



AEROSPACE INFORMATION REPORT

AIR1600™

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Animal Environment in Cargo Compartments

RATIONALE

AIR1600A has been reaffirmed to comply with the SAE five-year review policy.

FOREWORD

Changes in this revision are format/editorial only.

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1. SCOPE:

The environmental factors of prime importance in the transport of animals in aircraft are air temperature, humidity and carbon dioxide concentration, and of course space (or volume) limitations.

Secondary factors are air velocity, noise, lighting, etc. Pressure is not addressed herein as pressure levels and rates of change are totally dictated by human occupancy requirements.

Some basic governmental documents, such as References 1, 2 and 3, define overall requirements for animal transportation, but with very limited data on environmental requirements. Reference 4 gives some airplane characteristics measured during animal transportation from the USA to foreign destinations. Temperature and humidity profiles are indicative of airplane characteristics.

This report presents information on the temperature, humidity, ventilation, and carbon dioxide limitations and the metabolic heat release rates for animals which will allow the determination of the environment required by the animals. Design features of ventilated and nonventilated cargo compartments are presented. Methods of calculation of the temperature, humidity, and carbon dioxide environment are provided that will allow for the determination of the animal capacities of animal carrying cargo compartments. Animals are being carried in the lower cargo compartments on passenger carrying aircraft which are only provided with coarse temperature control. These compartments provide a very satisfactory environment for most animals if knowledge of the animal's requirements are matched with the compartment's capability to produce that environment.

It should be noted that although animal is the definition of cargo being considered, data is also provided for birds.

1.1 Purpose:

The purpose of this AIR is to provide information on the environmental conditions that are required for the transportation of animals in the lower cargo compartments of passenger carrying aircraft. The intent is to provide guidelines to aircraft manufacturers, and background information to air carriers, that will assist in defining suitable animal carrying environments, and which will supplement good judgement and previous experience.

Values and units are given in both U.S. Customary and SI units.

2. REFERENCES:

1. Code of Federal Regulations, Title 9 - Animals and Animal Products, Chapter 1, Subchapter A - Animal Welfare
2. IATA Live Animal Regulations, 11th Edition, January, 1984
3. FAA Order 8110.29A, Cargo Compartment Requirements for Air Shipment of Livestock, April 11, 1979
4. USDA Report, "Environmental Conditions on Air Shipment of Livestock" AAT-NE-5, dated February, 1979
5. Internal Temperatures of Chick Shipping Boxes as Influenced by Environmental Temperatures. Poultry Science, Vol. XXIX No. 2, March, 1950, Wilbur O. Wilson
6. Livestock Trucking Guide, Livestock Conservation Institute, South St. Paul
7. Boeing Commercial Airplane Company Brochure, D6-46286. "Animal Passengers in the Boeing 727 Lower Compartments"
8. ASAE Paper Number 77-4523, "Air Transport of Livestock - Environmental Needs", 1977 Winter Meeting December 13-16, 1977
9. APHIS report 91-21, "Environmental Considerations for Shipment of Livestock by Air Freight" dated May, 1974
10. Energy and Gaseous Metabolism of the Chicken from Hatch to Maturity as affected by Temperature. J. Nutrition Volume 31, pages 35 to 50, 1946, Barott and Pringle.
11. SAE Aerospace Applied Thermodynamics Manual ARP1168, 2nd Edition, October 1969, page 110, EQ (ID-11b)
12. FAR 25.857, Cargo Compartment Classification

3. LIMITATIONS FOR VARIOUS ANIMALS:

This section discusses limitations of temperature, humidity, effective temperature, carbon dioxide, air velocity, noise and lighting. It should be noted that Reference 1 includes requirements for the welfare of animals, including transportation. Section 3.1 discusses the Reference 1 limitations on temperature, however familiarization with other aspects is also appropriate.

3.1 Temperature:

Temperature limitations are reviewed in this section as related to steady state limits and also as related to transients. Most available data is related to steady state.

- 3.1.1 Steady State: As a general rule, animals are reasonably comfortable at the same air temperatures as are humans. In determining the air temperature surrounding the animals one must consider the difference in temperature between inside and outside the container.

It has been observed that, when a number of animals are shipped in one container, as is the case for baby chicks, conditions within the container can be quite different from those of the surroundings. This is shown in Figure 1, which uses data from Reference 5. Such increases in temperature, as well as the increase in humidity within the shipping container, must be considered when evaluating the environment surrounding the animal. For example, if the temperature in the baby chick carton exceeds approximately 104 °F (40 °C) the potential for death due to overheat is very high. Baby turkeys have been observed to die if the temperature in the carton exceeds 95 °F (35 °C) for more than 10 minutes.

Information published in the Code of Federal Regulations (Reference 1) includes some limits that are not to be exceeded outside the primary enclosure at "terminal facilities". The requirements for the following animals include an 85 °F (29.4 °C) maximum and 45 °F (7 °C) minimum (see also section 3.1.2). These limits may be exceeded, with prior acclimatization, except for guinea pigs and hamsters. For these two animals the limits given in this AIR are more restrictive.

Dogs and cats
Guinea pigs and hamsters
Rabbits
Non-human Primates

Generally recognized temperature limits for various animals are included in Table 1. These are more detailed than provided by Reference 1. The Table 1 temperatures are acceptable in "normal" humidity levels of 40 to 60% RH. Higher humidity must be allowed for as discussed in section 3.3. The values given in Table 1 should be used with checks as necessary of the latest version of Reference 1.

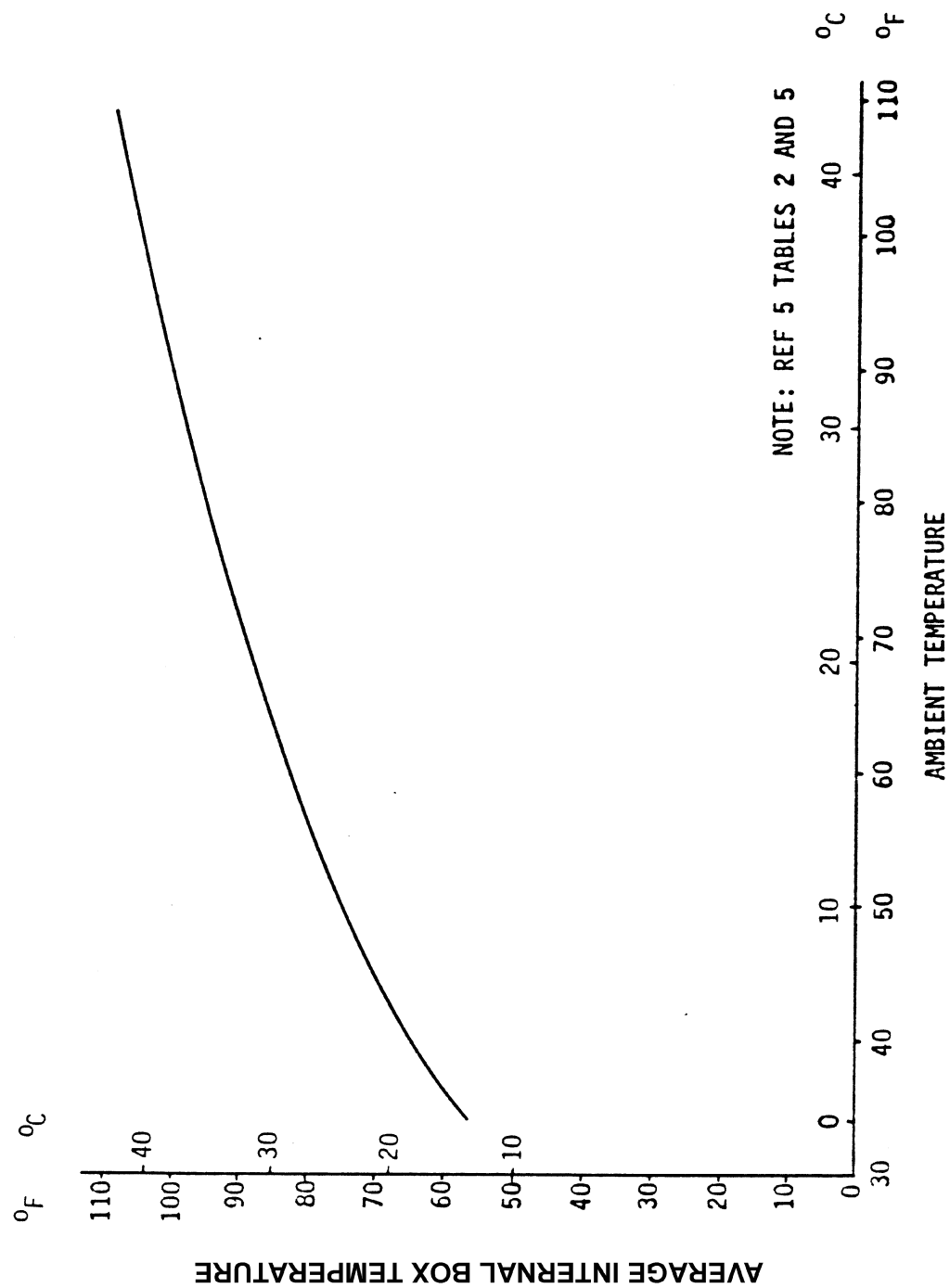


FIGURE 1 - Internal Chick Box Temperature as a Function of Ambient Temperature

TABLE 1 - Animal Temperature Limits

Animal	Temperature Limits °F	Temperature Limits °C
Ape	45 - 95	7 - 35
Badger	35 - 85	2 - 29
Bear (young)	35 - 85	2 - 29
Beaver	35 - 85	2 - 29
Birds	65 - 95	18 - 35
Bobcat	50 - 80	10 - 27
Bulldog	50 - 95	10 - 35
Canary	65 - 85	18 - 29
Capuchin monkey		
Adult	65 - 95	18 - 35
Infant	80 - 90	27 - 32
Cat	50 - 80	10 - 27
Cheetah	65 - 95	18 - 35
Chicken	60 - 90	16 - 32
Chick (baby)	70 - 85*	21 - 29*
Chimpanzee	65 - 95	18 - 35
Chinchilla	40 - 80	4 - 27
Civet	55 - 80	13 - 27
Cougar (puma)	40 - 80	4 - 27
Coyote	35 - 85	2 - 29
Dingo	45 - 85	7 - 29
Dog		
Long hair	40 - 85	4 - 29
Short hair	50 - 95	10 - 35
Dove	65 - 90	18 - 32
Duck	60 - 90	16 - 32
Duckling	70 - 85*	21 - 29*
Eagle	60 - 80	16 - 27
Ermine	45 - 85	7 - 29
Falcon	60 - 80	16 - 27
Ferret	45 - 85	7 - 29
Finch	65 - 85	18 - 29

TABLE 1 - Animal Temperature Limits (Continued)

Animal	Temperature Limits °F	Temperature Limits °C
Fox	40 - 80	4 - 27
Gazelle	65 - 85	18 - 29
Gerbil	55 - 85	13 - 29
German shepherd	40 - 85	4 - 29
Goose	60 - 90	16 - 32
Gosling	70 - 85*	21 - 29*
Great Dane	45 - 95	7 - 35
Green monkey		
Adult	65 - 95	18 - 35
Infant	80 - 90	27 - 32
Guinea pig	45 - 80	7 - 27
Hamster	50 - 85	10 - 29
Hawk	60 - 80	16 - 27
Hornbill	60 - 80	16 - 27
Hummingbird	65 - 95	18 - 35
Hunting dog	40 - 85	4 - 29
Hyena	45 - 85	7 - 29
Jaguar	65 - 95	18 - 35
Jay	65 - 85	18 - 29
Jerboa	55 - 90	13 - 32
Lemur monkey		
Adult	65 - 95	18 - 35
Infant	80 - 90	27 - 32
Leopard	65 - 85	18 - 29
Lion	65 - 85	18 - 29
Lynx	60 - 80	16 - 27
Magpie	65 - 85	18 - 29
Manx	50 - 80	10 - 27
Marmoset monkey		
Adult	65 - 95	18 - 35
Infant	80 - 90	27 - 32
Marmot	40 - 80	4 - 27
Marten	40 - 80	4 - 27
Mink	40 - 80	4 - 27
Mouse	55 - 90	13 - 32
Muskrat	40 - 80	4 - 27

TABLE 1 - Animal Temperature Limits (Continued)

Animal	Temperature Limits °F	Temperature Limits °C
Mynah	65 - 85	18 - 29
Ocelot	65 - 95	18 - 35
Opossum	55 - 90	13 - 32
Orangutang	70 - 95	21 - 35
Otter	40 - 80	4 - 27
Owl	60 - 80	16 - 27
Parrot	65 - 90	18 - 32
Peafowl	60 - 80	16 - 27
Pheasant	65 - 95	18 - 35
Pigeon	65 - 85	18 - 29
Polecat	45 - 85	7 - 29
Poodle	50 - 85	10 - 29
Porcupine	40 - 80	4 - 27
Pug	50 - 95	10 - 35
Quail	65 - 85	18 - 29
Rabbit	35 - 85	2 - 29
Raccoon	40 - 80	4 - 27
Rhesus monkey		
Adult	65 - 95	18 - 35
Infant	80 - 90	27 - 32
Rodent	55 - 85	13 - 29
Sable	40 - 80	4 - 27
Sandpiper	65 - 85	18 - 29
Shrew	55 - 85	13 - 29
Spider monkey		
Adult	65 - 95	18 - 35
Infant	80 - 90	27 - 32
Squirrel	45 - 85	7 - 29
St. Bernard	35 - 85	2 - 29
Standard poodle	45 - 85	7 - 29
Terrier	50 - 95	10 - 35
Turkey	60 - 80	16 - 27
Turkey poult	70 - 85*	21 - 29*
Vicuna	50 - 80	10 - 27
Waxbill	65 - 85	18 - 29
Weasel	40 - 80	4 - 27

TABLE 1 - Animal Temperature Limits (Continued)

Animal	Temperature Limits °F	Temperature Limits °C
Wild dog	45 - 85	7 - 29
Wolf	35 - 85	2 - 29
Wolverine	35 - 85	2 - 29

*This is compartment temperature. Temperature within the carton will be 90 - 100 °F (32 - 38 °C).

With correct packaging, the above animal requirements represent compartment limits.

- 3.1.2 Transients: As is implied by the Department of Agriculture in Reference 1, transient excursions beyond the limits set are acceptable. Of course the magnitude must be limited. For Reference 1 animals (see section 3.1.1), an excursion above 85 °F (29.4 °C) or below 45 °F (7.2 °C) is required by Reference 1 to be limited to 45 minutes.

The Livestock Conservation Institute has published information on a Livestock Weather Safety Index for use by the trucking industry, Reference 6 (See Figure 2). Reference 6 data is directed at transportation of cattle, sheep and hogs, whereas this AIR is primarily directed at smaller animals. However, the data is of use for comparison. Reference 6 recommends delay in shipment if the conditions in the "Emergency" region are predicted for the transportation time period.

Animals transported by air encounter a different exposure than do those transported by truck. Aboard the truck, they are generally exposed to the severe environment for the entire period of confinement on the vehicle. On the airplane, the situation is different in that the severe conditions exist with the airplane on the ground or at low altitude.

Transient conditions, primarily involving excitement during loading, are allowed for by the inclusion of excitement factors in Section 4, Metabolic Heat Rates.

With additional risk of animal loss, acceptable transient temperature could be revised by approximately 6 °F (3.3 °C) as indicated by translation from the ALERT/DANGER boundary of Figure 2 to the DANGER/EMERGENCY boundary.