A Reusable Double Cardboard Box Package for Shipping Fragile Objects – Canadian Conservation Institute (CCI) Notes 20/4

Disclaimer

List of abbreviations

g	acceleration due to gravity
Hz	Hertz or cycles per second
pcf	pounds per cubic foot

Introduction

This Note describes and explains how to construct a complete double cardboard box package designed for fragile objects. It can be adapted to ship a variety of objects and can be reused many times. The package components are easy to store, recycle or replace. This Note includes basic performance data on its protective capabilities. It also provides several examples of how to use the package. Because this package has performed well and has proven to be a convenient size for many uses, it is presented here for readers who may wish to duplicate it.

The package

The package consists of a double cardboard box system with pre-designed cushions that provide high protective capabilities (Figure 1). The outer box measures 61 cm × 61 cm × 61 cm (24 in. × 24 in. × 24 in.). Hand-hole cutouts, positioned at approximately 3/4 of the height, reduce the likelihood of accidentally dropping the box as well as the severity of the impact, if this should occur. The inner box measures 41 cm × 41 cm × 41 cm (16 in. × 16 in. × 16 in.). Both boxes are made of double-wall cardboard, which has been chosen for its load capacity and durability.

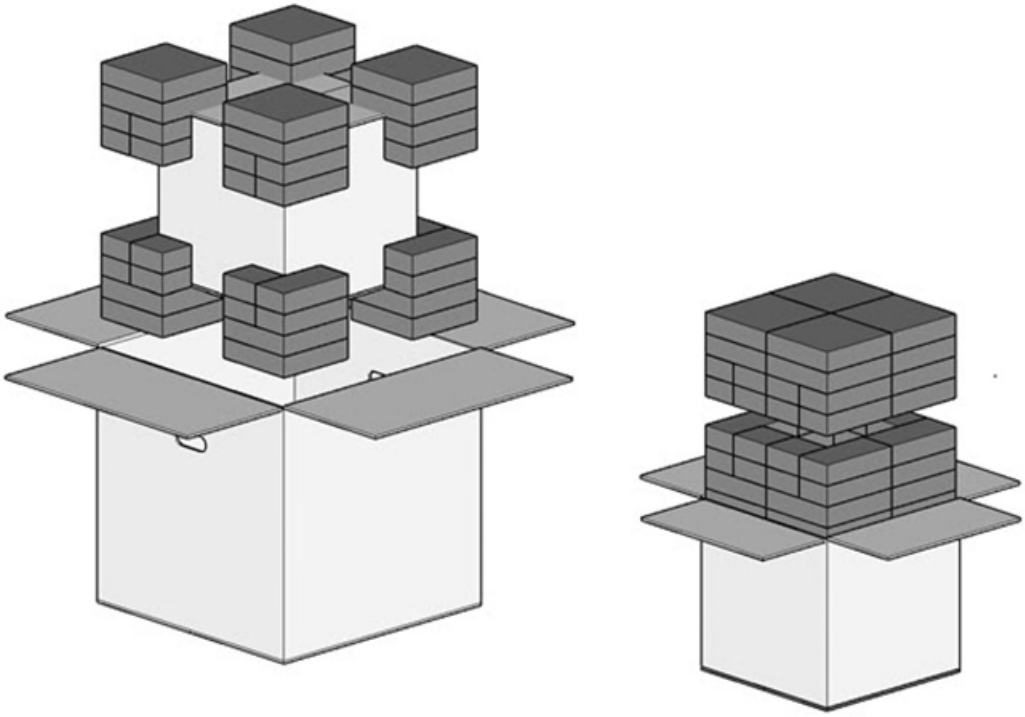

Figure 1. Left: double cardboard box package showing the outer box and the inner box supported on eight corner pad cushions. Right: corner pads being lowered into the inner box for storage.

The inner box floats on eight foam corner pads. The performance of the corner pads has been evaluated for an inner box weight range of 2.3 to 18.0 kg (5 to 40 lb.). This information appears in Table 1.

The package components are reusable, and the external box is easy to replace or recycle. The eight corner pads fit neatly into the inner box for return shipment, storage and reuse.

Cushion performance

Table 1 outlines the performance of the cushioning system across four different weight ranges and a drop height of 76 cm (30 in.) [1]. The maximum g values (acceleration due to gravity) pertain to flat drops onto a hard floor surface. The cushion resonant frequency is an indication of the vibration tendency that every cushioning system will have. Care is necessary to ensure that the cushioned object can withstand the resulting movement and that there is not an overlap between content and cushion vibration tendencies (resonances). In practice, this means that the cushioning system is the most flexible part of the protective package. For more information, consult CCI Technical Bulletin 34 *Features of Effective Packaging and Transport for Artwork*.

Table 1: predicted performance of double cardboard box package for a range of content weights

Inner box weight	Maximum acceleration	Cushion resonant frequency
2.3 kg (5 lb.)	38 g	41 Hz
5.0 kg (10 lb.)	26 g	36 Hz
9.0 kg (20 lb.)	24 g	17 Hz
18.0 kg (40 lb.)	29 g	<13 Hz

Constructing the package

The package can be constructed as described here without the need for design tools if the weight supported by the cushions remains within the ranges specified in Table 1. The cushioning system has been pre-designed for this weight range using cushion performance data[2]. The double-wall cardboard boxes are common sizes available from shipping, industrial and packaging material suppliers.

Foam pad construction

To construct the eight corner pads, use polyurethane ester foam with a density of 33 kg/m^3 (2 pcf). Note that each side of the inner box will come into contact with four foam surfaces, each approximately 100 mm × 100 mm (4 in. × 4 in.) in area and 100 mm (4 in.) in thickness.

The dimensions of the corrugated box refer to the box interior, so there will be less than a full 100 mm (4 in.) of sway space between the boxes. Figure 2 illustrates an example of corner pad construction using 50 mm (2 in.) thick material. Other construction methods can be used as long as these dimensions are maintained.

Figure 2 shows how to achieve a snug cushion fit by transferring the inner box profile to the foam pads. Place four 203 mm × 203 mm × 50 mm (8 in. × 8 in. × 2 in.) foam pads tightly in each corner of the outer box, centre the inner box on top, and then trace the box outline onto two sets of pads. This outline can be used to size the smaller pad parts shown. Use a similar procedure for the top. Assemble the parts to make eight corner pads. Hot-melt glue can be used to bond the parts together (ensure that there is adequate ventilation in the room during this process).

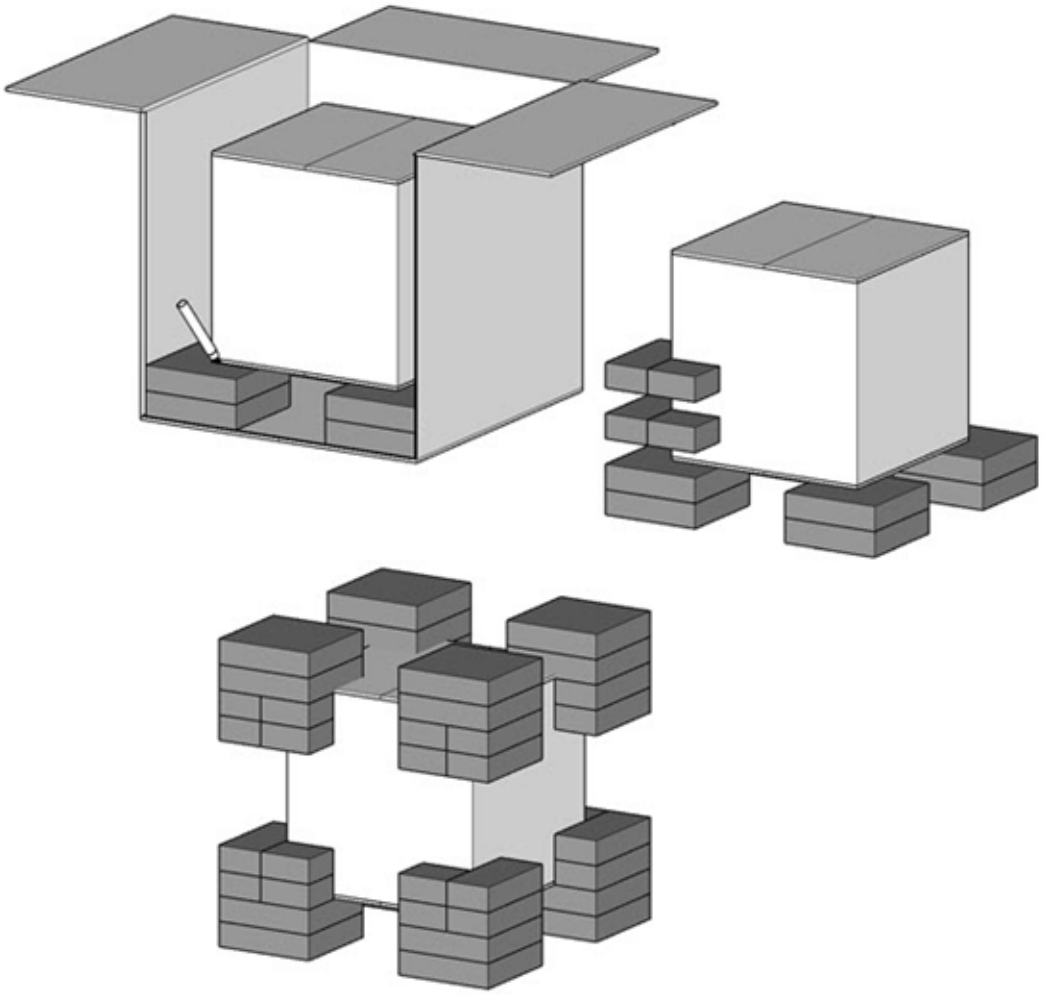

Figure 2. Top left: tracing the inner box outline. Top right: adding smaller corner pad parts. Bottom: the inner box floating on eight corner pads.

Assemble the package and mark the top pad faces for trimming if they extend beyond the top of the outer box, as shown in Figure 3. Check the fit of the corner pads inside the inner box, as shown in Figure 1, and trim the side faces if necessary. After this is done, mark each corner pad with a number to ensure proper positioning and orientation inside the package (as shown in Figure 3).

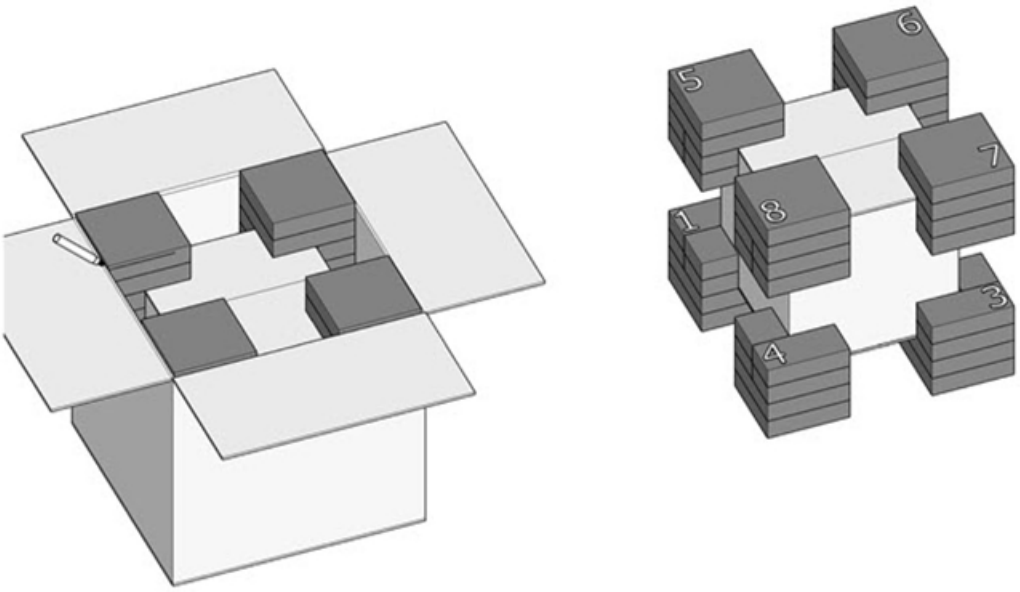

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Figure 3. Left: top corner pad material extending above the box being marked for trimming. Right: an example of how to number the corner pads to ensure that they are correctly oriented and positioned.

Chamfered edges can improve cushion effectiveness in isolating low-level shock and vibration events, which occur most frequently during shipment. These chamfers also make the package easier to assemble. If chamfers are cut, be careful not to remove too much material, as this could overload the corner pad and lead to a loss of cushion thickness over time. Figure 4 shows 45° chamfers with leg lengths of 25 mm (1 in.).

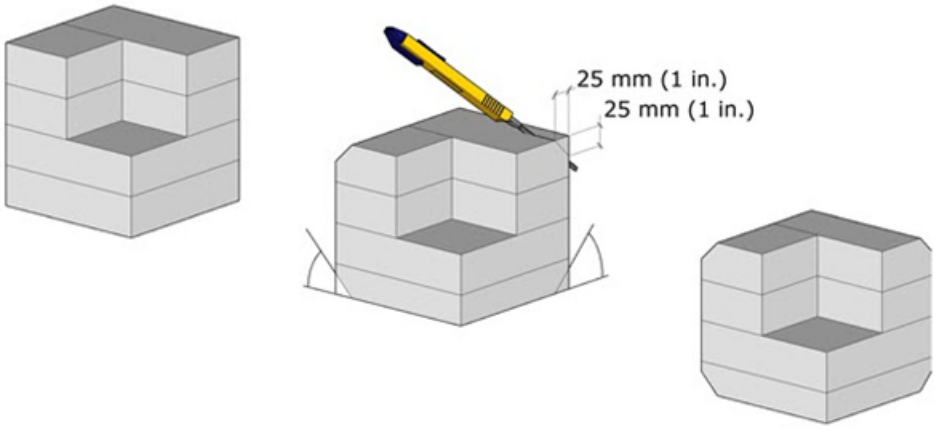

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Figure 4. Left: corner pad assembly. Middle: cutting edge chamfers. Right: corner pads with edge chamfers.

Packing the contents of the inner box

The contents of the inner box can be packed in various ways. Whichever approach is taken, ensure that the box and its contents function as a single, stable assembly relative to the cushioning system. The first objective is to provide firm support and restraint for the object overall. However, care must be taken to avoid causing strain on or deforming the parts, either during packing or when shock and vibration are dissipated during shipment.

Small, lightweight objects without fragile surfaces or projections can be wrapped and securely nested inside the inner box. Void fills, such as foam supports or inserts, or crumpled tissue paper, can be used to fill gaps and help secure the wrapped objects, preventing them from rotating or colliding.

Objects with fragile projections, such as the archaeological ceramic vessel in Figures 5a and 5b, are immobilized and supported from below with a fitted base mount and from above with a conforming insert. The fragile edges are left to float freely.

Figure 5a. Archaeological ceramic vessel with a fitted base mount carved of polyethylene (for example, Ethafoam 220) with a thin conforming polyester layer and Tyvek (non-woven polyethylene) covering.

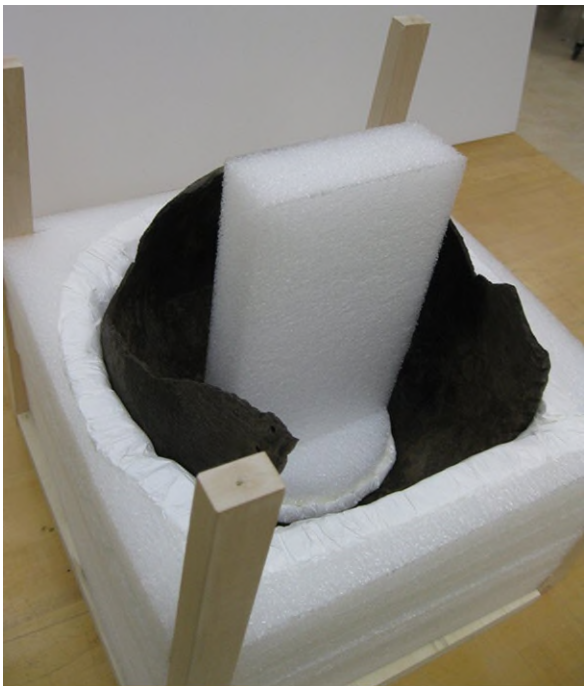

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Figure 5b. A polyethylene foam insert with closely conforming base profile and a surface covered in polyester and Tyvek.

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Figure 6a. Installing the cover on the mount and insert assembly. The insert height is trimmed in order to place it under mild pressure when the cover is installed.

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Figure 6b. Lowering the archaeological ceramic vessel and mount and insert assembly into the inner corrugated box.

When packing two or more heavier objects, durable partitions will isolate them from each other and provide support. This approach has been applied in the case of the two ceramic dogs in Figures 7a and 7b.

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Figure 7a. Items required to build a restraint system for two ceramic dog sculptures separated by a triwall corrugated partition.

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Figure 7b. The dog sculpture restraint on one side of the partition. White foam is firm polyethylene (such as Ethafoam 220).

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Figure 8a. The restraint system containing two dog sculptures being lowered into the inner box.

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Figure 8b. Protective covers being installed before closing the inner box.

Package assembly

The final package assembly is shown in Figures 9a and 9b. The numbered corner pads discussed above and shown in Figure 3 will help ensure the correct position and alignment of the individual corner pads. The outer box in this example was sealed with packaging tape.

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Figure 9a. Bottom corner pads set inside the outer box.

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Figure 9b. The inner box floating on eight corner pads before closure of the outer box.

Storage and reuse

The outer box can be disassembled, stored or easily recycled. The eight corner pads fit inside the inner box and can be returned to the shipper in this compact form for reuse, as shown in Figure 1. If long storage periods are anticipated, line the box interior with black polyethylene material (for example, garbage bags) as light and contact between the foam and the container, as well as airborne chemicals, may accelerate the deterioration of the polyurethane over time. With proper storage, the cushions should remain useful for many years. Replace the cushions if they are no longer springing back after being deformed or are breaking apart, loosing particles or becoming tacky.

Final comments

This package provides a high level of protection for fragile objects using thick cushioning. When using protective cushions like these, be mindful of cushion flexibility and its potential effects. Flexibility plays an important role in the protective ability, but it is essential to ensure that the cushioning system is the most flexible part of the package and that the cushioned object(s) remain a firm assembly. Note that while the cushioning system offers protection against shock and vibration, corrugated boxes have certain limitations. Despite this, the double-wall corrugated boxes can provide good protection at a low cost and with weight savings in the controlled shipment scenarios that cultural institutions often encounter, such as art handler transport.

Bibliography

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Endnote

1 Data Source: U.S. Department of Defense. *Military Standardization Handbook: Package Cushioning Design*. Washington, D.C.: U.S. Department of Defense, 1978.

2 Ibid.