NOVE TEHNOLOGIJE U PRORAČUNU CJEVOVODA – REVIZIJA SIF FAKTORA I FAKTORA ELASTIČNOSTI CJEVOVODNIH KOMPONENTI

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SADRŽAJ

- SIF! Što je to?
- Povijest (jučer – danas – sutra)
- Povijest razvoja standarda
- Što današnji standardi / kodovi kažu?
- SIF izrazi nekad i danas (primjer)
- Primjer
- Zaključak

SIF! Što je to?

- **SIF**
  - **Stress Intensification Factor**
  - Faktor intenzifikacije naprezanja

  - Zbunjujući termin/naziv
    - Multiplikator prosječnih naprezanja u cijevi
    - Definiran za koljena, T komade, redukcije, zavare …..

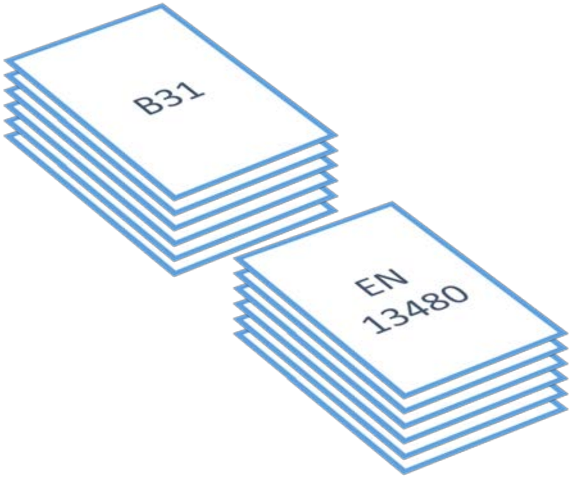
  - Minimalna vrijednost 1 (ravna cijev)
  - >1 u ostalim slučajevima

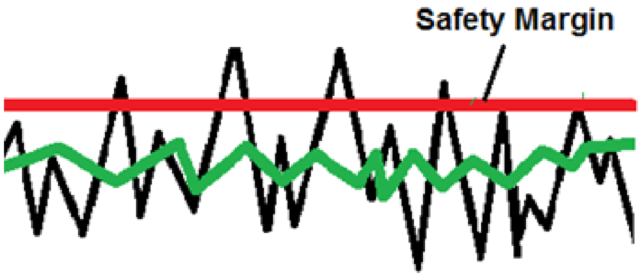
- Greške mogu biti velike!

- *NAPOMENA:*

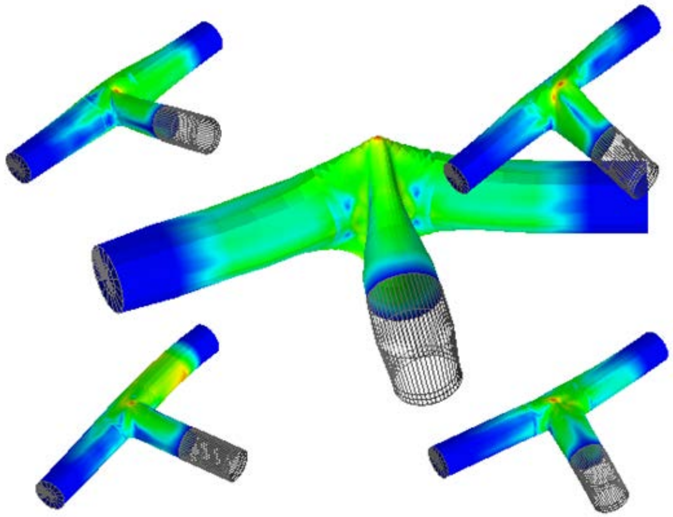
  Proračun naprezanja i elastičnosti cjevovoda kao sustava, a ne analiza detaljne raspodjele naprezanja u npr. koljenu!

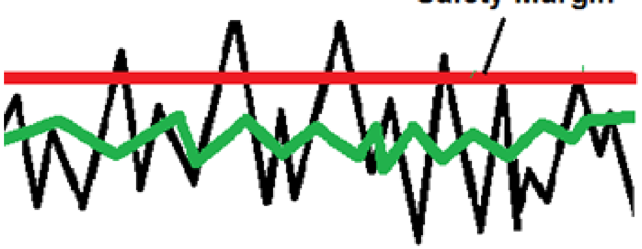
JUČER (ali i danas na žalost)



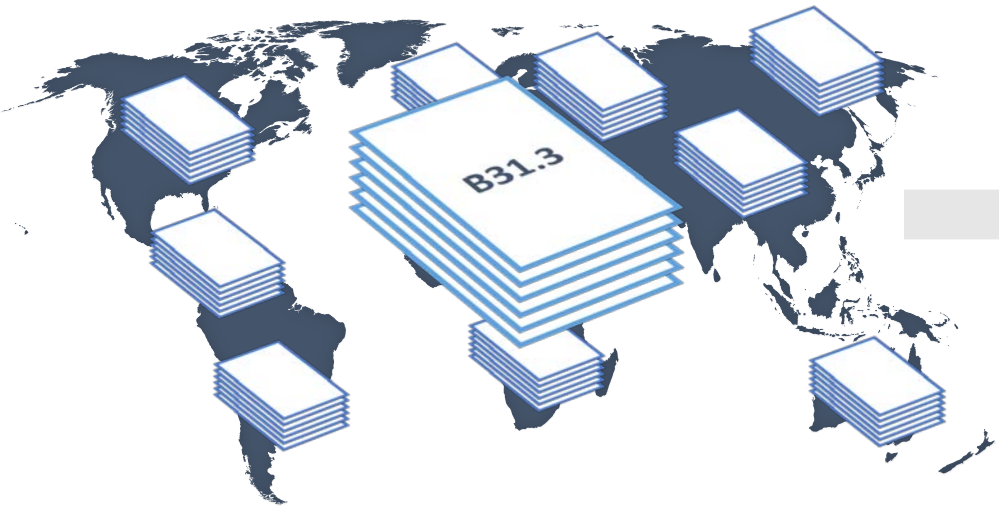


SUTRA (ali trebalo bi biti i danas)





JUČER – DANAS – SUTRA



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2019

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MODERNE TEHNOLOGIJE

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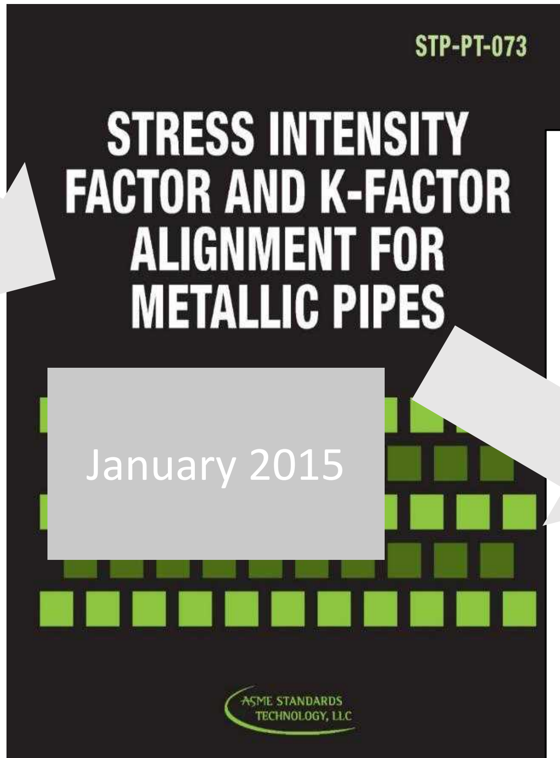
BOLJE INFORMACIJE

ASME B31J

Povijest razvoja

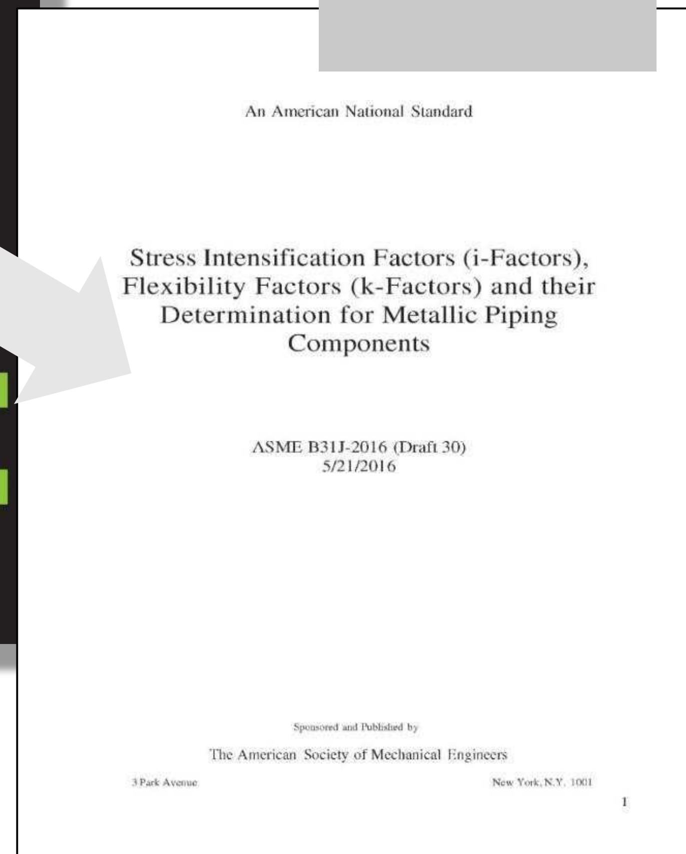
ASME
SETTING THE STANDARD

ST-LLC 07-02



January 2015

January 2017


An American National Standard

Stress Intensification Factors (i-Factors), Flexibility Factors (k-Factors) and their Determination for Metallic Piping Components

ASME B31J-2016 (Draft 30)
5/21/2016

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Što današnji standardi / kodovi kažu?

APPENDIX D
FLEXIBILITY AND STRESS INTENSIFICATION FACTORS

See Table D300.

Table D300 Flexibility Factor, *k*, and Stress Intensification Factor, *i*

ASME B31.3-2014

Table D300 Flexibility Factor, *k*, and Stress Intensification Factor, *i* (Cont'd) (14)

GENERAL NOTE: Stress intensification and flexibility factor data in Table D300 are for use in the absence of more directly applicable data (see para. 319.3.6). Their validity has been demonstrated for $D/\bar{T} \le 100$.

NOTES:

(1) The flexibility factor, *k*, in the Table applies to bending in any plane; also see para. 319.3.6. The flexibility factors, *k*, and stress intensification factors, *i*, shall apply over the effective arc length (shown by heavy centerlines in the illustrations) for curved and miter bends, and to the intersection point for tees.

(2) A single intensification factor equal to $0.9/h^{2/3}$ may be used for both i_i and i_o if desired.

319.4.4 Flexi...

(*a*) The axial ... stress ranges shal... ulus of elasticity ... in para. 319.2.2(b... with eq. (17) to determine the computed di... stress range, S_E, which shall not exceed the ... displacement stress range, S_A, in para. 302.3.5... also eq. (1d) and Appendix S, Example 3 for the ... computed displacement stress range.

i_a = axial stress intensification factor. In ... absence of more applicable data, i_a = 1. ... elbows, pipe bends, and miter bends (si... closely spaced, and widely spaced), and ... i_o (or i when listed) in Appendix D for ... components; see also para. 319.3.6.

i_t = torsional stress intensification factor. In ... absence of more applicable data, i_t = 1.0... see para. 319.3.6.

$$S_L = \sqrt{(|S_a| + S_b)^2 + (2S_t)^2} \quad (23a)$$

$$S_b = \frac{\sqrt{(I_i M_i)^2 + (I_o M_o)^2}}{Z} \quad (23b)$$

where

I_i = sustained in-plane moment index. In the absence of more applicable data, I_i is taken as the greater of $0.75i_i$ or 1.00.

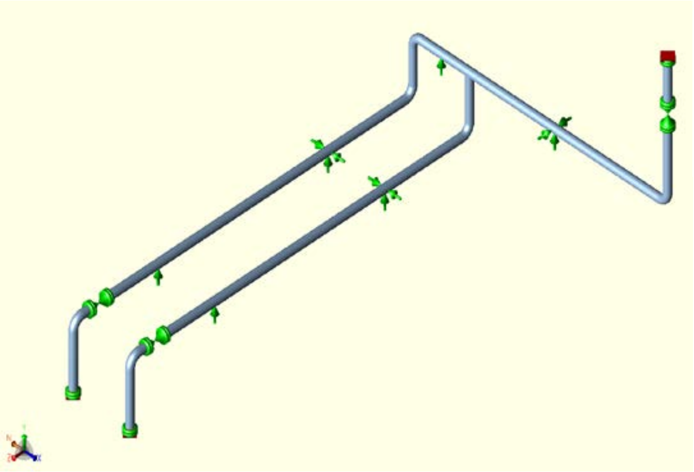
I_o = sustained out-plane moment index. In the absence of more applicable data, I_o is taken as the greater of $0.75i_o$ or 1.00.

SIF izrazi nekad i danas

Opis komponente	*k*-faktor	SIF faktor		Karakteristika elastičnosti, *h*
		Van ravnine, i_o	U ravnini, i_i	
Zavareno koljeno ili savijena cijev	$1{,}65/h$	$0{,}75/h^{2/3}$	$0{,}9/h^{2/3}$	$\bar{T}\cdot R_1/r_2^2$
Segmentno koljeno: uski razmak	$1{,}52/h^{5/6}$	$0{,}9/h^{2/3}$	$0{,}9/h^{2/3}$	$0{,}5\cdot \cot\theta \cdot s\cdot \bar{T}/r_2^2$
Segmentno koljeno: široki razmak	$1{,}52/h^{5/6}$	$0{,}9/h^{2/3}$	$0{,}9/h^{2/3}$	$0{,}5\cdot(1+\cot\theta)\cdot \bar{T}/r_2$
T-komad prema ASME B16.9	1,0	$0{,}9/h^{2/3}$	$0{,}9/h^{2/3}$	$3{,}1\cdot t/r$
Ojačani zavareni T-komad	1,0	$0{,}9/h^{2/3}$	$0{,}75\cdot i_o + 0{,}25$	$(\bar{T}+0{,}5\cdot \bar{T}_r)^{2{,}5}/(\bar{T}^{1{,}5}\cdot r_2)$
Neojačani zavareni T-komad	1,0	$0{,}9/h^{2/3}$	$0{,}75\cdot i_o + 0{,}25$	$\bar{T}/r_2$
Zavareni spoj	1,0	1,0	1,0	-

Faktor		Izraz
Glavna cijev	*k*-faktor u ravnini, k_{ir}	$0{,}18\cdot(R/T)^{0{,}8}\cdot(d/D)^5$
Glavna cijev	*k*-faktor van ravnine, k_{or}	1
Glavna cijev	Torzioni *k*-faktor, k_{tr}	$0{,}08\cdot(R/T)^{0{,}91}\cdot(d/D)^{5{,}7}$
Grana	*k*-faktor u ravnini, k_{ib}	$[1{,}91\cdot d/D-4{,}32\cdot(d/D)^2+2{,}7\cdot(d/D)^3]\cdot(R/T)^{0{,}77}\cdot(d/D)^{0{,}47}\cdot t/T$
Grana	*k*-faktor van ravnine, k_{ob}	$[0{,}34\cdot d/D-0{,}49\cdot(d/D)^2+0{,}18\cdot(d/D)^3]\cdot(R/T)^{1{,}46}\cdot t/T$
Grana	Torzioni *k*-faktor, k_{tb}	$[1{,}08\cdot d/D-2{,}44\cdot(d/D)^2+1{,}52\cdot(d/D)^3]\cdot(R/T)^{0{,}77}\cdot(d/D)^{1{,}61}\cdot t/T$
Glavna cijev	SIF faktor u ravnini, i_{ir}	$0{,}98\cdot(R/T)^{0{,}35}\cdot(d/D)^{0{,}72}\cdot(t/T)^{-0{,}52}$
Glavna cijev	SIF faktor van ravnine, i_{or}	$0{,}61\cdot(R/T)^{0{,}29}\cdot(d/D)^{1{,}95}\cdot(t/T)^{-0{,}53}$
Glavna cijev	Torzioni SIF faktor, i_{tr}	$0{,}34\cdot(R/T)^{2/3}\cdot d/D\cdot(t/T)^{-0{,}5}$
Grana	SIF faktor u ravnini, i_{ib}	$0{,}33\cdot(R/T)^{2/3}\cdot(d/D)^{0{,}18}\cdot(t/T)^{0{,}7}$
Grana	SIF faktor van ravnine, i_{ob}	$0{,}42\cdot(R/T)^{2/3}\cdot(d/D)^{0{,}37}\cdot(t/T)^{0{,}37}$
Grana	Torzioni SIF faktor, i_{tb}	$0{,}42\cdot(R/T)^{2/3}\cdot(d/D)^{1{,}1}\cdot(t/T)^{1{,}1}$

Primjer



Faktor	[2]	[6]	[7]	Markl	MKE
SIF faktor u ravnini za glavnu cijev, i_{ir}	3,169	2,889	2,925	-	2,886
SIF faktor van ravnine za glavnu cijev, i_{or}	3,892	2,366	1,601	-	1,584
Torzioni SIF faktor za glavnu cijev, i_{tr}	-	3,296	3,957	-	3,930
SIF faktor u ravnini za granu, i_{ib}	3,169	2,325	2,964	2.340	2,817
SIF faktor van ravnine za granu, i_{ob}	3,892	4,056	3,283	2.690	3,228
Torzioni SIF faktor za granu, i_{tb}	-	2,608	2,152	-	2,112

[1] Markl, A.R.C.: *Piping-Flexibility Analysis*, Transactions of ASME 77 (1955)

[2] American Society of Mechanical Engineers. *ASME B31.3: process piping*, American society of mechanical engineers, New York (2016)

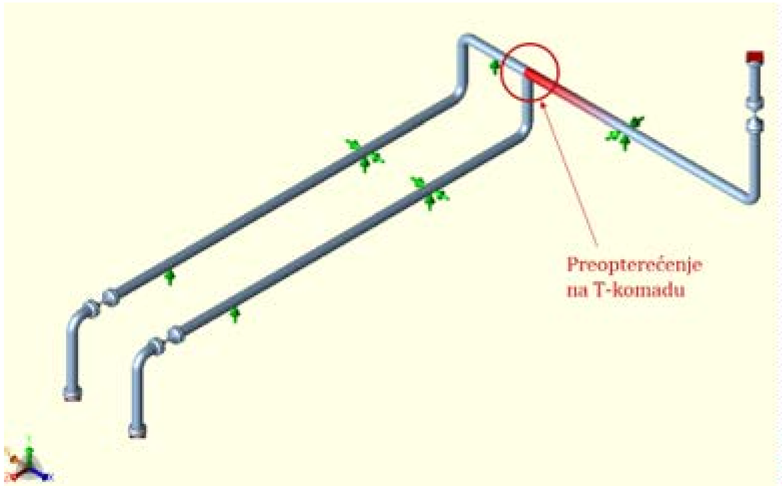
[3] Markl, A.R.C.: *Fatigue tests of welding elbows and comparable double-miter bends*, Transactions of ASME 69 (8) (1947)

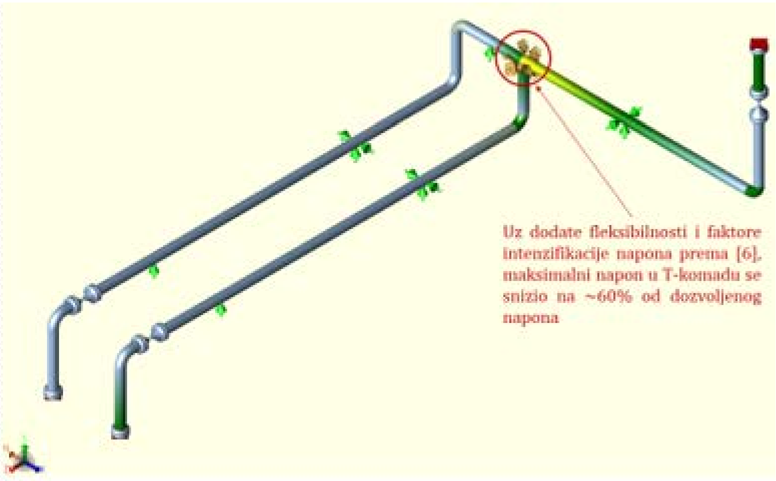
[4] Markl, A.R.C.: *Fatigue tests of piping components*, Transactions of ASME 74 (3) (1952)

[5] Rodabaugh, E.C., George, H.H.: *Effect of internal pressure on flexibility and stress intensification factors of curved pipe or welding elbows*, Transactions of ASME 79 (1957)

[6] American Society of Mechanical Engineers. *ASME B31J: stress intensification factors (i-Factors), flexibility factors (k-Factors), and their determination for metallic piping components*, American Society of Mechanical Engineers, New York (2017)

[7] Jacimovic, N.: *Analysis of piping stress intensification factors based on numerical models*, International Journal of Pressure Vessels and Piping 163 (2018) 8-14





ZAKLJUČAK

- Današnji standardi / kodovi nisu dovoljni!
- Novi standard ASME B31J ima svoje nedostatke i ograničenja!
- Primjena metode konačnih elemenata na definiranje SIF-ova je rješenje!
- No SIF-ovi nisu jedini „problem"!
- Tu su i faktori fleksibilnosti, no o tome neki drugi puta!

HVALA NA POZORNOSTI !

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