The National Greenhouse Manufacturers Association

Heat Loss Guideline

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Foreword, Energy Balance, Transmission & Infiltration Losses & Design Temperatures

FOREWORD

These standards as published here present factors involved in the determination of overall heat loss from a greenhouse and are based on the values of properties of materials used in greenhouse construction and glazing as determined by recognized tests and published values by the various manufacturers. These standards are not intended to present the method of application rather the method of application is the responsibility of the design engineer.

ENERGY BALANCE

A complete energy balance includes solar, transmission exchange, ventilation loss, infiltration loss, ground interchange, plant biological activity interchange, reradiation to the sky, heat generated by workers and equipment and heat furnished by the heating system. However, since design loads are calculated under the most stringent conditions, which occur in the winter at night during early morning hours many of these factors are not considered.

Ground interchange is minimal, because the ground temperature has stabilized near the air temperature during the heating season. Biological plant activity is low. Solar energy and ventilation are not involved. Normally, workers are not in the area using lights or other equipment. This leaves only the heating system operating. Reradiation, primarily in the long wave infrared range, will vary because the difference in opacity to this radiation by the different materials, and is therefore considered in the heat transmission coefficients given for the various glazing materials. The design load then simplifies to the amount of heat required to offset the heat transmission loss through the shell of the structure and that lost by infiltration's.

TRANSMISSION LOSSES

Heat transmission loss through any exposed surface is expressed by the formula: $Q = UA (T_i - T_o)$, where Q is the design heat loss in BTU per hour, U is the overall heat transmission coefficient in BTU/hr/Sq Ft/°F Temperature Difference, A is exposed area in square feet, and T_i and T_o are inside and outside design temperatures respectively.

Since many greenhouses have curtain walls of different material than the glazing material these two should be considered separately. U values for the more commonly used glazing materials and curtain materials are given in Table 1. These are only recommended values and the manufacturer should be consulted for the specific materials.

Glazing materials require some type of framework to hold them in place and present day construction utilizes metal, primarily aluminum. To accommodate this difference it is recommended to multiply the U value of the glazing material by a construction factor, C, to take into account exposure through ridges, glazing bars, eaves, gutters and sash framing. Recommended values for construction factors are given in Table 2.

INFILTRATION LOSSES

Heat loss calculations are commonly based on winds not exceeding 15 mph. Higher velocity winds will increase the loss, so in areas where consistent winds exceed this figure the transmission losses should be increased by a wind factor. Recommended wind factors are given in Table 3.

Infiltration losses are calculated by the formula: $Q = 0.018NV (T_i - T_o)$, where N is the expected number of design air changes per hour and V is the inside volume of the greenhouse in cubic feet. Values for expected air changes per hour, N, for different types of construction are given in Table 4.

DESIGN TEMPERATURES

Recommended design outside temperatures can be obtained from the ASHRAE Guide or other climactic data. If the guide is used, the 97 1/2% winter dry bulb is common practice.

Inside design temperatures will vary considerably depending on the crop grown, the variety of that crop and the stage of growth of that crop. The owner or user should supply information on the desired inside temperature to be maintained. Recommendations may also be obtained from the horticulture departments of colleges or other research institutes, either through their research department or extension services.

GENERAL

To assist in calculating areas, dimensions and areas for portions of arch construction are shown in Table 5 and for gable greenhouses in Table 6. Reduced heat loss values are not considered for structures with heat curtains, since even though these curtains do reduce the heat loss it is common practice to open these curtains in the winter during snow storms to reduce the snow accumulation on the roof.

TABLE I

SUGGESTED HEAT TRANSMISSION COEFFICIENTS (U)

Glass, single	1.13
Glass, double glazing	0.70
Glass, insulating	Mfrs. Data
*Single film plastic	1.20
Double film plastic, inflated	0.70
Single plastic film over glass	0.85
Double plastic film over glass	0.60
Corrugated FRP panels	1.20
**Plastic Structured sheet (winter):	
16 mm thick	0.58
8 mm	0.65
6 mm	0.72

Wall Materials

Corrugated Cement Asbestos Board	1.15
Concrete, 4 inch	0.78
Concrete, 8 inch	0.58
Concrete Block, 4 inch	0.64
Concrete Block, 8 inch	0.51
Insulated Panels	Mfrs. Data

*There is some evidence that newer infrared polyethylene films reduce heat loss; however the industry feels that for a factor of safety, make no reduction.

**Plastic Structured Sheet is the name common to the industry for double-skin rigid plastic materials.

TABLE 2

CONSTRUCTION FACTORS

Metal frame & glazing system 16-24 inch spacing	1.08
Metal frame & glazing system 48 inch spacing	.05
Fiberglass on metal frame	1.03
Film plastic on metal frame	1.02
Film or fiberglass on wood	1.00

TABLE 3

WIND FACTOR (W)

Wind Velocity, mph	Factor (W)
15	1.00
20	1.04
25	1.08
30	1.12
35	1.16

TABLE 4

SUGGESTED DESIGN AIR CHANGES (N)

New Construction	
Single glass lapped-unsealed	1.25
Single glass lapped-laps sealed	1.00
Plastic film covered	0.60-1.00
Structured sheet	1.00
Film plastic over glass	0.90
Old Construction	
Good Maintenance	1.50
Poor Maintenance	2.00-4.00

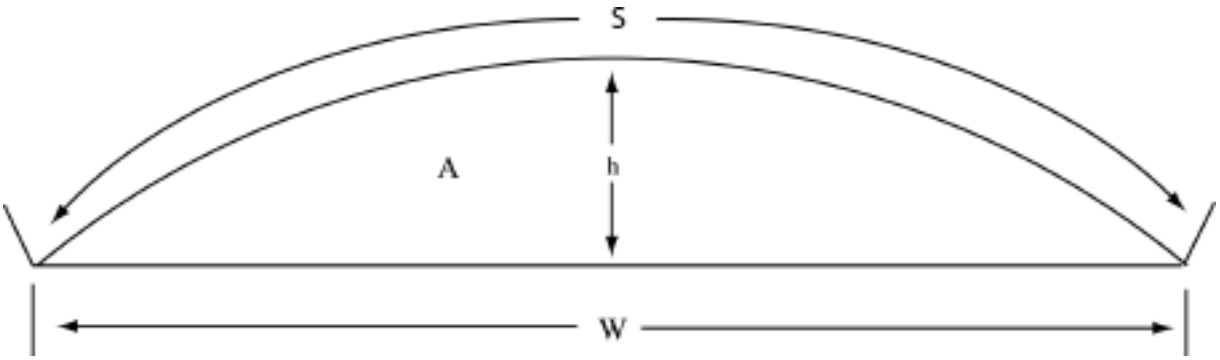

Table 5. Distance over and area of gables for commonly available arch type houses.

	Area (A)						Distance Over (s)					
	← h →						← h →					
W	3	4	5	6	8	10	3	4	5	6	8	10
22	45	60	76	93			23.1	23.9	24.9	26.1		
24	46	65	83	101			25.0	25.7	26.7	27.8		
26	53	71	89	108			26.9	27.6	28.5	29.5		
28	57	76	96	116			28.8	29.5	30.3	31.3		
30	60	81	102	124	169	217	30.8	31.4	32.2	33.1	35.4	38.2
32	65	86	109	132	179	229	32.7	33.3	34.0	34.9	37.1	39.8
34				139	189	242				36.8	38.8	41.4
36				147	199	254				38.6	40.6	43.0
40				163	220	280				42.4	44.1	46.4
42				171	230	292				44.2	46.0	48.1

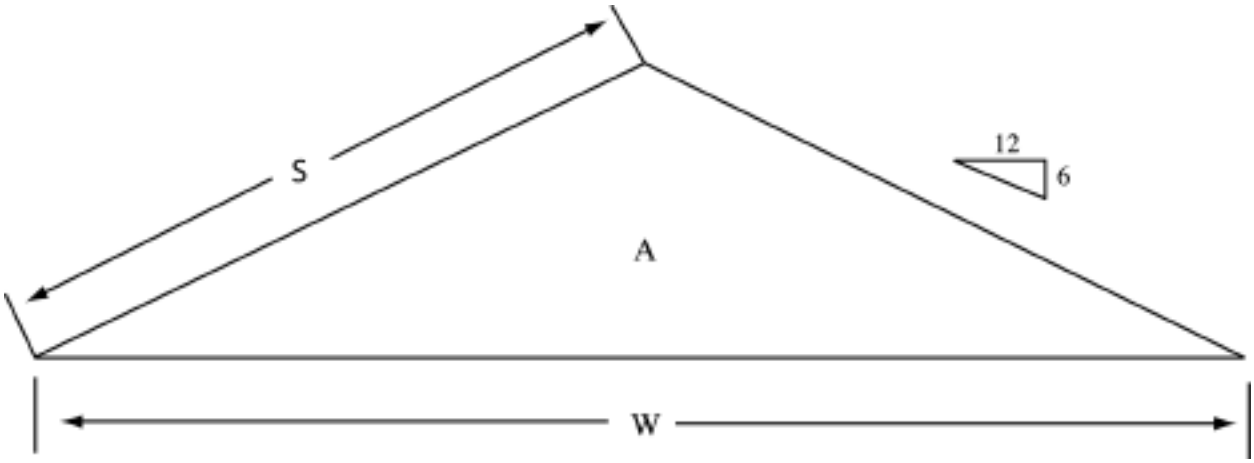

Table 6. Slope distance and area of gables for gable type houses with 6/12 pitch.

	Width (W)							
	18	21	25	28	32	36	42	50
s	10.1	11.7	14.0	15.7	17.9	20.1	23.5	28.0
A	41	55	78	98	128	162	221	313

NATIONAL GREENHOUSE MANUFACTURERS ASSOCIATION
STATEMENT OF POLICY GREENHOUSE RETROFIT

Adopted April 15,1983

Although the adoption of an industry wide standard applicable to all the various methods and systems of retrofit or renovation of existing greenhouses is not considered at this time, the National Greenhouse Manufacturers Association does make the following statement of policy with regard to the responsibility of and relationship between the owner and the contractor.

The National Greenhouse Manufacturers Association does subscribe to the policy that the contractor has the responsibility of bringing to the attention of the owner the question regarding the structural integrity of the existing framework and its capability to withstand loads that may be applied as the result of application of any new glazing system or other rework. The contractor may suggest an engineering analysis and, if necessary, furnish and install structural supports to accomplish the requirements as determined by the analysis.

If the above course of action is not acceptable to the owner the contractor should advise him that the owner is accepting for himself the responsibility and liability for any future failures that might occur as a result of any such retrofit.

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