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**Environmental Considerations
For Shipment
of Livestock by Air Freight**

**Animal and Plant Health Inspection Service
in Cooperation with
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UNITED STATES DEPARTMENT OF AGRICULTURE**

CONTENTS

	<i>Page</i>
Flight phases	1
Stress	2
Air temperature	2
Air movement	2
Barometric pressure	2
Ventilation rate	2
Air quality	3
Other physiological considerations	5
References	5

24
200

ENVIRONMENTAL CONSIDERATIONS FOR SHIPMENT OF LIVESTOCK BY AIR FREIGHT

by

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In the past few years, the number of livestock that have been shipped by air freight has increased tremendously. Guidelines are needed on the range of environmental conditions in which livestock can be safely shipped. The problems with providing suitable conditions are similar to those encountered in human transportation; but they are greatly multiplied due to the greater heat production per animal, proportions of latent heat (evaporative) to total heat, and management factors

encountered when shipping livestock. The animals produce large quantities of heat and metabolic by-products which must be removed from the aircraft by ventilation and refrigeration to maintain acceptable conditions. The environmental factors which must be controlled to provide a healthy climate are: Air temperature, humidity, air movement, air quality, and barometric pressure. All of these factors are interrelated as to their control and their effect on the well being of the animals.

FLIGHT PHASES

The air freight shipment can be divided into three phases:

1. Loading, unloading and refueling; that is, when the plane is sitting with the engines turned off
2. Taxiing; that is, when the engines are running but the air conditioning system is not working at peak efficiency
3. In flight; that is, all air conditioning and ventilation systems are running.

Each of the phases requires separate consideration when trying to control the environment in the cabin.

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When loading, unloading and refueling, temperature control inside the cabin is provided by ground units. If the capacity of these units is inadequate, exhaust fans must be installed in the rear door of the cabin so outside air can be pulled through the entire cabin.

While taxiing, if the air conditioning and ventilation systems are inadequate to maintain desirable conditions inside the cabin, auxiliary exhaust fans must be used or all doors must be opened to provide the maximum amount of fresh air to the animals.

In flight, when the air conditioning system is working at peak efficiency, it should be sufficient to maintain the temperature and relative humidity in the cabin within the acceptable range for a proper load of animals.

STRESS

The stress under which the animal is placed has an effect upon his tolerance to shipment. Interactions serve to compress acceptable ranges of stress factors. Therefore, stress of any kind should be minimized so the animals will remain healthy during the shipment and after delivery. The types of stress factors that should be reduced to a minimum are:

1. Temperature (excesses, fluctuations, thermal shock)
2. Humidity (excesses, fluctuations)
3. Noise
4. Vibration
5. Water deprivation
6. Dust
7. Odors
8. Carbon dioxide and ammonia buildup
9. Air-pressure fluctuations
10. Handling
11. Fatigue

All of these stress factors combine to weaken the animal and make it more susceptible to disease and death. To reduce stresses caused by water deprivation, handling, and fatigue, holding pens should be provided at the departure and arrival terminals to allow the animals to be fed, watered, and rested before they are loaded and after they are unloaded from the aircraft. Water deprivation should not exceed 36 hours for mature animals and 24 hours for young animals.

Air Temperature

In pressurized cabins, air temperature is the most important design criterion. Table 1 shows the recommended temperature ranges for shipment of livestock.

Animal heat is dissipated into the surrounding air in proportions of sensible and latent (evaporative) heat that depend upon the air temperature. As the cabin temperature approaches the body temperature of the animal, the amount of sensible heat given off approaches zero, and evaporation is the only means by which the animal can dissipate heat. Figures 1 and 2 provide technical data on these relationships in graphic form.

Humidity

Humidity levels must be controlled at moderate levels to allow the animals to dissipate heat through evapora-

tion and to minimize moisture condensation on the interior walls of the aircraft. High humidity combined with high temperatures becomes a lethal combination. Generally, a desirable range of humidity level for all animals is between 40 and 60 percent relative humidity (RH), with acceptable limits of 10 percent RH above or below that range.

Air Movement

The movement of air in the cargo area must be such that adequate circulation is provided *within the containers* for all animals. An air velocity of at least 40 feet per minute (20 cm/sec) at the animal's surface must be provided in order to move the heated and vapor-laden air away from the animals.

Barometric Pressure

At sea level, the barometric pressure is about 76 mm Hg, and the oxygen tension is about 159 mm Hg. The oxygen tension is reduced to about 101 mm Hg at 12,000 feet. This amount is the minimum that can be tolerated by the animals without oxygen starvation. Therefore, at elevations above 12,000 feet, the cabin must be pressurized (3).⁴ The acceptable cabin pressurization level is below 8,000 feet.

Ventilation Rate

The ventilation rate, i.e., fresh air supplied from outside, must be sufficient to provide adequate:

1. Oxygen
2. Odor removal
3. Heat removal
4. Water vapor removal

The amount of fresh air will usually be controlled by either the amount of sensible heat or water vapor removal required and the temperature and relative humidity of the incoming air. The lower limit is set by the oxygen requirements of the animals. Figures 1 and 2 give data on the heat production of livestock that are needed to determine the ventilation rate required for heat and vapor removal, and Table 1 gives the minimum ventilation rate that will provide for oxygen requirements.

⁴Italicized numbers in parentheses refer to references at end of report.

For on-ground situations, outside air can often be used to maintain desirable conditions when adequate cooling is unavailable. The recommended ventilation rates for use when supplying air from outside only are as follows (4):

	Winter	Summer
Hogs	10 cfm/100 lb. body wt.	50 cfm/100 lb. body wt.
Dairy	75 cfm/1000 lb. body wt.	600 cfm/1000 lb. body wt.

Air Quality

The buildup of metabolic byproducts in the form of carbon dioxide and ammonia must be considered when enclosing livestock in an airtight structure. They are not

a problem while the aircraft is in flight, because the normal ventilation is more than adequate to remove the carbon dioxide and ammonia from the cabin.

Ammonia concentrations below 20 ppm are not harmful to livestock. This concentration is just above the level that can be sensed by humans. Therefore, when the odor of ammonia can be sensed by the flight crew, it is an indication that corrective measures should be taken.

A carbon dioxide concentration above 5 percent by volume is approaching the lethal level. Figure 3 gives the carbon dioxide productions for swine, cattle, and horses. The maximum time that the cabin can be without ventilation can be calculated from the data for the specific animal. However, temperature and other considerations usually govern.

Table 1.—Recommended environmental ranges for shipment of livestock

Animal	Acceptable temperature range	Maximum temperature ¹	Minimum ventilation rate	Temperature ² differential
Dairy cow, mature, Dry . . .	40-80° F.	90° F.	50 cfm/1,000 lb. body wt.	30° F.
Dairy heifer, pregnant	40-75° F.	85° F.	50 cfm/1,000 lb. body wt.	30° F.
Hogs				
Over 15 lb.	50-75° F.	85° F.	15 cfm/animal	20° F.
Pregnant gilts	50-70° F.	80° F.	15 cfm/animal	15° F.
Dairy calves	50-75° F.	85° F.	10 cfm/100 lb. body wt.	20° F.
Sheep	50-75° F.	85° F.	100 cfm/100 lb. body wt.	30° F.
Poultry				
Over 10 days	50-80° F.	85° F.	0.75 cfm/bird	20° F.
Day old (unfed)	90-100° F.	90° F.	2 cfm/100 birds	10° F.
Horses	40-80° F.	90° F.	50 cfm/1,000 lb. body wt.	30° F.
Beef	40-80° F.	90° F.	50 cfm/1,000 lb. body wt.	30° F.

¹ Acceptable for short duration (not to exceed 1 hour and only when relative humidity is low to moderate [less than 50%]).

² Difference between the maximum and minimum temperature to which animal is exposed during loading for departure and unloading at destination.

³ Inside box temperature. Cabin temperature of 70-85° F. will usually provide such conditions.

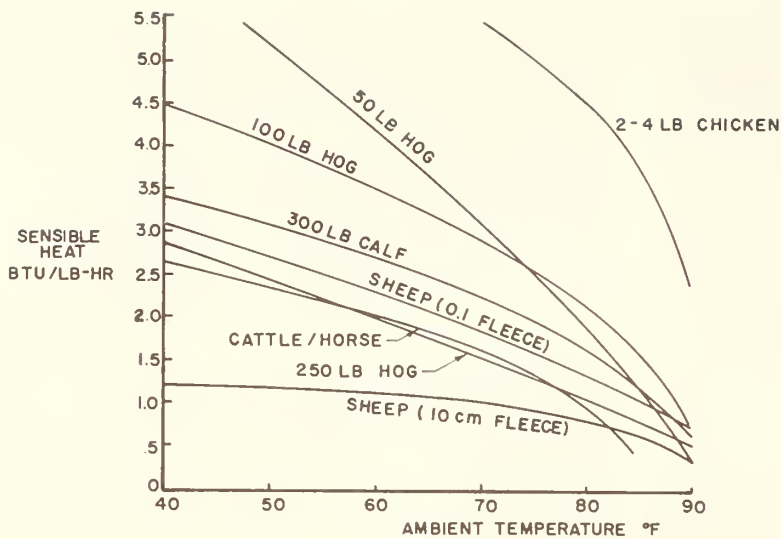


Figure 1.—Sensible heat production: Calves (8), Sheep (1), Chickens (6), Swine (2), and Cattle (9).

Figure 2.—Latent heat production: Calves (8), Sheep (1), Chickens (6), Swine (2), and Cattle (9).

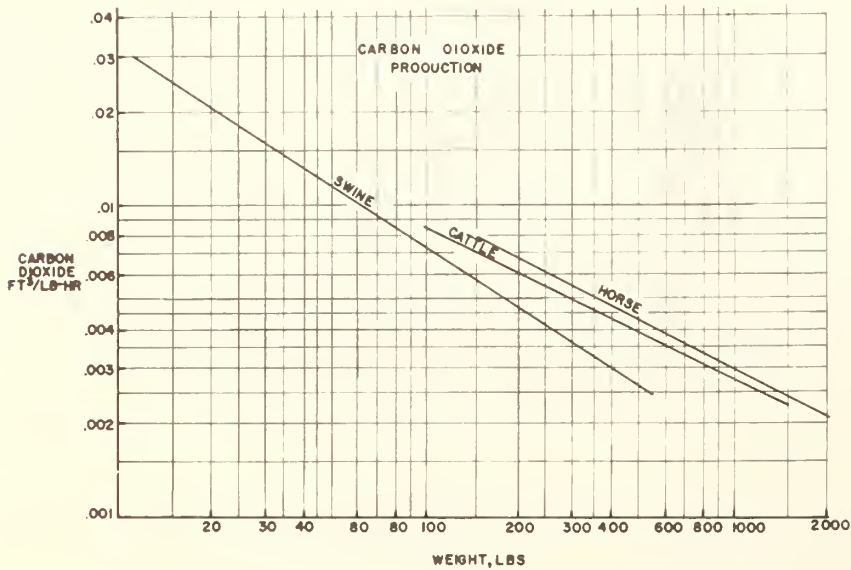
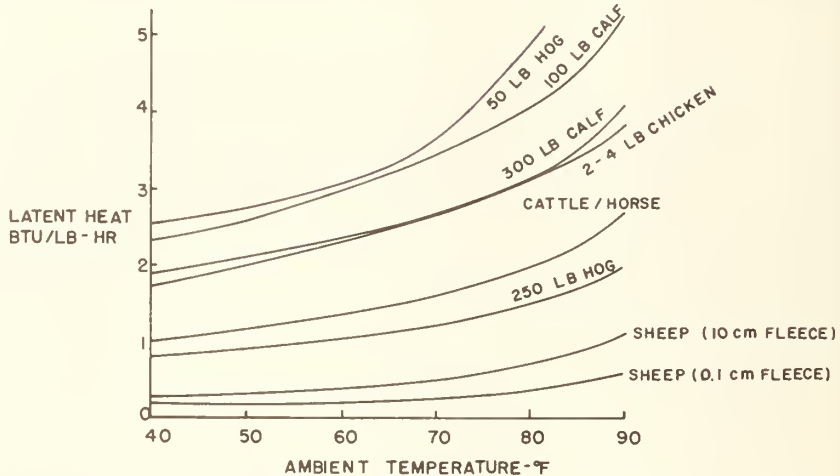


Figure 3.—Carbon dioxide production (7).

OTHER PHYSIOLOGICAL CONSIDERATIONS

Other physiological factors that must be considered when shipping livestock are thermal shock and acclimation. Thermal shock can occur when the animal's environment is changed from a high temperature to a low temperature, or vice versa; for example, when an animal is moved from a very warm temperature in the cargo area to a very cold temperature outside; any acute change in environmental conditions should be avoided as much as possible. Sudden exposure to a very cold environment in chilling can cause pneumonia and other respiratory problems, especially in young animals.

Acclimation, the physiological adjustment of an animal to its environment, must be considered when selecting the temperature and relative humidity inside the cabin. When an animal is acclimated to one set of climatic conditions and is moved to another set, the stress placed upon the animal is proportional to the climatic change. Therefore, the cabin conditions when the animal is loaded should approach the climatic conditions from which the animal is being moved, without going outside the acceptable range. Then the conditions should be gradually adjusted during the flight to the conditions that will be encountered upon arrival at destination.

REFERENCES

1. Blaxter, K. L., Graham, McC. N., and Wainman, F. W. Environmental Temperature, Energy Metabolism and Heat Regulation in Sheep. III. The Metabolism and Thermal Exchanges of Sheep with Fleeces. 1959. *Journal of Agric. Sci.* 52:41-49.
2. Bond, T. E., Kelly, C. F. and Heitman, H., Jr. Effect of Diurnal Temperature Upon Swine Heat Loss and Well Being. 1963. *Trans. of the ASAE* 6:132-135.
3. Brewer, N. R., Some Physiological Considerations in the Transportation of Animals by Air. Unpublished manuscript.
4. Lytle, Esmay and Muehling. *Farm Builders Handbook*. 1969. Structures Publishing Co., 32580 Grand River Ave., Farmington, Mich. 48024.
5. Midwest Plan Service, Structure and Environment Handbook. 1973. Iowa State University, Ames, Iowa.
6. Ota, H. and McNally, E. H. Calorimetric Studies of Broilers. 1966. Proc. of the 4th Internatl. Jour. of Biometeorology. Rutgers Univ.
7. Spector, W. S. Handbook of Biological Data. 1956. W. B. Saunders Co., Philadelphia, Pa.
8. Yeck, R. G., Stable Heat and Moisture Dissipation With Beef Calves at Temperatures of 50° and 80° F. 1957. Mo. Agr. Expt. Sta. Bul. 645.
9. Yeck, R. G. and Stewart, R. E. A Ten-Year Summary of the Psychroenergetic Laboratory of Dairy Cattle Research at the University of Missouri. 1959. *Trans. of the ASAE* 2:71-77.

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