

# SHIPPING AND HANDLING OF NATURAL HISTORY SPECIMENS IN DANGEROUS GOODS

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*Abstract.*—Most collection-holding natural history institutions, as part of their daily operating procedures, deal with the shipping of specimens, through loans and gifts of material to other institutions as well as the accepting of incoming material. A large number of these shipments contain flammable or hazardous solutions such as ethanol, isopropanol or formaldehyde in varying concentrations. Dangerous goods regulations, most of which were in place long before 11 September 2001, were brought sharply into focus after that tragic event. The shipping and handling of wet-preserved natural history specimens have been affected by the more rigorous enforcement of these regulations, which has impacted the methods and frequency with which museums and other collection-holding institutions can send loans and gifts of materials to others. There is a great deal of confusion concerning the application of these regulations which, along with a lack of knowledge, has resulted in serious misinterpretations of the regulations within the natural history community.

Most alcoholic specimen shipments are sent by airmail to minimize the length of time specimens are exposed to the hazards of transport, thereby reducing the chances of damage and dehydration. Shipping dangerous goods by air presents particular problems. International shipments must comply with both the International Civil Aviation Organization (ICAO) technical instructions as well as national regulations. In order to meet commercial standards, shippers are also required to meet the International Air Transport Association (IATA) Dangerous Goods Regulations. Furthermore, some countries have added variations to many of these requirements.

## REGULATING AGENCIES

The ICAO governs the implementation and adoption of standard aircraft shipping and packaging regulations by both the Department of Transportation (DOT) in the United States and IATA internationally. DOT regulations are unique to the United States. Other countries have similar domestically enforced regulations while a large number rely on IATA regulations for both domestic and international regulations. Domestic shipments sent through the mail within the United States must also conform to United States Postal Service (USPS) regulations while courier shipments (FedEx, UPS and DHL) must conform to the individual company's specific regulations (which for the most part follow DOT or IATA regulations). USPS and private courier regulations must meet or exceed the DOT or IATA regulations respectively; in many instances they are more restrictive.

## TRAINING

The first and most important requirement stipulated by all regulations is that people who pack, handle or ship dangerous goods must be properly trained and certified. Training can be obtained from any number of commercial companies that specialize in Dangerous Goods or Hazardous Materials Training, and may range in price from \$300 to \$500. Training programs can take from a couple of hours to two days, depending on the scope and complexity of training, and cover general shipper's compliance and responsibilities together with specific case scenarios. Participants should be provided with a copy of the relevant regulations, and the training should cover restricted quantity (small quantities for DOT and excepted quantities for IATA) dangerous goods packing and

shipping. For quantities above and beyond restricted quantities, more extensive training is required, which involves additional time and cost. The majority of museum shipments will fall within the restricted quantity regulations outlined below.

Every employee who handles, packs or ships dangerous goods is required to complete this training and maintain current certification. In addition, refresher training is required every 24 mo. Depending on the size of the institution, the training of a single person (or two) to handle, pack and ship all dangerous goods shipments may be sufficient. At some institutions, especially those affiliated to universities, there may already be trained individuals on staff (for example, in an environmental health and safety unit) who can ship and receive packages. University museums may also be able to make use of the institution's environmental health and safety unit for training of museum personnel, and for assistance with shipments larger than those covered by restricted quantities. There are also certified commercial re-packing companies that will handle packing and labeling requirements.

#### DANGEROUS GOODS/HAZARDOUS MATERIALS

Dangerous goods/hazardous materials are classified according to Hazard Class and Packing Group. For example, most flammable liquids fall into Hazard Class 3 (flashpoint of less than 60.5°C or 141°F). Within Hazard Class 3, materials are classified into three Packing Groups. Materials in Packing Group I, considered the most dangerous, have a boiling point less than or equal to 35°C (95°F). Materials in Packing Group II, considered moderately dangerous, have a boiling point above 35°C (95°F) and a flashpoint less than 23°C (73°F). Materials in Packing Group III have a boiling point above 35°C (95°F) and a flashpoint between 23°C (73°F) and 60°C (140°F).

Of the four substances most commonly used in wet collections only ethanol, isopropanol and formaldehyde are covered under dangerous goods regulations. Glycerin (glycerol) used for cleared and stained specimens, is not regulated in any concentration.

Ethanol (ethyl alcohol), most commonly used in concentrations of 70% and above, is regulated for transport. Concentrations between 10% and 80% fall into Packing Group III while concentrations above this fall into Packing Group II.

Isopropanol (isopropyl alcohol), most commonly used at concentrations of 50% and above, falls into Packing Group III at concentrations of 10–30% while concentrations above this fall into Packing Group II.

Formaldehyde (formalin), usually sold as a saturated solution of formaldehyde gas in water and measured by weight or volume concentration, is most commonly used in concentrations of 3.7% or 4.0% (what is called 10% formalin in natural history collections) and is unregulated for transport. Above 10% is a Class 9, packing group III substance and is regulated for transport.

Other solutions used in tissue storage include dimethyl sulfoxide (DMSO), propylene glycol and proprietary solutions such as RNAlater. DMSO and propylene glycol are unregulated in any concentration. RNAlater is proprietary (of unknown composition, although thought to be made up primarily of propylene glycol), but is not listed as a dangerous good.

The shipment of infectious substances, natural history specimens not containing dangerous goods (pinned insects, skins, skeletons etc.), biological materials other than natural history specimens and any material on dry ice is covered by a separate set of regulations, and are outside the subject of this paper. There may also be ancillary permitting/documentation requirements for the domestic or international transfer of biological specimens (U.S. Fish and Wildlife import/export or CITES permits, APHIS,

etc.). APHIS in particular has specific approved treatment methods required for import of avian, ruminant, equine and swine specimens. These regulations (when relevant) should be adhered to during the transport of any natural history materials.

### REGULATIONS

Domestic and international shipping and packing guidelines vary slightly in scope and limitations but both include special dispensations for smaller quantities of dangerous goods. The two sets of limited quantity regulations are very similar in scope and content but have a number of limitations that must be adhered to. It is important to consult the original texts of both the DOT and IATA regulations before shipping. USPS and DOT regulations are available online (see references cited 1 & 2) while IATA regulations must be purchased (reference 3).

### DOMESTIC REGULATIONS

In the United States, the shipment of dangerous goods (referred to as hazardous materials) is covered in DOT Title 49 CFR<sup>1</sup> (Parts 100 to 185) and USPS Publication 52<sup>2</sup>. An exception to the regulations is made for dangerous goods in restricted quantities termed "small quantity regulations" outlined in DOT 173.4 and USPS Publication 52 (334). These small quantities are considered exempt from regular DOT and USPS hazardous goods requirements. Most fluid preserved natural history specimens can be packed and shipped utilizing these small quantity regulations. Institutions in other countries should consult their national dangerous goods regulations to ascertain if similar regulations exist and ensure compliance. In some instances this may mean using IATA regulations as outlined below in the international section of this document. Outlined below are the important relevant points from the DOT and USPS regulations:

1. Small quantities may be sent through the United States Postal Service via air transportation (Express, Priority and First-Class mail) or surface transportation as Standard or Parcel Post, or by any of the three major courier companies (FedEx, UPS and DHL) that follow DOT 49 CFR 173.4 small quantity regulations.
2. Class 3 dangerous goods (all packing groups) are acceptable (ethanol and isopropanol).
3. The maximum quantity of dangerous goods per inner receptacle cannot exceed 30 ml for acceptable liquids (as above). This inner receptacle cannot be liquid full at 55°C (131°F) and is to be constructed of plastic (having a minimum thickness of 0.2 mm) earthenware, glass, or metal. A removable closure on an inner receptacle must be held securely in place using wire, tape or other positive means.
4. Each inner receptacle must be placed within a securely sealed secondary package.
5. Sufficient cushioning and absorbent material (that will not react chemically with the dangerous goods) must surround each inner receptacle and be capable of absorbing the entire contents of the receptacle.
6. The secondary packages must be securely packed in a strong outer package (box) which complies with DOT mandated drop and compressive load tests without breakage or leakage from any internal receptacle:
  - a. Drop tests—free drop on top, bottom, long and short side and the junction of three sides of the package from 1.8 m (5.9 ft) onto a solid unyielding surface.
  - b. Compressive load test—stack packages of similar size and weight to a height of no less than 3 m (10 ft) for 24 hr.

7. The gross mass of the package must not exceed 29 kg (64 pounds).
8. Labeling—the address side of each package must be clearly marked with “This package conforms to 49 CFR 173.4” and complete return address and delivery address must be furnished. There are no other labeling requirements. Custom labels can be produced that follow these guidelines:

The University of Kansas  
**Natural History Museum and Biodiversity Research Center**  
 1345 Jayhawk Blvd.  
 Lawrence, KS 66045-7561 U.S.A. • (785) 864-4540

## **Scientific research specimens**

**No endangered species  
No commercial value**

**This package complies with 49 CFR 173.4**

060805

### INTERNATIONAL REGULATIONS

International shipments of dangerous goods are covered in Section 2.7<sup>3</sup> of the IATA regulations. As above, restricted quantity regulations exist for international shipping, contained in IATA Section 2.7.1 and referred to as “Dangerous Goods in Excepted Quantities.” Dangerous goods in excepted quantities, in contrast to DOT and USPS regulations, are considered dangerous goods under IATA regulations but are exempt from large portions of the dangerous goods regulations applicable to larger quantities.

1. The United States Postal Service may not be used for international shipping of dangerous goods. All international shipments must be sent using a private courier service (FedEx, UPS or DHL) while adhering to IATA regulations.
2. Class 3 dangerous goods (all packing groups) are acceptable.
3. As above, each inner receptacle may not contain more than 30 ml while the same construction, liquid full and closure security regulations apply.
4. Each inner receptacle must be placed within a securely sealed secondary package.
5. Sufficient cushioning and absorbent material (that will not react chemically with the dangerous goods) must surround each inner receptacle and be capable of absorbing the entire contents of the receptacle.
6. The same package drop and compressive load test regulations as above apply.
7. IATA regulations state that each inner receptacle must be placed within a securely sealed secondary packaging the total contents of which may not exceed 500 ml for Packing Group II liquids and 1 liter for Packing Group III liquids.
8. Labeling—each package must be labeled with the label below (Fig. 1), having minimum dimensions of 100 mm × 100 mm (4 in. × 4 in.). This label must be completed and signed by the packer. The “Nature and Quantity of Goods” section of the air waybill must be completed with the words “Dangerous Goods in Excepted Quantities.”

<b>DANGEROUS GOODS IN EXCEPTED QUANTITIES</b>															
<p><b>This package contains dangerous goods in excepted small quantities and is in all respects in compliance with the applicable international and national government regulations and the IATA Dangerous Goods Regulations</b></p>															
<p>_____</p> <p style="text-align: center;">Signature of Shipper</p>															
<p>_____</p> <p>Title</p>	<p>_____</p> <p>Date</p>														
<p>_____</p> <p>Name and address of Shipper</p>															
<p><b>This package contains substance(s) in Class(es) in Class(es)</b> <b>(check applicable box(es))</b></p>															
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<p>and the applicable UN Numbers are:</p>															

Figure 1. Dangerous goods in excepted quantities label for international shipments.

All three major courier services (FedEx, UPS and DHL) accept dangerous goods in excepted quantities for international delivery<sup>4,5,6</sup> and waive their normal dangerous goods surcharges for packages containing excepted quantities. All three couriers do, however, only accept dangerous goods on a contract or pre-approval basis and will only accept dangerous goods in boxes (no envelopes). FedEx has the added stipulation that the box must measure at least 7 in. × 4 in. × 4 in. All three companies will only ship dangerous goods to approved countries as there are various countries within which they are prohibited from shipping (due in part to these countries not adopting IATA dangerous goods regulations for domestic transport). This means that the courier could deliver a package to the designated international airport but no further. There are also various countries where shipment is allowed but only to certain regions or postal codes. The list of countries to which this applies changes constantly, so the carrier should be contacted for an up-to-date list<sup>4,5,6</sup>. It should also be noted that in some countries, additional customs, veterinary, or fish and wildlife fees may be incurred which will need to be paid by the recipient of the package. The list of these fees and to which countries they apply are not available or, in most cases, unknown to the courier.

It has recently been noted that FedEx has regulations in place against the carrying of “whole dead animals” and that museum specimens fall into this category and are therefore prohibited in FedEx mail. There are various groups working with FedEx to institute exempt status for museum specimens and resolve this impasse.

### TRANSPORT IN PERSONAL BAGGAGE AS CARRY-ON OR CHECKED LUGGAGE

With so many variables and so many different people and organizations to deal with, there are inevitably differences in interpretation of regulations—for these reasons, I do not recommend attempting transporting specimens on board an airplane. In the majority of cases it is easier and safer to send the specimens by courier.

Due to the fact that DOT defines small quantities as non-hazardous, these quantities are allowed in hand and checked baggage on domestic flights but must be declared to the airline staff before boarding. The final decision as to whether or not to accept these packages is made by the pilot of the aircraft being boarded, thus you may be denied permission to carry the package on board at the last minute. Whether or not the package will be allowed on board varies from flight to flight and from airline to airline. Some individuals have suggested simply pouring off the excess liquid preservative before flying but there is no guarantee that this will be acceptable and it has yet to be determined whether removing liquid alcohol from specimens and carrying them “dry” would negate the need to declare these as dangerous.

With the present heightened security measures in force at airports and the policy of no liquids or gels (or limited to 3 oz bottles in a clear quart zip-lock bag depending on which airport you fly through) no specimens in fluid would be allowed as carry-on baggage at all.

Internationally, dangerous goods in any quantity are prohibited as carry-on or checked baggage and cannot be carried on your person or checked onto any international flight (IATA Section 2.7.3).

### NATURAL HISTORY SPECIMENS

In real world collection scenarios, the common practice of wrapping specimens in cheese cloth or gauze moistened with alcohol and sealed in plastic would keep the material from being a dangerous good as long as no more than 30 ml of 70% ethanol was used in each individual package and the heat sealed plastic bags are at least 0.2 mm thick. Each package would need to be placed in secondary packaging material (usually another bag) sealed in the same way and with sufficient absorbent material (vermiculite or 3M absorbent pad) and then placed in an approved box with cushioning material (packing peanuts). Purchasing boxes of various sizes that can be cut down to the appropriate size (available from ULINE) reduces the number of differently sized boxes kept on hand. It is recommended that old boxes not be re-used for shipping specimens, as they may have old labels that cause confusion at mailing facilities. All old labels must be defaced or removed before packing.

Specimens preserved in 3.7% formaldehyde can be shipped in regular mail both domestically and internationally without any dangerous goods requirements.

Tissues can be placed in cryo-vials or glass vials in less than 30 ml of 99% ethanol if the caps are secured with tape or Parafilm, and the vials placed in a secondary heat-sealed plastic bag with absorbent material and packed as described above.

Although it is widely believed that reducing the concentration of the alcohol below 24% renders specimens outside of the scope of dangerous goods regulations, from Tables 1 and 2 this is clearly not the case. Even at concentrations of 10%, both ethanol and isopropanol fall within the bounds of Packing Group III (flash points greater than 23°C and less than 60°C). The confusion stems from passages in the IATA regulations (Section 2.3) pertaining to beverage alcohol which state that “alcoholic beverages containing 24% or less alcohol by volume are not subject to any restrictions.” This

Table 1. Flash points of ethanol based water solutions.

	Conc. (% by volume)										
	0	10	20	30	40	50	60	70	80	90	100
Temperature (°F)	—	135	105	90	80	80	80	80	75	65	55
(°C)	—	57	41	32	27	27	27	27	24	18	13
Packing Group	PG III									PG II	

regulation only pertains to beverage alcohol in retail packaging and cannot be used for natural history specimens.

It has also been suggested that fluid preserved specimens may be placed in water for shipment. Although this may put specimens outside of the scope of dangerous goods regulations, the possibility of damage to specimens from swelling and subsequent shrinkage upon reinsertion into alcohol, cell wall rupture, mold, and bacterial growth will severely endanger the specimens, particularly if the shipment is delayed.

#### PROBLEMS AND CONCERNS

These two scenarios cover the majority of all natural history dangerous goods shipments but there are still some areas of concern or where problems still exist:

1. Large specimens that require more than 30 ml to adequately moisten the specimen for transport must be packaged as regular dangerous goods (not excepted/small quantities) and are subject to the more restrictive regulations, labeling and paperwork of such shipments.
2. Specimens may not be sent to countries that do not accept dangerous goods. At present there is no solution to this problem.
3. Specimens may not be carried internationally as carry-on or checked baggage due to dangerous goods restrictions. As discussed above, it has yet to be determined whether specimens can be drained of alcohol thereby negating the need to declare them as dangerous goods.
4. Specimens sent on loan to researchers who have not had the necessary training to repack and return the material (or have no access to a certified packer) once they have completed their study can also pose a problem. This is especially pertinent for international shipments as regulations and training requirements differ between countries.
5. According to the regulations, packages entering the USPS postal system (whether sent as loan, gift or exchange) by international institutions and packed by untrained staff should be refused and returned to the sender. To do this would expose the specimens to the vagaries of the international postal system a second time, which would also

Table 2. Flash points of isopropanol based water solutions.

	Conc. (% by volume)										
	0	10	20	30	40	50	60	70	80	90	100
Temperature (°F)	—	105	85	75	70	65	65	65	65	65	53
(°C)	—	41	29	24	21	18	18	18	18	18	12
Packing Group	PG III						PG II				

expose the postal system to an illegal package a second time that may not have been packaged correctly or may be leaking fluid.

It is important to remember that dangerous goods regulations are not written to specifically address the shipment of natural history specimens. This is a shortcoming that would ideally be addressed through the planning of a meeting at which all of these issues will be discussed with representatives of all involved parties—ICAO, IATA, DOT, USPS, FedEx, UPS and DHL. This author has been working in conjunction with the Society for the Preservation of Natural History Collections (SPNHC) and the American Society of Ichthyologists and Herpetologists (ASIH) to put together such a meeting. However, even if legislation is written specifically for natural history specimens, it would take five to six years to take effect. Clearly, a short term solution to these problems is necessary and this author will be working to achieve this, keeping the museum community updated on any progress made.

#### LITERATURE CITED

- <sup>1</sup> US Department of Transportation. 2007. Title 49 CFR, Subtitle B, Chapter 1, Subchapter C: Hazardous materials regulations.  
US Department of Transportation (DOT). [http://www.access.gpo.gov/nara/cfr/waisidx\\_99/49cfrv2\\_99.html](http://www.access.gpo.gov/nara/cfr/waisidx_99/49cfrv2_99.html)
- <sup>2</sup> United States Postal Service. 1999. Publication 52: Hazardous, Restricted, and Perishable Mail. Part 3: Hazardous Materials. Pp. 15–60. <http://www.usps.com/cpim/ftp/pubs/pub52.pdf>
- <sup>3</sup> International Air Transport Association. 2007. IATA Dangerous Goods Regulations, 48<sup>th</sup> ed. Section 2—Limitations Pp. 9–80.
- <sup>4</sup> FedEx Dangerous goods shipping website: <http://www.FedEx.com/us/services/options/express/dangerousgoods/hidden.html>  
FedEx Dangerous Goods/Hazardous Materials Hotline: 1-800-463-3339.
- <sup>5</sup> UPS dangerous goods shipping website: <http://www.ups.com/content/us/en/resources/prepare/idg/information/definition.html>  
UPS Hazardous Materials Support Center: 1-800-554-9964.
- <sup>6</sup> DHL dangerous goods shipping website: <http://www.dhl-usa.com/usgov/servopt>  
DHL Hazardous Materials Hotline: 1-866-588-2002.