REPORT ON A CONDUCTED STUDY

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Report on a Study

Report Contents:

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1. Description of the Issues

A list of materials that the company currently uses or is considering to use in the future for shipping was provided for this study. The list contained air cushions (PELD film), 90g cushioning paper, cardboard and double-layer corrugated cardboard.

Boxes, which are packed with goods for customers, are made of cardboard. Double-layer corrugated cardboard is primarily used to protect products filled into glass containers. Glass bottles are wrapped with corrugated cardboard and fixed with paper adhesive tape.

Air cushions or 90g cushioning paper can be used to fill in void spaces in the box and to fix the products. The air cushions (see Fig. 1) are manufactured immediately prior to insertion into the box using a machine that fills the film with air, creating a long strip of air cushions that can be divided into shorter ones as needed. Cushioning paper (see Figure 2) is produced by a machine that scrunches the paper into the desired shape to protect the products in the box during shipping and fill the unused space between the shipped products and the inside of the cardboard box.

Fig. 1. PELD film

Fig. 2. Cushioning paper

Using filler materials (especially plastic and paper), the burden on the environment resulting from their production, working with these materials for employees of the contracting company within the expedition process and handling them as waste by the end user are very topical issues nowadays.

Therefore, this study is divided into the following chapters discussing individual aspects of filler material use, both from an ecological and economic point of view, as well as with respect to the handling of packaging material for the Client's expedition staff.

2. Volume Differences

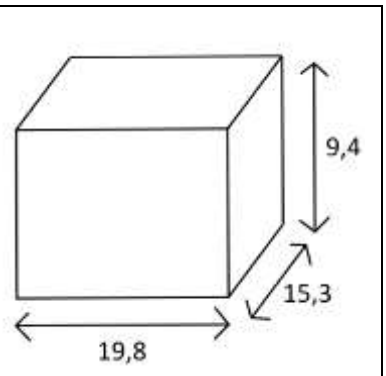
An indisputable advantage of using plastic air cushions as the filler material is that 99 % of the volume is actually air and only 1 % is made up by the material used[1].

As a result, using cushioning paper as a filler material requires a much greater weight of consumed material compared to the plastic air cushions.

This study focused on three box sizes (small, medium, large – *see Tabs. 1 - 3*) into which the Client packs the dispatched goods by default. A product/combination of products routinely packaged into the appropriate box size was selected for each box. Every box was first filled with the product(s) (see *Figs. 3 - 5*) using cushioning paper as filler material, and then the same box was filled with the same products using air cushions instead. The weight differences between each version were compared for the following three types of boxes:

• a "small" box with the following dimensions was filled with one product:

Size [cm]	
length	19.8
height	9.4
width	15.3

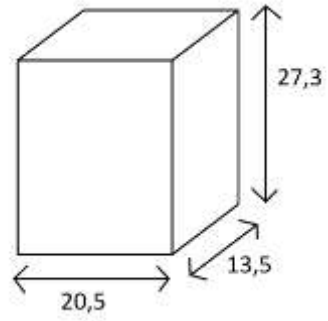


Tab. 1. Dimensions of the "small" box

Fig. 3. The "small" box with a product

• a "medium" box with the following dimensions was filled with three products:

Size [cm]	
length	20.5
height	27.3
width	13.5

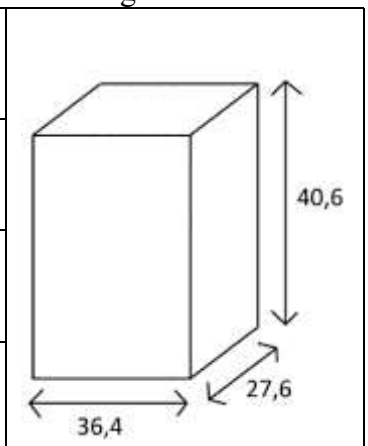


Tab. 2. Dimensions of the "medium" box

Fig. 4. The "medium" box with products

• a "large" box with the following dimensions was filled with five products:

Size [cm]	
length	36.4
height	40.6
width	27.6



Tab. 3. Dimensions of the "large" box

Fig. 5. The "large" box with products

After filling all boxes with products and plastic or paper filler, the differences in weight were as follows:

box	**weight of cushioning paper filler**	**weight of air cushions filler**
"small"	73 grams	6 grams
"medium"	146 grams	20 grams
"large"	527 grams	90 grams

Tab. 4. Weight of filler material in individual types of boxes

When filling the "small" box, the filler consumption in kilograms, when air cushions are used, is approximately 12 times lower, for the "medium" box it is approximately 7 times lower, and when large boxes are filled, the difference is approximately 5 times less.

When the above values are averaged, the weight consumption of the air cushions filler is approximately **8.4 times lower** versus the use of cushioning paper (see *Tab. 4*). The above calculations are purely approximate due to the different number of shipped boxes of each size.

However, it is clear that when taking care to reduce the carbon footprint, water consumption, recycling process, financial aspects and handling of the filler material, it is necessary to consider the filler material consumption in kilograms as well.

To perform the following calculations, we will use the data of the box filling experiment to calculate the average weight of the filler necessary to fill the voids in the box.

This average value is **248.67 g** for cushioning paper and **38.67 g** for air cushions. These data are approximate only and they are intended exclusively for contrasting the following calculations.

3. Environmental Study

3.1 Carbon (Greenhouse) Footprint in the Production of Filler Material

The manufacture of any product can be a very environmentally demanding process. There are many studies on how to assess the life cycle of any product, on the so-called cradle-to-grave approach. From the environmental point of view, however, the most important aspect is the so-called "carbon footprint".

The carbon footprint is the sum of the greenhouse gases emitted into the atmosphere in any process where carbon is converted to carbon dioxide.

Filler material supplier states[1] that while **1 kg PELD** film is produced, **347.6 g CO_2** is released into the atmosphere, whereas **367.8 g CO_2** is released during the manufacture of the same mass of **paper**.

However, any production also produces other greenhouse gases. The size of the carbon footprint is most often given in tons of CO_2 and other greenhouse gases are converted to CO_2 equivalents so that the carbon footprint values are comparable.

The carbon footprint of the material production also includes energy the flue gas released into the air during operation.

1.1 kg of CO_2 eq. is released into the atmosphere during production of **1 kg of paper**. In contrast, production **1 kg of plastic matter** (namely PELD film) burdens the air with **2.5 kg of CO_2 eq**. In the manufacture of packaging material from recycled materials, the carbon footprint decreases by 90 % for plastics and 40 % for paper[2].

Examples of calculating the carbon footprint of the filler material taking into account the use of a portion of the recycled material and a comparable filler volume are given in *Tab. 5*.

material	CO^2 (eq.) consumption per 1 kg of material	CO^2 (eq.) consumption to fill an average box
PELD – pure raw material	2.50 kg	0.10 kg
paper (90g) – pure raw material	1.10 kg	0.27 kg
PELD – using recycled material	0.25 kg	0.01 kg
paper (90g) – using recycled material	0.66 kg	0.16 kg

Tab. 5. Carbon footprint values in the production of filler material

3.2 Water Consumption in the Production of Filler Material

Water consumption is an integral part of any industrial process, not only from the perspective of drinking water consumption, but also of the waste water production which still has to undergo an intensive treatment.

In paper production, the water consumption varies greatly depending on the technology applied, the material used and the demands on the final product. The lowest water consumption for production of 1 kg of **paper** amounts to **321 liters** of water[3]. Production of 1 kg of **plastic** consumes **13.7 liters** of water.

In this case too, the weight of the material needed to fill the same volume must be taken into account (see Table 6.).

material	water consumption per 1 kg of material	water consumption to fill an average box
PELD	13.70 l	0.53 l
paper (90g)	321.00 l	79.82 l

Tab. 6. Water consumption values in the production of filler material

3.3 Recycling of Materials

In the Czech Republic, 90 % of paper but only 69 % of plastics is sorted[4].
An average Czech household sorts out 30.2 kg of plastic[5] and 47.3 kg of paper[6] per year. Paper can be recycled up to 7 times, while plastics more or less indefinitely[7]. *Tab. 5* shows that using recycled plastic to produce PELD air cushions reduces CO2 eq. more significantly than when paper is used.

Another aspect when considering the recycling of materials is the end user and his/her handling of the filler material as sorted waste. The advantage of air cushions is clearly the option to puncture them easily to reduce their volume. For a more realistic idea, another experiment disclosed that the "**small**" box can hold approximately 100 g of cushioning paper and 70 g of deflated air pads. Due to the amount of material used in the standard box, the end user has much smaller amount of waste when air cushions are used (see comparison in *Figs. 6 and 7*).

Ex.: When receiving an order shipped in the "**medium**" box, the air cushions weigh **20 g** and, after being deflated, occupy a volume of approximately **2.14 dm^3** while cushioning paper weighs **146 g** and takes approximately **10.95 dm^3**.

Fig. 6. Comparison of filler materials in the expedition condition

Fig. 7. Comparison of filler materials ready for being separated

The above experiment demonstrates that if the package shipped in a "medium" box is filled with air cushions, the end user will have **five times** less waste to separate than paper.

3.4 Degradability of Materials

Paper is degradable in nature within **months**. **Plastics** are degradable in nature in **decades** (70-100). Some sources[8] state that their gradual decomposition will give rise to **micro-plastics**, which are more or less harmful to the environment to the same extent as plastics on a macro scale. With regard to the amount of unseparated plastic material (31 %) mentioned in the previous chapter, this aspect is very important.

4. Legislation and General Awareness

At present, the issue of plastics and their circulation in the environment is taken into account in the framework of national and EU legislations. The European Commission (EC) has proposed a ban on disposable plastic straws, dishes and some other disposable plastic products[9].

At the same time, the Ministry of the Environment of the Czech Republic calls on multinational companies to reduce the use of disposable plastics through their "#dostbyloplastu" campaign and offer customers more environmentally friendly alternatives[9].

In addition, at their first reading MEPs adopted the proposal to regulate the use of plastic bags in the EU by 80 per cent by 2019[11].

5. Economic Evaluation

The price of filler material plays an important role in the evaluation of its use as well.
The filler supplier states that Aelos Premium Air Cushion Package 93211 delivered in a 6.6 kg roll (500 m) costs EDITED.

Supplier of Ri-Pad **cushioning paper** states the price is EDITED per a 30.8 kg package (350 m).
The calculation at the end of the second chapter indicates that when the average box is filled with cushioning paper of **248.67 g**, the price of the filler per box shipped amounts to **EDITED**. Filling an average box with air cushions weighing 38.67 grams costs **EDITED**.
Thus, the air cushions are **2.3 times cheaper**.

6. Functionality and Handling of Filler Material

From the data supplied by the EDITED company, the air cushions provide a very effective protection for shipments, as they dampen any impacts and easily adapt to the transported products. One pack of air cushions, which is put into the air inflating machine, weighs **6.6 kg**. Handling this package is therefore easy and even a single expedition employee can handle it. The plastic material is soft without sharp edges and there is no risk of minor injuries.

In order to provide effective protection against product breakage, multiple layers of paper must be used. One package of paper that is loaded into the scrunching machine weighs **30.8 kg**. This requires 2 expedition employees to handle such paper package. When working with paper, there is a risk of scratches and cuts due to the sharp edges of paper.

There are 60 foil packs per pallet of air cushions, which corresponds to the weight of **396 kg**. This quantity is sufficient for packaging **10 343 boxes** (average value – see chapter 2).

On the other hand, there are 20 packs of paper on one pallet, which corresponds to the weight of **616 kg**. This quantity will cover approximately **2 477 boxes**. The above calculations demonstrate that it is necessary to transport approximately **4 x more pallets** to pack the same number of boxes, which means more handling and more required storage space when cushioning paper is used.

7. Study Conclusions

At the end of this study it is necessary to point out that the issues of filling material are very complex and every company approaches it differently with respect to their end customers. The requested analysis of filling material by the EDITED company deals with volume differences, environmental analysis, legislation, financial and functional economic evaluation of these issues.

The verified data show that the indisputable advantage of using air cushions is that the average filling of a box requires the use of 38.67 g of material, which is approximately **eight times** less than with cushioning paper (248.67 g).

In order to consider the environmental impact of the use of filler material, it should be stressed that many processes are involved in the production and life of individual types of filler material, and they contribute differently to environmental damage.

Important aspects include the carbon footprint and also the water consumption during the production. **Carbon footprint** of paper production is smaller than that of plastic, but taking into account the weight of the filler material used to fill the same volume, the carbon footprint of the PELD cushions is approximately **three times** lower than when filling the same volume with paper and the use of **recycled** material can reduce the carbon footprint of **PELD** cushions **sixteen times** more than recycled paper.

Concerning **water consumption** in the production of paper, it exceeds the water consumption in the production of plastics ten times; however, with regard to filling in the same volume, the difference is **one hundred and fifty times**.

Nevertheless, current legislation is trying to avoid plastics and their presence in the environment is perceived rather negatively.

When **sorting** filler material as waste, using air cushions is more beneficial for the end user, as they take up **five times** less volume compared to cushioning paper.

On the other hand, it is clear from the above data that if the carbon footprint is related to the amount of material produced, **the use of PELD cushions significantly reduces the consumption of filling material and thus its environmental impact**.

The economic evaluation of this issue shows that the use of air cushions is approximately **twice** cheaper compared to cushioning paper.

The data supplied by EDITED implies that the handling of the filler material is safer and more convenient for the expedition company employees when PELD cushions are used.

8. Final Recommendations

Based on the conclusions of this study, considering most of the factors affecting all aspects of the issue of using filler material in the expedition of goods, including the environmental impact, we can **recommend** the EDITED company to use **PELD air cushions** as a filler material for shipped boxes. It also follows from the above data that if the supplier undertakes to use recycled PELD, even milder environmental impact may be further enhanced. The aspects of financial savings and easier handling for expedition employees are also noticeable.

References

1. Promoting Presentation of **RIPAC** company, “Protecting your valuables... valuing your environments”
2. Amounts of CO2 Released when Making & Using Products [online]. The.CO2list.org: ©2018 [qtd. on 20 June 2018]. Available at: http://www.co2list.org/files/carbon.htm
3. P.R. van Oel A.Y. Hoekstra. (2010). THE GREEN AND BLUE WATER FOOTPRINT OF PAPER PRODUCTS: METHODOLOGICAL CONSIDERATIONS AND QUANTIFICATION. VALUE OF WATER RESEARCH REPORT SERIES NO. 46 UNESCO-IHE Institute for Water Education, Delft. Available at: http://waterfootprint.org/media/downloads/Report46-WaterFootprintPaper_1.pdf
4. Přehled dosahovaných výsledků [online]. EKOKOM: 2018 [qtd. on 25 June 2018]. Available at: http://www.ekokom.cz/cz/ostatni/vysledky-systemu/vyrocni-shrnuti
5. Recyklace a využití plastů [online]. EKO-KOM, a.s.: ©2018 [qtd. on 20 June 2018].

Available at: http://www.jaktridit.cz/cz/co-se-deje-s-odpadem/recyklace-a-vyuziti-plastu
6. Recyklace a využití papíru [online]. EKO-KOM, a.s.: ©2018 [qtd. on 20 June 2018]. Available at: http://www.jaktridit.cz/cz/co-se-deje-s-odpadem/recyklace-a-vyuziti-papiru
7. Kolikrát se dají jednotlivé druhy odpadu recyklovat? [online]. SIEGL kontejnery: ©2017 [qtd. on 5 June 2018]. Available at: https://www.siegl.cz/blog/recyklace-odpadu/kolikrat-se-daji- jednotlive-druhy-odpadu-recyklovat
8. Siegfried, M; Koelmans, AA; Besseling, E; Kroeze, C (2017). Export of microplastics from land to sea. A modelling approach. Water Research; Vol.:127; 249-257. DOI: 10.1016/j.watres.2017.10.011
9. Evropská komise chce zakázat brčka a plastové nádobí, které nelze recyklovat [online]. Czech Television: ©2018 [qtd. on 26 June 2018]. Available at: http://www.ceskatelevize.cz/ct24/svet/2492158-evropska-komise-chce-zakazat-brcka-a-plastove-nadobi-ktere-nelze-recyklovat
10. K tažení proti plastům se v Česku připojily Benzina, Leo Express či Bageterie Boulevard [online]. Czech Television: ©2018 [qtd. on 26 June 2018]. Available at: http://www.ceskatelevize.cz/ct24/ekonomika/2514556-k-tazeni-proti-platum-se-v-cesku-pripojily-benzina-leo-express-ci-bageterie
11. Poslanci EU dali první ránu igelitkám, zmizet jich má 80 procent [online]. idnes.cz.: ©2018 [qtd. on 26 June 2018]. Available at: https://ekonomika.idnes.cz/poslanci-eu-reguluji-igelitove-tasky-dwt-/eko_euro.aspx?c=A140416_151915_eko_euro_fih

In Ústí nad Labem, the 14 December 2018

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