

5 Tornadoes

- FEMA P-361, Safe Rooms for Tornadoes and Hurricanes: Guidance for Community and Residential Safe Rooms



Safe Rooms for Tornadoes and Hurricanes

Guidance for Community and Residential Safe Rooms

FEMA P-361, April 2021
Fourth Edition

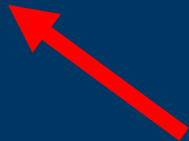
https://www.fema.gov/sites/default/files/documents/fema_safe-rooms-for-tornadoes-and-hurricanes_p-361.pdf



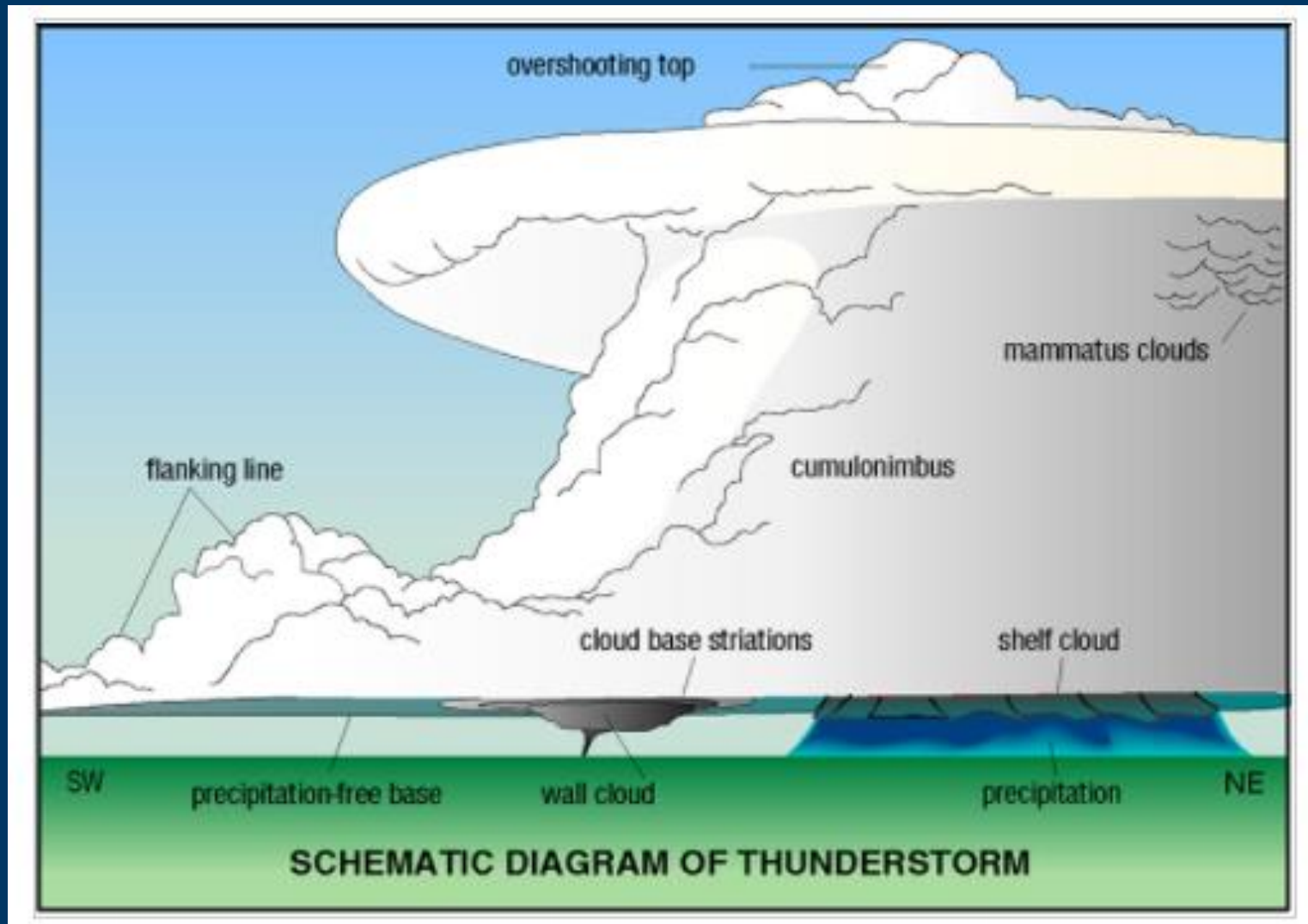
5 - Tornado Definition

The National Weather Service defines a tornado as:

“A violently rotating column of air, usually pendant to a cumulonimbus, with circulation reaching the ground. It nearly always starts as a funnel cloud and may be accompanied by a loud roaring noise. On a local scale, it is the most destructive of all atmospheric phenomena.”



5 - Tornado Formation



5 - Tornado Damage Rating Scale

OPERATIONAL EF SCALE	
EF Number	3 Second Gust (mph)
0	65-85
1	86-110
2	111-135
3	136-165
4	166-200
5	Over 200

The EF-scale is a set of wind estimates (not measurements) based on damage. It uses three-second gusts estimated at the point of damage based on a judgment of 8 levels of damage to the 28 indicators.



5 - 28 Indicators

<u>1</u>	Small barns, farm outbuildings	<u>8</u>	Small retail bldg. (fast food)	<u>15</u>	School - 1-story elementary (interior or exterior halls)	<u>22</u>	Service station canopy
<u>2</u>	One- or two-family residences	<u>9</u>	Small professional (doctor office, branch bank)	<u>16</u>	School - jr. or sr. high school	<u>23</u>	Warehouse (tilt-up walls or heavy timber)
<u>3</u>	Single-wide mobile home (MHSW)	<u>10</u>	Strip mall	<u>17</u>	Low-rise (1-4 story) bldg.	<u>24</u>	Transmission line tower
<u>4</u>	Double-wide mobile home	<u>11</u>	Large shopping mall	<u>18</u>	Mid-rise (5-20 story) bldg.	<u>25</u>	Free-standing tower
<u>5</u>	Apt, condo, townhouse (3 stories or less)	<u>12</u>	Large, isolated ("big box") retail bldg.	<u>19</u>	High-rise (over 20 stories)	<u>26</u>	Free standing pole (light, flag, luminary)
<u>6</u>	Motel	<u>13</u>	Automobile showroom	<u>20</u>	Institutional bldg. (hospital, govt. or university)	<u>27</u>	Tree - hardwood
<u>7</u>	Masonry apt. or motel	<u>14</u>	Automotive service building	<u>21</u>	Metal building system	<u>28</u>	Tree - softwood

<https://www.spc.noaa.gov/efscale/ef-scale.html>



2. ONE-AND TWO-FAMILY RESIDENCES (FR12)

(1000 – 5000 sq. ft.)

Typical Construction

- Asphalt shingles, tile, slate or metal roof covering
- Flat, gable, hip, mansard or mono-sloped roof or combinations thereof
- Plywood/OSB or wood plank roof deck
- Prefabricated wood trusses or wood joist and rafter construction
- Brick veneer, wood panels, stucco, EIFS, vinyl or metal siding
- Wood or metal stud walls, concrete blocks or insulating-concrete panels
- Attached single or double garage

DOD*	Damage description	EXP	LB	UB
1	Threshold of visible damage	65	53	80
2	Loss of roof covering material (<20%), gutters and/or awning; loss of vinyl or metal siding	79	63	97
3	Broken glass in doors and windows	96	79	114
4	Uplift of roof deck and loss of significant roof covering material (>20%); collapse of chimney; garage doors collapse inward; failure of porch or carport	97	81	116
5	Entire house shifts off foundation	121	103	141
6	Large sections of roof structure removed; most walls remain standing	122	104	142
7	Exterior walls collapsed	132	113	153
8	Most walls collapsed, except small interior rooms	152	127	178
9	All walls	170	142	198
10	Destruction of engineered and/or well constructed residence; slab swept clean	200	165	220

* DOD is degree of damage



24. ELECTRICAL TRANSMISSION LINE (ETL)

Typical Construction

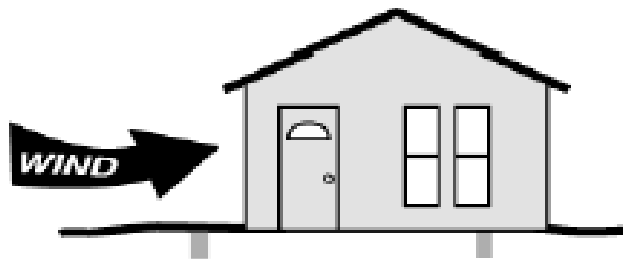
- Single wood poles with wood cross arms
- Single steel or concrete poles with metal cross arms
- Metal trussed towers

DOD*	Damage description	EXP	LB	UB
1	Threshold of visible damage	83	70	98
2	Broken wood cross member	99	80	114
3	Wood poles leaning	108	85	130
4	Broken wood poles	118	98	142
5	Broken or bent steel or concrete poles	138	115	149
6	Collapsed metal truss towers	141	116	165

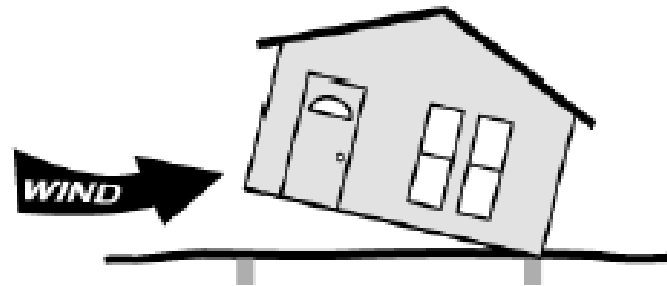
* DOD is degree of damage



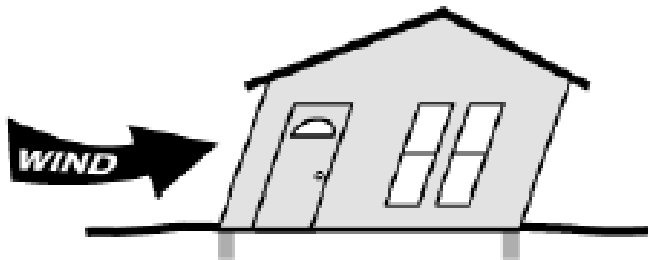
5 - General Wind Failure Modes



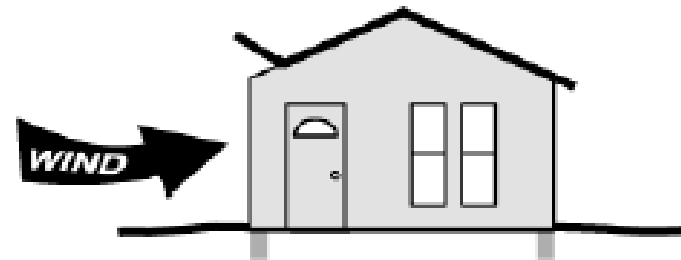
Translation or Sliding
(Lateral Movement)



Overturning



Racking
(Lateral Collapse)



Material Failure





5 – Indicator 28

28. TREES (SOFTWOOD)

Typical Construction

- Softwood: Pine, Spruce, Fir, Hemlock, Cedar, Redwood, Cypress

DOD	Damage description	EXP	LB	UB
1	Small limbs broken (up to 1" diameter)	60	48	72
2	Large branches broken (1" – 3" diameter)	75	62	88
3	Trees uprooted	87	73	113
4	Trunks snapped	104	88	128
5	Trees debarked with only stubs of largest branches remaining	131	112	153

* DOD is degree of damage



5 - Tornado Damage Rating Scale

Aerial Study – Determine Path

Ground
Study
Estimate
DOD's

Upper
Bound-
Lower
Bound
Velocities

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5 - Tornado EF Scale

Developed in 1971 by T. Theodore Fujita

Enhanced Feb 2007

FUJITA SCALE			OPERATIONAL EF SCALE	
F Number	Fastest 1/4-mile (mph)	3 Second Gust (mph)	EF Number	3 Second Gust (mph)
0	40-72	45-78	0	65-85
1	73-112	79-117	1	86-110
2	113-157	118-161	2	111-135
3	158-207	162-209	3	136-165
4	208-260	210-261	4	166-200
5	261-318	262-317	5	Over 200



EF 4 Tornado

Scope : Can we reuse the foundation?



EF-4 Tornado

Scope: Determine the extent of Damage

