Dawson Thermally Broken
Ultra-Narrow Stile
Center Pivoted Double Entrance

Thermal Analysis Process Documentation

U-Factor Calculation Using Lawrence Berkeley National Laboratories

THERM Software & NFRC Procedure 100

Dawson Metal Company

825 Allen St.

Jamestown, NY 14701

Table of Contents

Initial Statements

This document details the approach and methods used by Dawson Doors to calculate the U-Value (a.k.a. thermal transmittance) for a U.N.S. Center Pivoted Double Door Entrance. The entrance is sized according to NFRC Procedure 100 as 75-1/2" inches wide and 82-3/8" inches tall.

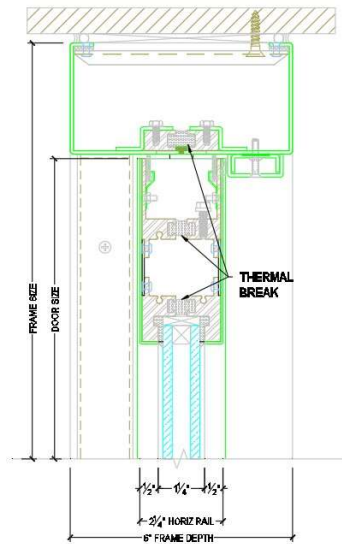The following details show the basic design of the door on which the calculation is based:
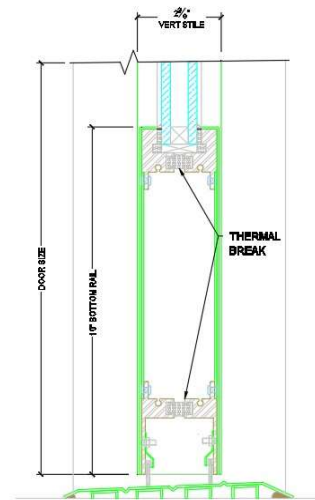

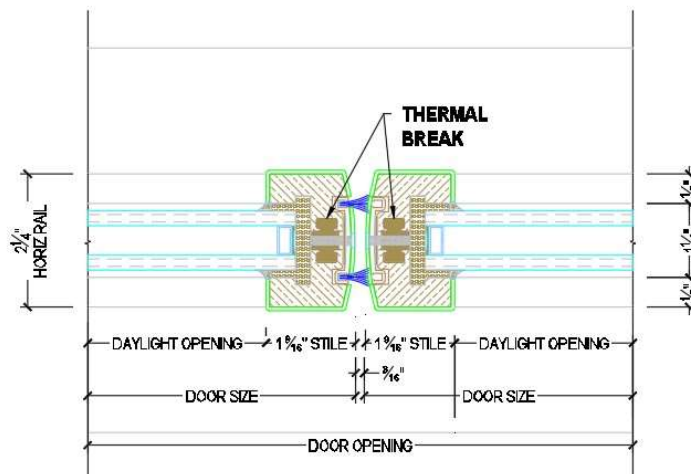**Figure 1:** *Standard Header*

Figure 2: *Standard Bottom Rail*
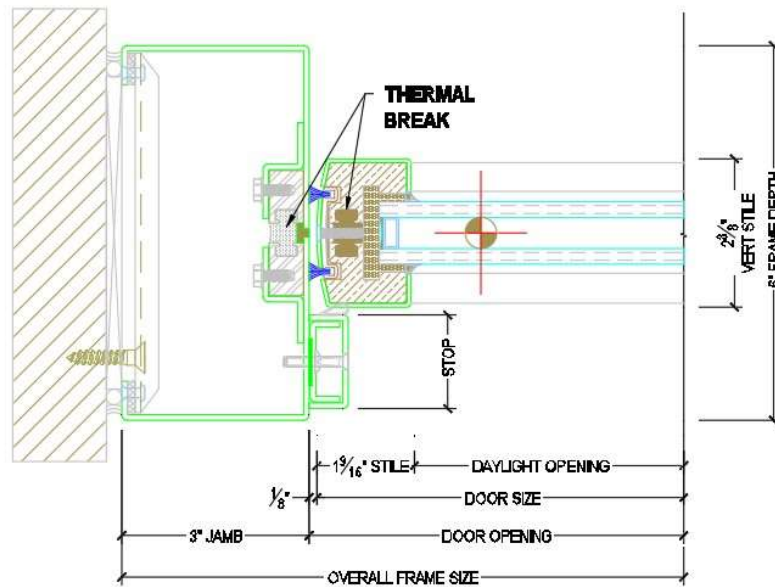

Figure 3: *Standard Meeting Stiles*

Figure 4: *Standard Pivot Jamb & Stile*

Methodology

This analysis was performed in accordance with NFRC (National Fenestration Rating Council) Procedure 100 for determining the thermal transmittance of fenestration products, using approved software developed by the Lawrence Berkeley National Laboratories (LBNL). The software package used to conduct this analysis was LBNL THERM 7.7 (THERM). This piece of software is a Finite Element Analysis modeling tool that utilizes meshing matrices to break down complex geometry into small, simple elements. THERM uses an algorithm known as the Quadtree Method for Mesh Generation, which breaks each component into quadrants, and then those quadrants into further and further quadrants until the geometry is broken into "sufficiently small and sufficiently simple" elements. The mesh generation will achieve the goal of small and simple according to ISO 15099 which states: "The error between the theoretical U-Value and the computed U-Value is less than 1%." Additional tools used to compute the U-Value are detailed throughout this report.

The NFRC Procedure 100 manual outlines the use of two-dimensional heat transfer analysis of the various profiles that make up the fenestration product. In order to accurately predict the heat transfer through the product, the geometry must be captured and analyzed. THERM is the 2-D heat transfer software used to conduct this analysis. THERM applies steady state thermal conditions to the boundaries of the fenestration product model. Conduction, convection and radiation are all included in this thermal analysis and the application of appropriate boundary conditions to accurate product geometry (internal and external) provides THERM with the inputs needed to calculate the relevant mode of heat transfer through the fenestration product.

The output from THERM is a U-Value for the individual components of the fenestration product, for a pair of Dawson Ultra-Narrow stile Center Pivoted Doors, those components are the Frame and the Door which are composed of sub components. The individual frame components include the Pivot Stiles along with the Pivot Jambs, Bottom Rail, Threshold, the Top Rail, and the Header. These components were combined according to Figures 5 and 6 where the header part of the frame is combined with the top rail of the door, the pivot jambs of the frame is combined with the pivot stile of the door, etc. This decision was made to ensure that the gap between the door and the frame, as well as the weather stripping that was designed to seal that gap, is all being accounted for in the analysis. The NFRC Procedure 100 states: "The use of a spreadsheet, in accordance with ISO150999 Section 4.1.4, is required to compute the total U-Value of the door using an area-weighted-average method of calculation." According to this method, the U-Values for the components of the door are multiplied by the respective component areas and then divided by the total area of the door. The weighted U-Values are then added and the resulting total is the overall U-Value for the door system.

Simulation Conditions & Assumptions

The steady state thermal conditions applied to the outermost surfaces of the models in the simulations performed by Dawson were obtained from ISO 150999 Section 8.2 as well as NFRC Procedure 100 and are listed as:

Exterior Conditions:

- T_{out} = exterior ambient temperature of -18℃ (-0.4℉)

- V = wind speed of 5.5 m/s (12.3 mph)

Interior Conditions:

- T_{in} = interior ambient temperature of 21.0℃ (69.8℉)

Materials Used:

- Door Pans -
    - Muntz Metal

- Door Structure -
    - Aluminum

- Thermal Break -
    - Urethane

- Glass -
    - 1" IGU composed of:
        - Sun Guard snx62/27 on 6mm clear/ ½" air gap/6mm clear

Thermal Bridging

In order to ensure simulation accuracy, areas of the door where thermal bridging occurs were taken into consideration. The method for analyzing elements that bridge the thermal break is outlined in the NFRC THERM 7/ WINDOW 7 Simulation Manual under **Section 8.8 Non-Continuous Thermal Bridge Elements**. This section of the NFRC documentation identifies elements such as bolts, partially de-bridged, and thermally slotted cross sections. Dawson, following this manual used the K-Effective method of analysis which is a small weighted average formula that takes the thermal heat transfer coefficients for the relevant modes of heat transfer and averages them according to their area weights along the section of the door that contains those elements. A sample equation of how the K-Effective values are determined is included below in Equation (1).

$$K_{eff} = (F_b * K_b) + (F_n * K_n) \qquad (1)$$

Where:

- K_{eff} = Weight Averaged Thermal Conductivity

- F_b = Fraction of area which is thermally bridged

- K_b = Thermal conductivity coefficient of bridging material

- F_n = Fraction of area which is not thermally bridged

- K_n = Thermal conductivity coefficient of non-bridging material

Equations

To calculate the weighted average for frame components U-Value in a Dawson Stile & Rail Center Pivoted Door, use Equation (2) presented below.

$$U_f = \frac{\sum[(U_H A_H),(U_S A_S),(U_P A_P),(U_{TR} A_{TR}),(U_{BR} A_{BR})(U_M A_M),(U_{EGT} A_{EGT}),(U_{EGB} A_{EGB}),(U_{EGP} A_{EG}\ ),(U_{EGM} A_{EGM})]}{A_f} \tag{2}$$

Where:

- U_F = U-Frame $A_F = \sum(A_H, A_{BR}, A_P, A_M, A_{EGT}, A_{EGB}, A_{EGP}, A_{EGM})$
- U_H = U-Header A_H = Area of Header
- U_{BR} = U-Bottom Rail A_{BR} = Area of Bottom Rail
- U_{TR} = U-Bottom Rail A_{TR} = Area of Top Rail
- U_P = U-Pivot Jamb A_P = Area of Pivot Stile
- U_M = U-Meeting-Stile A_M = Area of Meeting Stile
- U_S = U-Pivot Stile A_S = Area of Pivot Stile
- U_{EGT} = U-Edge of Glass Top A_{EGT} = Area of Edge of Glass Top
- U_{EGB} = U-Edge of Glass Bottom A_{EGB} = Area of Edge of Glass Bottom
- U_{EGP} = U-Edge of Glass Pivot Stile A_{EGP} = Area of Edge of Glass Pivot Stile
- U_{EGM} = U-Edge of Glass Meeting Stile A_{EGM} = Area of Edge of Glass Meeting Stile

To calculate the weighted average for center of glazing U-Value in a Dawson Stile & Rail Center Pivoted Door, use Equation (3) presented below.

$$U_G = \frac{U_{cg} A_{cg}}{A_{cg}} \tag{3}$$

Where:

- U_G = U-Glass
- U_{CG} = U-Center of Glazing
- A_{CG} = Area Center or Glazing

To calculate the weighted average for the total U-Value Dawson Stile & Rail Center Pivoted Door, use Equation (4) presented below.

$$U_t = \frac{[\Sigma(U_f A_f) + \Sigma(U_g A_g)]}{A_T}$$

(4)

<u>Where:</u>

- U_t = Total product U-factor A_t = Total fenestration area
- U_f = Frame U-factor A_f = Frame Area
- U_g = Center-of-glazing U-factor A_g = Center-of-glazing Area

The U-values for the U_f and U_g are weighted averages that were pulled from Equations (2) and (3). The total area is simply the area of the entire entrance system, frame and doors combined. As stated in the Methodology section of the report, frame and the door stiles and rails have been combined to include the gap around the door and the weather stripping that seals that gap. In this way, a more comprehensive analysis of the door system is accomplished, not excluding major areas of thermal energy transfer.

To help gain a better understanding of the different U Factors that have been mentioned, Figures 5 and 6 below point out the respective areas the U Factors are coming from.
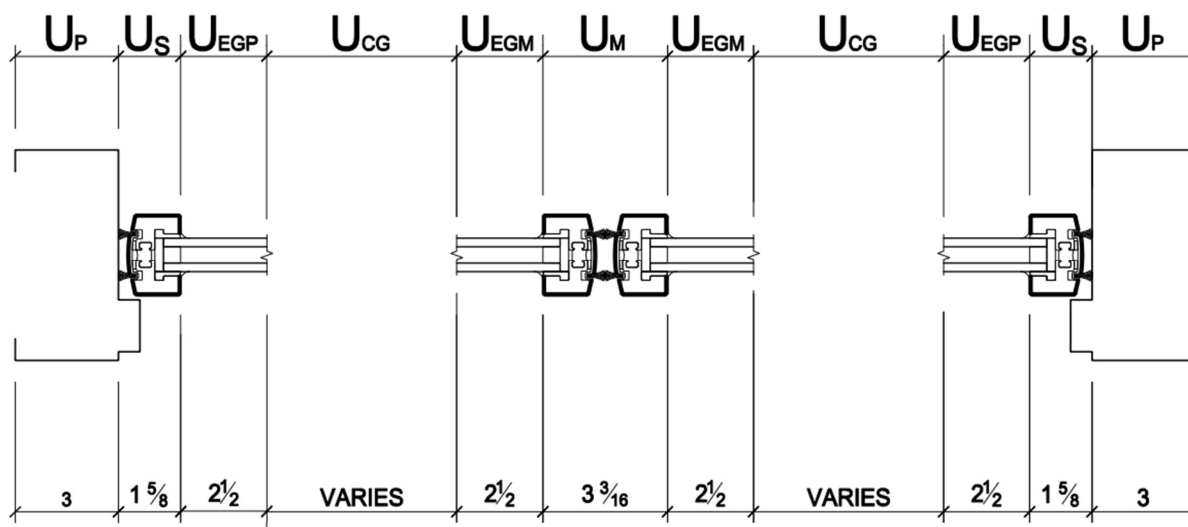

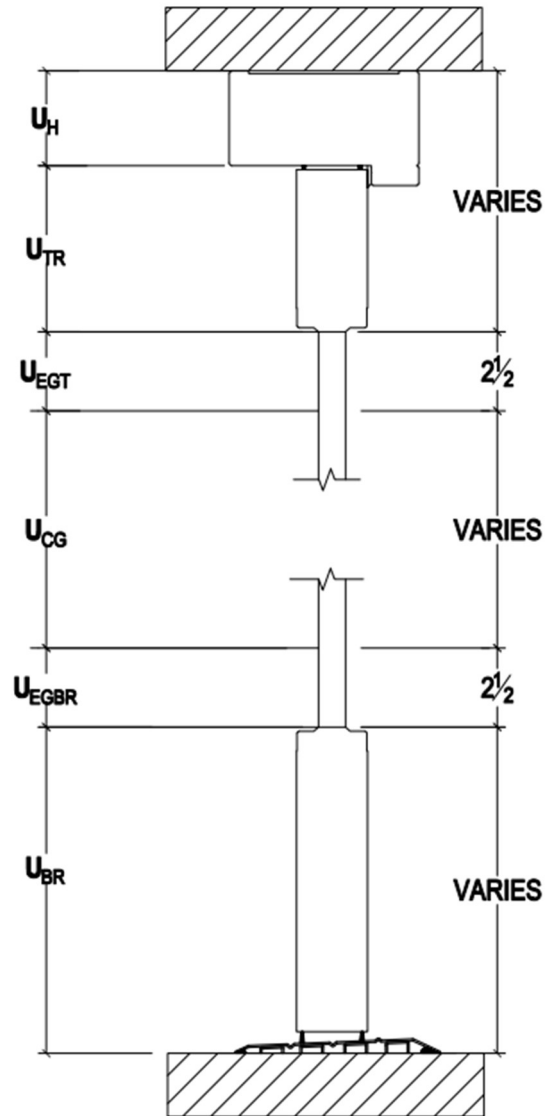**Figure 5**: *Component Section View Taken Along a Horizontal Section Line*

Figure 6: *Component Section View Taken Along a Vertical Section Line*

Calculation Results

The result shown below was calculated in a spreadsheet which allows Dawson engineers to input sizes and component u-values generated using THERM 7.7 program for all of the individual contributing components. This method provides Dawson engineers the ability to compute the Total Fenestration Product U-Value for any door, glass or hardware configuration. The "TOTAL SYSTEM U-VALUE" which is highlighted in the green cell represents the result for a standard NFRC size double entrance (82 3/8" x 37 3/4"), an increase in door size will result in the reduction in the overall U-value, shown in Figure 13 below.
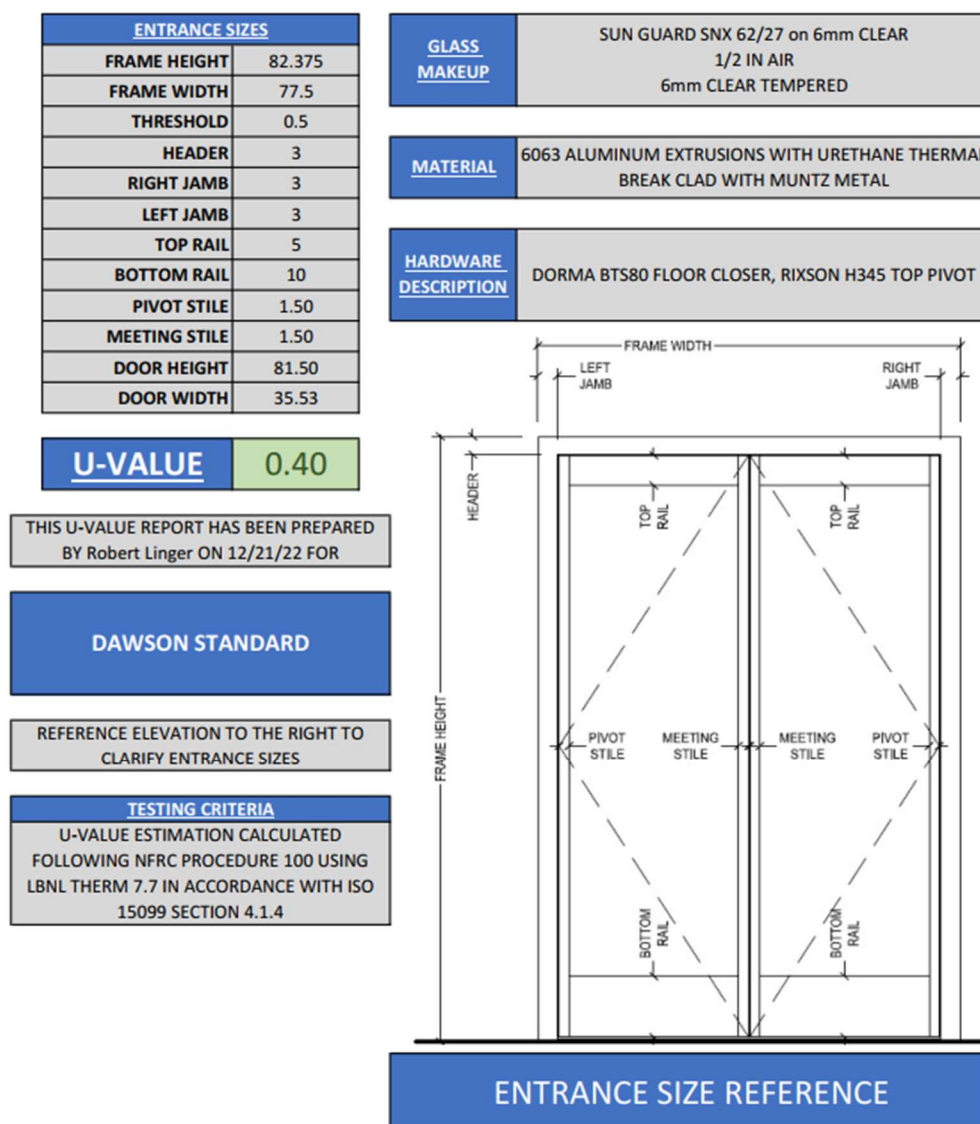
ENTRANCE SIZES	
FRAME HEIGHT	82.375
FRAME WIDTH	77.5
THRESHOLD	0.5
HEADER	3
RIGHT JAMB	3
LEFT JAMB	3
TOP RAIL	5
BOTTOM RAIL	10
PIVOT STILE	1.50
MEETING STILE	1.50
DOOR HEIGHT	81.50
DOOR WIDTH	35.53

GLASS MAKEUP	SUN GUARD SNX 62/27 on 6mm CLEAR 1/2 IN AIR 6mm CLEAR TEMPERED
MATERIAL	6063 ALUMINUM EXTRUSIONS WITH URETHANE THERMAL BREAK CLAD WITH MUNTZ METAL
HARDWARE DESCRIPTION	DORMA BTS80 FLOOR CLOSER, RIXSON H345 TOP PIVOT

U-VALUE   0.40

THIS U-VALUE REPORT HAS BEEN PREPARED BY Robert Linger ON 12/21/22 FOR

DAWSON STANDARD

REFERENCE ELEVATION TO THE RIGHT TO CLARIFY ENTRANCE SIZES

TESTING CRITERIA
U-VALUE ESTIMATION CALCULATED FOLLOWING NFRC PROCEDURE 100 USING LBNL THERM 7.7 IN ACCORDANCE WITH ISO 15099 SECTION 4.1.4

ENTRANCE SIZE REFERENCE

Figure 7: *Results page from Excel Spreadsheet that brings in component sizes and performs the weighted average calculation described in Equations 2,3, and 4.*

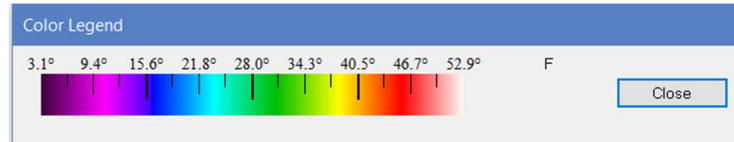## Thermal Gradient Profiles

Figure 8: *This temperature gradient applies to the following thermal images.*

The screenshots shown in Figures 8, 9, 10, 11, and 12, which were taken from THERM, are assuming the steady state thermal conditions as discussed in the "Simulation Conditions and Assumptions" section of this report. The door was modeled as Muntz metal for this simulation, thus ensuring a worst-case scenario for materials offered, and a conservative heat transfer value.
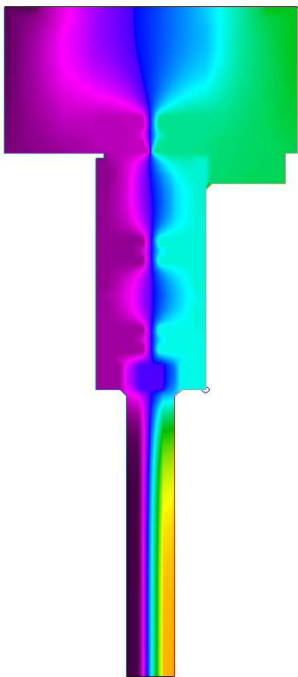
Interior
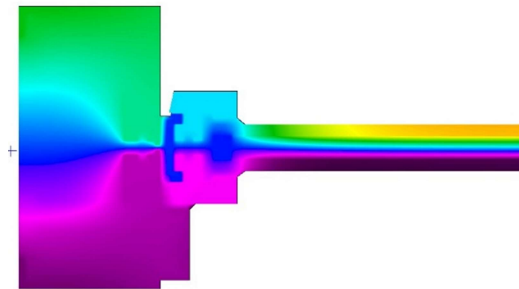
Exterior

Figure 9: *Pivot stile with pivot jamb and appropriate weather stripping and edge of glass thermal profiles*
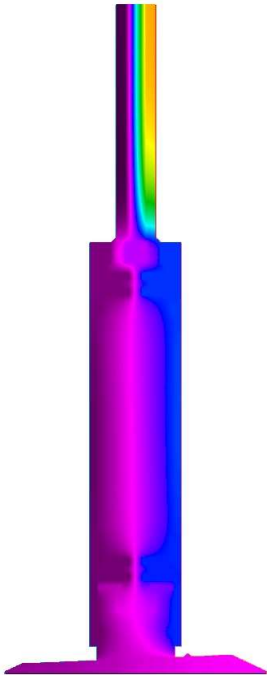
Interior

Exterior

Figure 10: *Meeting stiles with appropriate weather stripping and edge of glass thermal profile*

Exterior   Interior

Figure 11: *Top rail and header with door stop.*

Exterior   Interior

Figure 12: *Bottom rail and Threshold*

		FRAME WIDTHS				
		70	72	74	76	78	80
FRAME HEIGHTS	83	0.41	0.41	0.40	0.40	0.40	0.40
	85	0.41	0.40	0.40	0.40	0.40	0.40
	87	0.41	0.40	0.40	0.40	0.40	0.40
	89	0.40	0.40	0.40	0.40	0.40	0.40
	91	0.40	0.40	0.40	0.40	0.40	0.39
	93	0.40	0.40	0.40	0.40	0.40	0.39
	95	0.40	0.40	0.40	0.40	0.39	0.39
	97	0.40	0.40	0.40	0.40	0.39	0.39
	99	0.40	0.40	0.40	0.39	0.39	0.39
	101	0.40	0.40	0.40	0.39	0.39	0.39
	103	0.40	0.40	0.39	0.39	0.39	0.39
	105	0.40	0.40	0.39	0.39	0.39	0.39
	107	0.40	0.40	0.39	0.39	0.39	0.39
	109	0.40	0.39	0.39	0.39	0.39	0.39
	111	0.40	0.39	0.39	0.39	0.39	0.39
	113	0.40	0.39	0.39	0.39	0.39	0.39
	115	0.39	0.39	0.39	0.39	0.39	0.39
	117	0.39	0.39	0.39	0.39	0.39	0.39
	119	0.39	0.39	0.39	0.39	0.39	0.38

Figure 13: *Gradient Chart for Approximate U-Values of Various Size Doors & Frames.*

11