THE REVERSE LOGISTICS MANAGEMENT WITH RFID APPLICATIONS

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Abstract: This paper presents the main matters of RFID as the modern tool using in reverse logistics management. It is very important to understand the power of reverse logistics, because nowadays the traditional one is not enough to deal with all environmental problems facing companies. The reason for this article is to analyze the reverse logistics evolution, to show its basic terms, rules and conditions.

Key words: reverse logistics, RFID

Fundamental aspects of reverse logistics

In the subject literature four principles in relation to reverse logistics might be indicated, ordered according to their priority [5]. They include:

- using of recycled materials for production, at the cost of new materials,
- using ecological materials,
- reuse of recycled materials (mainly packaging),
- recovery of materials and worn-out products.

However, these activities are often expensive and require additional efforts from companies, which is neither desirable nor commonly used. As early as in the stage of design of products the requirements for re-use of waste, mainly from the point of view of cost-effectiveness should be taken into consideration. Activities of reverse logistics result in particular consequences for all company's production-related activities. If a life cycle of ready products is analysed, along with the impact of environmental factors on production process, use by the customer and disposal of products, it will become possible to design such products which are easy to be disassembled and passed to recovery. The manufacturers will be forced to cooperate with suppliers and their subcontractors so that they deliver materials and components which are suitable to be reused.
An example of the system solutions possible to be employed might be a policy adopted in relation to packaging [3]. It is an essential issue from the point of view of reverse logistics. If the route of packaging is analysed from the moment of completion of its fundamental task, i.e. protection of goods, one can see that the locations of waste generation are scattered and there is a lack of determined rules which would explain the principles of their appearance. This creates the problems with their re-use. Typical characteristics of the networks of products' recovery contain a convergent part of amassing and transport from the disposal market to the recovery unit and divergent part for the distribution to the re-use market as well as the middle part connected with the required stages of recovery process. Moreover, they

derive from typical types of networks through recovery options, where the networks differ for recycling materials, processing, reuse components, re-packaging, warranty and commercial returns. These types of networks vary in relation to types of networks, their role and cooperation between their participants, systems of determination of their use. Thus, environmental aspect might impact on type of networks, their role and cooperation between participants and system of determination of the method of use. It is commonly recommended that the entities which produce goods should be located in possibly closest distance from end users. Such a policy enables unconstrained direct deliveries of worn-out products from end users to manufacturers.

Legal solutions and their impact on activities of reverse logistics

In operation of companies in common European Union market one can highlight particular limitations in implementation of common policy in relation to waste. This results mainly from the fact of lack of such common policy. Obviously, each EU country have their own procedures and standards on that issue, however, they are not standardized for all the member states of the Fifteen. Currently the companies must continue preparations to ever-increasing environmental regulations and management of hazardous substances since EU regulations of WEEE and RoHS assume that it is manufacturers who are responsible for final disposal of any electronic equipment which is sold by them, and this indicates direction of organization of reverse logistics. The issue of products retired from sales is currently considered not only theoretically: this has become a normal procedures of manufacturers of industrial and consumer goods.
European directive on Restriction of Hazardous Substances (2002/95/EC), on 27 January 2003, in force since 1 July 2006 is supposed to limit use of hazardous substances in electronic and electrical equipment and to ensure health and environment protection through appropriate recycling of such equipment. The directive assumes that new electronic equipment implemented in the territory of the European Union after 1 July 2006 must not contain harmful materials: lead, mercury, cadmium, hexavalent chromium, polybrominated biphenyls (PBBs) or polybrominated diphenyl ethers (PBDE) The maximal permissible amounts of these substances in elements and equipment where defined where the presence of these substances can not be eliminated – e.g. mercury in fluorescent lamps or lead additions in glass. Reduction of lead contents in computer system components is supposed to last until 2010. The RoHS directive derives immediately from other EU directive, WEEE (Waste from Electrical and Electronic Equipment), i.e. the waste directive, and they are strictly related to each other. Both directives are supposed to reduce waste from electrical and electronic products while elimination of risk of pollution of natural environment. After 1 July 2006, each end product, subject to the directive and implemented into European market has to meet the requirements of RoHS directive. This concerns products imported into the European Union and the products designated to sales, manufactured within the European Union. The scope of RoHS encompasses finished products but do not concern elements and semi-finished products being the components of the final product. In practice, manufacturers will need the components complying to RoHS directive so that the final products meets the requirements of the directive. The products under the RoHS directive include:

- large-size household equipment,
- small-size household equipment,
- IT and telecommunications equipment,
- consumer equipment,
- lighting equipment,

- electronic and electrical devices (except for large-size, stationary industrial devices),
- toys, recreational and sport equipment,
- automated machines.

The RoHS directive concerns European Union markets, however, it has immediately become a standard throughout world markets due to globalization of electronic market. Similar initiatives, conditioned by RoHS directive are implemented in many countries which are not the European Union members. The appropriate implementation of the RoHS directive is supervised by the execution body, which may undertake steps necessary to assessment of properly fulfilled requirements of the directive by the manufacturers. Any discrepancies may lead to penalty as well as to total retiring of the product from EU market. The directive contains several concessions on limitation of use of hazardous substances due to lack of technical possibilities to replace such substances. Main exceptions include lead and mercury. Lead may be used for:

- solder alloys with high melting point (>85% of lead)
- piezoelectric materials,
- kinescope glass,
- alloys defined by the directive
- While mercury:
- fluorescent lamps and other types of lamps.

The directive also permits, under special conditions, use of cadmium processing and application of hexavalent cadmium. In case of special applications, the European Union may conditionally permit other harmful substances, however, the permission is granted only temporarily [1]. There are no standards which condition marking of the elements in accordance with RoHS, although the manufacturers implemented their own systems of marking in order to facilitate unambiguous identification of the products by the customers. It is remarkable that the directive has impact not only on manufacturers and procurement companies, but also on logistics, quality control, inventory, supplies or on the final customer. RoHS has also influence on products which are not directly defined within this directive since manufacturers should forecast various use of their products by the final user, whose protection became the aim of the RoHS directive. The EU do not require any particular declaration of conformity with RoHS directives, however, customers may require delivery of the documents proving such a conformity with a form to be filled in or with entire documentation. The manufactures prefer, however, only to add information about conformity or about lack of it. It is also common practice that the elements subject to RoHS directive are marked on bulk and individual containers and packages, in invoices or bills of consignment. There are also the markings by manufacturers such as green or PB free. These markings are not in accordance with RoHS directive. First one means only the limitation in using harmful substances, not adapted to process of lead-free soldering (higher soldering temperature), while the latter means products with eliminated lead. The limitations of use of harmful substances is followed by the necessity of implementation of new, more expensive metals and their compounds during the production process. The process itself will be also changed so as it can be adapted to production in accordance with RoHS. All the changes involve quite considerable rise in costs of manufacturing of products in accordance with the directive. Full conformity with RoHS requires not only limitation of the substances forbidden by the directive, but also adaptation of elements to the process of lead-free soldering, i.e. preparation of the element for use of higher soldering temperatures. Sadly, lead-free solder alloys melt at the temperatures higher by about 40°C than lead alloys. This enlarges the time

of soldering, which negatively impacts on the quality of the solder. Possible alternative to that issue are electricity conducting glues, however, currently they are not commonly used.
The directive of RoHS is closely related to WEEE directive (**W**aste of **E**lectrical and **E**lectronic **E**quipment), whose aim is to minimize negative impact of electronic waste on environment. This directive imposes responsibility on producers, suppliers and importers for collection, reuse and recycling and recovery of electronic waste. The waste is subdivided into various categories and for each of them the different principles of recycling have been defined.
Products which are subject to WEEE directive include:

- large-size household equipment,
- small-size household equipment,
- IT and telecommunications equipment,
- consumer equipment,
- lighting equipment,
- electronic and electrical devices (except for large-size, stationary industrial devices),
- toys and sport equipment,
- medical equipment (except implanted and infected products),
- monitoring and control equipment,
- automated machines.

The standards of the directive must be met by the companies and individuals who:

- manufacture or sell electronic and electrical equipment under their trademark,
- resell equipment produced by other party under their trademark,
- import or export electrical or electronic equipment to member states in the EU.

The role of RFID application in reverse logistics management

The system of identification of goods- *Radio Frequency Identification* is based on technology enabling data transfer between a tag (electronic ‘label’, chip, transponder) and an RFID reader by means of radio waves. It operates similarly to technology of barcodes, however, giving more opportunities. It enables extended automation of work connected with reading the data and it is comfortable and easy to use. The features which distinguish this technologies from other previously used technologies of remote identification include[2]:

- relatively high resistance to external conditions, such as: dust, changes in temperature, rain/snowfalls, vibrations, shocks, solar radiation,
- lack of necessity of direct contact between a tag and a reader, which enables locating these components in an invisible places,
- opportunity to read information from more than one source at the same time while protecting it to be copied or lost,
- ensured low level of data transmission errors,
- increased amount of information on products; these data are of a dynamic type as the company can make changes within computer system,
- product information safety, standard barcodes contain information which might be read by anybody. RFID standard enables data storage within the system to which access may be possible for a particular group of authorized users.

Development of RFID technology is progressing at a fast pace; thus, it is worth to highlight features which distinguish the transponders between each other.
Decisive factors which determine quality of their operation include the following parameters:

- tag sensitivity; the parameter which determines possibility to power an integrated circuit and the power of the signal emitted towards the reader, which equals the range of the unit,
- tag size; the bigger size, the longer range,
- tag shape; shape of the antenna affects range scale,
- number of antennas connected to the integrated circuit. Two dipole antennas connected to one integrated circuit ensure lower sensitivity to direction of operation. This is of big importance when reading occurs from various directions,
- speed connected with efficiency of the reader reading tag identifier. Higher speeds enable more precise readings and they reduce load,
- density of tags; tags located in close distance might be a source of noise to each other,
- carrier material; using materials containing water and metals might cause disturbances in reading. This can be minimized through application of separators between a tag and the marked product, e.g. cardboard, plastic etc.

RFID technology opens large opportunities of innovation within large organizations with complex logistics processes. Profitability of use of this technology is particularly enhanced when a company:

- owns a wide range of products,
- owns plants with large floor area and scattered locations,
- encompasses various locations of storage,
- is a place of frequent warehouse goods exchange activities – increased circulation of materials, products, packages,
- has additional requirements and needs for information resulting from a branch specificity e.g. ‘best before’ dates, identification of a batch of raw materials etc.

Proper planning and coordination of activities in the abovementioned areas help minimize loss both for the customers, who have not been ensured an appropriate level of services as well as for a business who wastes their resources delivering defective products[4]. This is particularly visible in case of returns of goods returned to the manufacturer in order to be repaired or due to the mistakes in shipment. Application of solutions of radio identification enables minimizing possibility of failure during providing of services. This technology enables monitoring of products on the level of pallets and containers, which are transferred through RFID gates at the places of goods reception or dispatch and also in internal control points, which enables registration and supervision of any movements for the controlled assortment. Complex information results in facilitation of flow of products; they are delivered in right time to right place. The cases of losing or stealing of goods are also limited, the missing goods are reduced, customers are more loyal and, eventually, the incomes and profitability are enhanced. It is also worth to highlight the contribution of identification to the flow of such elements. RFID has the potential to benefit Europeans in many ways: safety (e.g., food traceability, healthcare), convenience and accessibility. This technology will most likely reduce energy and material use, which will in turn allow for an improved use of resources. The effects of larger amounts of RFID tags in other waste streams, and the effects of shift to semi-active and active tags in mass applications have not been investigated yet. It must be assumed the current RFID tag technologies have to be treated as electronics rather than as compatible with household waste or packaging. Currently, the disposal of RFID tags together with domestic waste does not cause large-scale problems as a small amount of materials used in passive RFID technology can be burnt in modern incinerators. More problems arise in connection with recycling processes.

Transponder materials might have to be separated from others during sorting processes. RFID can help optimise recycling processes by providing detailed information on equipment components, such as electronic equipment. Given the unlimited possibilities of tagging nearly everything with RFID, existing recycling processes must be adapted to the widespread use of RFID, as tags pose specific challenges to contemporary glass, paper and plastic recycling.

RFID manufacturers and the waste management industry are called upon to address these issues early on. Possible measures include environmentally friendly transponder design and adaptation of current disposal and recycling processes to deal with transponders appearing in refuse. The goal should be to recycle transponder materials whenever possible. In terms of environmental policy, it is desirable to begin this adjustment process at an early stage so that resources will be used frugally in RFID systems, too. But the development of environmentally friendly RFID technology by European technology vendors is also beneficial from the vantage point of industrial policy, because like other environmental technologies, it can uniquely position vendors of the Member States in the international market.

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Nowadays reverse logistics is a very useful tool for enterprises which have to deal with production wastes and commercial returns. Forward logistics is not able to manage them, because they show up on the beginning of reverse supply chain. That is the reason for growing importance of reverse flows. Reverse logistics is quite new logistics system and the most common is using in developed countries. The reasons of this are high costs of such system and some organizational problems.

For past decades enterprises have been using forward logistics processes in their economic performance and their management was fully successful. But since few years forward logistics become insufficient for some parts of management. A lot of companies faced of problems concerning high costs of materials to production, high costs of waste final disposal or problems with return products. Additionally many countries made their law stricter, what became a reason for firms to find some alternative ways to manage their problems.

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