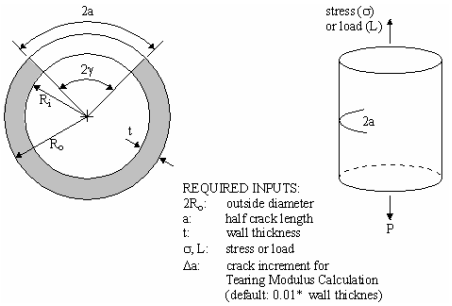
# Using pc-CRACK™ for Windows to Evaluate Flawed Stainless Steel Piping

Elastic Plastic Fracture Mechanics (EFPM) techniques are used to evaluate flawed ductile or semi-ductile materials, including materials exposed to higher temperatures. In **pc-CRACK for Windows**, nine EPFM solutions from the EPRI Ductile Fracture Handbook are provided to characterize ductile and semi-ductile materials. This includes an instability analysis based on the J-Integral/Tearing Modulus approach.

The following describes an engineering problem using **pc-CRACK for Windows**. In this example, a through-wall circumferential crack, 10" in length, has been detected in a welded Type 304 stainless steel pipe. The pipe is 16" in diameter and has a wall thickness of 0.5". A uniform stress of 10,000 psi is applied to this cracked pipe.

**pc-CRACK for Windows** can be used to calculate the applied J-Integral (both base and weld material) and Tearing Modulus of the damaged pipe and to assess the crack stability, using the EPFM crack model "*Through-wall Crack in Cylinder under Remote Tension*".




To account for both base and weldment materials in the pipe, two sets of material properties will be considered. For these materials, the elastic plastic stress-strain properties are as follows (numbers in parenthesis are for weldment):

$\sigma_0$ = yield (flow) stress = 24,800 (53,900) psi
$\varepsilon_0$ = yield strain = 0.000827 (0.0018)
E = Young's Modulus = 30E6 (30E6) psi
$\nu$ = Poisson's Ratio = 0.3 (0.3)

These properties are represented by the following Ramberg-Osgood equation:

$$(\varepsilon/\varepsilon_0) = (\sigma/\sigma_0) + \alpha(\sigma/\sigma_0)^N$$

Where:

$\alpha$ = 17.3 ( 2.83)
N = 2.49 (11.84)

Also, the material fracture resistance is characterized by a J-Integral R-curve which can be represented by the following power law:

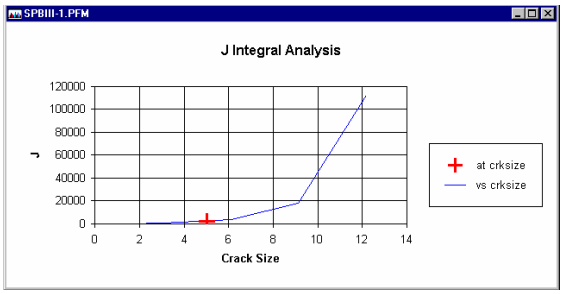
$$J = C\,(\Delta a)^n$$

Where:

C = 24,128 (2,673)
n = 0.5184 (0.3162)
$J_{Ic}$ = 600 (2000) in-ksi
$J_{max}$ = 10000 (10000) in-ksi

$\alpha$, N, C and n are known, but could also have been obtained through curve fitting of the non-linear stress-strain curve and material J-R curve within **pc-CRACK for Windows**.

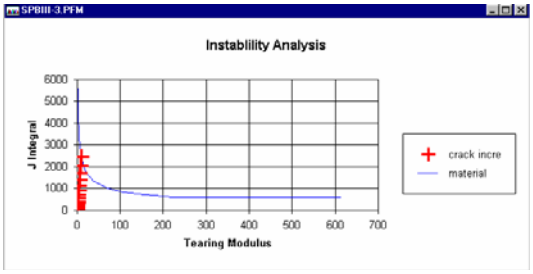
To view the **pc-CRACK for Windows** J-Integral solution, retrieve the following EPFM files, *SPBiii-1.pfm* (J-Integral analysis of pipe base material)

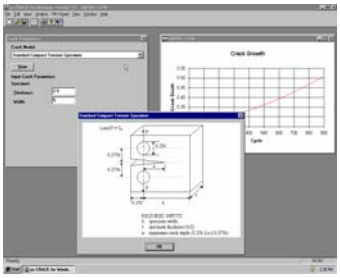



and *SPBiii-2.pfm* (J-Integral analysis of pipe weld material), by selecting "OPEN" from the "FILE" Main Menu Option and "EPFM FILE (*.pfm) from the "LIST FILES OF TYPE:" option. Then, activate the **FM WIZARD** option by selecting "J INTEGRAL/TEARING MODULUS..." (under the "FM WIZARD" Main Menu Option). The **FM WIZARD**, or Fracture Mechanics Wizard, guides you through the various steps of the EPFM damaged pipe fracture mechanics analysis. Once **pc-CRACK for Windows** completes the J-Integral analysis, results in the form of J versus crack size, will be displayed on the screen.

Based on these results, an instability analysis can be conducted using **pc-CRACK for Windows**. To view the **pc-CRACK for Windows** Instability solution, retrieve *SPBiii-3.pfm* by selecting "OPEN" from the "FILE" Main Menu Option and "EPFM FILE (*.pfm) from the "LIST FILES OF TYPE:" option. Then, activate the **FM WIZARD** option by selecting "INSTABILITY..."(under the "FM WIZARD" Main Menu Option). This guides you through the various steps of the instability analysis for the damaged pipe.

Once **pc-CRACK for Windows** completes the instability analysis, results in the form of J Integral versus Tearing Modulus are displayed on the screen. **pc-CRACK for Windows** calculates J-applied and T-applied for the initial conditions specified, compares them to J-material and T-material, and continuously increments load or crack size by user-defined increments of strain/stress/pressure or crack size specified until T-applied exceeds T-material, or until the total number of increments specified has been exceeded.



As shown with this problem, **pc-CRACK for Windows** expands the capability of your engineering staff by providing an easy-to-use tool that allows the user to rapidly perform highly sophisticated fracture mechanics analyses, with immediate graphics display of the results!

For more information on **pc-CRACK for Windows**, please contact:


***Structural Integrity*** *Associates, Inc.*

*3315 Almaden Expressway, Suite 24*
*San Jose, California 95118-1557 USA*
*Phone: (408) 978-8200*
*Fax: (408) 978-8964*
*e-mail: info@structint.com*
*www.structint.com*