CHAPTER 7678
DEPARTMENT OF PUBLIC SERVICE
ENERGY DIVISION
MINNESOTA ENERGY CODE

NOTE This chapter was adopted at 23 SR 145 on July 20, 1998 It becomes effective on July 20, 1999

THERMAL TRANSMITTANCE CALCULATIONS FOR OPAQUE ENVELOPE COMPONENTS; HVAC SPECIFIC EFFICIENCIES

7678.0100 AUTHORITY AND PURPOSE.

This chapter is adopted pursuant to Minnesota Statutes, section 216C 19, subdivision 8 The purpose of this chapter is to provide a basis for thermal transmittance calculations for opaque envelope components for determining energy code compliance as required in chapters 7670, 7672, and 7674 This chapter also provides specific efficiencies for heating, ventilating, and air conditioning equipment and service water heating equipment

Statutory Authority: *MS s 216C 19*

History: *23 SR 145*

7678.0200 APPLICATION.

This chapter applies to buildings and equipment covered by chapters 7670, 7672, 7674, and 7676

Statutory Authority: *MS s 216C 19*

History: *23 SR 145*

7678.0300 INCORPORATIONS BY REFERENCE.

Subpart 1 **Incorporated items.** The following standards and references are incorporated by reference

A. ASHRAE, 1997 Handbook of Fundamentals, chapters 25 to 28,

B. Code of Federal Regulations, title 10, part 430, Energy Conservation Program for Consumer Products,

C Code of Federal Regulations, title 10, part 435, Energy Conservation Voluntary Performance Standards for New Commercial and Multi–Family High Rise Residential Buildings Mandatory for New Federal Buildings,

D ASTM C236–89 (1993)e1, Steady–State Thermal Performance of Building Assemblies by Means of a Guarded Hot Box,

E ASTM C976–90 (1996)e1, Thermal Performance of Building Assemblies by Means of a Calibrated Hot Box,

F. NFRC 100–91, Procedure for Determining Fenestration Product Thermal Properties (Currently Limited to U–values), and NFRC 100 (1997 ed.), Procedure for Determining Fenestration Product U–Factors, National Fenestration Rating Council, G NFRC 200, Procedure for Determining Fenestration Product Solar Heat Gain Coefficients at Normal Incidence (1995), National Fenestration Rating Council, and

H ASTM E283–91, Standard Method of Test for Rate of Air Leakage through Exterior Windows, Curtain Walls, and Doors

Subp 2 **Availability.** All standards and documents incorporated by reference are available for public inspection at the Minnesota State Law Library and through the Minitex interlibrary loan system.

Statutory Authority: *MS s 216C 19*

History: *23 SR 145*

7678.0400 DEFINITIONS.

Subpart 1 **Definitions.** The definitions in this part apply to this chapter.

Subp 2 **Annual fuel utilization efficiency or AFUE.** "Annual fuel utilization efficiency" or "AFUE" means the efficiency descriptor for furnaces and boilers determined using test procedures prescribed in Code of Federal Regulations, title 10, part 430

Subp 3 **Boiler capacity.** "Boiler capacity" means the rate of heat output in Btu/h measured at the boiler outlet, at the design inlet and outlet conditions, and rated fuel/energy input

Subp 4. **Efficiency, combustion or Ec.** "Efficiency, combustion" or "Ec" means 100 percent minus flue loss

Subp. 5 **Efficiency, thermal or Et.** "Efficiency, thermal" or "Et" means the results of a thermal efficiency test referenced in Code of Federal Regulations, title 10, part 430 or 435

Subp 6 **Energy efficiency ratio or EER.** "Energy efficiency ratio" or "EER" means the ratio of net equipment cooling capacity in Btu/h to total rate of electric input in watts under designated operating conditions, as determined by Code of Federal Regulations, title 10, part 430 or 435

Subp 7 **Heating degree day.** "Heating degree day" means a unit, based upon temperature difference and time, used in estimating fuel consumption and specifying nominal heating load of a building in winter For any one day, when the mean temperature is less than 65 degrees Fahrenheit, there exist as many degree days as there are Fahrenheit degrees difference in temperature between the mean temperature for the day and 65 degrees Fahrenheit

Subp 8 **Heating seasonal performance factor or HSPF.** "Heating seasonal performance factor" or "HSPF" means the total heating output of a heat pump during its normal annual usage period for heating, in Btu, divided by the total electric energy input during the same period, in watt–hours, as determined by Code of Federal Regulations, title 10, part 435

Subp 9 **Integrated part load value or IPLV.** "Integrated part load value" or "IPLV" means a single number figure of merit for air–conditioning and heat pump equipment based on weighted operation at a set of less than full capacities for the equipment, as determined by Code of Federal Regulations, title 10, part 435

Subp 10 **Once–through system.** "Once–through system" means an HVAC or refrigeration system used for any type of temperature or humidity control application using groundwater that circulates through the system and is then discharged without reusing it for a higher priority purpose

Subp. 11 **Roof/ceiling assembly.** "Roof/ceiling assembly" means the surface area of all components of the roof/ceiling envelope through which heat flows, thus creating a building transmission heat loss or gain, where such assembly is exposed to outdoor air and encloses a conditioned or semiconditioned space

Subp. 12 **Seasonal energy efficiency ratio or SEER.** "Seasonal energy efficiency ratio" or "SEER" means the total cooling output of an air conditioner during its normal annual usage period for cooling, in Btu/h, divided by the total electric energy input during the same period in watt hours, as determined by Code of Federal Regulations, title 10, part 430 or 435

Subp 13 **Thermal resistance or R.** "Thermal resistance" or "R" means the reciprocal of thermal transmittance (h ft^2 ° F/Btu)

Subp 14 **Thermal transmittance or U.** "Thermal transmittance" or "U" means the coefficient of heat transmission (air–to–air) Thermal transmittance is the time rate of heat flow per unit area and unit temperature differential between the warm side and cold side of air films (Btu/h ft^2 °F)

Subp. 15 **Thermal transmittance, overall or U_o.** "Thermal transmittance, overall" or "U_o" means the overall thermal transmittance of an exterior building envelope component, such as a wall, floor, or roof/ceiling The value of U_o is calculated by the parallel path heat flow method using the areas and thermal transmittance values of the various elements, such as windows, doors, and opaque surfaces that comprise the gross area of the building component.

Statutory Authority: *MS s 216C.19*

History: *23 SR 145*

7678.0500 ENVELOPE THERMAL TRANSMITTANCE CALCULATIONS.

Subpart 1 **General.** The thermal transmittance of thermal envelope components must be determined in accordance with this part

Subp 2 **Overall thermal transmittance.** Overall thermal transmittance must be determined in accordance with this subpart The parallel heat flow U_o is the area weighted average of the thermal transmittance of the components of an overall assembly

The equation for thermal transmittance of an assembly is as follows.

$$U_o = (A_1/R_1 + A_2/R_2 + A_3/R_3 + \quad)/A_o$$

Where

$A_1, A_2, A_3,$ = the cross–sectional area of the different elements, such as opaque walls, windows, and doors

$R_1, R_2, R_3,$ = the cross–sectional R–value of the different elements

A_o = the gross area of the element or overall assembly

Subp 3 **Thermal transmittance of opaque building components.** Thermal transmittance of opaque building components must be determined according to this subpart

EXCEPTION Calculations performed by a professional engineer registered in Minnesota according to the procedures in the ASHRAE Handbook of Fundamentals, Chapter 27

A. When return air ceiling plenums are employed, the roof/ceiling assembly must.

(1) for thermal transmittance purposes, not include the ceiling proper nor the plenum space as part of the assembly, and

(2) for gross area purposes, be based upon the interior face of the upper plenum surface

B Calculation of overall thermal transmittance for framed walls must be based upon the percentage of wall area in this item.

FRAMING AREA FACTORS FOR LOAD BEARING STUD WALLS

Stud Spacing	Studs and Headers	Insulated Cavity
16 inches	23 percent	77 percent
24 inches	17 percent	83 percent

FRAMING AREA FACTORS FOR
BLOCK WALLS WITH WOOD STUD FURRING

Stud Spacing	Studs and Headers	Insulated Cavity
16 inches	12 percent	88 percent
24 inches	9 percent	91 percent

C The proposed design may take into account the thermal mass of the building components in considering energy conservation This applies only for walls in locations with less than 8,000 heating degree days and a base temperature of 65 degrees Fahrenheit with a heat capacity equal to or exceeding 6 0 Btu/ ft^2 °F The required wall thermal transmittance is adjusted accordmg to the table in this item

Required Value of U_w without Consideration of Thermal Mass	Required Value of U_w with Consideration of Mass (position of insulation)		
	Exterior of wall mass	Interior of wall mass	Integral with wall mass
0 20	0 22	0 21	0 22
0 18	0 20	0 19	0 20
0 16	0 18	0 17	0 18
0 14	0 15	0 14	0 16
0 12	0 13	0 13	0 13
0 10	0 11	0 10	0 11
0 08	0 09	0 08	0 09
0 06	0 07	0 06	0 07
0 04	0 05	0 04	0 05

D Conversion to metric (SI) units

Unit of Measure	Multiply	By	To Obtain Metric Unit
Thermal transmittance	R–value (h•ft²•°F/Btu)	0 578	RSI–value (m²•°C/W)
Thermal conductance	U–value (Btu/h/ft²/°F)	1 73	U–value (W/m²•°C)
Heat capacity	(Btu/lb/°F)	0 43	k/kg/°K

Subp 4 **Wood frame construction.** The thermal transmittance of wood frame construction must be determined by the parallel heat flow method in this subpart. The parallel heat flow U–value is the area weighted average of the thermal transmittance of the components of an assembly

A The equation for thermal transmittance of an assembly is as follows

$U = (A_1/R_1 + A_2/R_2 + A_3/R_3 + \ldots)/A_o$

Where:

$A_1, A_2, A_3, \ldots$ = the cross–sectional area of the different elements, such as framing and insulated cavities Subpart 3, item B, must be used to calculate insulated and framing areas unless different values are shown by documentation

$R_1, R_2, R_3, \ldots$ = the cross–sectional R–value of the different elements

A_o = the gross area of the element or overall component

B. The U–values table for wood framed wall assemblies is as follows

WOOD FRAMED WALL ASSEMBLIES

Framing	Insulation R–Value	OSB or Plywood Sheathing	25/32 Fiberboard Sheathing	With Foam Plastic Insulation Sheathing: Extruded Polystyrene (in.) (R–5/inch minimum) 0 75	1	Poly–isocyanurate (in.) (foil–backed foam board) 0 75	1
			Total Opaque Wall U–values*				
2x4	13	0 074	0.067	0 060	0 056	0 055	0.050
16"	15	0.067	0 061	0 055	0.052	0 051	0.046
o c **							
2x6	19	0 056	0 051	0 047	0 045	0 044	0 041
16"	21	0 049	0 046	0 043	0 041	0 040	0 037
o.c **							

*This U–value includes studs and insulated cavity as well as siding, sheathing, gypsum board, and air films

**o c refers to "on center" spacing of studs, rafters, and trusses

C The U–values table for wood framed rim and band joists is as follows

WOOD FRAMED RIM AND BAND JOISTS

Rim/Band Joist Description	OSB or Plywood Sheathing	25/32 Fiberboard Sheathing	With Foam Plastic Insulation Sheathing: Extruded Polystyrene (in.) (R–5/inch minimum) 0 75	1	Poly–isocyanurate (in.) (foil–backed foam board) 0.75	1
		Rim/Band Joist U–values*				
2x or TGI, R–13 batt	0 074	0 067	0 060	0 056	0 055	0 050
2x or TGI, R–19 batt	0 045	0 042	0 040	0 038	0 037	0.035
2x or TGI, R–21 batt	0 042	0 039	0 037	0 035	0 035	0 033

Floor truss**, R–13 batt						
Floor truss**, R–19 batt	0 053	0 049	0.045	0 043	0 042	0 039
Floor truss**, R–21 batt	0 048	0 045	0 042	0 040	0 039	0 037
Floor truss, air seal***	0 061	0 056	0 051	0 048	0 047	0 043

*This U–factor includes floor joists or trusses and insulated cavity as well as siding, sheathing, and air films

**These values are for bottom chord bearing trusses For top chord bearing trusses, include the truss area as part of the framed wall

***Air–sealed design incorporates 1–1/2 inches of polystyrene and 1–1/2 inches of polyisocyanurate board to form an air–vapor barrier

D Roof/ceiling assemblies with rafter, truss, or scissors truss construction is as follows

Loose Fill Insulation R–value	U–value
30	0 033
38	0 026
44	0 022
49	0 020

E Roof/ceiling assemblies with cathedral ceiling (solid lumber, not truss framing) is as follows

Batt Insulation R–value	With R–5 Sheathing	Without Insulation Sheathing
	U–values	
25	0 040	0 050
30	0 033	0 040
38	0 026	0.030

Subp 5 **Masonry block walls.** To determine the thermal transmittance of masonry block walls with insulation inserts or filled cores, the series–parallel method must be used The series–parallel transmittance calculation shall be deemed in compliance with this subpart if the product is certified under the National Concrete Masonry Association's Certification of Thermal Performance of Integrally Insulated Concrete Masonry Walls

A The series–parallel heat flow method is a procedure that accounts for the fact that heat does not always flow straight through a wall

The equations for series–parallel thermal transmittance are as follows

$U = 1/R_o$

$$R_o = \frac{1}{\frac{a_{11}}{R_{11}} + \frac{a_{12}}{R_{12}} + \_\_ + \frac{a_{1p}}{R_{1p}}} + \_\_\_\_ + \frac{1}{\frac{a_{n1}}{R_{n1}} + \frac{a_{n2}}{R_{n2}} + \_\_ + \frac{a_{np}}{R_{np}}} + R_{film}$$

Where.

R_o = total thermal resistance of the representative concrete masonry wall, including surface air film resistances.

a_{11} = proportionate area of thermal path number 1 of thermal layer number 1
R_{11} = thermal resistance of thermal path number 1 of thermal layer number 1
a_{1p} = proportionate area of thermal path number "p" of thermal layer number 1
R_{1p} = thermal resistance of thermal path number "p" of thermal layer number 1.
a_{np} = proportionate area of thermal path number "p" of thermal layer number "n"
R_{np} = thermal resistance of thermal path number "p" of thermal layer number "n"
R_{film} = thermal resistance of inside air film (0 mph) and outside air film (15 mph)

B The U–value table for normal weight blocks is as follows

Normal Weight Concrete Blocks (132 PCF) U–Value Table[1]

Block Width.
12 Inches

Core	Block Only	Type	Additional Insulation Thickness (in) 0 75	1	2	2x4 studs R–11	2x2 furring 1 5 inch
grouted	0 51	expanded[2]	0 20	0.17	0 10		0 13
grouted	0 51	extruded[3]	0 16	0 13	0 081		
grouted	0.51	poly–isocyanurate[4]	0 13	0 10	0 059		
grouted	0 51	fiberglass				0 083	
empty	0 45	expanded	0 19	0 16	0 101		0 13
empty	0.45	extruded	0 16	0 13	0 079		
empty	0 45	poly–isocyanurate	0 12	0.10	0 059		
empty	0 45	fiberglass				0 081	
filled[5]	0.20	expanded	0 12	0 11	0 080		0 094
filled	0 20	extruded	0 11	0 097	0 065		
filled	0.20	poly–isocyanurate	0 093	0 080	0.051		
filled	0 20	fiberglass				0 066	
UFFI[6]	0 19	expanded	0 12	0 11	0 078		0 09
UFFI	0 19	extruded	0 11	0 094	0 064		
UFFI	0.19	poly–isocyanurate	0.091	0.078	0 050		
UFFI	0 19	fiberglass				0 065	

[1]All U–values include air film coefficients and one–half inch gypsum board when insulation is present

[2]Expanded is typically white "bead board" foam plastic

[3]Extruded is typically colored R–5 per inch of foam plastic

[4]Polyisocyanurate (iso board) is foam plastic, foil faced on both sides

[5]Filled with vermiculite or EPS beam insulation

[6]UFFI means filled with urea formaldehyde

Normal Weight Concrete Blocks (132 PCF) U–Value Table[1]

Block Width
10 Inches

Additional Insulation

Core	Block Only	Type	Thickness (in) 0 75	1	2	2x4 studs R–11	2x2 furring 1 5 inch
grouted	0 56	expanded[2]	0.20	0 17	0 11		0 076
grouted	0 56	extruded[3]	0 17	0 14	0 082		
grouted	0 56	poly–isocyanurate[4]	0.13	0 11	0 060		
grouted	0 56	fiberglass				0 085	
empty	0 46	expanded	0 19	0 16	0 10		0 073
empty	0 46	extruded	0 16	0 13	0 079		
empty	0 46	poly–isocyanurate	0 12	0 102	0 059		
empty	0 46	fiberglass				0 082	
filled[5]	0 23	expanded	0 13	0.12	0 083		0 100
filled	0 23	extruded	0 12	0 10	0 068		
filled	0 23	poly–isocyanurate	0.098	0 083	0 052		
filled	0 23	fiberglass				0 069	
UFFI[6]	0 22	expanded	0 13	0 12	0 082		0 062
UFFI	0 22	extruded	0 11	0 10	0 067		
UFFI	0 22	poly–isocyanurate	0 10	0 082	0 051		
UFFI	0 22	fiberglass				0.068	

[1]All U–values include air film coefficients and one–half inch gypsum board when insulation is present

[2]Expanded is typically white "bead board" foam plastic.

[3]Extruded is typically colored R–5 per inch of foam plastic

[4]Polyisocyanurate (iso board) is foam plastic, foil faced on both sides

[5]Filled with vermiculite or EPS beam insulation

[6]UFFI means filled with urea formaldehyde

Normal Weight Concrete Blocks (132 PCF) U–Value Table[1]

Block Width
8 Inches

Additional Insulation

Core	Block Only	Type	Thickness (in) 0 75	1	2	2x4 studs R–11	2x2 furring 1 5 inch
grouted	0 62	expanded[2]	0 21	0 18	0 11		0 014
grouted	0 62	extruded[3]	0 17	0 14	0 083		
grouted	0.62	poly–isocyanurate[4]	0 13	0 11	0 061		
grouted	0.62	fiberglass				0 086	
empty	0 48	expanded	0 19	0 16	0 103		0 13
empty	0 48	extruded	0 16	0 13	0 080		
empty	0 48	poly–isocyanurate	0 13	0 10	0 059		
empty	0 48	fiberglass				0 083	
filled[5]	0 27	expanded	0 14	0 13	0 088		0 11

filled	0 27	extruded	0 13	0 11	0 070		
filled	0 27	poly–isocyanurate	0.10	0 088	0 054		
filled	0 27	fiberglass				0 072	
UFFI[6]	0 25	expanded	0 14	0 12	0 086		0 10
UFFI	0 25	extruded	0 12	0 11	0 069		
UFFI	0 25	poly–isocyanurate	0.10	0.086	0.053		
UFFI	0 25	fiberglass				0 071	

[1] All U–values include air film coefficients and one–half inch gypsum board when insulation is present

[2] Expanded is typically white "bead board" foam plastic

[3] Extruded is typically colored R–5 per inch of foam plastic

[4] Polyisocyanurate (iso board) is foam plastic, foil faced on both sides

[5] Filled with vermiculite or EPS beam insulation

[6] UFFI means filled with urea formaldehyde

C The U–value tables for lightweight blocks are as follows

Light Weight Concrete Blocks (100 PCF) U–Value Table[1]

Block Width
12 Inches

Core	Block Only	Type	Additional Insulation Thickness (in) 0 75	1	2	2x4 studs R–11	2x2 furring 1.5 inch
grouted	0 42	expanded[2]	0 18	0 16	0 10		0 12
grouted	0.42	extruded[3]	0 15	0 13	0 078		
grouted	0 42	poly–isocyanurate[4]	0 12	0 10	0 058		
grouted	0 42	fiberglass				0.080	
empty	0 37	expanded	0 17	0 15	0 097		0 12
empty	0 37	extruded	0 15	0 12	0 076		
empty	0 37	poly–isocyanurate	0 12	0 097	0 057		
empty	0 37	fiberglass				0 078	
filled[5]	0 12	expanded	0 089	0 082	0 063		0.072
filled	0 12	extruded	0 081	0 074	0 054		
filled	0 12	poly–isocyanurate	0 072	0 063	0.044		
filled	0 12	fiberglass				0 054	
UFFI[6]	0 11	expanded	0.083	0.077	0 060		0 068
UFFI	0 11	extruded	0 076	0 069	0 052		
UFFI	0 11	poly–isocyanurate	0 068	0 060	0 042		
UFFI	0 11	fiberglass				0 052	

[1] All U–values include air film coefficients and one–half inch gypsum board when insulation is present

[2] Expanded is typically white "bead board" foam plastic

[3] Extruded is typically colored R–5 per inch of foam plastic

[4] Polyisocyanurate (iso board) is foam plastic, foil faced on both sides

[5] Filled with vermiculite or EPS beam insulation.

[6] UFFI means filled with urea formaldehyde

Light Weight Concrete Blocks (100 PCF) U–Value Table[1]

Block Width:
10 Inches

Core	Block Only	Type	Additional Insulation Thickness (in.) 0.75	1	2	2x4 studs R–11	2x2 furring 1.5 inch
grouted	0.45	expanded[2]	0.19	0.16	0 10		0 13
grouted	0 45	extruded[3]	0 16	0 13	0.079		
grouted	0 45	poly–isocyanurate[4]	0 12	0.10	0 059		
grouted	0 45	fiberglass				0.081	
empty	0.37	expanded	0 17	0 15	0 097		0 12
empty	0 37	extruded	0 14	0 12	0 076		
empty	0 37	poly–isocyanurate	0.12	0.097	0 057		
empty	0 37	fiberglass				0 078	
filled[5]	0.14	expanded	0.099	0.091	0 068		0.079
filled	0 14	extruded	0 089	0 080	0.057		
filled	0 14	poly–isocyanurate	0 078	0 068	0 046		
filled	0.14	fiberglass				0 058	
UFFI[6]	0.13	expanded	0.092	0.085	0 065		0 074
UFFI	0.13	extruded	0 084	0 076	0.055		
UFFI	0.13	poly–isocyanurate	0.073	0 065	0.044		
UFFI	0 13	fiberglass				0 055	

[1]All U–values include air film coefficients and one–half inch gypsum board when insulation is present

[2]Expanded is typically white "bead board" foam plastic.

[3]Extruded is typically colored R–5 per inch of foam plastic.

[4]Polyisocyanurate (iso board) is foam plastic, foil faced on both sides.

[5]Filled with vermiculite or EPS beam insulation.

[6]UFFI means filled with urea formaldehyde

Light Weight Concrete Blocks (100 PCF) U–Value Table[1]

Block Width:
8 Inches

Core	Block Only	Type	Additional Insulation Thickness (in.) 0 75	1	2	2x4 studs R–11	2x2 furring 1.5 inch
grouted	0.51	expanded[2]	0 20	0 17	0 10		0 13
grouted	0 51	extruded[3]	0 16	0 14	0.081		
grouted	0.51	poly–isocyanurate[4]	0 13	0 10	0.060		
grouted	0.51	fiberglass				0 083	
empty	0 40	expanded	0.18	0.15	0 098		0 16
empty	0 40	extruded	0 15	0 13	0 077		
empty	0 40	poly–isocyanurate	0 12	0 098	0.058		
empty	0.40	fiberglass				0 091	
filled[5]	0 17	expanded	0.11	0.10	0.074		0.086

filled	0 17	extruded	0.099	0 088	0.061		
filled	0 17	poly–isocyanurate	0 085	0 074	0 048		
filled	0 17	fiberglass				0 062	
UFFI[6]	0 15	expanded	0 10	0 094	0 070		0 081
UFFI	0 15	extruded	0 092	0.083	0 059		
UFFI	0 15	poly–isocyanurate	0 080	0 070	0 047		
UFFI	0 15	fiberglass				0 059	

[1] All U–values include air film coefficients and one–half inch gypsum board when insulation is present

[2] Expanded is typically white "bead board" foam plastic

[3] Extruded is typically colored R–5 per inch of foam plastic

[4] Polyisocyanurate (iso board) is foam plastic, foil faced on both sides

[5] Filled with vermiculite or EPS beam insulation

[6] UFFI means filled with urea formaldehyde

Subp 6 **Metal buildings.** Thermal performance of envelope components of metal buildings with thermal insulation between purlins or girts must be determined by the effective assembly R–value method prescribed in this subpart

A The equation to determine thermal transmittance by effective assembly R–value thermal transmittance method is as follows

$U_o = 1/(R_1 + R_e)$

Where

R_1 = the R–values of series elements excluding the draped insulation and framing

R_e = the effective assembly R–value from tables in item B or C Interior air film coefficients are included in these table values

B The equivalent R–value of a purlin or girt system where the system is described in this item

ASSEMBLY EFFECTIVE R–VALUES (R_e)

Batt Insulation R–value	One Fastener Per Linear Foot of Purlin/Girt Purlin/Girt Spacing (Feet)			
	5	4	3	2
R–38	11 61	10 18	8 45	6 30
R–30	11 08	9 79	8.21	6 20
R–26	10 80	9 59	8.08	6 14
R–22	10 06	9 04	7 73	5 99
R–19	9 95	8 95	7 67	5 97

Batt Insulation R–value	Two Fasteners Per Linear Foot of Purlin/Girt Purlin/Girt Spacing (Feet)			
	5	4	3	2
R–38	9.96	8 64	7 07	5 19
R–30	9 56	8.36	6 91	5.12
R–26	9 35	8 21	6 81	5 09
R–22	8 80	7 80	6 56	4 98
R–19	8 71	7 74	6 52	4 96

C The assembly effective R–value (R_e) is defined in this item for purlin or girt insulation systems where purlin or girt spacing is five feet or greater Foam blocks must be a minimum R–value of five, and a minimum of two pound density

(1) For assemblies where the blanket insulation is draped over each purlin or girt and a foam block is installed between the purlin or girt and exterior panel, the R_e–values of this subitem apply

	INSULATION R–VALUE			
	10	11	13	19
EFFECTIVE SYSTEM R–VALUE	9 8	10 0	12 0	15 3

(2) For assemblies with a blanket total R–value of R–30, where a thicker layer is installed uncompressed between each purlin or girt and a thinner layer is draped over each purlin or girt, the R_e–values of this subitem apply

(a) When a foam block is installed between the purlin or girt and exterior panel, the R_e–value is 24 5

(b) When a foam block is not installed between the purlin or girt and exterior panel, the R_e–value is 17 4

(3) For assemblies where purlins or girts are completely filled with R–30, foam blocks of at least one–inch separate purlins or girts from the roof or wall sheet, and continuous insulation board covers the insulation and purlin or girt, the R_e–values of this subitem apply

(a) Where the continuous insulation board is at least R–6, the R_e–value is R–31 4

(b) Where the continuous insulation board is at least R–10, the R_e–value is R–43 2

Subp. 7 **Metal stud walls.** The overall thermal transmittance of metal stud walls are provided in this subpart The U–values given including studs and insulated cavity as well as siding, sheathing, gypsum board, and air films. The table U–values do not include effects of structural framing, which can substantially increase the U–value

U–Values for Metal Stud Walls
and Insulated Cavities

Size of Studs	Stud Spacing	Cavity Insulation R–value	Insulated Cavity Equivalent R–value	With Foam Plastic Insulation Sheathing: Extruded Polystyrene (in) (R–5/in minimum)			Polyisocyanurate (in) (foil–backed foam board)	
				0 75	1	1 5	0.75	1
				Total Opaque Wall U–values*				
2x4	16”	11	5 5	0 086	0.077	0 065	0 075	0 066
2x4	16”	13	6 0	0 082	0 075	0 063	0.072	0.064
2x4	16”	15	6 4	0 080	0 072	0 061	0 070	0.062
2x4	24”	11	6 6	0.078	0 071	0 061	0 069	0 061
2x4	24”	13	7 2	0 075	0 068	0 058	0 067	0 059
2x4	24”	15	7 8	0 072	0 066	0.056	0 064	0 064
2x6	16”	19	7 1	0 075	0 069	0 059	0 067	0.060
2x6	16”	21	7 4	0.074	0 067	0 058	0.066	0 059
2x6	24”	19	8 6	0 068	0 062	0 054	0.061	0 055
2x6	24”	21	9 0	0 066	0 061	0 053	0.059	0 059
2x8	16”	25	7.8	0 072	0 066	0 056	0 064	0 057
2x8	24”	25	9 6	0.063	0 059	0 051	0 057	0 052

*This U–value includes studs and insulated cavity, as well as siding, sheathing, gypsum board, and air film It does not include structural framing

Subp 8 **Zone method.** For assemblies with metal components that are not described in subpart 6 or 7, the zone method must be used The zone method is a procedure in which the thermal transmittance of a surface is computed by dividing the surface into its highly conductive and remaining areas The highly conductive area is a function of the width or diameter of the metal heat path terminal and the distance from the panel surface to the metal The respective thermal transmittance of the two areas are separately computed, combined, and then divided by the total cross–sectional area

The equation for zone method thermal transmittance is as follows

$U = (U_1 A_1 + U_2 A_2)/A_o$

Where

For the highly conductive area

A_1 = the highly conductive area

U_1 = the thermal transmittance of the highly conductive area

For the remainder of the area

A_2 = the remainder of the area

U_2 = the thermal transmittance of the remaining area.

A_o (cross–sectional area of the element) = A1 + A2

The equation for areas is as follows.

$A_1 = m + 2d$, $A_2 = A_o - A_1$

Where

m = width or diameter of the metal heat path terminal.

d = distance from panel surface to metal

Subp 9 **Thermal measurement method.**

A The overall thermal transmittance value of a building assembly determined by testing must be tested by either ASTM C236 or ASTM C976 by a laboratory meeting the qualities in item B.

B Approved laboratory means any testing facility, including a facility owned or operated by a manufacturer, that has been accredited by one or more of the following agencies to perform the required test

(1) United States Department of Commerce, National Voluntary Laboratory Accreditation Program,

(2) American Association for Laboratory Accreditation, Gaithersburg, Maryland; or

(3) Standards Council of Canada, Ottawa, Ontario, Canada

EXCEPTION: In the event that an approved laboratory program is temporarily delayed or is not capable of being accredited to perform a test or tests, a testing laboratory possessing the appropriate equipment, facilities, and qualified personnel to perform the required testing is an approved laboratory

C Product samples must be production line material or representative material as purchased by the consumer or contractor. If the assembly is too large to be tested at one time in its entirety, then either a representative portion must be tested or different portions must be tested separately and a weighted average determined. To be representative, the portion tested must include edges of panels, joints with other panels, typical framing percentages, and thermal short circuits

Statutory Authority: *MS s 216C 19*

History: *23 SR 145*

7678.0600 FENESTRATION PRODUCTS.

Subpart 1. **Labeling.** All windows must be labeled with their overall assembly U–value according to this part. Labels must not be removed until after inspection of installation

Subp 2. **Air infiltration.** Fenestration products must have air infiltration rates not exceeding those shown in this subpart The manufacturer must test for infiltration rates in accordance with ASTM E283–91, and window infiltration rates in accordance with applicable industry standards A labeled statement from the manufacturer that the product meets or exceeds the requirements of the Model Energy Code shall be deemed to comply with these requirements

ALLOWABLE AIR INFILTRATION RATE

Operable windows	0.34 cfm per lineal foot of operable sash crack or 0 30 cfm per square foot of window area
Residential doors, swinging	0 5 cfm per square foot of door area
Residential doors, swinging	0.37 cfm per square foot of door area
Nonresidential doors	1 25 cfm per square foot of door area

Subp. 3 **Thermal transmittance.** Thermal transmittance of windows, doors, and skylight elements must be determined in accordance with item A or B

A Thermal performance (U–values) of fenestration products (windows, doors, and skylights) must be determined in accordance with the National Fenestration Rating Council (NFRC) standard 100–91, 100–97, or equivalent by an accredited, independent laboratory, and labeled and certified by the manufacturer

B When a manufacturer has not determined product U–value according to NFRC standards for a particular product line, the U–value shall be determined by assigning products a default U–value from the U–value default table Product features must be verifiable for the product to qualify for the default value associated with those features Where the existence of a particular feature cannot be determined with reasonable certainty, the product must not receive credit for that feature Where a composite of materials from two different product types are used, the product U–value must be the high U–value

(1) The U–value default table for windows, glass doors, and skylights is as follows

Frame/Glazing Features	Double Pane	Double Pane w/ Low–E Permanent Label on Glass	Triple Pane
	U–value	U–value	U–value
Metal With Thermal Break			
Operable	0 67	0 62	0 54
Fixed	0 63	0 57	0 47
Glass door	0 66	0 60	0.50
Skylight	1 13	1 06	0.93
Metal–Clad Wood			
Operable	0.60	0 56	0 46
Fixed	0 58	0 52	0 41
Glass door	0.57	0 52	0.43
Skylight	0 88	0 82	0 71

Wood/Vinyl			
Operable	0.56	0 52	0.43
Fixed	0.57	0.52	0.41
Glass door	0.56	0.51	0 42
Skylight	0 85	0 79	0 67
Glass Block Assemblies	0.60		

(2) The U–value default table for nonglazed doors is as follows:

Steel Doors	U–Value
Without foam core	0 60
With foam core	0.35

Wood Doors	U–Value	
	Without Storm	With Storm
Panel with 7/16 inch panels	0 54	0.36
Panel with 1–1/8 inch panels	0.39	0.28
Solid core flush	0 40	0 26

Subp. 4. **Solar heat gain coefficients.** Solar heat gain coefficients of windows, glazed doors, and skylight elements must be determined according to this subpart

A The solar heat gain coefficient (SHGC) of glazed fenestration products (windows, glazed doors, and skylights) shall be determined according to the National Fenestration Rating Council (NFRC) standards by an accredited, independent laboratory, and labeled and certified by the manufacturer.

B. When a manufacturer has not determined product SHGC according to NFRC standards for a particular product line, the SHGC shall be determined by assigning such products a default SHGC from the SHGC default table. Product features must be verifiable for the product to qualify for the default value associated with those features. Where the existence of a particular feature cannot be determined with reasonable certainty, the product must not receive credit for that feature. Where a composite of materials from two different product types are used, the product shall be assigned the higher value.

The SHGC default table for windows, glazed doors, and skylights is as follows.

PRODUCT DESCRIPTION	SINGLE GLAZED			
Metal–Framed.	Clear	Bronze	Green	Gray
Operable	0 75	0 64	0.62	0.61
Fixed	0.78	0.67	0.65	0.64
Nonmetal Frames				
Operable	0 63	0 54	0.53	0 52
Fixed	0 75	0 64	0 62	0.61

PRODUCT DESCRIPTION	DOUBLE GLAZED			
Metal–Framed:	Clear	Bronze	Green	Gray
Operable	0 66	0 55	0.53	0 52
Fixed	0.68	0 57	0.55	0 54
Nonmetal Frames:				
Operable	0.55	0.46	0 45	0 44
Fixed	0.66	0.54	0.53	0 52

Statutory Authority: *MS s 216C.19*

History: *23 SR 145*

7678.0700 MECHANICAL EQUIPMENT EFFICIENCY REQUIREMENTS.

Subpart 1 **HVAC equipment performance requirements.** HVAC equipment must meet the minimum efficiency requirements specified in this part

A Standards and definitions for HVAC equipment mclude coefficient of performance, package terminal air conditioner, package terminal heat pump; room air conditioner, unitary cooling and heating equipment, unitary heat pump, water chilling package of absorption, water chilling package, centrifugal or rotary, and water chilling package, reciprocating, are located or referenced in Code of Federal Regulations, title 10, parts 430 and 435

B. Omissions of minimum performance requirements for equipment not listed in this part does not preclude use of such equipment.

C When multiple ratmg conditions or performance requirements are provided, the equipment must satisfy all stated requirements

Subp 2 **Air cooled, electrically operated equipment.** Unitary conditioners, heat pumps, and condensing units air cooled, electrically operated must meet the requirements of this subpart Deduct 0 2 from required EER and IPLV for units that have a heating section IPLV's are applicable to equipment with capacity modulation Minimum efficiencies have not been determined for condensing only units less than 135,000 Btu/h

UNITARY AIR CONDITIONERS AND AIR–COOLED, ELECTRICALLY OPERATED HEAT PUMPS

EQUIPMENT CATEGORY	EQUIPMENT SIZES AND MODE	RATING CONDITION	EFFICIENCY
Single Package	<65,000 Btu/h Cooling Capacity Cooling Mode	Seasonal Ratmg	9 7 SEER
Split System	<65,000 Btu/h Cooling Capacity Cooling Mode		10.0 SEER
Split System and Single Package	≥65,000 and <135,000 Btu/h Cooling Mode	Standard Rating (95°F db)	8 9 EER
		Integrated Part Load Value (80°F db)	8 3 IPLV
Heat Pumps – Cooling Mode			
Split System and Smgle Package	>135,000 Btu/h and <240,000 Btu/h		8 5 EER 7 5 IPLV
Phase Split System and Smgle Package	>240,000 Btu/h and <760,000 Btu/h		8 5 EER 7 5 IPLV
Phase Split System and Smgle Package	>760,000 Btu/h		8 2 EER 7 5 IPLV
Heat Pumps – Heatmg Mode			
Split System	<65,000 Btu/h Cooling Capacity Heating Mode	Seasonal Ratmg	6 8 HSPF
Single Package			6 6 HSPF

Split System and Single Package	≥65,000 and <135,000 Btu/h Cooling Capacity Heating Mode	High Temperature Rating (47°F db/ 43°F wb)	3 0 COP
		Low Temperature Rating (17°F db/ 15°F wb)	2.0 COP
Split System and Single Package	≥135,000 and <240,000 Btu/h Cooling Capacity Heating Mode	High Temperature Rating (47°F db/ 43°F wb)	2 9 COP
		Low Temperature Rating (17°F db/ 15°F wb)	2 0 COP
Split System and Single Package	>240,000 and <760,000 Btu/h	High Temperature Rating (47°F db/ 43°F wb)	2 9 COP
		Low Temperature Rating (17°F db/ 15°F wb)	2 0 COP
Split System and Single Package	>760,000 Btu/h	High Temperature Rating (47°F db/ 43°F wb)	2 9 COP
		Low Temperature Rating (17°F db/ 15°F wb)	2.0 COP
Condensing Units	≥135,000 Btu/h		11.0 IPLV 9 9 EER

Subp 3 **Electrically operated, water and evaporatively cooled equipment.** Unitary air conditioners, heat pumps, and condensing units electrically operated, evaporatively cooled must meet the requirements of this subpart. Deduct 0 2 from required EER and IPLV for units that have a heating section IPLV's are applicable to equipment with capacity modulation Minimum efficiencies have not been determined for condensing only units less than 135,000 Btu/h

ELECTRICALLY OPERATED, EVAPORATIVELY COOLED EQUIPMENT

EQUIPMENT	EQUIPMENT SIZES AND MODE	RATING CONDITION	EFFICIENCY
Split System and Single Package	All	For EER. Indoor Temperature (80°F db/67°F wb) Outdoor Temperature (95°F db/75°F wb) For IPLV (80°F db/67°F wb)	
Split System and Single Package	<65,000 Btu/h Cooling Capacity		9 3 EER 8.4 IPLV

Split System and Single Package	<135,000 Btu/h Cooling Capacity		10 5 EER 9.7 IPLV
Split System and Single Package	≥135,000 and <240,000 Btu/h Cooling Capacity		9 6 EER 9.0 IPLV
Split System and Single Package	≥240,000 and <760,000 Btu/h Cooling Capacity		9 6 EER 9 0 IPLV
Split System and Single Package	>760,000 Btu/h		9.6 EER 9 0 IPLV
Condensing Units	≥135,000 Btu/h		12 9 EER 12 9 IPLV

Subp 4 **Water–cooled equipment.** Water–cooled air conditioners, heat pumps, and condensing units must meet the requirements of this subpart Minnesota Statutes, section 103G 271, subdivision 5, prohibits once–through systems

WATER–COOLED EQUIPMENT

EQUIPMENT	EQUIPMENT SIZES AND MODE	RATING CONDITION	EFFICIENCY
Water Source Heat Pumps	<65,000 Btu/h Cooling Capacity	Standard Rating Indoor Air (80°F db/65°F wb) and Entering Water (85°F)	9 3 EER
		Low Temperature Rating Indoor Air (80°F db/67°F wb) and Entering Water (75°F)	10 2 EER
	≥65,000 and <135,000 Btu/h Cooling Capacity	Standard Rating Indoor Air (80°F db/67°F wb) and Entering Water (85°F)	10 5 EER
		Entering Water (75°F)	11.00 EER
Groundwater Cooled Heat Pumps	<135,000 Btu/h Cooling Capacity	Standard Rating Entering Water (70°F)	11 0 EER
		Low Temperature Rating Entering Water (50°F)	11.5 EER

Subp 5 **Packaged terminal equipment.** Packaged termınal aır condıtioners and heat pumps aır cooled, electrıcally operated must meet the requırements of thıs subpart Equıpment must comply wıth all effıcıencıes when multıple effıcıencıes are ındıcated "Cap" means the rated capacıty ın Btu/h If the equıpment capacıty ıs less than 7,000 Btu/h, use 7,000 Btu/h m the calculatıon If the equıpment capacıty ıs greater than 15,000 Btu/h, use 15,000 Btu/h ın the calculatıon

PACKAGED TERMINAL EQUIPMENT

EQUIPMENT	EQUIPMENT SIZES AND MODE	RATING CONDITION	EFFICIENCY
PTAC AND PTAC Heat Pumps	All Capacıtıes Coolıng Mode	Standard Rating (95°F db)	10.0 – (0 16 x Cap /1,000) EER
		Low Temperature Ratıng (82°F db)	12 2 – (0 20 x Cap /1,000) EER
PTAC Heat Pumps	All Capacıtıes Heatıng Mode	Standard Ratıng (47°F db/43°F wb)	2.9 – (0.026 x Cap./1,000 COP

Subp 6 **Room equipment.** Room aır condıtioners and room aır condıtıoner heat pumps must meet the requırements of thıs subpart Equıpment must comply wıth all effıcıencıes when multıple effıcıencıes are ındıcated

ROOM EQUIPMENT

EQUIPMENT	EQUIPMENT SIZES & MODE	EFFICIENCY
Wıthout Reverse Cycle and wıth Louvered Sıdes	<6,000 Btu/h	8.0 EER
	≥6,000 and <8,000 Btu/h	8 5 EER
	≥8,000 and <14,000 Btu/h	9 0 EER
	≥14,000 and <20,000 Btu/h	8.8 EER
	≥20,000 Btu/h	8.2 EER
Wıthout Reverse Cycle and wıthout Louvered Sıdes	<6,000 Btu/h	8.0 EER
	≥6,000 and <20,000 Btu/h	8 5 EER
	≥20,000 Btu/h	8.2 EER
Wıth Reverse Cycle and With Louvered Sıdes – All Capacıtıes		8.5 EER
Wıth Reverse Cycle and Wıthout Louvered Sıdes – All Capacıtıes		8 0 EER

Subp. 7 **Water source equipment.** Water source, groundwater source, and ground source heat pumps electrıcally operated must meet the requırements of thıs subpart Mınnesota Statutes, sectıon 103G.271, subdıvısıon 5, prohıbıts once–through systems

WATER SOURCE EQUIPMENT

EQUIPMENT	EQUIPMENT SIZES AND MODE	RATING CONDITION	EFFICIENCY
Water Source	<135,000 Btu/h	Standard Rating Entering Water (70°F)	3 8 COP
		Entering Water (75°F)	3 9 COP
Groundwater Source Heat Pumps	<135,000 Btu/h	High Temperature Rating Entering Water (70°F)	3 4 COP
		Low Temperature Rating Entering Water (50°F)	3.0 COP
Ground Source Heat Pumps	<135,000 Btu/h	High Temperature Rating Entering Water (41°)	2 70 COP
		Low Temperature Rating Entering Water (32°)	2 50 COP

Subp 8. **Gas–fired and oil–fired equipment.** Gas–fired and oil–fired boilers, furnaces, and unit heaters and combination furnace/air conditioner units must meet the requirements of this subpart Minimum and maximum ratings must be as provided for and allowed by the equipment controls

GAS–FIRED AND OIL–FIRED EQUIPMENT

EQUIPMENT	EQUIPMENT SIZES AND MODE	RATING CONDITION	MINIMUM EFFICIENCY
Gas–fired boilers	<300,000 Btu/h	Hot water	80% AFUE
		Steam	75% AFUE
	>300,000	Both maximum and minimum rated capacity	80% Ec* or 80% Et**
Gas–fired furnaces	<225,000 Btu/h	Seasonal rating	78% AFUE
	>225,000 Btu/h	Maximum rated capacity	80% Et**
		Minimum rated capacity	78% Et
Gas–fired duct furnaces	All sizes	Maximum rated capacity	78% Et
		Minimum rated capacity	75% Et

Gas–fired unit heaters	All sizes	Maximum rated capacity	78% Et
		Minimum rated capacity	74% Et
Oil–fired furnaces	<225,000 Btu/h	Seasonal rating	78% AFUE
	>225,000 Btu/h	Both maximum and minimum rated capacity	81% Et**
Oil–fired boilers	<300,000 Btu/h	Seasonal rating	80% AFUE
	>300,000 Btu/h	Both maximum and minimum rated capacity	83% Ec*
Oil–fired boilers (residual)	>300,000 Btu/h	Both maximum and minimum rated capacity	83% Ec
Oil–fired unit heaters	All sizes	Both maximum and minimum rated capacity	81% Et

*Ec = Efficiency, combustion

**Et = Efficiency, thermal

Subp 9 **Mobile home equipment.** Mobile home furnaces, steam boilers, and direct heating equipment must meet the requirements of this subpart.

MOBILE HOME EQUIPMENT

EQUIPMENT	EQUIPMENT SIZES	EFFICIENCY (AFUE)
Mobile Home Furnaces		75 percent
Gas Steam Boilers		75 percent
Gas Fueled Direct Heating Equipment		
Vented Wall Furnaces	<42,000 Btu/h	73 percent
Fan Type	≥42,000 Btu/h	74 percent
Vented Wall	<10,000 Btu/h	59 percent
Furnaces	≥10,000 and <12,000 Btu/h	60 percent
Gravity Type	≥12,000 and <15,000 Btu/h	61 percent
	≥15,000 and <19,000 Btu/h	62 percent
	≥19,000 and <27,000 Btu/h	63 percent
	≥27,000 and <46,000 Btu/h	64 percent
	≥46,000 Btu/h	65 percent
Vented Floor Furnaces	<37,000 Btu/h	56 percent
	≥37,000 Btu/h	57 percent
Vented Room Heaters	<18,000 Btu/h	57 percent
	≥18,000 and <20,000 Btu/h	58 percent

≥20,000 and <27,000 Btu/h	63 percent
≥27,000 and <46,000 Btu/h	64 percent
≥46,000 Btu/h	65 percent

Subp 10 **Water chilling packages.**

A Double effect, heat operated water chilling packages must be used in lieu of single effect equipment.

EXCEPTION Single effect equipment may be used when all energy input is from low temperature waste heat or renewable energy sources.

B. Water chilling packages, water and air cooled, electrically operated must meet the requirements of this subpart

ELECTRICALLY OPERATED WATER CHILLER PACKAGES

WATER–COOLED	CFC	NON–CFC
Centrifugal	0 63 KW/Ton	0 73 KW/Ton
Helical–rotary (screw)	0 75 KW/Ton	0.80 KW/Ton
Reciprocating or scroll	0 93 KW/Ton	
AIR–COOLED (any type)		
≥150 Ton	1 41 KW/Ton	
<150 Ton	1 30 KW/Ton	

Statutory Authority: *MS s 216C.19*

History: *23 SR 145*

7678.0800 SERVICE WATER HEATING EQUIPMENT EFFICIENCY REQUIREMENTS.

Subpart 1 **Scope.** Service water heating equipment must meet the minimum efficiency requirements in this part.

Subp. 2 **Standards.** Standards for service water heating equipment are located in Code of Federal Regulations, title 10, parts 430 and 435

Subp. 3 **Efficiency.** Efficiency requirements for water heaters regulated by the National Appliance Energy Conservation Act.

EFFICIENCY REQUIREMENTS FOR WATER HEATERS REGULATED BY THE NATIONAL APPLIANCE ENERGY CONSERVATION ACT

Fuel Type (Size)	Energy Factor
Storage gas (<75,000 Btu/h)	$0.62 - (0\ 0019 \times V_V)$
Instantaneous Gas (<200,000 Btu/h)	$0\ 62 - (0.0019 \times V_V)$
Storage oil (<105,000 Btu/h)	$0.59 - (0.0019 \times V_V)$
Instantaneous oil (<210,000 Btu/h)	$0.59 - (0\ 0019 \times V_V)$
Electric (<12 kw)	$0.93 - (0.00132 \times V_V)$
Pool heater (all sizes)	Thermal efficiency > 78 percent

Where. V_V = rated storage volume in gallons

Subp 4 **Other water heaters.** Efficiency requirements for all other water heaters

EFFICIENCY REQUIREMENTS FOR ALL OTHER WATER HEATERS

Fuel Type	Input Rating or Volume	Input to Volume Ratio (Btu/gal)	Minimum Thermal Efficiency	Maximum Standby Loss (% hour)
Electric	>12 KW			0 30 + 27 – V_t
Gas/Oil	≤155,000 Btu/h		78 percent	1 30 + 114 – V_t
Gas/Oil				1 3 + 95 – V_t
Gas/Oil	≥10 gal	>4,000	80 percent	2.3 + 67 – V_t
Gas/Oil	<10 gal	<4,000	78 percent	
Gas/Oil	All	>4,000	77 percent	2 3 + 67 – V_t
Unfired storage tanks	All			≤6 5 Btu/hr/sq ft based on 80°F water–to–air temperature difference

Where V_t = the measured storage volume in gallons

Statutory Authority: *MS s 216C 19*

History: *23 SR 145*

7678.0900 EFFECTIVE DATE.

This chapter is effective July 20, 1999

Statutory Authority: *MS s 216C.19*

History: *23 SR 145*

NOTE Two parts were originally adopted at 23 SR 145 as 7678 0800 This part was renumbered editorially