

One-way or reusable distribution items?

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ONE-WAY OR REUSABLE DISTRIBUTION ITEMS?

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ABSTRACT

For companies it becomes still more important to pay attention to the load carriers, containers and package materials, that they buy, lease or rent to distribute their products due to increasing expenses for disposing the above distribution items (DIs) after use and a changing public opinion in favor of the environment. The same holds for the DIs used by their suppliers.

A concrete framework, based on the life-cycles of DIs, is presented to provide in a systematic way insight into the potential pro's and con's of one-way and reusable DIs. Attention is paid to the strategic, functional, technical, environmental, logistics, information, organisational and financial aspects related to the use of DIs. Special attention is paid to the specific consequences of using the two types of DIs for suppliers and purchasers. Suggestions for further research are given.

Key-words: product life-cycle, reusable distribution item, one-way distribution item.

INTRODUCTION

For companies it becomes still more important to pay attention to the load carriers (like pallets and crates), containers (like bottles, cans and boxes) and package materials (like dunnage and foam) used by these companies themselves **as well as to the load carriers, containers and package materials used by their suppliers**. A growing concern for the environment has resulted, and will still more result, in environmental laws making the disposal of the above **distribution items (DIs)** still more expensive or even impossible. But also the public opinion with respect to the environment has changed, forcing companies to produce and distribute as environmentally friendly as possible. But also in case the above considerations (still) do not apply, it may be worthwhile to (re)consider critically for pure financial reasons; load carriers, containers and package materials give rise to considerable expenses to a lot of companies.

From a disposal point of view, the best thing to do is to use as less as possible of the items that will become part of the waste stream for which the company is responsible. As far as DIs are concerned there exist in general three options for realising the above: reduction of the materials contents of DIs, reuse and recycling. See also (Kopicki et al. 1994. p.132) and (Stock. 1992. pp. 35-36). This paper deals with the second option. Most of the presently available literature on reusing DIs deals with this option either in general terms, like (Kopicki et al. 1993), (Trunk. 1993. p.81), (Auguston. 1993. p.41), (Witt. 1994. p. PIM8), (Stock. 1992), (Andel. 1991), or pays attention to "only" one or some of the aspects related to this option, like (Giuntini and Andel. 1994), whereas companies are looking for a **concrete** framework to get in a **systematic** way insight into the potential pro's and con's of using one-way and reusable DIs. Part of such a framework has recently been presented in (Dubiel. 1994). This paper aims at setting a further step, where the life-cycle of a DI is used as the starting point for estimating the different aspects that should be considered when deciding on which DI to use, where explicit attention is paid to the relations between these aspects. The aspects briefly dealt with in this paper are the strategic, functional, technical, environmental, logistics, information, organisational and financial aspects. As will be (come) clear, all the above aspects are essential when deciding on which DI to use for which purpose. The framework presented can be applied to all kinds of DIs independent of the materials from which they are made or whether they are used by producers, wholesalers or retailers. In order to focuss attention to the essentials, it may help to have in mind a situation with one supplier and one customer when reading this paper, although most statements also directly apply to all kinds of networks with several suppliers or customers. Based on the insight obtained in the consequences of using one-way or reusable DIs, the consequences of using these items for purchasers and suppliers are discussed. Finally topics for further research are indicated.

FUNCTIONAL ASPECTS

Deciding on which (type of) DI to use requires first insight into the product(s) and purpose(s) for which a given DI is planned to be used. In general a DI is used for several of the following purposes: transport, protection, marketing, see e.g. (Byrne and Deeb. 1993. p.36), as well as for storage and keeping products together. Further it is important to know whether a given DIs will be used for only one type of products (specific DIs), or for several types of products (multi-purpose DIs) where with respect to the latter a further distinction should be made between DIs for distributing several different products simultaneously and DIs sequentially used for different products.

STRATEGIC ASPECTS

Before going in detail into the different tactical and operational aspects of using specific types of DIs, first the following questions should be answered by a company: What is, or may become, the strategic importance of (some) DIs for us? Are some of these DIs, or may some of these DIs become, a weapon to strike our competitors or are we able to make them such weapons? Is distribution, or should it become, a major activity? How much do we spend on DIs at the moment, both for DIs used for our own products **and for DIs used by others to supply us their goods**? How much are DIs expected to cost us in the (near) future? How much do we want to spend on these DIs, where it is important to take into account (future) legal or otherwise forced acceptance of DIs returned to us by customers? Once having answered the above questions, every company should go through all the aspects dealt with hereafter, because the decision to use a one-way or reusable DI for certain purposes usually involves much more than "just" a "simple" purchase, lease or rent decision.

THE LIFE-CYCLE OF DISTRIBUTION ITEMS

Deciding on which DI to use requires insight into the complete life-cycle of a DI. In Fig.I the main physical flow that may be followed by a (reusable) DI have been sketched for the relative simple situation with one supplier and one customer.

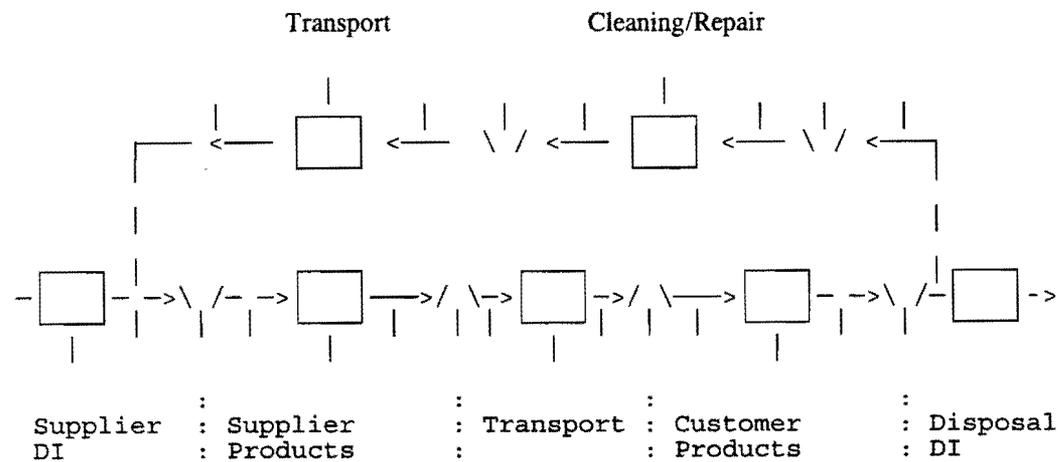


FIGURE I : PHYSICAL FLOWS OF REUSEABLE DISTRIBUTION ITEMS

where

- denotes a transformation process
- denotes transport of an empty DI
- denotes transport of a (partly) filled or loaded DI
- denotes storage of an empty DI

∧ denotes storage of a (partly) filled or loaded DI
| denotes the loss of a DI

In general the following phases can be distinguished within the life-cycle of a DI

- production
- transport to the (first) user
- storage empty
- loading or filling
- storage loaded or filled
- transport to customer for load or contents
- storage loaded or filled
- unloading
- collection
- sorting
- cleaning
- repair
- storage empty
- transport (for reuse or disposal)
- final disposal.

See also (HMSO. 1981. p. 23), (Dubiel. 1994) and (Trunk. 1993. p. 82).

The above set of phases will be used as the starting point for systematically deriving the potential requirements for using a given DI and thereby for deriving its potential pro's and con's.

TECHNICAL ASPECTS

Although this paper primarily has been written for non technicians, some attention has to be paid to the pure technical aspects of DIs.

Having estimated for which purposes a given DI is planned to be used, among others decisions have to be made concerning

- the material(s) the item is to be made from
- the weight, shape and size of the DI,

where the latter two aspects should be considered both for the DIs with and without load, the latter for return transport and disposal, see also (Dubiel. 1994).

When deciding on the above aspects, not only the characteristics of the products for which the DI is aimed to be used should be taken into account, like their weight and shape and the conditions under which they have to be distributed and stored (see also (Witt. 1994. pp. PIM22-PIM23)), and the function(s) that the DI should provide, but also aspects like reuseability, possibilities for cleaning, repair, handling and storing the DI with and without load.

The above mentioned technical aspects are directly related to the DIs themselves. The above decisions also requires insight (and decisions) with respect to which facilities will be used for internal and external transport, like lift trucks, the machines to which goods are (to be) provided via the DI or the machines from which goods are (to be) collected in the DI, the facilities for storage, like racks, the widths of corridors in storage locations, as well as whether handling and storing is (to be) dealt with automatedly or manually. Within the context of this paper no further attention will be paid to the above mentioned, very important technical aspects. For some more details on these technical aspects see e.g. (Trunk. 1993. p.83) and (Witt. 1994) and the references mentioned in these publications.

ENVIRONMENTAL ASPECTS

As mentioned in the introduction it becomes still more important for companies to produce and distribute as environmentally friendly as possible due to legislations and the public opinion concerning the environment. Although a lot of research has been, and still is, done in this field, like life-cycle analysis, see e.g. (HMSO. 1981), it still is hardly ever possible to make a statement about whether or not a given DI is "more environmentally friendly" than another DI. The above is not only due to a lack of insight into the environmental effects related to the production, (re)distribution, (re)use, cleaning, repair and disposal of DIs, but also often due to a lack of insight into whether the potential advantages of using a given DI over another can be realised

from a logistics' and organisational point of view (like the actual number of times a given reusable DI will be reused). One of the few things that is often known however is to which substances a given DI item may give rise when disposed in a certain way. Purely based on this insight it is sometimes possible to discard a given DI, see e.g. (Witt. 1994. p.PIM6). It will be clear that also from a financial point of view insight into the environmental aspects of using a given DI is of the utmost importance for companies.

LOGISTICS ASPECTS

A given DI can be reusable from a technical point of view, but logistics are required to take care that the right quantity of the DI is at the right time available at the right place for reuse for the lowest costs. Without this some, or maybe all, of the potential advantages of reusable DIs over one-way DIs will be lost. Hereafter the earlier mentioned different phases in the life-cycle of a DI are considered in more detail from a logistics' point of view.

-Selling/leasing/hiring

The logistic problem to be solved in this context concerns the timely ordering of the right quantities of DIs at the supplier of these and, when required, taking care of the transport of the ordered quantities to the place where they are required. The above requires among others insight into the quantities of DIs directly available for use, those quantities that may become available after unloading, cleaning or repair, as well as insight into the times and lot sizes related to these activities and the delivery of new copies of DIs. Further the above requires a decision concerning which quantities of which DI to keep where as a safety stock against fluctuations in supply and demand. Different methods for forecasting return flows of DIs, requiring different information, are discussed in (Kelle and Silver. 1989ab). Another, maybe more expensive, option might be to use DRP (distribution requirements planning) as suggested for rail cars in (Bookbinder and Sereda. 1987).

-Collection

This may involve the collection of used (empty) DIs within part of a company as well as the collection of DIs from other companies.

Logistic aspects: when, how much of which DIs to collect from where and how much time does this take.

-Sorting

This can vary from very roughly, for instance purely based on the material(s) from which a given DI is made (like card board, wood, plastic), upto very detailed, i.e. at the level of individual (types of) DIs because each of these DIs requires a different further treatment.

Logistic aspects: when, where, how much, as well as required time.

-Cleaning

This may include the cleaning of drums and crates using water under high pressure but also may mean removing stickers from cardboard boxes.

From a logistics' point of view it is important to decide on the minimal quantity of a DI (or group of DIs) that has to be available before certain cleaning activities are started, as well as to have insight into the probability that the different cleaning activities give rise to desired results.

-Repair

With respect to repair the same holds as stated above for cleaning have to be answered.

-Return transport

Within this context a decision has to be made with respect to which means of transportation will be used. Further as for cleaning and repair.

-Disposal

From a logistics' point of view the following question has to be answered: When must which quantities of which DIs how be disposed? Also for disposal activities lot sizes have to be agreed upon.

ORGANISATIONAL ASPECTS

Having got insight into the logistics aspects related to the (re)use of DIs, time has come to consider the organisational aspects of using a given DI for a given purpose in some more detail.

One of the most important aspects to be taken into account when deciding on one-way or reusable DIs is the loss of DIs due to damage, theft or alternative usage. See also (HMSO. 1981. pp.131-132) and (Auguston. 1993. p.42). Insight into these flows, and more importantly, into the possibilities to restrict these flows, is of the utmost importance when deciding on whether to use one-way or reusable DIs for certain distribution activities. Clearly it does not make sense to invest in usually more expensive reusable DIs if most of these will not become available for reuse due to one of the above mentioned reasons. Suggestions for reducing losses of reusable DIs include apart from tracking, minimising the number of locations where DIs are located, using numbered DIs, "return to" stencils and reducing the number of reusable DIs in the DI network (Auguston. 1993).

Independent of which DI is to be used, it has to be decided for each DI who will be responsible for the activities corresponding to each of the phases distinguished in the life-cycle of a DI. With respect to each activity one of the following options exists:

- The customer(s) of the goods for which distribution a given DI is used
- The supplier(s) of these goods
- Both
- A third party.

The agreements concerning which activities are taken care of by whom and who are responsible for their proper execution should be explicitly defined (Twede. 1993).

In (Dubiel. 1994) suggestions for allocating the different activities to the different participants in a DI network are given for two different situations. See also (Schricker. 1993).

Note that the above concerns the execution of activities. Moreover a decision has to be made with respect to ownership, where in principle the same options as mentioned above exist.

When deciding on which role(s) to play by a company in a DI network, it is very important to know how each of the other participants look upon ownership or other responsibilities: a (future) kernel activity or an unavoidable burden. Without the above insight a network for reusable DIs is doomed to break down, which may result into considerable losses for everyone.

Within the context of this introductory paper it is not possible to pay more attention to the pro's and con's of ownership and responsibilities for the different activities to be executed within the context of a DI network for the different participants.

How can care be taken that every participant in the network behaves as agreed upon?

Hereafter follow a number of strategies, where some of these strategies are directly based on financial stimuli whereas other are not.

-Repacking

When received, delivered goods are immediately removed from the DI used for their supply and stored on or into the storage facilities used by the company. In this way the DIs used for transport can immediately be taken back by the transporter.

Problems related to this strategy: there must always be enough facilities for storage available and almost always extra handling is required.

-Direct return after use

This strategy may be notably successful in case of voluminous DIs where the receiving company has only very limited storage space, or as discussed hereafter, a high deposit or rent has to be paid for keeping a DI. See (Witt. 1994. p.PIM6) and (Kopicki et al. 1994. pp.205-212) for implementations of this strategy in practice.

-Direct replacement

This strategy resembles the repacking strategy. If x copies of a certain DI with goods are delivered, exactly x copies of this DI in the same state should be directly available for the transporter. In general this strategy is less suited for DIs which requirements heavily fluctuate. At first sight this strategy may notably be useful in case of JIT (just-in-time) deliveries, see (Witt. 1994) and (Trunk. 1993. p.79).

-Deposit

The company receiving DIs has to pay the owner of the DIs a deposit for every copy of these DIs received. At the moment these copies are returned to or back at the owner, the latter pays back part or all of the deposit depending on the state of the returned copies. See also (Dubiel. 1994).

Problem to be solved: which deposit to choose?

-Account management with periodical payments

In essence this strategy is an postponed deposit strategy. This strategy requires, like most of the strategies considered in this paper, that incoming and outgoing quantities of DIs are registered carefully. Periodically payments based on these registrations take place. See also (Dubiel. 1994). In this case an extra problem to be solved is: which period to choose?

-Hiring

The user of a DI has to pay the owner rent for each copy of a DI for every day it is at the user, which may be in- or exclusive the days for transport back to the owner. See also (Dubiel. 1994).

Problem to be solved: which rent to be paid?

For some qualitative suggestions concerning the hights of the deposits and rents to be used in the latter three strategies, see e.g. (Giuntini and Andel. 1994. p.60), (Dubiel. 1994) and (HMSO. 1981. pp.74-75). Within the context of this paper it is not only important to estimate the impact of each of the above strategies, or combinations of these, on how DIs are dealt with by companies as far as losses, damage, handling and storage are concerned, but also whether these strategies contribute to realise that the right quantities of the right DIs will be available at the right place at the right time, which is essential for making the concept of networks for DIs financially attractive. This holds both for reusable and non reusable DIs. According to (Giuntini and Andel. 1994. p.55), about 50% of reusable containers are not available for (re)use at any one time. As far as the timely availability is concerned, it seems that, apart from the account mangement with periodical payments strategy, all the above strategies may stimulate a quick return of DIs to the supplier. See also (Dubiel. 1994).

INFORMATION ASPECTS

Three points of attention are distinguished in this context: supply of new copies of a DI, control of available copies and disposal of copies that can no longer be (re)used.

Starting points for deriving the corresponding information requirements are Fig.I and the phases in the life-cycle of a DI mentioned thereafter.

Supply.

-Which quantities of which (types of) DIs have to be bought, leased or rented when?

Control.

-Which quantities of which (types of) DIs are (expected to be) required where and when?

-Where are which quantities of which (types of) DIs available in which state?

-Which quantities of which (types of) DIs are expected to become available where and when?

-Which quantities of which (types of) DIs are going from where (whom) to where (whom) and what are their contents?

-Which safety stocks of which DIs are where?

Disposal.

-When should which quantities of which DIs be disposed?

Further there are the usual information requirements concerning

-the producers/suppliers of different types of DIs, including delivery times, minimal order quantities,

-the customers for DIs that can not be (re)used anymore, and

-the companies that are or may be involved in the transport, cleaning, repair or recycling of the different (types of) DIs.

One option to deal with the above information requirements might be to introduce a DRP (distribution requirements planning) based information system, see e.g. (Bookbinder and Sereda. 1987).

Apart from the above information it can be useful or required to indicate on the DIs where (with whom) it has

been the last time and in case of a reusable DI, the number of trips made till now, the (kinds of) repairs upto now and for which product it has been used last. Depending on the type of DI and its use, the above information may be denoted via stickers, ink, paint but also be stored in chips. It may be useful to use bar codes. See also (Witt. 1994. p. PIM27).

It will be clear that the above overview is not complete and that not all the above information is as important for every company.

FINANCIAL ASPECTS

Once having got insight into the different non-financial aspects of using one-way or reusable DIs, it is, at least in principle, possible to estimate the financial consequences of the two options.

Starting point thereby are all the activities mentioned in the foregoing sections of this paper, where further the costs related to control activities, including administration and registration, as well as opportunity costs have to be taken into account. See also (Dubiel. 1994).

-Opportunity costs

In the context of this paper this means missed rent.

-Losses

Apart from losses due to theft, unrepairable damage, and undesired use, also the costs due to unexpected reductions and ending of the production of products belong to this class of costs.

-Selling/leasing/hiring

In general it is more expensive to buy, lease or rent reusable DIs than one-way DIs, see e.g. (Auguston. 1993. p.41) and (Twede. 1993). For a real comparison between these prices, the costs per trip should be compared requiring all other costs to make such a reuse possible to be taken into account as well.

-Storage

Includes the expenses for sorting, handling (as far as required for storage) and storage space. Both in case of reusable and one-way DIs almost always extra space will be required to store empty copies of these DIs before they are reused or disposed. See also (Stock. 1992).

-Stocks

Loss of rent.

-Cleaning

Costs to be included are labor costs, costs of help materials, tools. But also the costs for transport, handling, loading, unloading where the latter may be notably important in case cleaning is dealt with externally.

-Repair

Here we have the same types of costs as mentioned above in the context of cleaning.

-Return transport or transport for disposal.

The expenses for the actual transportation as well as the costs for loading or unloading means of transportation and the costs for transportation to and from the places where these activities take place to and from the places where the DIs have been stored or will be stored. (The actual storage costs have been mentioned before.) Thereby one should distinguish between the expenses when these transports are taken care of by the company herself or by others. In the first case the expenses to be considered are labor as far as drivers are concerned, means of transportation like trucks (buying, maintenance, insurance, gasoline), whereas in the second case only the costs for letting others take care of these activities have to be taken into account.

-Disposal

Costs considered in this context are the actual expenses for the final disposal of DIs that can not be (re)used by a company anymore, which include the payments to the owners of land fills or to the processors of or the customers for the (parts of) DIs to be disposed.

-Administration/Control/Registration

Labor costs, expenses for setting up and using (information) systems.

All the above costs should be considered simultaneously for the set of all DIs used for distribution by the company and by the suppliers of goods to the company! For suggestions concerning which accounting practice to use, see e.g (Giuntini and Andel. 1994) and (Twede. 1993).

MULTI-PURPOSE VERSUS SPECIFIC DISTRIBUTION ITEMS

In many articles, including (Andel. 1991) and (Dubiel. 1994), it is suggested that it may be worthwhile trying to use as few different DIs as possible. Hereafter some attention will be paid to this important topic. Again the phases in the life-cycle of a DI as distinguished before will be the starting points.

-Stock

If every supplier uses his or her own specific DI, or if for every product a specific DI is used, in general the total quantity of DIs to be kept in stock will be larger than in case only a limited number of multi-purpose DIs are used. One reason for the above is that it will not be possible to correct a shortage of DIs for one product by an abundance of DIs for another product. Minimal purchase quantities of DIs as well as lot sizes used for transport, cleaning and repair, may make the differences even larger.

Another important reason is that it usually is cheaper to buy, lease or hire large quantities of one DI than the same quantity made up of a number of different (types of) DIs.

-Collection

It does not seem possible to state generally whether collecting a given quantity made up of many different DIs takes more time than collecting the same quantity of one or only few DIs.

-Sorting

In general the time required for sorting as well as the possibility to make mistakes tend to increase with a rising number of different DIs.

-Storage

It may be that every (type of) DI requires its own storage location, requiring a separate registration as well.

-Cleaning

It may be required to clean minimal quantities whereas different (types of) DIs may require their own specific cleaning programmes. The above may result in extra requirements for certain DIs, which may result in purchasing, leasing or hiring extra quantities of these DIs.

-Repair

With respect to repair the same remarks apply as stated above with respect to cleaning. Moreover, due to reduced scale effects, the repair activities themselves may require more time and more often give rise to less satisfying results.

-Handling

Different types of DIs may require their own treatment, due to difference in e.g. size and fragility. It is not possible to make general statements concerning the consequences of using a few standard DIs instead of many specific DIs for handling in general terms.

-Return transport

It can be expensive to transport less than certain quantities of given types of DIs, not only because of transportation costs but also because of the required administration. The above notably applies if it is not possible to combine the supply and return flows of DIs.

-Disposal

It may be less expensive to dispose large quantities of one type of DI than the same quantity made up of small

quantities of a number of different DIs, for instance because this may make it easier for recyclers to sell large quantities to their customers.

From the above it seems that also from a financial point of view it will generally be preferred to use as less as possible different (types) of DIs. However there may as well be disadvantages related to use of very few types of DIs! One may be that too expensive DIs are used for some purposes, where too expensive may not only concern the purchase price or the costs for leasing or hiring but also be due to reduced loading fractions. Moreover multi-purpose DIs may give rise to problems when used in combination with different machines. Finally standardisation of DIs may increase the number of applications, which may make the tracking of these DIs more difficult.

THE DECISION

It will have become clear that deciding on which DI to use for which good and for which purpose is much more complicated than might have seem to be the case at first sight.

One reason for this is that often it will not be possible to decide on DIs for individual product-purpose combinations in isolation. Another reason is that the above decision can not be based on purely financial arguments, but also requires insight into whether or not all participants in a given DI network will behave as agreed upon. A financially optimal strategy may require much attention of some or all of the participants in a given DI network, which not may be possible. The latter may notably apply to limiting the losses due to theft, uncaredful handling and alternative use, but also taking care of the timely return of containers and a correct registration of incoming and outgoing flows may require too much attention.

Whether a DI network will have a chance to be(come) succesful, usually strongly depends on the possibilities for creating a win-win situation for all participants and the power relations between the different participants. As far as the decision between one-way and reusable DIs is concerned, going through the phases in the life-cycle of DIs makes clear that the main advantage of reusable DIs over one-way DIs is the possible reduction of DI materials (and the less tangible but very important "green image".) The main con's of reusable DIs over one-way DIs are relative high intial investments, more uncertainties, expenses for repair and cleaning, although the latter also may be required for one-way DIs.

See also (Dubiel. 1994). According to (Byrne and Deeb. 1993. p.37), one-way DIs seem notably be useful for supplying goods to their ultimate consumers as well as for exporting goods, whereas reusable DIs are notably expected to be useful for pure transport activities. Several authors, including (Twede. 1993) and ((Witt. 1993), suggest that it is notably the distance and the frequency of use that determine which type of DI to use in the first place.

THE POSSIBLE CONSEQUENCES FOR PURCHASERS AND SUPPLIERS

In the above the consequences of using reusable and one-way DIs have been systematically derived in general terms. In this section special attention will be paid to what may be the consequences of using the different DIs for suppliers and purchasers. With respect to the latter one should distinguish between purchasers of goods that are supplied by other to the company in order to be processed or distributed further, and the purchasers that are responsible for the timely supply of DIs used by companies for the distribution of their products. In the latter case they have to look at DIs from a suppliers' point of view. Table I shows the different situations that can be met in practice.

Primary User

Type of DI	Used by supplier	Used by company
One-way		
Reusable		

TABLE I : DISTRIBUTION ITEM - USER COMBINATIONS

Purchasers responsible for purchasing of goods should estimate in advance the consequences related to the DIs used by their suppliers. Moreover they should try to estimate the explicit costs of these DIs as part of the total

cost of these goods, in order to be able to estimate the pro's and con's of certain DIs and the possibilities for setting up DI networks with their suppliers. (Upto now hardly any attention has been paid to this important point.) Purchasers of DIs should take care that these DIs do not give rise to (too much) extra work and costs to the customers of the products for which the DIs are used or they should take care that these are taken into account when setting sales prices of products. (There are companies that pay their customers for taking care of the disposal of their DIs when these can no longer be used, see e.g. (Cooke. 1992. p.44).) For both purchasers it becomes more and more important to take care that the materials contents of DIs is reduced.

It will have become clear that deciding which DI to use still more often requires the same approach as presently used in the context of purchasing durable production facilities like machines. (For references on life-cycle costing see e.g.(Kopicki et al. 1994. pp.303-304).) Also with respect to DIs the relations between suppliers and customers will become still more like for these facilities, where among others service contracts play a role. Similarly it will no longer satisfy for purchasers of DIs to consider purchasing as the only option to fulfil requirements for DIs. Also leasing and hiring should be considered.

Whatever DI will be chosen, it may be expected that depending on the role that their company plays within a given DI network, purchasers will become responsible for the contracts with third parties taking care of the cleaning, repair and final disposal of DIs. Moreover it may be expected that purchasers will also become responsible for the timely supply and return of DIs in DI networks.

SUMMARY AND CONCLUSIONS

In this paper a systematic overview has been given of the different aspects related to the use of DIs, all of which are important when deciding on which DI to use for which product for which purpose. Concrete suggestions for dealing with some of these aspects have been given. Special attention has been paid to the considerable consequences of using DIs for purchasers and suppliers among others due to a growing concern for the environment of both governments and customers. The aspects to be considered in the context of deciding on which DI to use will still more resemble the aspects presently taken into account when deciding on durable facilities like machines. It will have become clear that also with respect to DIs suppliers and customers will still more depend on each other and that this holds both for reusable and one-way DIs.

Within the context of this introductory paper it was only possible to deal with the different aspects rather globally. In order to make concrete decisions concerning which DIs to use and which role to play in given DI networks, more, quantitative research is required to estimate

- the pro's and con's of the different roles in different DI networks for the different participants,
- the effectivity and efficiency of different strategies for realising that the different participants in a DI network behave as agreed upon,
- the actual number of copies of a given DI that is required in a given DI network.

Moreover more quantitative research is required to give insight into the pro's and con's of different network structures, see e.g. (Dubiel. 1994) or (Schricker. 1993), for different types of products.

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