



Enhanced Fujita Scale

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Original Fujita Scale

- Developed by Dr. T. Theodore Fujita 1971 and published as "Proposed Characterization of Tornadoes and Hurricanes by Area and Intensity"
 - F0 (Gale)
 - F1 (Weak)
 - F2 (Strong)
 - F3 (Severe)
 - F4 (Devastating)
 - F5 (Incredible)
- Categorized by area and intensity with an estimated wind speed
- Became the standard for tornado ratings in 1974



Original Fujita Scale

EF3



EF2

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Fig. 1. Connection of Beaufort force, Fujita scale and Mach number. In deriving the equation for F-scale wind computation, the following considerations were made, (1) To connect Beaufort force 12 with Mach number 1 with a smooth curve, (2) To correspond B 12 with F 1 and M 1 with F 12, so that a 1 through 12 graduated scale, as in the case Beaufort force, covers the desired speed range. (3) Beaufort 0 indicates calm or no wind and Fujita 0 likewise denotes the wind speed causing no damage on most structures, (4) To give wider speed range as the speed increases because the faster the wind speed the wider the speed range to allow a visual distinction of damage from one scale to the next, and (5) An exponent 3/2 is likely to serve the above purpose. Furthermore, the square of the speed or the kinetic energy is proportional to the cube of F + 2. About 20

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F040-72 mph



Next 6 slides courtesy Wikipedia



- F1
- 73-112 mph





- F2
- 113-157 mph





- F3
- 158-206 mph



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• 207-260 mph

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- F5
- 261-318 mph



Limitations

- Subjective based solely on the damage caused by a tornado
- No recognition in difference in construction
- Difficult to apply with no damage indicators
 - if the 3/4-mile wide tornado does not hit any structures, what F-scale should be assigned?
- Based on the worst damage (even if it is one building or house)
- Overestimates wind speeds greater than F3
- Too much reliance on the estimated wind speeds
- Oversimplification of the damage description
- Unrecognizing weak structures
 - mobile homes

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- modified homes

New Enhanced Fujita Scale (EF)

- Developed from 2000 to 2004 by cross-disciplinary experts and scientists
- First used in 2007

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Why the EF-Scale was created

- Need more damage indicators
- recalibrate winds associated with F-scale ratings
- better correlate wind and rating
- account for construction variability
- Flexibility, Extensibility, Expandability

The framed house is one of only a few F-scale damage indicators.



Evidence indicates a well constructed house can be blown away by winds much less than 260 mph (Phan and Simiu,2003).

The forum identifies EF-Scale development strategies

- Identify additional Damage Indicators (DI)s
- Correlate damage to wind speed
 Degrees of Damage (DOD) for each DI
- Preserve the historical database
- Seek input from users
- Maximize usability

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EF-Scale Damage Indicators (DIs)

- 28 DIs were identified by the Steering Committee
- DIs and DODs can be added or modified
- Each DI has several Degrees of Damage (DOD)



28 Damage Indicators

Table 3.

Damage Indicators for EF Scale

DI No.	Damage indicator (DI)
1	Small Barns or Farm Outbuildings (SBO)
2	One- or Two-Family Residences (FR12)
3	Manufactured Home – Single Wide (MHSW)
4	Manufactured Home – Double Wide (MHDW)
5	Apartments, Condos, Townhouses [3 stories or less] (ACT)
6	Motel (M)
7	Masonry Apartment or Motel Building (MAM)
8	Small Retail Building [Fast Food Restaurants] (SRB)
9	Small Professional Building [Doctor's Office, Branch Banks] (SPB)
10	Strip Mall (SM)
11	Large Shopping Mall (LSM)
12	Large, Isolated Retail Building [K-Mart, Wal-Mart] (LIRB)
13	Automobile Showroom (ASR)
14	Automobile Service Building (ASB)
15	Elementary School [Single Story; Interior or Exterior Hallways] (ES)
16	Junior or Senior High School (JHSH)
17	Low-Rise Building [1-4 Stories] (LRB)
18	Mid-Rise Building [5-20 Stories] (MRB)
19	High-Rise Building [More than 20 Stories] (HRB)
20	Institutional Building [Hospital, Government or University Building] (IB)
21	Metal Building System (MBS)
22	Service Station Canopy (SSC)
23	Warehouse Building [Tilt-up Walls or Heavy-Timber Construction](WHB)
24	Transmission Line Towers (TLT)
25	Free-Standing Towers (FST)
26	Free-Standing Light Poles, Luminary Poles, Flag Poles (FSP)
27	Trees: Hardwood (TH)
28	Trees: Softwood (TS)

Residences

Commercial/retail structures

Schools Professional buildings Metal buildings/canopies

Towers/poles

Vegetation

Objectives: 3, EF-Scale structure

Degrees of Damage

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DOD	Damage Description	EXP	LB	UB
1	Threshold of visible damage	?	?	?
2	Loss of roof covering material (<20%), gutters and/or awning; loss of vinyl or metal siding			
3	Broken glass in doors and windows			
4	Uplift of roof deck and loss of significant roof covering material (>20%); collapse of chimney; garage doors collapse inward or outward; failure of porch or carport			
5	Entire house shifts off foundation			
6	Large sections of roof structure removed; most walls remain standing			
7	exterior walls collapsed			
8	Most walls collapsed except small interior rooms.			
9	All walls collapsed			
10	Destruction of engineered and/or well constructed residence; slab swept clean			

DOD for a Framed House, FR12 or DOD2



F-Scale Converted to EF-Scale

F Scale	Wind Speed	EF-Scale	Wind Speed
F0	45-78	EF0	65-85
F1	79-117	EF1	86-109
F2	118-161	EF2	110-137
F3	162-209	EF3	138-167
F4	210-261	EF4	168-199
F5	262-317	EF5	200-234

Wind speeds in mph, 3-second gust

Objectives: 3, EF-Scale structure; 4, EF vs F-Scale

Strengths of EF-Scale

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- 28 DIs
- Accounts for differences of structural integrity within a DI
- Wind speeds determined from damage
- Continuity from the F-scale
- Expandibility, Flexibility, Extensibility

- F Scale
 - Only a Couple DIs
 - No accounting for differences of structural integrity within a DI
 - Wind speeds not derived from damage

EF-Scale limitations

- Change in scale may introduce artifacts into the historical record
- Complicated

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- Wind speeds subject to change for each rating
- No function relating wind speed to rating
- Debate continues about wind speed assignments

EF-Scale Tools

EF3

A Recommendation for the Enhanced Fujita Scale

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http://www.spc.noaa.gov/efscale/

The EFkit



http://wdtd.noaa.gov/courses/ef-scale

EF kit 2008 Files

 Download from this site: <u>http://wdtd.noaa.gov/courses/ef-scale</u>

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- Make sure you have EFkit folder unzipped
- In the EFkit folder, double click on EFkit.exe

Software developed by Ed Mahoney, WDTD Image library compiled by Kishor Mehta, TTU Simulated images by Matt Murnan, WDTD

Name 🔺	Size	Туре	Date Modified
Buttons		File Folder	2/13/2008 3:35 PM
🚞 Examples		File Folder	2/13/2008 3:35 PM
Cons Cons		File Folder	2/13/2008 3:35 PM
🛅 Sandbox2		File Folder	2/13/2008 3:35 PM
C Sounds		File Folder	2/13/2008 3:35 PM
C Terms		File Folder	2/13/2008 3:35 PM
🛅 Training		File Folder	2/13/2008 3:35 PM
EFkit08.vbw	1 KB	VBW File	2/1/2008 4:50 PM
EFKit.exe	168 KB	Application	2/13/2008 3:33 PM
EFKit.vbp	1 KB	VBP File	2/13/2008 3:33 PM
🖬 EFKit.vbw	1 KB	VBW File	2/13/2008 3:33 PM
EfkitConfig.txt	24 KB	Text Document	12/14/2007 2:11 PM
🖬 frmBrowser.frm	9 KB	FRM File	2/4/2008 12:23 PM
🖬 frmBrowser.frx	5 KB	FRX File	2/4/2008 12:23 PM
🖬 frmMenu. frm	4 KB	FRM File	2/12/2008 11:27 AM
🖬 frmMenu. frx	8 KB	FRX File	2/12/2008 11:27 AM
🖬 frmTerms.frm	3 KB	FRM File	2/12/2008 11:28 AM
🖬 frmTerms.frx	8 KB	FRX File	2/12/2008 11:28 AM
🖬 frmTraining.frm	3 KB	FRM File	2/13/2008 3:33 PM
🖬 frmTraining.frx	8 KB	FRX File	2/13/2008 3:33 PM
🖬 frnMain.frm	26 KB	FRM File	2/4/2008 11:47 AM
🖬 frnMain.frx	63 KB	FRX File	2/4/2008 11:47 AM
🖬 Killer.bas	3 KB	BAS File	2/12/2008 11:13 AM
🔟 moduleEfkit.bas	1 KB	BAS File	2/4/2008 11:11 AM

Rating a DI with the EF-Scale

- Match the description and/or pictures with the damage you see
- Expected wind = structure adhering to code
- Example: For FR12, what construction is normal (benchmark)?



Accounting for construction quality in F vs EF

• F-scale paradigm

F-0: (Light Damage) Chimneys are damaged, tree branches are broker

F-1: (Moderate Damage) Roof surfaces are peeled off, windows are broke some tree trunks are snapped, unanchored manufactured homes are over-

Lower the rating

structures are lifted from foundations and blown some distance, cars are blown some distance, large debris becomes airborne.

F-5: (Incredible Damage) Strong frame houses are lifted from foundations reinforced concrete structures are damaged, automobile-sized debris becomes airborne, trees are completely debarked.

are torn from structures, i masonry buildings are de

ted houses are destroyed, some

hallow-moted trees are toppled

F-3: (Severe Damage) Rom

F-4: (Devastating Damage) V

small buildings are destroy

turned, attached garages may be destroyed

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 If structure is weaker (stronger) than standard, consider dropping (raising) F-scale

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• EF-Scale paradigm

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 If structure is weaker (stronger) than standard, lower (raise) wind speed toward the LB (UB) and then see if that lowers (raises) the EF rating.



A strategy for surveying tornado tracks with the EF-Scale

- Identify DIs first with broad survey
- Carefully rate DODs for chosen DIs
- Use the highest rated DIs to help rate the tornado

http://wdtd.noaa.gov/courses/EFscale/lesson2/FinalNWSFscaleAssessmentGuide.pdf LIRB: DOD 6: Inward, outward collapse of exterior walls. Expected wind = 137 mph EF3



FR12: DOD7: Exterior walls collapsed. Expected wind = 132 mph, EF2

Additional Information

- Texas Tech Wind Science Engineering Center: <u>http://www.depts.ttu.edu/nwi/Pubs/FScale/EFScale.pdf</u>
- A Guide to F-Scale Damage Assessment <u>http://www.wdtd.noaa.gov/courses/EF-scale/lesson2/FinalNWSF-scaleAssessmentGuide.pdf</u>
- EFKIT: <u>http://wdtd.noaa.gov/courses/ef-scale</u>
- Storm Prediction Center:

http://www.spc.noaa.gov/efscale/

Training Package:

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<u>http://training.weather.gov/wdtd/courses/EF-</u> <u>scale/index.html</u>