Upheavle Buckling

This shows the basic calculations for upheaval buckling for:
•Project: Tibr Houshi Development Phase 2B FEED+DD
•Doc. No.: TIB-17-PDFEED-LA-0515-00001-0000
V0.2:
Inconsistency of thermal force units
/Other inconsistencies (force, energy) ==> |FIXED|

inputs

Height of imperfection

$\delta := 0.1\ m$

Design pressure

$P := 95\ bar$

Selected wall thickness

$t := 4.8\ mm$

Outside diameter of the pipe

$D := 6.625\ in = 0.1683\ m$

Inside diameter of the pipe

$Di := D - 2 \cdot t = 0.1587\ m$

Modulus of elasticity

$E := 2.394 \cdot 10^{10}\ \frac{N}{m^2}$

Poisson's Ratio

$\nu := 0.3$

Coefficient of thermal expansion

$\alpha := 0.000011\ \frac{\frac{mm}{mm}}{\Delta °C} = 1.1 \cdot 10^{-5} \cdot \frac{1}{K}$

pipe content density

$\rho_f := 935\ \frac{kg}{m^3}$

Installation temperature

$Ti := 21\ °C$

Max. Design temperature

$T2_{max} := 85\ °C$

Difference between Max. design temperature & Installation temperature (T2-Ti)

$\Delta T := T2_{max} - Ti = 64\ \Delta °C$

the depth of cover from the top of the pipe to the soil surface above the pipe centerline

$H := 0.6\ m$

Soil Density

$\gamma := 1600\ \frac{kg}{m^3}$

an uplift resistance coefficient

$f := 0.15$

Steel density

$\rho_s := 7800\ \frac{kg}{m^3}$

Pressure Force

$$F_P := P \cdot \frac{\pi \cdot Di^2}{4} = 19156.2204 \ \text{kgf}$$

Poisson's effect Force

$$F_\nu := \frac{P \cdot D}{2 \cdot t} \cdot \nu \cdot \frac{\pi \cdot \left(D^2 - Di^2\right)}{4} = 12557.8418 \ \text{kgf}$$

Thermal Force

$$F_T := E \cdot \alpha \cdot \Delta T \cdot \frac{\pi \cdot \left(D^2 - Di^2\right)}{4} = 41546.9609 \ \text{N}$$

Effective Axial Force

$$F_{EAF} := F_P + F_\nu + F_T = 3.5256 \cdot 10^5 \ \text{N}$$

Pipeline weight including content per unit length

$$w := \frac{\rho_s \cdot \pi \cdot \left(D^2 - Di^2\right)}{4} + \frac{\rho_f \cdot \pi \cdot (D - 2 \cdot t)^2}{4} = 37.7173 \ \frac{\text{kg}}{\text{m}}$$

Moment of inertia

$$I := \frac{\pi \cdot \left(D^4 - Di^4\right)}{64} = 8.2419 \cdot 10^{-6} \ \text{m}^4$$

Required downforce for uplift resistance

$$W := \left(\left(1.16 \cdot \frac{4.76 \cdot \left(\frac{E \cdot I \cdot w}{\delta}\right)^{\frac{1}{2}}}{F_{EAF}}\right) \cdot F_{EAF} \cdot \left(\frac{\delta \cdot w}{E \cdot I}\right)^{\frac{1}{2}}\right) = 208.2601 \ \frac{\text{kg}}{\text{m}}$$

Downward force per unit length required to hold pipeline in position

$$q := H \cdot \gamma \cdot D \cdot \left(1 + \frac{f \cdot H}{D}\right) = 247.944 \ \frac{\text{kg}}{\text{m}}$$

if statment

Check the pipeline stability against upheaval Buckling

$$\Psi := \begin{cases} \text{"stable"} & \text{if } w + q > W \\ \text{"not stable"} & \text{otherwise} \end{cases}$$

$$\Psi = \text{"stable"}$$