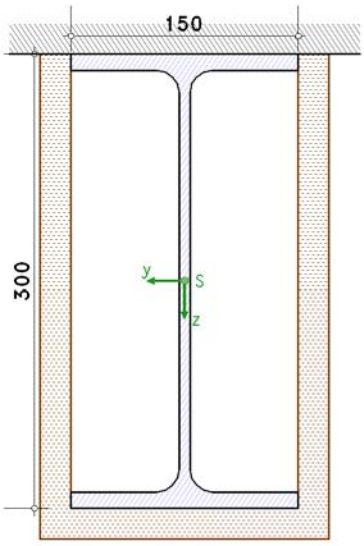
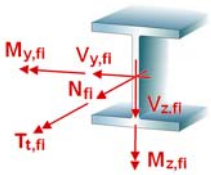
POS. 3: FIRE DESIGN EX. 5.2

fire design EC 3-1-2 (12.10), NA: Deutschland

1. input report



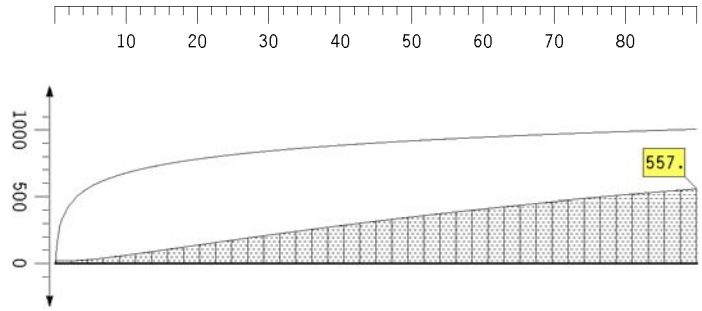
steel
steel grade S235
material safety factor
resistance of cross-sections γ_{M0} = 1.00
resistance of components in the event of fire $\gamma_{M,fi}$ = 1.00
geometry
section IPE300
cross-section temperature
thermal action due to the standard curve, fire resistance time t = 90 min
shadow effect of the section by wall/ceiling top
thermal insulation protection by Faser-Zement-plated structures:
thermal conductivity λ_p = 0.15 W/(m·K), specific heat capacity c_p = 1200 J/(kg·K), maximum density ρ_p = 800 kg/m³
thickness of insulating material d_p = 20.2 mm
resistance
plastic verification incl. c/t-verification
fire design at temperature level
adjustment factors for uneven temperature distribution
across the cross section κ_1 = 0.85, along the beam κ_2 = 1.00
internal forces and moments (event of fire)
σ-generating forces (N, M) work at centroid, τ-generating forces (V, T_t) work at shear center
Lk 1: $M_{y,fi}$ = 67.60 kNm
Lk 2: $V_{z,fi}$ = 67.60 kN



notes
stability is not investigated.

2. cross-section temperature

internal development of the fire-stressed box A_p = 750.0 mm²/mm
section factor of the protected component A_p/V = 750.0 / 5381.2 ·10³ = 139.4 1/m
temperature development:



temperature in °C
fire time in min
max T_a = 557.2°C
max t = 90 min

cross-section temperature acc. to t = 90 min: T_a = 557.2 °C

3. Lk 1

3.1. fire design

internal forces and moments (event of fire, uneven temperature distribution): $M_{y,fi} = 57.46$ kNm

3.1.1. plastic verification

3.1.1.1. verification at temperature level

Utilisation rate at time t = 0 (normal temperature)
  plastic verification for $M_y = 57.46$ kNm
  max. load factor of normal stresses (plastic): $f_{\sigma,pl} = 2.570 \Rightarrow U_{\sigma,pl} = 0.389$
  verification: $U_{pl} = 0.389 < 1$ ok
critical temperature $T_{a,cr} = 39.19 \cdot \ln[1/(0.9674 \cdot \mu_0^{3.833}) - 1] + 482 = 624.0$ °C with $\mu_0 = 0.389$
existing temperature $T_a = 557.2$ °C
verification: $U_T = T_a/T_{a,cr} = 0.893 < 1$ ok

cross-section in class 1, material coefficient $\varepsilon = 0.85 \cdot (235/235.0)^{0.5} = 0.850$
c/t-verification: outstand flange: utilization $U_{c/t} = 0.621 < 1$ ok
internal compression parts: utilization $U_{c/t} = 0.496 < 1$ ok
total: utilization $U_{c/t} = 0.621 < 1$ ok (reg. section class 2)

4. Lk 2

4.1. fire design

internal forces and moments (event of fire, uneven temperature distribution): $V_{z,fi} = 67.60$ kN

4.1.1. plastic verification

4.1.1.1. verification at temperature level

Utilisation rate at time t = 0 (normal temperature)
  plastic verification for $V_z = 67.60$ kN
  max. load factor of shear stresses (plastic): $f_{\tau,pl} = 4.272 \Rightarrow U_{\tau,pl} = 0.234$
  verification: $U_{pl} = 0.234 < 1$ ok
critical temperature $T_{a,cr} = 39.19 \cdot \ln[1/(0.9674 \cdot \mu_0^{3.833}) - 1] + 482 = 701.3$ °C with $\mu_0 = 0.234$
existing temperature $T_a = 557.2$ °C
verification: $U_T = T_a/T_{a,cr} = 0.795 < 1$ ok

5. final result

maximum utilization [Lk 1]:	temperature	max $U_T = 0.795 < 1$ ok
	stress	max $U_{\sigma,t=0} = 0.389 < 1$ ok
	c/t-ratio	max $U_{c/t} = 0.621 < 1$ ok
	resistance	max $U = 0.893 < 1$ ok

verification succeeded

6. Regulations

DIN EN 1990, Eurocode 0: Grundlagen der Tragwerksplanung;
  Deutsche Fassung EN 1990:2002 + A1:2005 + A1:2005/AC:2010, Ausgabe Dezember 2010
DIN EN 1990/NA, Nationaler Anhang zur DIN EN 1990, Ausgabe Dezember 2010

DIN EN 1991-1-2, Eurocode 1: Einwirkungen auf Tragwerke - Teil 1-2: Allgemeine Einwirkungen -
  Brandeinwirkungen auf Tragwerke; Deutsche Fassung EN 1991-1-2, Ausgabe Dezember 2010
DIN EN 1991-1-2/NA, Nationaler Anhang zur DIN EN 1991-1-2, Ausgabe September 2015

DIN EN 1993-1-2, Eurocode 3: Bemessung und Konstruktion von Stahlbauten - Teil 1-2: Allgemeine Regeln -
  Tragwerksbemessung für den Brandfall; Deutsche Fassung EN 1993-1-2, Ausgabe Dezember 2010
DIN EN 1993-1-2/NA, Nationaler Anhang zur DIN EN 1993-1-2, Ausgabe Dezember 2010