Occupant Load Calculations

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Polling Features of WebEx

• We will be using the polling features of WebEx
• This does the following:
  – Allows attendees to participate in the exercises
  – Tracks attendance so we can issue certificates
  – Provides demographic data
• You are also welcome to submit questions; there are staff monitoring the chat function
When Are Occupant Load Calculations Used?

- Determine overcrowding
- Establish minimum number of exits
- Establish minimum width of exits
- Determine the occupancy classification
- Determine thresholds for fire protection systems
- COVID-19 capacities
Learning Objectives

• Select the appropriate occupant load factor based on the function of the space
• Apply the occupant load factors to a given size space to determine the number of people that can be in building or area
• Determine the number and size of exits needed
• Evaluate the adequacy of the means of egress system based on the number of occupants
Four Concepts of Egress
# Four Concepts of Egress

#1: Exits must be provided for all building occupants

- Code assumes a “worst-case scenario”
- Building is occupied to its maximum capacity all the time
#2: Occupants must have control of all elements of the exit system

- Occupants must be able to get from any point in the building to the “public way” (point at which they are safe)
- All exits must be easily identified, openable from inside, and unobstructed
Four Concepts of Egress

#3: Once the size and number of exits have been established, they cannot be reduced

- This requirement establishes the baseline for exiting; it is not allowed to be decreased
- Exception: if the use changes and lesser exiting is required by new use
#4: Once a level or degree of safety in the exit system has been established, it cannot be diminished

- Travel through the exit system must increase protection for the occupants
- Occupants can go through areas of equal or lesser danger, not more hazardous than where they were
Occupant Load Calculations

MSFC 1004
Design Occupant Load:

- This is the “basis” of many means of egress and fire protection requirements
- Refers to occupant load factors (OLF)
- Where accessory areas egress through a primary space, the occupant load of both spaces are added together
Occupyant Loads Can be Cumulative – MSFC 1004.2.1

Room 1: 45 occupants

Room 2: 75 occupants

Egress capacity for 120 (45 + 75)
Areas without fixed seating

• Divide floor area by the occupant load factor in Table 1004.5

• If intended function is not listed, should choose one that resembles the function

• The exception to MSFC 1004.5 allows the actual number of occupants instead of the design occupant load (use extreme caution when using this exception)
Areas with fixed seating

- Chairs, seats – number of seats
- Benches, bleachers – 1 person per 18 inches
- Booths – 1 person per 24 inches
- For curved benches, pews, or booths, the larger radius determines the length
- Outdoor areas are treated the same
Occupant Load Definitions

- Table 1004.5 uses “net” and “gross” numbers
- “Net” means the actual occupied area
  - Area where people can actually stand or occupy
  - Excludes unoccupied accessory spaces (stairs, halls, restrooms, mechanical rooms, closets, etc.)
- “Gross” means the area bounded by exterior walls
  - Includes all spaces that can be occupied or not
  - Excludes vent shafts and courts
Net Floor Area

• Excludes areas where people don’t congregate
Gross Floor Area

Ventilation shaft excluded
Common Occupant Load Factors – MSFC 1004.5

<table>
<thead>
<tr>
<th>Function:</th>
<th>OLF (ft² / person):</th>
<th>Gross or Net:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assembly – standing / sitting</td>
<td>7</td>
<td>Net</td>
</tr>
<tr>
<td>Assembly – table seating</td>
<td>15</td>
<td>Net</td>
</tr>
<tr>
<td>Assembly – waiting space</td>
<td>5</td>
<td>Net</td>
</tr>
<tr>
<td>Exercise areas</td>
<td>50</td>
<td>Gross</td>
</tr>
<tr>
<td>Classrooms</td>
<td>20</td>
<td>Net</td>
</tr>
<tr>
<td>Shops / laboratories / vocational</td>
<td>50</td>
<td>Net</td>
</tr>
</tbody>
</table>
# Common Occupant Load Factors – MSFC 1004.5

<table>
<thead>
<tr>
<th>Function</th>
<th>OLF (ft² / person):</th>
<th>Gross or Net:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Offices</td>
<td>150*</td>
<td>Gross</td>
</tr>
<tr>
<td>Stages</td>
<td>15</td>
<td>Net</td>
</tr>
<tr>
<td>Day care centers</td>
<td>35</td>
<td>Net</td>
</tr>
<tr>
<td>Exercise areas</td>
<td>50</td>
<td>Gross</td>
</tr>
<tr>
<td>Kitchens</td>
<td>200</td>
<td>Gross</td>
</tr>
<tr>
<td>Industrial / manufacturing</td>
<td>100</td>
<td>Gross</td>
</tr>
<tr>
<td>Function</td>
<td>OLF (ft² / person):</td>
<td>Gross or Net:</td>
</tr>
<tr>
<td>-------------------------------------------------------------------------</td>
<td>---------------------</td>
<td>--------------</td>
</tr>
<tr>
<td>Residential</td>
<td>200</td>
<td>Gross</td>
</tr>
<tr>
<td>Warehouses</td>
<td>500</td>
<td>Gross</td>
</tr>
<tr>
<td>Mercantile</td>
<td>60*</td>
<td>Gross</td>
</tr>
<tr>
<td>Mercantile – storage/stock/shipping</td>
<td>300</td>
<td>Gross</td>
</tr>
<tr>
<td>Storage &amp; mechanical rooms</td>
<td>300</td>
<td>Gross</td>
</tr>
</tbody>
</table>
• Occupant load calculations apply to existing (as well as new) occupancies:
  – 1104.1.1 – Number of occupants per Section 1004
  – 1104.1.2 – Minimum egress width per Section 1005.1
Occupant Load Exercise #1 (Office)
Occupant Load Exercise #1 (Office)

- $120\text{ ft} \times 60\text{ ft} = 7,200\text{ ft}^2$
- $7,200\text{ ft}^2 / 150 = 48\text{ people}$
Waiting area = 40
Dance floor = 100
Stage = 15
Seating area = 400
TOTAL = 555 people
Occupant Load Exercise #3 (Mixed Use Assembly)

- Waiting Area: 15’ x 20’
- Table and chairs: 30’ x 70’
- Chairs: 30’ x 70’
- Stage: 15’ x 40’
- Restroom
- Restroom
- Bar
- Office
Occupant Load Exercise #3 (Mixed Use Assembly)

- **Waiting area:**
  - 15’ x 20’ = 300 sq. ft.
  - 300 / 5 = 60
- **Table & chairs:**
  - 30’ x 70’ = 2,100 sq. ft.
  - 2,100 / 15 = 140
- **Chairs:**
  - 30’ x 70’ = 2,100 sq. ft.
  - 2,100 / 7 = 300
- **Stage:**
  - 15’ x 40’ = 600 sq. ft.
  - 600 / 15 = 40

60 + 140 + 300 + 40 = 540
Occupyant Load Exercise #4 (Gymnasium)

Bleachers 75’ long by 10 rows

Basketball Court
84’ by 50’

Bleachers 75’ long by 10 rows
Occupant Load Exercise #4 (Gymnasium)

• Bleachers:
  – 75’ / 1.5’ = 50 / row
  – 10 rows = 500
  – 2 bleachers = 1,000
• Basketball court:
  – 84’ x 50’ = 4,200 ft²
  – 4,200 / 50 = 84
• Total = 1,084 people
Occipant Load Exercise #5 (Gymnasium)

Bleachers 75’ long by 10 rows

Chair Seating 84’ by 50’

Bleachers 75’ long by 10 rows

Stage 450 ft²
• Bleachers = 1,000
• Seating = 4,200 ft²
  – 4,200 / 7 = 600
• Stage = 450 ft²
  – 450 / 15 = 30
• Total = 1,630 people
Assembly Seating

Chair seating – 7 sq. ft.

Bleacher seating ~ 3.5 sq. ft.
Egress Width

MSFC Section 1005
Egress Width – MSFC 1005.3

- After the occupant load of the area or building has been determined, the necessary width can be computed
- Called the “Capacity Factor”
- Capacity factors are based on:
  - Type of egress component
  - The area it serves
# Capacity Factors for Egress Width

Capacity factors are based on inches per person.

<table>
<thead>
<tr>
<th>Use</th>
<th>Stairways</th>
<th>Other components</th>
</tr>
</thead>
<tbody>
<tr>
<td>All occupancies – except H &amp; I-2</td>
<td>0.3</td>
<td>0.2</td>
</tr>
<tr>
<td>All occupancies (except H &amp; I-2) with sprinklers &amp; voice alarm</td>
<td>0.2</td>
<td>0.15</td>
</tr>
<tr>
<td>Smoke-protected assembly seating / open-air seating</td>
<td>1029.6.2 or 1029.6.3</td>
<td>1029.6.2 or 1029.6.3</td>
</tr>
</tbody>
</table>
Capacity of Egress Features

- Occupant load factors based on former “units of exit width” (22 inches)
- Based on studies showing how people move through various egress features
- Studies factored in flows (number of people in an amount of time)
Capacity of Egress Features

• For level egress components:
  – 22 inches / 100 persons = 0.22 inches per person
  – Rounded to 0.2 inches per person

• For stairs:
  – 22 inches / 75 persons = 0.293 inches per person
  – Rounded to 0.3 inches per person
Egress Width Formulas

- Required width = number of people x capacity factor
- Maximum number of people = width / capacity factor
- Examples:
  - 300 people x 0.2 = 60 inches of width
  - 60 inches of width / 0.2 = 300 people
  - 300 people x 0.3 (stairs) = 90 inches of width
  - 90 inches of width / 0.3 (stairs) = 300 people
Egress Width Formulas

• Stairs:
  – Width (in inches) / 0.3 = # of occupants

• Other egress components:
  – Width (in inches) / 0.2 = # of occupants
Egress Width Calculation Examples

- Door capacity (3 feet wide = 36 inches):
  - 36” – 4” (door & hardware) = 32”
  - 32” / 0.2 = 160 people

- Stair capacity (4 feet wide = 48 inches):
  - 48” – 9” (4 ½” handrail on each side) = 39”
  - 39” / 0.3 = 130 people
Each 3 ft. wide door can accommodate 150 people
- $36'' - 4''$ (door & hardware) = $32''$
- $32'' / 0.2 = 160$ people

Gymnasium egress calculation based on number of doors (next slide)
Determine Egress Capacity of Doors
Assembly Seating

-bleachers: 500 occupants
-100 portable chairs
-100 portable chairs
-100 portable chairs
Egress Width Exercise (Bar)

- 555 people
- Level egress or stairs?
- 555 times 0.2 = 111 inches of egress needed
- Is there enough egress width provided?
Egress Width Exercise (Gymnasium)

Basketball Court
84’ by 50’

Bleachers 75’ long by 10 rows

Bleachers 75’ long by 10 rows
Egress Width Exercise (Gymnasium with Chairs)

- Is there sufficient egress width for this function?
  - With 36” doors (32” clear opening)
  - With 48” doors (44” clear opening)
Egress Width Exercise (Gymnasium with Chairs)

- Bleachers = 1,000
- Seating = 4,200 ft²
  - 4,200 / 7 = 600
- Stage = 450 ft²
  - 450 / 15 = 30
- Total = 1,630 people
- 8 x 32” doors = 256”
- 256 / 0.2 = 1,280
Number of Exits
Number of Exits Required – MSFC 1006.2.1 (new)

- Second exit is required from spaces where:
  - The occupant load is:
    - 50 or more people in A, B, E, F, M, & U occupancies
    - 11 or more people in H-4, H-5, I-1, I-2, I-3, I-4 & R-1 occupancies
    - 21 or more people in R-2, R-3, & R-4 occupancies
    - 30 or more people in S occupancies
    - 4 or more people in H-1, H-2, & H-3 occupancies
  - Common path of travel is exceeded
- There are numerous exceptions
Number of Exits Required – MSFC 1006.3.2 (new)

- Three (3) exits are required where:
  - The occupant load is 501-1,000

- Four (4) exits are required where:
  - The occupant load is 1,001 or more
Number of Exits Required – MSFC 1104.25 (existing)

- Second exit is required from spaces where:
  - The occupant load is:
    - 50 or more people in A, B, E, F, M, S, & U occupancies
    - 11 or more people in H, I, & R occupancies
    - 17 or more people in R dormitories (with conditions)
  - Common path of travel is exceeded

- Three (3) exits required for 501-1,000 occupants
- Four (4) exits required for 1,001 or more occupants
Egress is Usually Fairly Simple

- Egress design in most buildings is fairly simple:
  - Most buildings have relatively few occupants
  - Most buildings do not have excessive travel distances
  - Most buildings are not real tall

- What types of buildings have complex egress systems?
Two Exits = ~ 300 People

- Office = 45,000 ft²
- Residential = 60,000 ft²
- Industrial = 30,000 ft²
- Classroom = 6,000 ft²
- Mercantile = 30,000 ft²
- Storage = 150,000 ft²
Social Distancing
Social Distancing

- The human body is elliptically shaped
- To maintain 6 ft. for social distancing, each person needs 45-55 sq. ft.

The formula for an ellipse is $\pi ab$. $\pi \times 4' \times 3.5' = 43.96$ sq. ft.
The formula for a rectangle is length times width. $8' \times 7' = 56$ sq. ft.
Social Distancing

• The previous two examples assume that people are sitting or standing still
• If moving around, social distancing will likely increase to 100-150 sq. ft. per person depending on their activity and movement
Next Steps

• If you participated in the polling function (so we know you were on-line and paying attention), you will receive an e-mail providing you a link:
  – Fill out an evaluation
  – Get a certificate

• The presentation (PowerPoint slides) will be uploaded to our website for future download and reference
Questions

Website: https://sfm.dps.mn.gov
Thank you

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