

AE837

Advanced Mechanics of Damage Tolerance

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upcoming schedule

- Oct 31 - Crack Tip Plasticity, Homework 6 Due
- Nov 5 - Exam 2 Review
- Nov 7 - FE Demo?, Homework 7 Due
- Nov 12 - Exam 2

outline

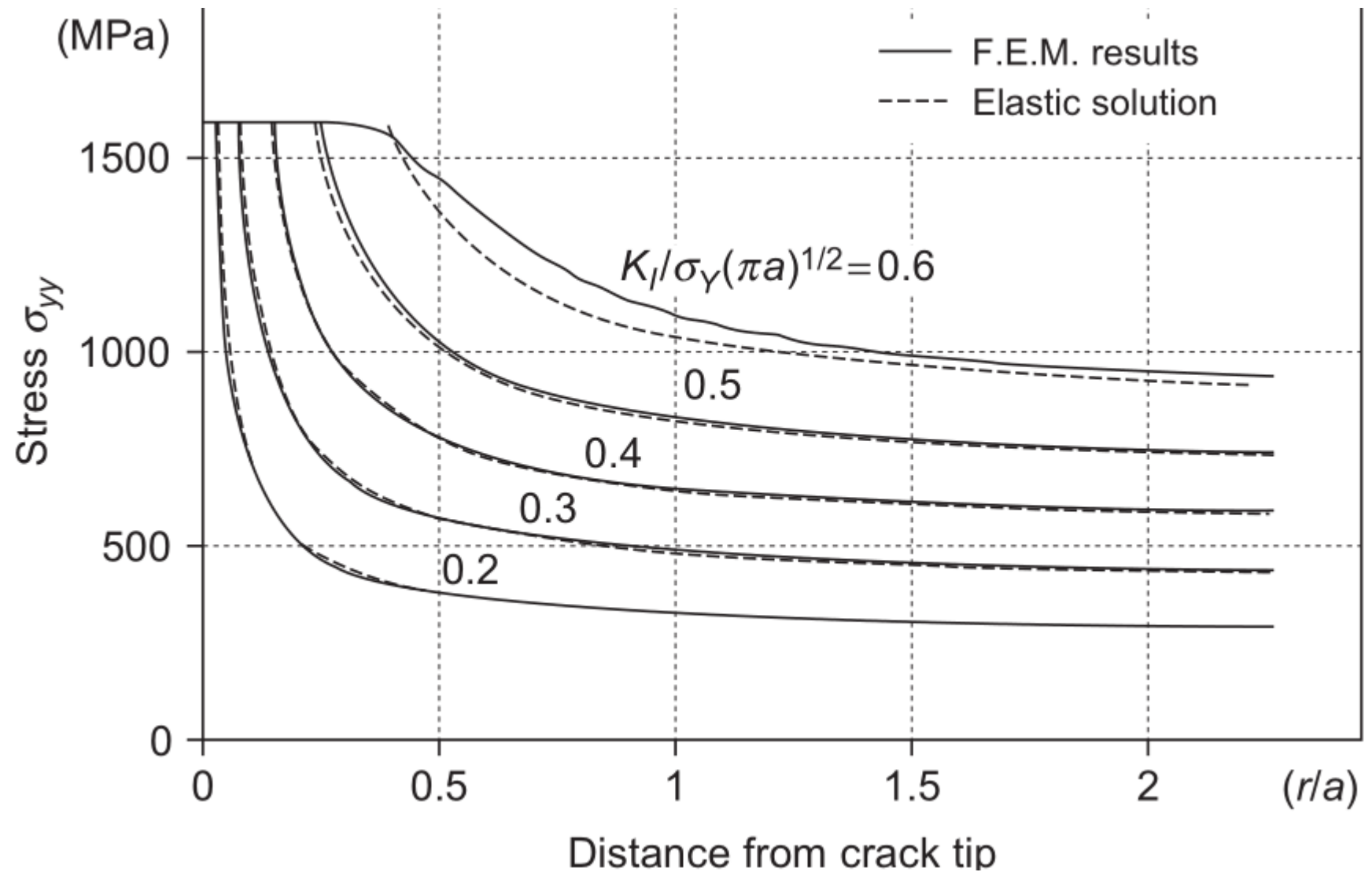
- adjusted stress intensity
- resistance curve
- j integral
- crack tip displacement
- crack tip angle

**adjusted stress
intensity**

adjusted stress intensity

- Irwin's approach to predicting fracture in plastic materials is to simply use the adjusted stress intensity factor
- Thus fracture would occur when $K_I(a_{eff}) = K_c$

irwin stress field

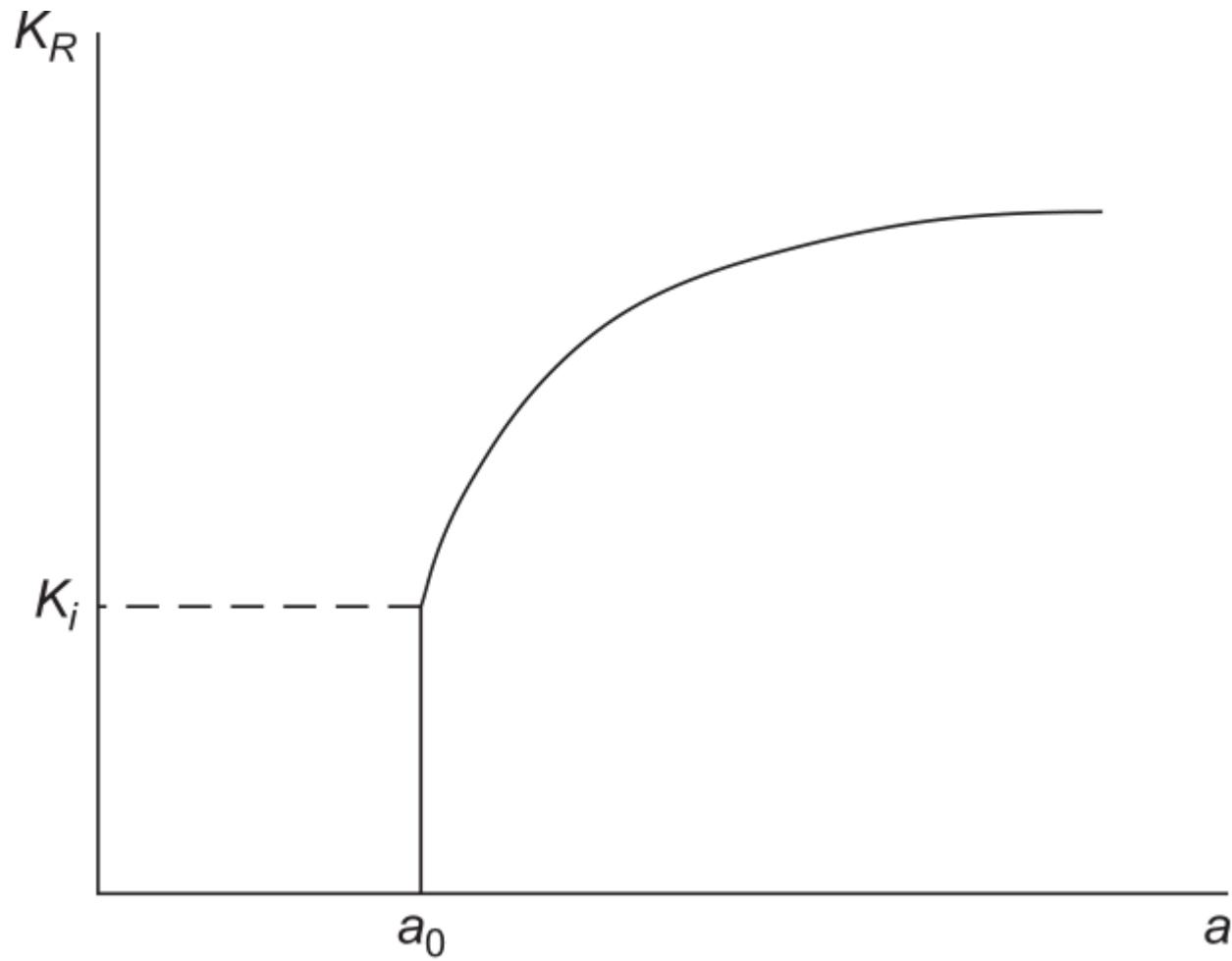


resistance curve

resistance curve

- The Irwin approach is good for small and moderate scale yielding, but thin materials with much larger plastic zones are not described well by this approach
- In these materials we look at the resistance (or K_R) curve
- This is like an adapted version of a stress-strain curve for a cracked panel
- Plots stress intensity factor vs. crack length for a test

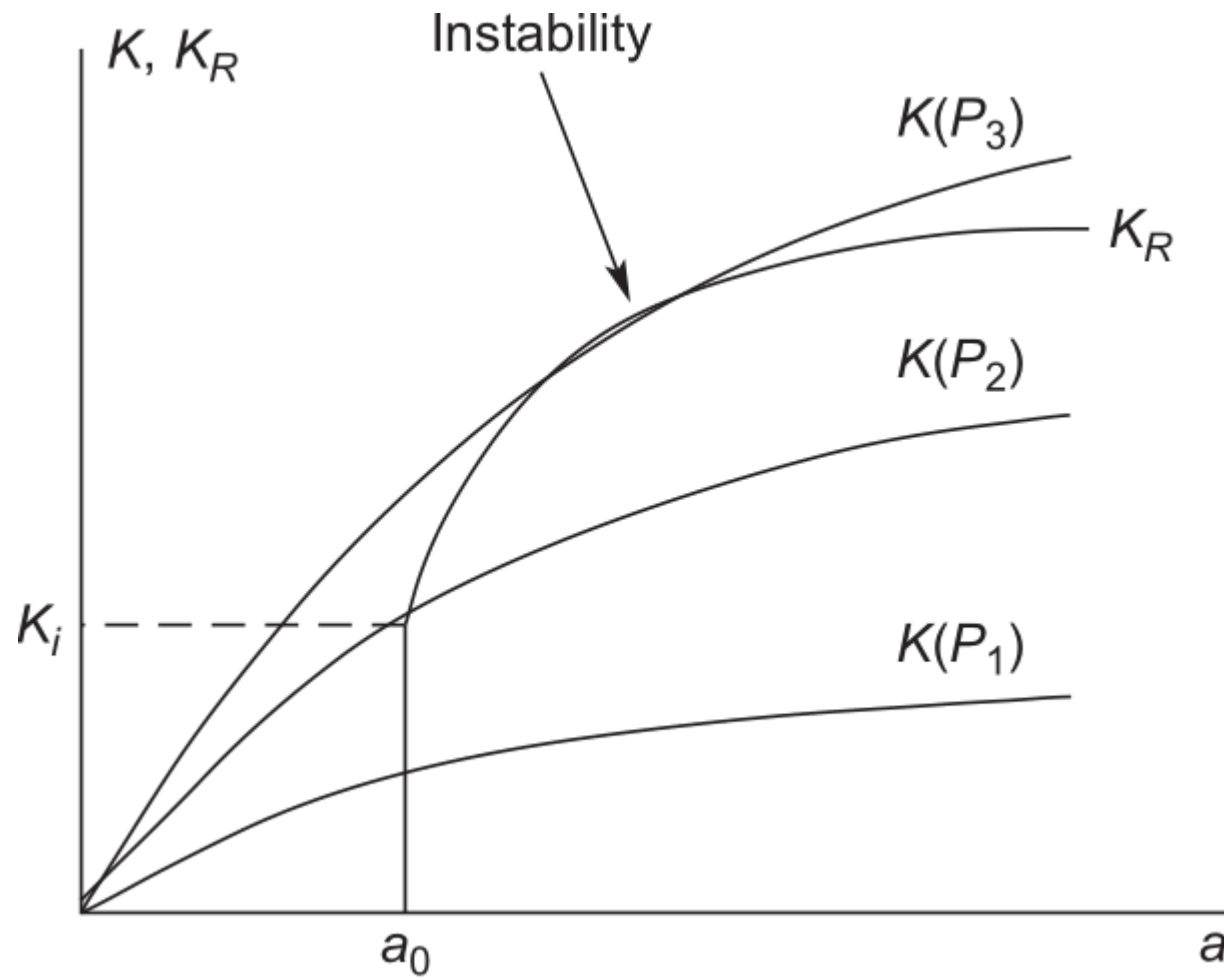
resistance curve



failure

- To determine fracture from the resistance curve we need to look at not just the stress intensity at the current crack length, but also its slope
- We can do this visually by comparing some stress intensity factors at constant load to the K_R curve

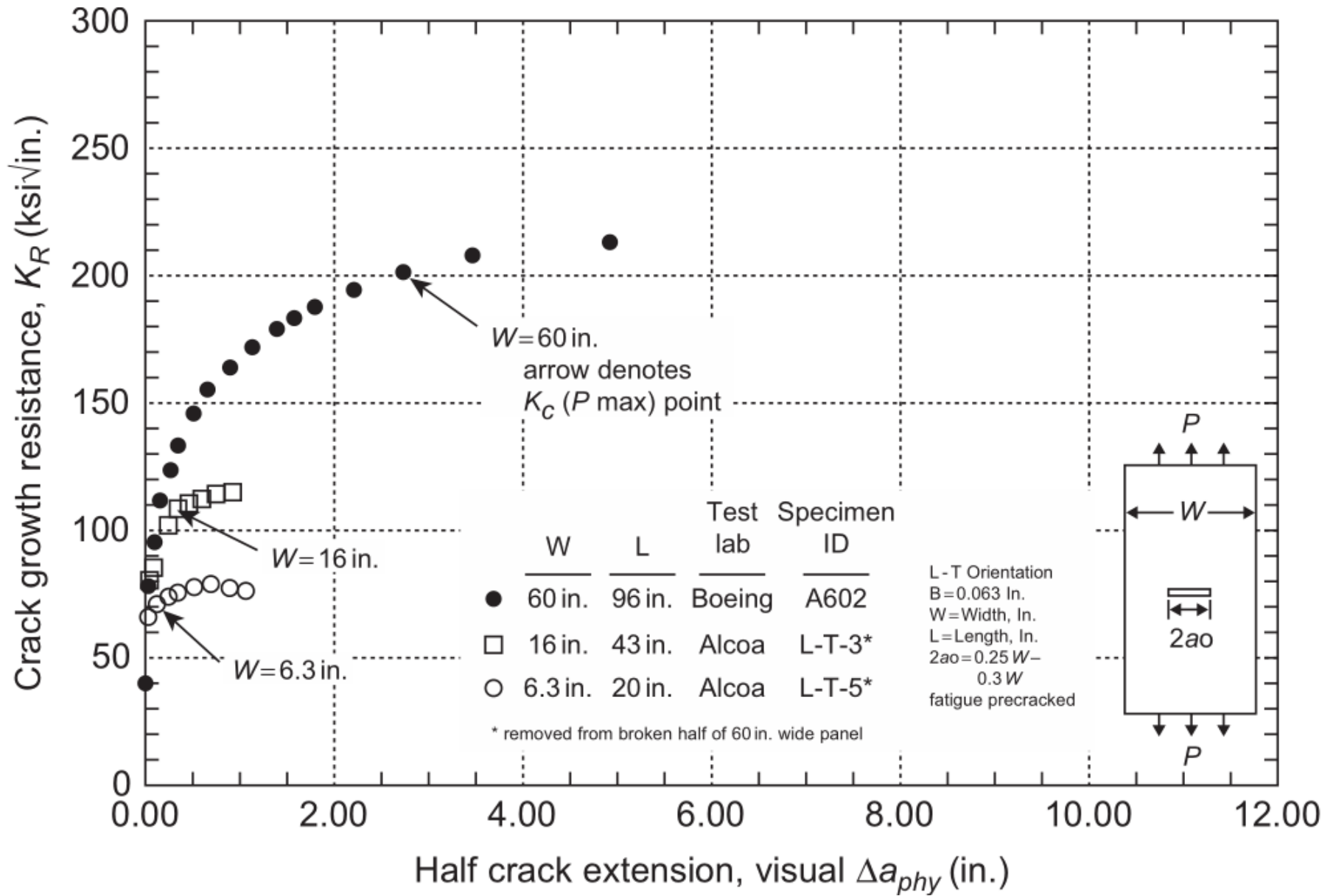
failure



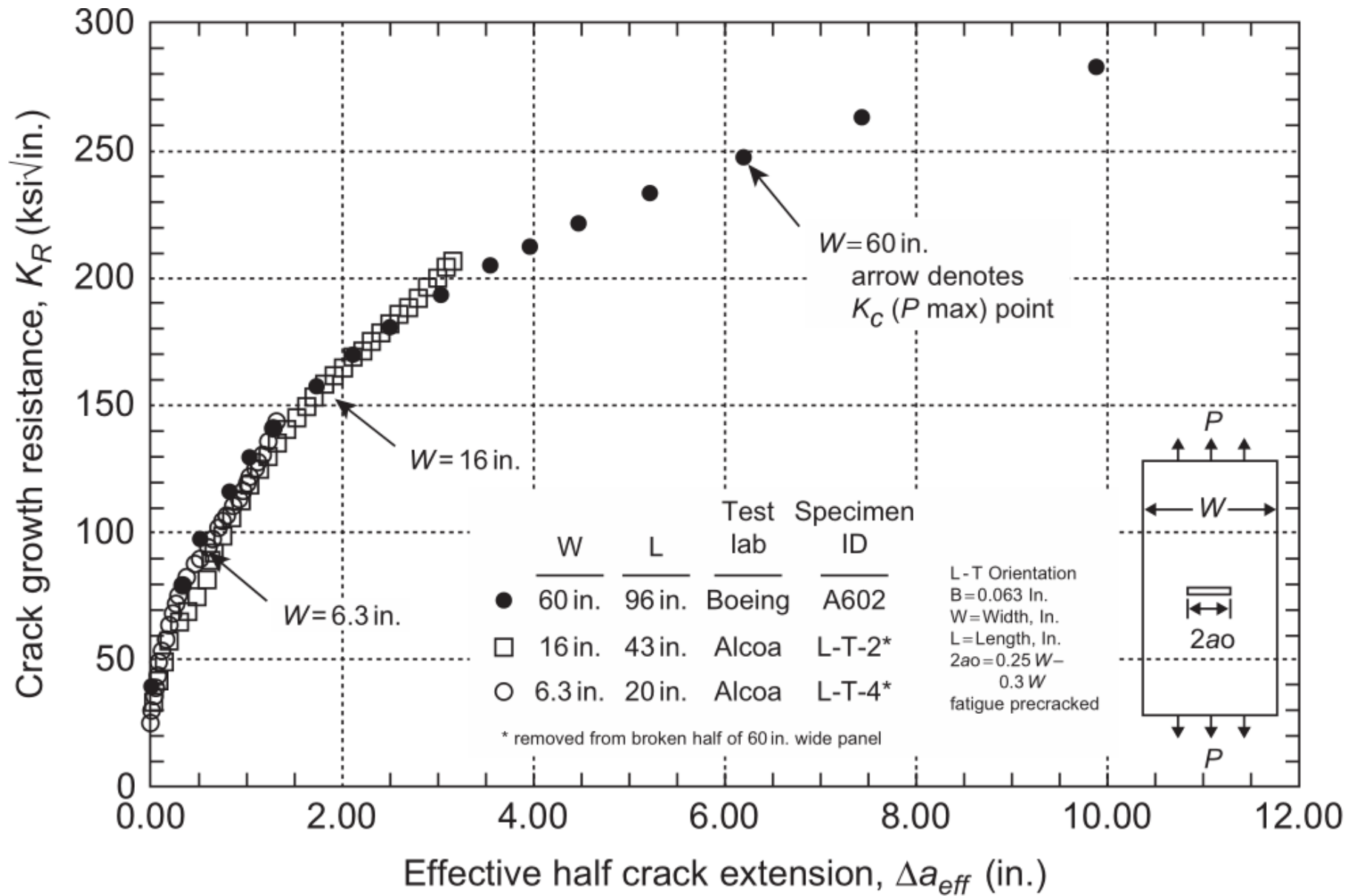
effective crack

- We need to be sure to use the effective crack length
- Difference can be significant for thin materials (where K_R curve is often most useful)

physical crack



effective crack



j integral

j integral

- Since the J-integral can be used for plastic materials as well, it is an attractive idea for a failure criteria
- $J = J_c$ would mark failure
- Unfortunately, under large scale yielding this is limited to some specific cases

**crack tip
displacement**

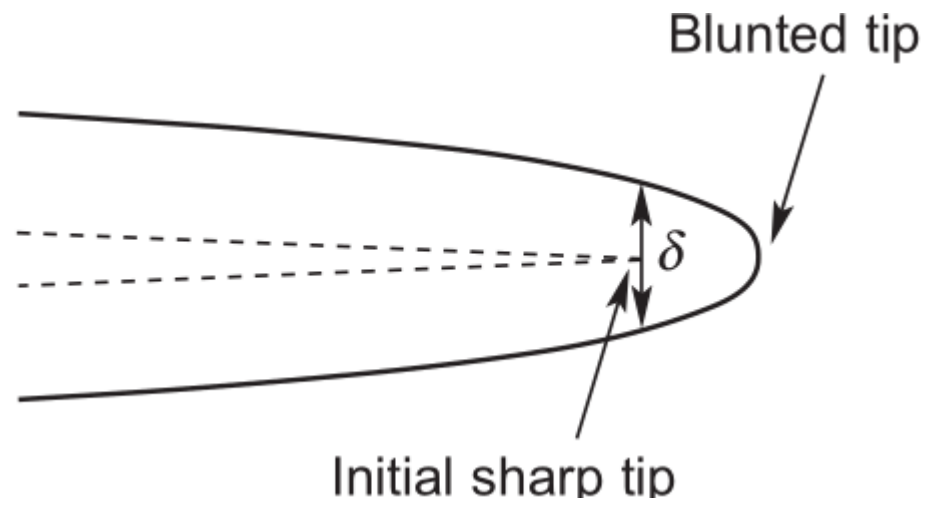
crack tip opening displacement

- under large scale yielding, it is difficult to find a single parameter (like K_I) which can characterize the intensity of a crack tip for both stationary and growing cracks
- the K_R curve is only valid when the plastic zone does not touch the end of the specimen
- J-integral is only for stationary cracks

ctod

- It has been proposed that the displacement near the crack tip could describe fracture behavior and reflects the overall severity of plastic deformation
- crack initiation occurs when $\delta = \delta_c$
- one difficulty is in defining exactly where the crack tip opening displacement occurs

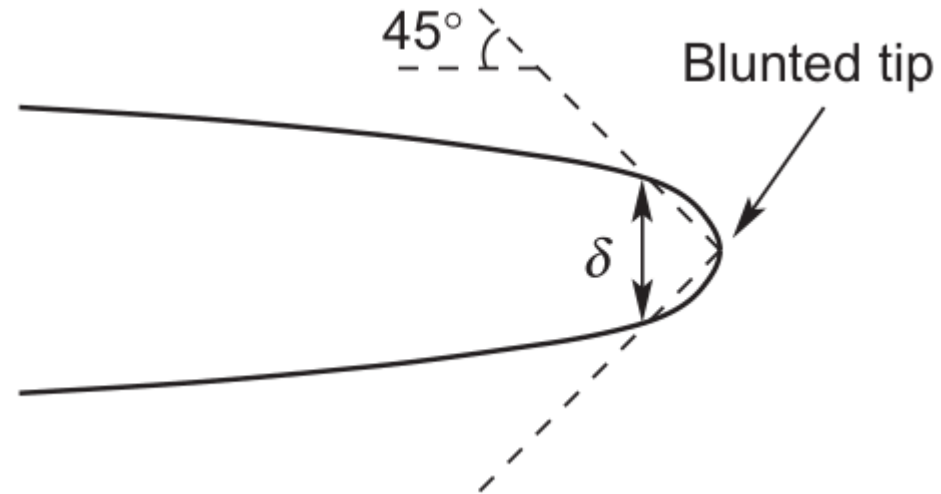
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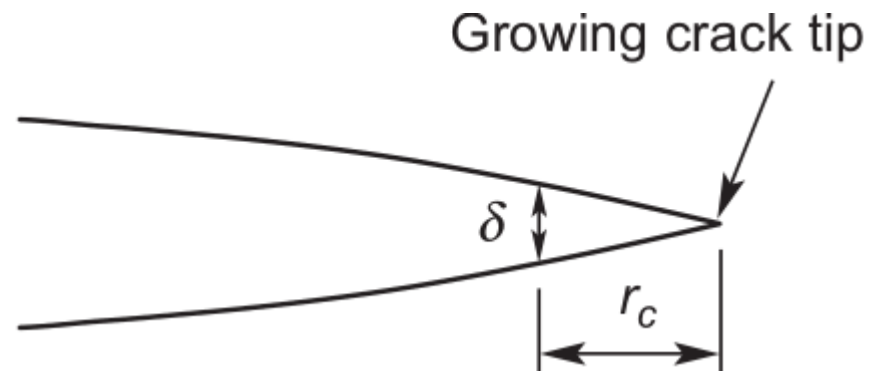
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- In practice, two approaches are often used
- The 45 degree rule is used for static cracks, where a 45 degree line is taken from the center of the blunted crack tip and where it intersects is the point to measure displacement
- For growing cracks, a "characteristic distance" is used instead

45 degree



characteristic distance



crack tip angle

crack tip opening angle

- Theoretically, the crack tip opening angle is defined as the angle between crack faces at the crack tip
- This presents practical challenges for cracks that are not perfectly straight, in which case the angle is averaged
- However, it is a popular approach currently for fracture in ductile materials