# ASSIGNMENT GUIDELINE

The following points are important to remember:

1. You must complete the assignment in this MS Word document, and rename the file as:
	1. NWP 701 Fatigue (Assignment by Surname Initials).docx.
	2. Excel files shall be saved as NWP 701 Fatigue (Assignment by Surname Initials).xlsx
2. Submit the assignment and Excel file (if applicable) by e-mail to: **mheyns@investmech.com** and **paceo@investmech.com**. No faxed assignments will be evaluated. Please submit the documents in MS Word format to allow the lecturer to make changes, comments and mark it directly in the document.
3. Copy and paste all diagrams, tables, figures, etc. into this document.
4. Include proper referencing to detail according to the Harvard Method.
5. Hand sketches may be scanned/photographed and copied into the document.
6. Delivery date: see <http://investmech.com/FatigueBlog/> .
7. The following documents make part of this assignment:
	1. This document.
	2. Class notes and applicable standards.
	3. Presentations used in class.
8. Clearly articulate and motivate assumptions made, steps followed and application of theory/equations.

# STRESS-LIFE

A circular rod made of SAE 4142 (450 HB) steel is loaded axially and has a step change in diameter with dimensions . The fillet radius is ground and the surface is not exposed to a corrosive environment. Note, material parameters are available in Dowling Table 9.1.

1. Using the S-N curve estimate of Budynas, evaluate the safety factors in both stress and life if the expected service loading is 30 000 cycles at zero-to-tension force of .



Figure 1: Part geometry

# STRESS-LIFE FROM STRESS HISTORY

A double-edged-notched plate of 2024-T3 aluminium alloy with has a nominal stress versus life curve in the form , where is given by the Walker relationship:

With fitting constants: . The notch root radius is .

The plates will be repeatedly subject in engineering service to the nominal stress history shown in Figure 2. Assume that the surface is ground and is surface protected. Do the following using the Walker mean stress compensation.

1. Generate the stress spectrum (table of nominal stress and applied cycles) using Rainflow counting.
2. Estimate the number of repetitions to failure, , for 50% probability of failure.
3. Estimate the number of repetitions for a 5% probability, , of crack initiation.
4. If 200 repetitions are expected to be applied in service, what are the safety factors in life and stress for 50% probability of survival?



Figure 2: One repetition of nominal stress history on the double-edge-notched plate

# HYSTERESIS CURVE AND STRAIN-LIFE

A member made of 2024-T351 aluminium has a notch with an elastic stress concentration factor (or theoretical stress concentration factor) . One repetition of the nominal stress is shown in Figure 3 (note that the stress history has already be reordered to start at zero and have the first and last peak the peak or valley with the maximum absolute value). Please do the following:

1. Qualitatively sketch the local stress-strain response.
2. Estimate the number of repetitions, , to cause fatigue cracking using the Ramberg-Osgood stress-strain curve and:
	1. Morrow mean stress compensation
	2. Modified Morrow mean stress compensation
	3. SWT mean stress compensation
	4. Walker mean stress compensation
3. Interpret and discuss the results.
4. Which mean stress compensation rule would you suggest for this material? Why?



Figure 3: Nominal stress repetition on component

# EVALUATION OF PAPERS

Read the following paper and answer the question(s) below:

<https://reader.elsevier.com/reader/sd/pii/S0142112314000152?token=9DC0295C61884B50E0B3F08A68E34FA87221F1A473F76E30BB1943521A78EE221A5B06FBD1CF86F31223EBD20EF42AEC>

1. Comment on the fatigue curves used in paper.
2. What multiaxial approach is best to analyse the fatigue on a 1045 carbon steel?
3. Why?

# WELD FATIGUE

## Problem Statement

A 10 mm thick circular tube with dimeter 500 mm is welded to a mounting plate of thickness 50 mm with a complete joint penetration weld that is reinforced by a 5 mm fillet weld as shown in the figure below. The weld is made from the outside only.

The circular tube is made of 350 WA structural steel with yield strength 350 MPa and ultimate tensile strength 480 MPa. The joint is surface protected and is operating at a temperature of 300 °C.

Strain gauges were used and analysed, rainflow counting carried out, from which the nominal force, , and bending moment, , (which are applied in phase with each other) resulted in the load spectrum in Table 1 over a period of 1 year.

A finite element analysis indicated that the change in radial stiffness at the joint results in a stress concentration factor of 1.2 for stress in the longitudinal direction. This is due to the fact that Poisson effects want to result in a change in the pipe diameter during loading that is restricted by the thick endplate.

Table 1: Load spectrum on a welded joint over a period of 1 year



10

500

50

x

y

z

A

B

Figure 4: Tube to endplate connection cross-section

Questions:

1. By just analysing the direction of the applied forces and moments, at which point of A or B would you expect the crack to initiate first? Please motivate your answer. **[20%]**
2. By just looking at the weld sizes applied in this joint, and by comparing the characteristic strengths for crack initiation at the weld toe in the tube and at the weld root, where do you expect the crack to initiate first? Motivate why. **[20%]**
3. What is the fatigue life of the joint for a 95% probability of survival? This is a critical joint that requires a safe life with high consequence of failure design philosophy. **[50%]**
4. What post weld treatment would you recommend to increase life, why and what increase in life will result? **[10%]**