate purchase through distributors • Both available either in silicone or rubber; all phthalate-free • Primarily purchase tubing from Saint-Gobain and repackage under own label
DeLaval[56]	• Swedish-based international dairy equipment and services company with operations in US • All liners and tubes phthalate-free • Initial challenge, later solved, when ended all use of phthalates in products in US market at end of 2015: some hoses became hard in cold weather • Produces rubber liners and tubing in plant in US, silicone and some other rubber products in facilities in Europe
Finger-Lakes Extrusion (FLE)[57]	• Glitex 181 series milk hose is PVC plasticized with DEHP, a significant ortho-phthalate, in range of 30%-40% by weight • FLE currently provides hoses without phthalates, but not that can withstand the extreme cleaning conditions for dairy hoses or remain flexible at low temperatures in winter. • Currently near end of pilot effort at several dairy farms with PVC hose with a non-phthalate plasticizer. Expect to put in market this year. Once on market, only plan to have one (non-phthalate) milk hose.
TBL[58]	• Manufactures one of tested hoses: DairyFlow high performance milk and dairy transfer tubing (styrene block co-polymer with mineral oi); plasticizer free. • Described on website as having superior tear resistance to "traditional silicone and rubber milk tubing."
Kuriyama[59]	• Tigerflex one of tested milk hoses (PVC with DOTP, a terephthalate). • Kuriyama of America a part of Kuriyama Holdings Co., a Japanese based corporation manufacturing plastics and rubber products for a variety of industrial and construction applications, including Tigerflex MILKTM Series Low Temperature Food Grade PVC Liquid Suction Hose

https://www.gea.com/en/binaries/DairyFarming_Flyer_IQ_Liner_EN_tcm11-19980.pdf; https://www.gea.com/en/productgroups/milking-systems/liners-tubing/index.jsp

[56] Email from Sarah Tolleson, DeLaval (2/7/18); https://www.delaval.com/en-us/about-us/; http://www.delavalcorporate.com/; https://www.delaval.com/en-us/our-solutions/milking/at-the-milking-point/liners-tubes/; personal communications

[57] Emails from Ted Liberatore, Customer account Manager (12/7/17, 2/5/18); copy of general letter (To Whom It May Concern) from Keith Ellsworth, Finger Lakes Extrusion Production Manager, dated 6/21/13 stating that Glitex 181 tubing contains DEHP; http://www.flextubing.com/products/dairy/glitex-181ms-milk-tubing/. See Appendix II

[58] https://www.tblplastics.com/tubing/dairy-flow-milk-transfer-hose/

[59] https://www.kuriyama.com/; https://products.kuriyama.com/keyword/kuriyama-of-america/ature-food-grade-pvc-liquid-suction-hose-1?keyword=food%20hoses&key=product&SchType=2&filter=1

Milkrite[60]	• Two-layer hose: inner layer of thermoplastic vulcanizate (TPV) rubber; outer layer of black rubber • States that butterfat can't migrate through inner liner. • Provides table of durability of liners/inflations (apparently of same material) • They also have other hoses where they don't specify material • No statement about what or if any plasticizer.
Conewango[61]	• Went DEHP/phthalate-free in 1999-2000 for both liners and hoses • Provide both rubber and silicone hoses
Ace Sanitary[62]	• FlexRite ADL dairy line tubing is DEHP- and phthalate-free • While not silicone, no description of materials (possibly TPE).
Lauren Agrisystems[63]	• Silicone milk hoses and liners; no plasticizers • Uses "silicone-like compounds using FDA approved ingredients for food contact"
Freelin-Wade[64]	• Produces PVC80A tubing from specialty thermoplastic elastomer compound; no phthalates. • Identified in general statement from Freelin-Wade (3/24/17) as compliant with REACH and Prop 65, and in Data Document (September 2015) as formulated for the medical and food industries. • While described as suitable for milk processing, may not be suitable for dairy farm milk hose since not compliant with 3A dairy standards.

[60] www.milkrite.com/US/Products/ultraclean.htm; www.milkrite.com/US/Advice/2500_milkings.htm
[61] Phone interview with Jeffrey Perkins, General Manager, Conewango (2/5/18); https://conewango.com
[62] http://acesanitary.com/sites/default/files/ADL%20cut%201-13-14.pdf;
[63] http://www.laurenagrisystems.com/milking-systems;
http://www.laurenagrisystems.com/lib/sitefiles/pdf/whitepapers/Liner-Material.pdf
[64] Phone conversation (2/12/18) and email (12/7/17), Lori Durand, Inside Sales, Freeing-Wade; https://www.freelin-wade.com/clear-pvc-tubing#1; PVC80A Data Document (issued September 2015); certification statement on PVC80A tubing by Freelin-Wade General Manager Scott Schwarm (3/24/17).

V. Findings

Both the testing of equipment for phthalates and the brief reviews of individual companies involved in one or more phases of supplying the equipment to dairy farms were limited in scope. But they nonetheless provide some valuable indicators about potential sources of phthalates from dairy farm equipment, of trends toward less reliance on phthalates, and opportunities to promote greater reductions in equipment containing phthalates. This section reviews some of the relevant findings. The next section suggests some possible next steps.

1. Both the tests of materials and the statement by a company still using phthalates in its milk hose demonstrate continued use of phthalates in milking equipment, both in PVC and rubber materials.

a. Because of the high percent content of phthalates used in some milking equipment PVC and rubber products, and the continuous exposure to warm, high fat raw milk, such equipment poses the highest risk of dairy farm equipment for causing the presence of phthalates in the raw milk.

b. Uncertainties about whether companies have made a full transition to phthalate-free materials result from:

   i. Questions, in the case of some companies, about whether they are still selling phthalate-plasticized equipment as well as phthalate-free equipment.

   ii. Preference of some companies to make no statements about phthalates even though they may have made the transition.

2. A substantial range of alternatives to PVC or rubber plasticized with phthalates are currently available in the market for dairy farm equipment.

a. Alternatives include both PVC and synthetic rubber materials with non-phthalate plasticizers and alternative polymeric materials that require no plasticizers.

b. Alternatives are not only from niche companies, but are readily available from major dairy farm equipment providers.

3. There is substantial evidence that many suppliers are moving away from phthalates, but limited information and divided opinions on the extent to which use of phthalate-plasticized equipment has declined.

a. European-based companies have made public changes – e.g., Saint-Gobain (France) reformulated one of its main hose products in 2012; DeLaval (Sweden) cancelled all phthalate-based equipment by end of 2015; much of GEA's (Germany) flexible milking-system equipment is supplied by Saint-Gobain.

b. An increasingly wide range of alternative polymers and non-phthalate plasticizers are available in the market, though specific information about those alternatives is often proprietary.

4. **While more suppliers are moving away from phthalates, dairy farmers show relatively little interest in (or often even awareness of) the issue**.[65]

5. **Equipment durability has increased, but turnover rates for most equipment is a year or less.**
    a. One example is the transition from natural rubber liners (good for a maximum of 800-1,000 milkings) to synthetic rubber and silicone liners (2,500 milkings) to an even higher claim for a new thermoplastic urethane liner (5,000 milkings); but the longest-lasting materials are phthalate-free.
    b. Because of the relatively short lifecycles of any of the materials plasticized with phthalates, there is opportunity for a relatively rapid transition away from phthalate-plasticized equipment.

[65] One company that developed a non-phthalate replacement stated that only one customer had ever asked about phthalates prior to new product development.

VI. Next Steps

Because of European restrictions on the use of phthalates in food contact materials, many of the large European-based dairy supply companies playing major roles in the US dairy farm market have made a complete transition to phthalate-free materials in milk hoses, inflations and other flexible equipment. Other companies are making similar changes in anticipation of possible regulations or pressures in the U.S. At the same time, there appears to be limited awareness or concern about phthalates among dairy farmers.

It seems clear that dairy suppliers are increasingly sensitive to the need to eliminate phthalates, while dairy farmers are not yet focused on the problem. This suggests an opportunity to focus additional attention on the equipment suppliers.

While there are a substantial number of suppliers, a large part of the market is likely covered by a manageable subset of those suppliers. Developing a supplier-focused approach as part of the overall information-development strategy would involve:

- Developing information about current phthalate or phthalate-free products by the suppliers and focusing attention both on those who have transitioned away from phthalates and those who have yet to make that change.
- Gather readily available price point information (principally through distributors) for comparable products (e.g., PVC milk hoses with or without phthalates). To the extent information is readily available, this could also include assessments to compare the cost-effectiveness of alternative materials. For liners, for example, some companies publish estimates of the number of milkings after which liners should be replaced.[66]

To develop information on major and mid-sized suppliers of relevant equipment (e.g., liners, milk hoses, etc.), potential sources could include:

  - Market studies, to the extent available and relevant.
  - Dairy extension services.
  - Dairy organizations.
  - Individual experts.
  - On-line searches.

Subsequent steps could include:

- Reviewing website information for the suppliers about their products, and whether or not the relevant products are phthalate-free.
- Contacting suppliers by email and/or phone to clarify information on:

[66] It would generally not be feasible, however, to address other functional issues, such as ease of use or factors affecting speed or efficiency of milking.

- Whether all or some of the relevant products they supply are phthalate-free.
- Plans for replacing any products currently using phthalates.

This information could be used to highlight availability and price/long-term cost comparability of phthalate-plasticized and phthalate-free equipment.

Additionally, other potential sources of phthalate migration into food products should be investigated, including:

- Other potential sources at the dairy farm level;
- Other potential sources further downstream in the dairy product supply chain, including processing, packaging, and food preparation; and
- Other potential sources of phthalate migration into other types of food products.

Appendix I

Phthalate Test Results

Ecology Center FTIR Results (Qualitative identification)

Web ID	Product Type	Product Name	Distributor	Intact material	Solvent extraction of material
25426	Tubing	DairyFlow High Performance Milk and Dairy Transfer Tubing	McMaster Carr	Polystyrene copolymer (e.g. polystyrene/ethylene-propylene)	Mineral oil
25427	Tubing	Black Rubber Milk Tubing 9/16 in 1.0 1 ft	Leedstone	Poly(isoprene) or EPDM rubber, kaolin	Mineral oil; Santoflex 13
25428	Tubing	Black Rubber Milk Tubing 5/8 in I.D w/o stripe 1 ft	Leedstone	Poly(isoprene) or EPDM rubber, kaolin	Mineral oil; Santoflex 13
25431	Tubing	1.5 inch I.D. Tigerflex Milk Hose/Tubing	Hamby Dairy	PVC; DOTP	DOTP
25432	Bottle	Replacement bottle for Ambic Dip Cups	Hamby Dairy	Polyethylene	Nothing extracted.
25433	Bottle	Replacement bottle for Hamby & RJB Dip Cups	Hamby Dairy	Polyethylene	Nothing extracted.
25434	Inflations	Inflation (Liner) medium bore for 06 shells WESTFALIA ORIGINAL 086 set of 4	Hamby Dairy Supply	Acrylonitrile; polystyrene; polybutadiene; SiO_2; carbon black	Adipate; Santoflex 13
25435	Tubing	3/4 ID Milk hose/tubing per foot	Hamby Dairy	PVC; glycerin triacetate	Glycerin triacetate
25436	Gasket/O-ring	1.5 Surge Gasket for stainless steel pipeline	Hamby Dairy	Acrylonitrile; polybutadiene; talc	DOTP
25437	Gasket/O-ring	Gasket for Bou-Matic barrel claw	Hamby Dairy Supply	Inconclusive polymer (may be EPDM); calcium carbonate; silica.	Mineral oil; silica
25438	Tubing	5/8 ID Silicone Milk Hose/Tubing	Hamby Dairy	Polydimethylsiloxane	Polydimethyl-siloxane
25439	Tubing	5/8 ID Surge Milk Hose/Tubing	Hamby Dairy	PVC	Glycerin triacetate
25440	Gasket/O-ring	Window Gasket for Westfalia Bio-Milker	Hamby Dairy Supply	Inconclusive due to carbon black distortion of spectrum	Inconclusive. No evidence of phthalates
25441	Tubing	Clear PVC tubing 1/2in ID x 3/4in OD food grade, 100ft/roll	Nelson Jameson	PVC; DOTP	DOTP
25442	Tubing	CSC200 Cleargard PVC clear helix, 2in suction hose, food grade, 100ft/roll	Nelson Jameson	PVC; DOTP	DOTP
25443	Gasket/O-ring	212 0-ring FDA EPDM Black	Nelson Jameson	Inconclusive due to carbon black distortion of spectrum	Mineral oil; other components inconclusive. No evidence of phthalate.

25444	Inflations	NuPulse Cow Inflations (4) OEM Parts	Hamby Dairy Supply	Acrylonitrile; polystyrene; polybutadiene; SiO2; carbon black	Ortho-phthalate
25457	Tubing	Clear tubing for ambic teat sprayer ATS410	Hamby Dairy	PVC; DOTP	DOTP
25458	Filter	Schwartz Filter-Clean Tuffy 49/16" milk filter	Hamby Dairy Supply	Polyester, styrene acrylic polymer	Inconclusive. No evidence of phthalate.
25466	Silage Wrap	Silage Wrap Sample	0	Polyethylene; poly(isobutene)	Nothing extracted.

Links for Tested Products

Web ID	Product Type	Webpage
25426	Tubing	https://www.tblplastics.com/tubing/dairy-flow-milk-transfer-hose/
25427	Tubing	http://www.leedstone.com/black-rubber-milk-tubing-5.html
25428	Tubing	http://www.leedstone.com/black-rubber-milk-tubing-5.html
25431	Tubing	http://hambydairysupply.com/xcart/product.php?productid=1307&cat=&page=1
25432	Bottle	http://hambydairysupply.com/xcart/product.php?productid=802
25433	Bottle	http://hambydairysupply.com/xcart/product.php?productid=17580
25434	Inflations	http://hambydairysupply.com/xcart/product.php?productid=19042
25435	Tubing	http://www.hambydairysupply.com/xcart/product.php?productid=17827
25436	Gasket/O-ring	http://hambydairysupply.com/xcart/product.php?productid=498
25437	Gasket/O-ring	http://www.hambydairysupply.com/xcart/product.php?productid=1054
25438	Tubing	http://hambydairysupply.com/xcart/product.php?productid=347&cat=325&page=1
25439	Tubing	http://hambydairysupply.com/xcart/product.php?productid=356
25440	Gasket/O-ring	http://hambydairysupply.com/xcart/product.php?productid=18457
25441	Tubing	http://nelsonjameson.com/1-2-PVC-Tubing-Clear-p10416.html
25442	Tubing	http://nelsonjameson.com/Versilon-Clear-Helix-Hose-CSC-p8597.html
25443	Gasket/O-ring	http://nelsonjameson.com/O-Ring-p44994.html
25444	Inflations	http://hambydairysupply.com/xcart/product.php?productid=18219&cat=309&page=
25457	Tubing	http://hambydairysupply.com/xcart/product.php?productid=18896&cat=&page=1
25458	Filter	http://hambydairysupply.com/xcart/product.php?productid=50
25466	Silage Wrap	

Ecology Center Test Results Summary: Dairy Equipment

Feb. 28, 2018

Ecology Center's Healthy Stuff researchers analyzed 20 samples of dairy milking equipment for the primary purpose of detecting ortho-phthalate plasticizers (abbreviated "phthalates"). The secondary purpose was to identify other plasticizers, other additives or contaminants, and the polymer matrix.

Full results for each product are displayed in the spreadsheet titled "Ecology Center Full Test Results Dairy Equipment Feb 2018".

XRF Results

Low levels of **lead** were measured in four black rubber items ranging from 3.1 to 21.3 ppm lead. Two of these were milk tubing and two were gaskets.

Two flexible PVC hoses contained **tin** at levels suggesting possible organotin compounds. Tin was measured to be 1656 and 2177 ppm.

Five of the synthetic rubber products, including tubing, gaskets, and inflations, contained **sulfur** between 2.2-3.4 wt% along with **zinc** 1.3-3.5 wt%. We did not identify the sources of the sulfur and zinc. Sulfur and zinc oxide can be used together in the vulcanization of rubber, so vulcanization compounds are a possible source.

FTIR Results

Table 1. Polymer identifications, product types and plasticizers.

Polymer matrix	**No. of products**	**Product Types**	**Plasticizers detected**
Synthetic rubber based on acrylonitrile/butadiene/styrene	3	Inflation liners; Gasket	DOTP; DEHA*; DIDP*; DINP*
Synthetic rubber based on polystyrene/polypropylene	1	Tubing/hose	Mineral oil
Synthetic rubber based on polyisoprene or EPDM	2	Tubing/hose	Mineral oil
PVC	6	Tubing/hose	DOTP; Triacetin
Polyethylene	3	Bottle; Silage wrap	None
Silicone rubber (PDMS)	1	Tubing/hose	PDMS
Polyester with styrene acrylic	1	Milk filter	Inconclusive

Inconclusive	3	Gaskets/O-rings	Mineral oil; Inconclusive
Total	20		

* These specific adipate and phthalate species were identified by GC/MS.

Abbreviations:
EPDM = ethylene/propylene/diene monomer
PDMS = polydimethyl siloxane
DOTP = dioctyl terephthalate
DEHA = diethylhexyl adipate, bis(2-ethylhexyl adipate)
DIDP; DINP = diisodecyl-; diisononyl phthalate
Triacetin = glycerin triacetate

Table 2. Additives detected other than plasticizers.

Polymer matrix	**Additives**
Synthetic rubber based on acrylonitrile/butadiene/styrene or polystyrene	Silicon dioxide; carbon black; talc; Santoflex 13 antioxidant
Synthetic rubber based on polyisoprene or EPDM	Santoflex 13 antioxidant; kaolin
Inconclusive	Calcium carbonate, carbon black

Table 3. Comparison of Ecology Center's FTIR analysis and TUV's GC/MS analysis.

ID#	**Product Name**	**Plasticizer Identification from Solvent Extraction / FTIR**	**Result from GC/MS**
25434	Westfalia Inflation	Adipate	DEHA substantially present; trace DOTP
25444	NuPulse Cow Inflation	Phthalate	DIDP 9.06%; DINP 1.11%; trace adipate

The identifications from FTIR were consistent with the measurements from GC/MS.

TEST REPORT

TÜVRheinland

Test Report No.: 31850466.001 *Page 1 of* **3**
Report Date: 27 February 2018

Client:
Jeff Gearhart
Ecology Center
339 East Lterty, Stile 300, Ann Arbor, MI 48107
Phone: (734)369-9276
Emad: jeffgercocentrrorg

Client Number:	**50008114**
Order Number	**156682**
Date of Receipt:	**22 February 2018**
kem Description:	**Inflation Liners**
***St* of Samples Submitted:**	**2**
Product Code:	**NA**
kern Number:	**NA**
Style Number:	**NA**
Color:	**Black**
UPC:	**NA**
PO:	**1376**
Country of Drein:	**USA**
Manufacturers name:	**NA**
Country of Destination:	**NA**
Retest?	**No**
Delivery condition:	***Apparent good***
Test Category:	**General Purpose**
Testing Phase:	**NA**

Customer Test Institobons:

Test specification

1. Selected Phthalates

For and on behalf of
TUV Rhineland d of North America

...144.4

Mark Smith *I* **Laboratory Manager**
Phone: (479)250-0059
Emad: msmithfeus.tuv.00m

Test result:

See Data

For and on behalf of
TUV Rheinland of North America

William TyeeI Chemist
Phone: (479)250-1932
Emad: wtyreet2us.tuv.com

TuV Regere« *Nue* Nun. I,c 2709So4Ah Ent OZ Cal oa Diva Surn II. Soarzeena *AR* 72712
Phow 471,250.X66 /Fax 479254 0621 Zea> vetiYa./LCO/Tai

TÜVRheinland

Test Reort No.: 31850466.001 *Page 2 of 3*

Testing Period: 26 Feb 2018 to 27 Feb 2018

Material Breakdown List - Chemical Testing

Material No.	Material	Color	Component / Location
I	Substrate	Black	25434 Inflation Liner West Falia
2	Substrate	Black	25444 NuPulse Inflations

RESULTS

1. PHTHALATE CONTENT IN SUBSTRATES:

Test method: The sample was analyzed by organic solvent extraction and GCMS based on CPSC-CH-C1001-09.3. Detected analytes are highlighted in red.

Test No.		1	2
Material No.		1	2
Analyte	CAS	Results	Results
DEP	84-66-2	<0.005%	<0.005%
DIBP	84-69-5	<0.005%	<0.005%
DBP	84-74-2	<0.005%	<0.005%
DPP	131-18-0	<0.005%	<0.005%
DNHP	84-75-3	<0.005%	<0.005%
BBP	85-68-7	<0.005%	<0.005%
DEHP	117-81-7	<0.005%	<0.005%
DCHP	84-61-7	<0.005%	<0.005%
DNOP	117-84-0	<0.005%	<0.005%
DINP	28553-12-0 68515-48-0	<0.005%	1.11%
DIDP	26761-40-0 68515-49-1	<0.005%	9.06%
DOTP	6422-86-2	Trace	ND
DBA	105-99-7	ND	ND
B2EHA	103-23-1	Present	Trace
B2PHP	53306-54-0	ND	ND

Method Dezection Limit = 0.005%

DIBP = Diisobutyl phthalate
DBP = Dibutyl phthalate EIBP = Benzyl butyl phthalate
DP P = Dipentyl phthalate
DNHP = Di-n-hexyl phthalate
DNOP = Di-n-octyl phthalate
DEHP = Di-(2-ethylhexyl) phthalate
DCHP = Dizyclohexyl phthalate
DEP = Diethyl phthalate
DINP = Diisononyl phthalate
DIDP = Diisodecyl phthalate

Clualitatively Detect (Present)/ Non-Detect (ND) identified by retention time and mass spectrum

DOTP = Dioctyt terephthalate
DBA = Dibutyl adipate
B2EHA = Efs(2-ethylhex˙yl) adipate
82PHP = Bis(2.propylheptyt) phthalate

Methods for Ecology Center Screening of Dairy Equipment Samples

Feb. 28,2018

FTIR

Ecology Center's Healthy Stuff researchers analyzed 20 samples of dairy milking equipment for the primary purpose of detecting ortho-phthalate plasticizers (abbreviated "phthalates"). The secondary purpose was to identify other plasticizers, other additives, and the polymer matrix. The method is qualitative only, not quantitative. The approximate limit of detection is 1 wt% phthalate. This is a conservative LOD based on validation tests using gas chromatography/mass spectrometry carried out at third-party labs.

Before analysis, equipment samples were wiped with a Kimwipe wetted with isopropyl alcohol to remove dust and other contaminants from the surface. Pieces were cut with clean scissors or a knife to procure a sample of appropriate size.

A Thermo Scientific Nicolet iS5 Fourier Transform Infrared (FTIR) spectrometer was used in attenuated total reflection (ATR) mode with a diamond crystal. Each sample was clamped on the ATR sample stage and a spectrum was obtained from 4000-450 cm^{-1}. To avoid cross-contamination, the ATR stage was thoroughly cleaned with isopropyl alcohol after each spectrum was obtained.

The resulting infrared spectra were analyzed visually and compared against a library of known spectra to identify the polymer types and additives such as plasticizers and antioxidants. When a likely match was identified, we visually examined the positions and intensities of the major spectral peaks to judge the closeness of the match. We reported very close matches as the results.

Some of the dairy equipment products were made of complex polymer mixtures, resulting in complex spectra that were challenging to deconstruct in some cases, additives including carbon Mack and calcium carbonate obscured spectral signals from the polymer matrix.

To separate organic additives such as plasticizers from the polymer matrix, we used a solvent extraction procedure for each sample. A solvent extraction method customized in-house was carried out for each sample. FT1R spectra collected from the solvent extractions were analyzed visually and compared against a library of known spectra to identify plasticizers and antioxidants. When a likely match was identified, we visually examined the positions and intensities of the major spectral peaks to judge the closeness of the match. We reported very close matches as the results.

We thus obtained two spectra from each equipment sample: one from the solid material and one from liquid, if any, extracted from the material. From the solid material we identified the polymer matrix and certain additives. From the extract we identified plasticizers and antioxidants.

Since the primary purpose was to identify phthalates, we checked all spectra for the unique fingerprint of phthalates. In particular we looked for characteristic peak patterns centered at 1601, 1581, 1040, and 744 cm'. These peaks, or bands, in the infrared spectrum are virtually identical for all phthalate species. Our method therefore does not distinguish between the species. This feature carries the advantage that all phthalate species are detectable.

FTIR is a well-established technique to identify polymer types and mixtures. The Healthy Stuff lab has repeatedly validated its FTIR identification of plasticizers in polymeric products by using an independent contract laboratory that uses highly sensitive gas chromatography coupled with mass spectrometry (GC/MS). These validation tests have included phthalates, adipates, dioctyl terephthalate (DOTP), acetyl tributyl citrate (ATBC), dibenzoate esters, and 1,2-cyclohexane dicarboxylic acid diisononyl esMr (DINCH).

GC/MS

After FTIR screening, two products from the milking equipment sample set were sent to an independent contract lab, TUV Rheinland, to be analyzed for 12 phthalates (quantified) plus certain other plasticizers (qualitative detection) using GC/MS.

The GC/MS results corroborated the FTIR results. The Westfalia inflation liner was found to contain a substantial amount of bis(2-ethylhexyDadipate and the NuPulse inflation contained 9.06% diisodecyl phthalate and 1.11% diisononyl phthalate. The comparison is shown in Table 1.

Table 1. Comparison of Ecology Center's FTIR analysis and TUV's GC/MS analysis.

ID#	Product Name	Plasticizer Identification from Solvent Extraction / FTIR	Result from GC/MS
25434	Westfalia Inflation	Adipate	Bis(2-ethylhexyl adipate) substantially present; trace DOTP
25444	NuPulse Cow Inflation	Phthalate	DIDP 9.06%; DINP 1.11%; trace adipate

XRF

The 20 samples were analyzed by X-ray fluorescence for elemental composition using an XOS HD Prime benchtop analyzer. Elements heavier than magnesium are measured by this technique. The purpose was to gain insight into the composition of the products and to reveal any heavy metals or other hazardous elements that might be present Samples we placed intact under the XRF tip and analyzed in "Plastic" mode. Certified polymeric standard reference materials are used to verify accurate measurements.

Appendix II
Communication on Glitex 181 PVC Tubing

Finger Lakes Extrusion FLEX Tubing Products

Quality Tubing...At The Right Price

June 21, 2013

To Whom It May Concern:

Finger Lakes Extrusion Premium Glitex 181 PVC tubing complies with the European Union's RoHS Directive (*"Directive 2011/65/EU of the European Parliament and of the Council of 8 June 2011 on the restriction of the use of certain hazardous substances in electrical and electronic equipment (recast)."*).

The basis for compliance with RoHS is that Finger Lakes Extrusion does not intentionally add any restricted substances, which include cadmium, hexavalent chromium, lead, mercury, polybrominated biphenyls (PBBs) and polybrominated diphenyl ethers (PBDEs) and, to the best of our knowledge, there is no incidental occurrence of these substances in the raw materials we use. Accordingly, these products do not exceed the maximum concentration values (MCV) established under European Commission decision 2005/618/EC (*"Commission Decision of 18 August 2005 amending Directive 2002/95/EC of the European Parliament and of the Council for the purpose of establishing the maximum concentration values for certain hazardous substances in electrical and electronic equipment."*)

Glitex 181 series tubing does contain the Phthalate DEHP. The concentration of DEHP in the tubing is 30% – 40% by weight. As a result of this series of tubing containing DEHP is does not comply with REACH.

Thank you for your interest in our products. Please contact me if I may be of any further assistance.

Sincerely,

Keith Ellsworth
Keith Ellsworth
Production Manager

ISO 9001:2008 BUREAU VERITAS Certification

Finger Lakes Extrusion Corp.
2437 Route 21, Canandaigua, NY 14424

Phone (585) 905-0632 | Fax (585) 905-0603
www.flextubing.com

Appendix III

Companies Providing Flexible Tubing to Food Industry

The following spreadsheet is a list of companies providing flexible tubing to food industry, as well as some compounders, representing the universe of companies we considered for examination. For the purpose of the current study, we have considered some of these from the perspective of dairy equipment supplies. Only a very small number are companies we contacted directly for the report. We have also briefly reviewed data available on the website for some of the companies on the list to determine their relevance to this study. The “Notes” column provides that information. Those potentially or definitely of interest either for dairy or potential alternative materials are highlighted in green. This information has been included in the interest of transparency.

Company Name	Notes	Web
Spectrum Plastics Group	Focus on medical devices; no milk or dairy	www.spectrumplasticsgroup.com
Ilpea Industries Inc.	Appliance & construction; gaskets for food service	www.ilpeaindustries.com
Saint-Gobain Performance Plastics Corp.	See Table 6	www.plastics.saint-gobain.com
Tekni-Plex Inc.	Pharma, food service & packaging	www.tekni-plex.com
Teel Plastics Inc.	Medical	www.teel.com
NewAge Industries Inc.	For food & dairy products; nitrile	www.newageindustries.com
Custom Profile Inc.	Medical	www.custom-profile.com
Plastiflex Co. Inc.	Floor care; healthcare; industrial; sewer & sanitation	www.plastiflex.com
Poly Vinyl Co. Inc.	No indication of dairy use	www.polyvinyl.com
Markel Corp.	Automotive, coaxial, wire & cable	www.markelcorporation.com
Spiratex Co.	Industrial & military	www.spiratex.com
Fabricated Extrusion Co. LLC	Equipment; refrigeration	www.fabexco.com
Sunlite Plastics Inc.	Medical	www.sunliteplastics.com
Thermoplastic Processes Inc.	Tygon equivalents; B-44-4X food tubing	www.excelon.com
ITW Medical Products	Medical	www.itwmedical.com
Drossbach N.A. Inc.	Industrial	www.drossbach.com
Reschcor Inc.	Household, medical, electrical	www.reschcor.com
Petro Plastics Co. Inc.	Largely industrial	www.petroplastics.com
Freelin-Wade Co.	See Table 6	www.freelin-wade.com

VIP Rubber Co. Inc.	Makes Santoprene tubing that meets FDA specs; no indication of dairy	www.viprubber.com
Keller Products Inc.	Medical; anti-microbial	www.kellerproducts.com
Versaprofiles Products Inc.	Water distribution; natural gas	www.versaprofiles.com
SeaGate Plastics	Possibly food applications	www.seagateplastics.com
Applied Plastics Inc.	States can manufacture extrusions for any applications	www.appliedplasticsinc.com
Plastifab Industries	Retail, lighting, transportation, mining, oil & gas	www.plastifab.ca
Inplex LLC	Multiple industries, including 'food & candy'	www.inplexllc.com
Formtech Enterprises Inc.	List of applications does not include food, except for refrigeration	www.formtech.com
Jet Plastics	Available products in catalog don't include dairy	www.jetplastics.com
Reeves Extruded Products Inc.		www.reevesextruded.com
Certified Thermoplastics Co. Inc.		www.ctplastics.com
Middlefield Plastics Inc.		www.middlefieldplastics.com
Parker Nexgen		www.nexgenhose.com
GSH Industries		www.gshindustries.com
Hudson Extrusions Inc.		www.hudsonextrusions.com
Crafted Plastics Inc.		www.crafted.com
Finger Lakes Extrusion Corp.	See Table 6	www.flextubing.com

Inline Plastics Inc.		www.inlineplasticsinc.com
Blackwell Plastics LLP		www.blackwellplastics.com
Excalibur Extrusions Inc.		www.excaliburextrusions.com
Meltpoint Plastics International Inc.		
Plastic Extrusion Technologies		www.plasticextrusiontech.net
Hi-Tech Profiles Inc.		www.hitechprofiles.com
PBS Plastics Inc.		www.pbsplastics.com
Plastics Resources Inc.		www.pri-plastics.com
Seiler Plastics Corp.		www.seilerpc.com
American Extruded Plastics Inc.	Lists agricultural applications, but no detail	www.aeplastics.com
Fram Trak Industries Inc.		www.framtrak.com
Fowler Products Inc.		www.fowler-inc.com
Reiss Manufacturing Inc.	Silicone & thermoplastics for a large range of industrial sectors; does not list food	www.reissmfg.com
Ryan Development Corp.		www.ryandevcorp.com
Advanced Extrusions/Midland Plastics	No indication of market	www.midlandplastics.com
Christi Plastics Inc.		www.christiplastics.com
Alpha Plastics Solutions Inc.		www.myapsi.com
San Diego Custom Extrusions		www.drgassoc.com
Poly Extrusions Inc.		www.polyextrusionusa.com

Teknor Apex	Variety of non-phthalate plasticizers; not dairy or food	www.teknorapex.com
Westlake Chem/Axial	Several phthalate-free compounds, but data sheet on food grade compound doesn't specify	www.westlake.com
PolyOne/Mexichem	Non-phthalate flexible food grade formulations; PolyOne recently acquired by Mexichem. Bio-derived epoxidized fatty acid mono ester plasticizer	www.polyone.com
ShinTech	Largest PVC resin producer in US; manufactures food grade TK 1300 equivalent to Oxyvinyl 255F	www.shintechinc.com