Critical Crack Size and Stress Intensity (LEFM)

Stress intensity factor for a crack and the critical crack size at which it reaches the fracture toughness, from stress, geometry factor and K_Ic.

Method: K_I = Yσ√(πa); fracture when K_I = K_Ic (Irwin; linear-elastic fracture mechanics)

Input parameters

Unit system: SI

Parameter	Value	Unit
Applied stress	200.00	MPa
Geometry factor 1.12 for a shallow edge crack, 1.0 for a centre crack in a wide plate; from a handbook for other shapes.	1.1200	
Fracture toughness (MPa·m^½)	50.000	
Crack size (depth or half-length)	5.0000	mm

Calculated results

Parameter	Value	Unit
Stress intensity factor (MPa·m^½)	28.074	
Critical crack size	15.860	mm
Failure stress for the crack	356.20	MPa

Notes for this case

- Linear-elastic fracture mechanics; tough, ductile steels yield first and need elastic-plastic methods. Compare the failure stress with the yield strength: if it is higher, the part yields before it fractures and LEFM does not apply.

Formula and method

$$K_I = Y\sigma\sqrt{\pi a}, \quad a_c = \frac{1}{\pi}\left(\frac{K_{Ic}}{Y\sigma}\right)^2$$

Variables

σ	Applied stress	Pa
Y	Geometry factor	-
K_{Ic}	Fracture toughness (MPa·m^½)	-
a	Crack size (depth or half-length)	m
K_I	Stress intensity factor (MPa·m^½)	-
a_c	Critical crack size	m
σ_f	Failure stress for the crack	Pa

Method and standards

LEFM.

Assumptions and limits

- Small-scale yielding: the failure stress must be well below the yield strength, which is not an input here.
- With no crack (a = 0) the failure stress is not shown.
- K_Ic and K_I are entered and shown in MPa·m^½ as their labels say; the unit lists do not convert them.

References

• K_I = Yσ√(πa); fracture when K_I = K_Ic (Irwin; linear-elastic fracture mechanics)

Report details

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Release checks	2 reference cases of this calculator, computed independently, are checked on every release

Results are for engineering estimation. Verify critical designs against the referenced standards and your own data.

This calculator online

https://calc.firecad.com/materials/properties/critical-crack-size

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.