GeniE User Manual
Code checking of beams
Implementation of API-LRFD 1st edition

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1. IMPLEMENTATION OF API-LRFD

The implementation of API LRFD is according to "**Planning, Designing and Constructing Fixed Offshore Platforms—Load and Resistance Factor Design**".

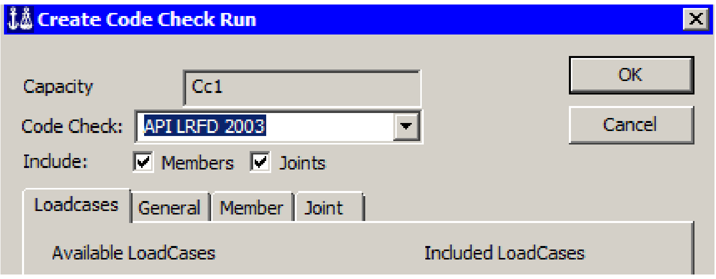
1.1 Revisions supported

1st Edition / July 1, 1993 / Reaffirmed, May 16, 2003"

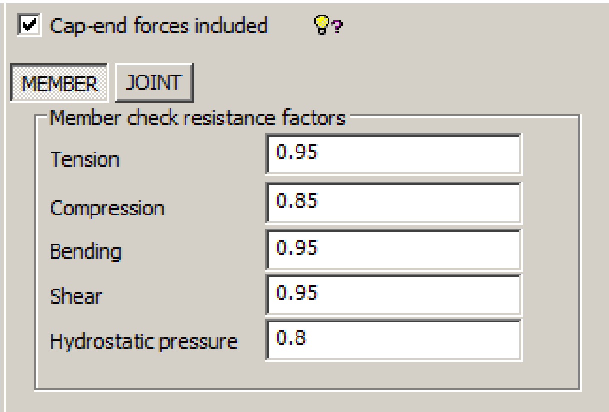
The check covers capacity check of cylindrical members, conical transitions and tubular joints according to chapters:

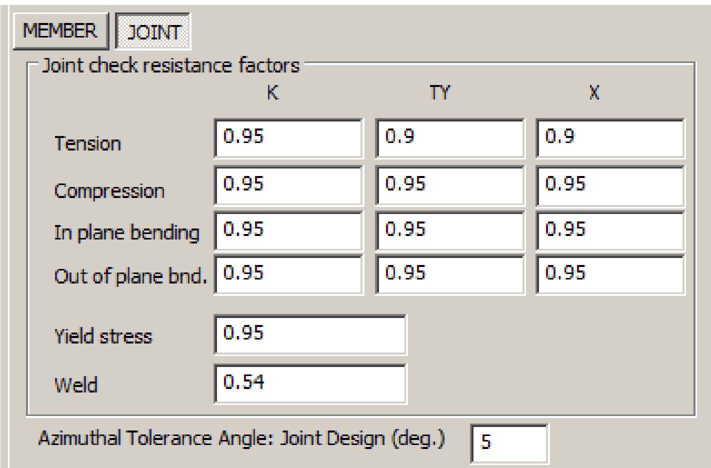
- D: "CYLINDRICAL MEMBER DESIGN"
- E: "CONNECTIONS OF TENSION AND COMPRESSION MEMBERS".

Select API WSD from the Create Code Check Run dialog.

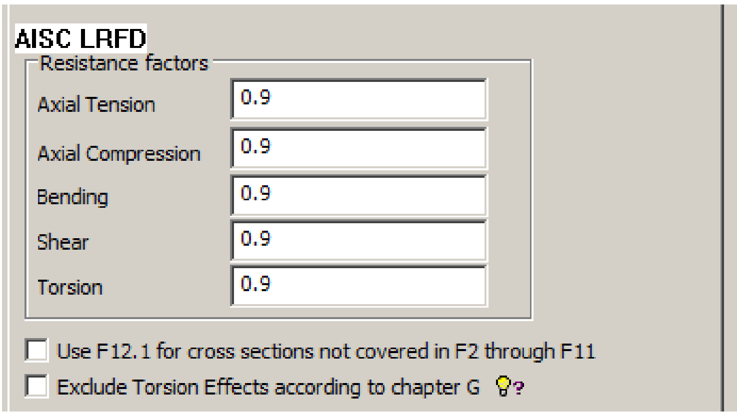


Define the global (General) parameters regarding capped-end forces and resistance factors. Resistance factors for both member check and punching check may be modified





Note that this code check includes AISC LRFD 2005 for non-tubular members.



Options:

<table>
<tr><td>Cap-end forces included</td><td>Select when Capped-end forces are included, i.e. the calculated axial stress includes the effect of the hydrostatic capped-end forces. This corresponds to an analysis where Wajac has been used.</td></tr>
<tr><td>Resistance factors</td><td>Give the resistance factors to be used for member check and joint check (inclusive the connection resistance factors defined in Table E.3-1). The default values are according to the standard:
TABLE E.3-1
CONNECTION RESISTANCE FACTORS — ϕ_j
<table>
<tr><th></th><th colspan="4">TYPE OF LOAD IN BRACE MEMBER</th></tr>
<tr><th>Type of Joint and Geometry</th><th>Axial Tension</th><th>Axial Compression</th><th>In-Plane Bending ipb</th><th>Out-of-Plane Bending opb</th></tr>
<tr><td>K</td><td>0.95</td><td>0.95</td><td>0.95</td><td>0.95</td></tr>
<tr><td>T and Y</td><td>0.90</td><td>0.95</td><td>0.95</td><td>0.95</td></tr>
<tr><td>Cross (X)</td><td>0.90</td><td>0.95</td><td>0.95</td><td>0.95</td></tr>
</table></td></tr>
<tr><td>Tolerance Angle</td><td>User can define azimuthal tolerance angle for joint design. Previous versions used 5 degrees as default value. This provides the possibility to define different sets of braces to be used on Joint Punch Check Analysis. The subdivision in Y-, K- and X- joint axial force patterns normally considers all members in one plane at a joint. Brace planes within ($\pm\alpha^{o}$) of each other may be considered as being in the same plane.</td></tr>
</table>

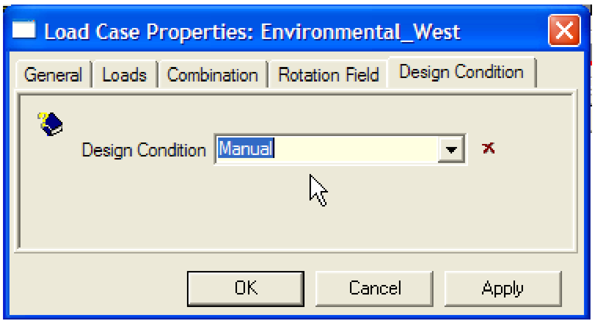
1.2 Member and cone design check – API LRFD 2003

The member and cone design code check is performed according to the chapters and sections referred to in the table below:

	Design consideration	Sections covered
D.2	CYLINDRICAL MEMBERS UNDER TENSION, COMPRESSION, BENDING, SHEAR AND HYDROSTATIC PRESSURE	**D.2.1** Axial Tension **D.2.2** Axial Compression D.2.2.1 Column Buckling D.2.2.2 Local Buckling **D.2.3** Bending **D.2.4** Shear D.2.4.1 Beam Shear D.2.4.2 Torsional Shear **D.2.5** Hydrostatic Pressure D.2.5.1 Design Hydrostatic Head [1)] D.2.5.2 Hoop Buckling
D.3	CYLINDRICAL MEMBERS UNDER COMBINED LOADS	**D.3.1** Combined Axial Tension and Bending **D.3.2** Combined Axial Compression and Bending D.3.2.1 Cylindrical Members D.3.2.3 Slenderness Ration and Reduction Factor **D.3.3** Combined Axial Tension, Bending and Hydrostatic Pressure **D.3.4** Combined Axial Compression, Bending and Hydrostatic Pressure
D.4	CONICAL TRANSITIONS [2)]	**D.4.1** Axial Compression and Bending D.4.1.1 Geometry D.4.1.2 Local buckling D.4.1.3 Unstiffened Cone-Cylinder Junctions D.4.1.3.1 Longitudinal Stress D.4.1.3.2 Hoop Stress **D.4.2** Hydrostatic Pressure D.4.2.1 Cone Design

Notes to the above:

1) The hydrostatic pressure load factor γ_D is specified through the "Design Condition" factor for the relevant load cases/combinations.



2) The formulas given for conical transitions in axial compression and bending are also used for axial tension and that the checks are always performed both for positive and negative resulting bending stress. With respect to the hoop stress the following approach is used: At the smaller-diameter junction, the hoop stress is tensile (or compressive) when (fa + fb) is tensile (or compressive). Similarly, the hoop stress at the larger-diameter junction is tensile (or compressive) when (fa + fb) is compressive (or tensile).

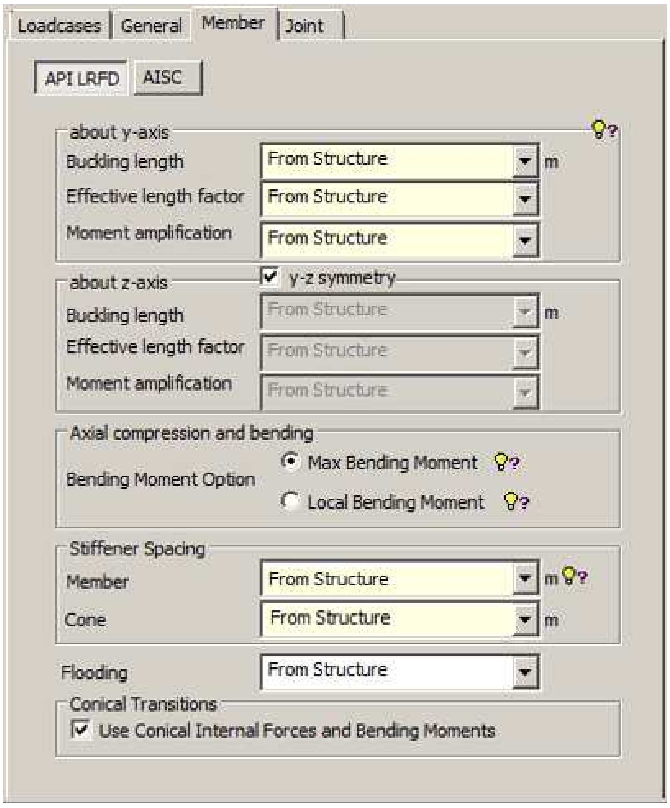
Note that for segmented beams with tubular cross sections of different sizes, the Euler buckling strength for the member is based on the cross section with the smallest radius of gyration. However, from V7.9 the "Energy method" is used, see User Documentation section 2.1.4.8 Compatibility Options: "**Energy method for column buckling of segmented members**".

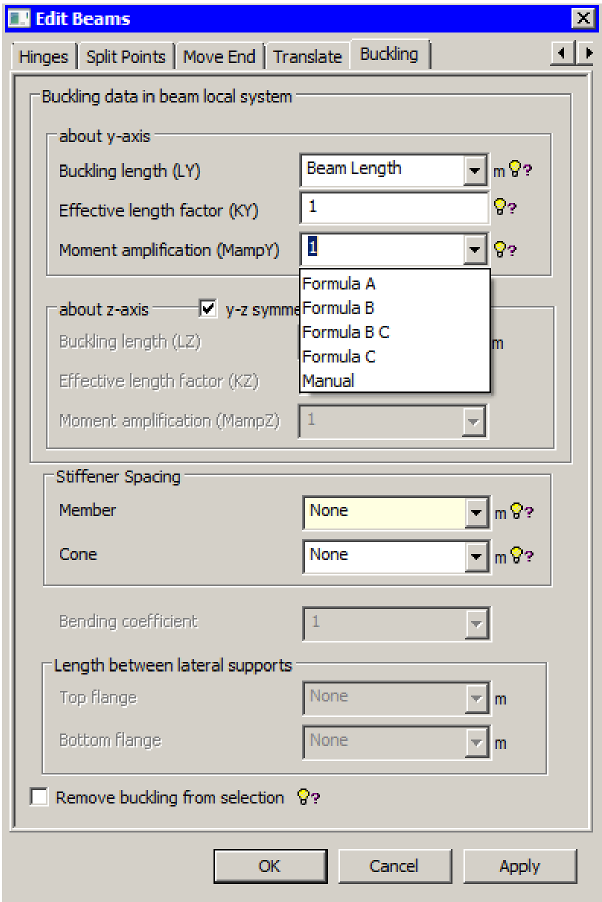
Definition of member specific parameters:

For the Member specific parameters shown below (to the left) set to From Structure the values will be inherited from the assignments done to the Beam concept (dialog to the right).

The default member data for tubular members are shown. Notice that there are different properties for tubular members and non-tubular members (using AISC LRFD 2005). GeniE will automatically detect which profiles are present in the capacity model.

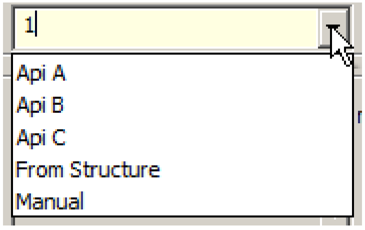
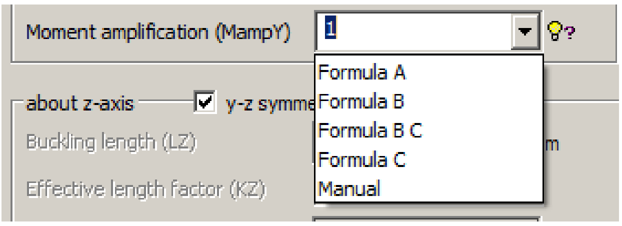
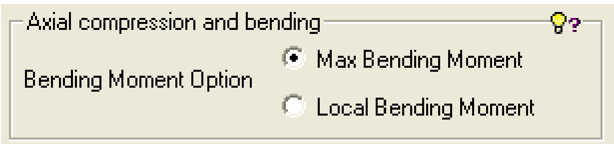
The From Structure alternative is only accepted in cases with one-to-one mapping between modelled beam and member, else the default value/option will be used.

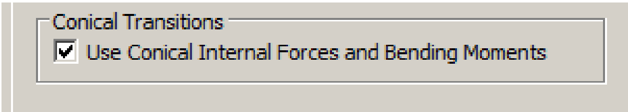




Options:

Buckling length	**From Structure** = use value/option assigned to the beam concept, ref. Edit Beam dialog **Member Length** = use the geometric length of the member (capacity model) **Manual** = specify the length to be used
Effective length factor	**From Structure** = use value/option assigned to the beam concept, ref. Edit Beam dialog **Manual** = specify the factor to be used

Moment amplification	Specify Rule according to the standard, ref. Table D.3-1 alternatives (a), (b) or (c)  or select: **From Structure** = use value/option assigned to the beam concept, ref. Edit Beam dialog  The moment amplification definitions are mapped as follows: Formula A → Api A, Formula B → Api B, Formula B C → Api C , Formula C → Api C **Manual** = specify the factor to be used
Axial compression and bending.	 **Max Bending Moment** This option selects the maximum bending moments along a capacity member derived by the effect of moment gradient, Cm. This method is considered to be best practise. **Local Bending Moment** This option uses the local bending moments at every code check positions. Use of local bending moment could be non-conservative.
Stiffener spacing, Member and Cone	**None** = no ring stiffeners given (For member: stiffener spacing = member length, for cone: stiffener spacing = cone length) **From Structure** = option will use the assignment given to the Beam concept, ref. Edit Beam dialog **Manual** = specify the length between stiffeners.
Flooding	**From Structure** = use the properties assigned to the beam concepts using the properties defined from the "Create/Edit Hydro Property" dialog **Flooded** = Manually set to flooded **Not Flooded** = Manually set to not flooded

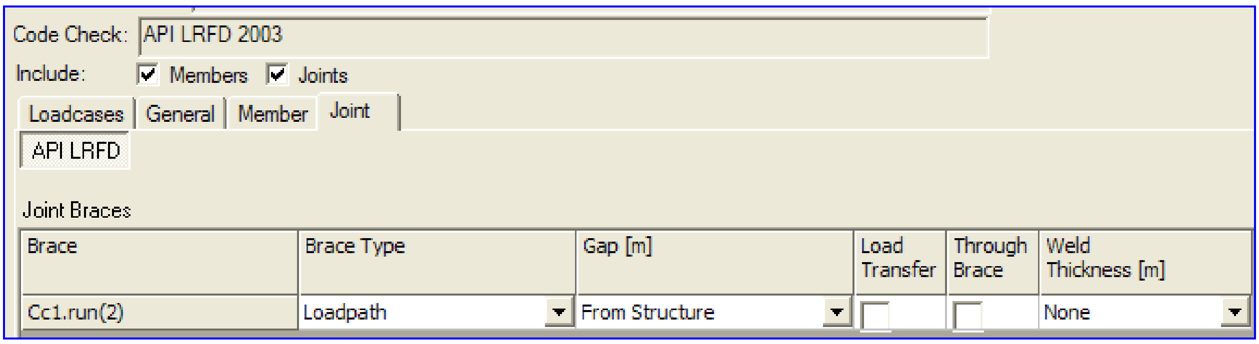
Conical Transitions	GeniE allows users to choose between internal forces on cone structures or adjacent forces on tubulars close to transitions points for Cone Code Check Analysis. Analysis, where the cap end forces are computed, present internal axial force values bounded by the axial forces at the transitions. Use of internal forces is coherent and recommended but the use of external forces provides conservative results. 

1.3 Tubular joint design code check - API LRFD 2003

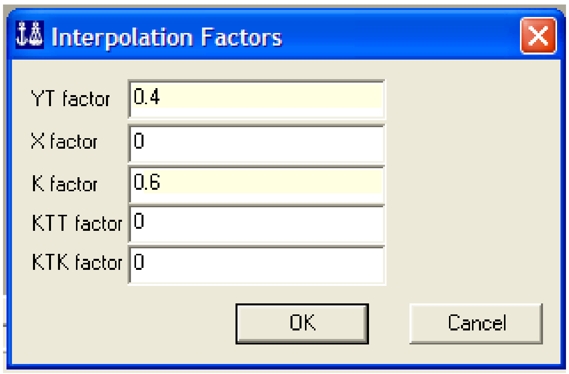
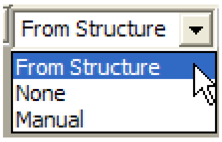
The tubular joint design code check is performed according to the chapters and sections referred to in the table below:

	Design consideration	Sections covered
E.1	CONNECTIONS OF TENSION AND COMPRESSION MEMBERS	All
E.3	TUBULAR JOINTS	**E.3.1** Simple Joints **E.3.2** Overlapping Joints **E.3.4** Load Transfer Across Chords

Joint specific parameters:



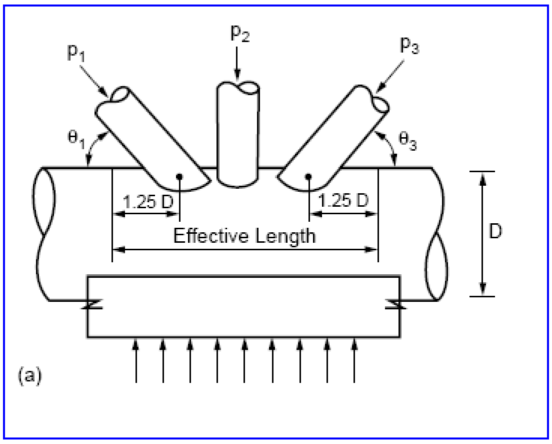
Options:

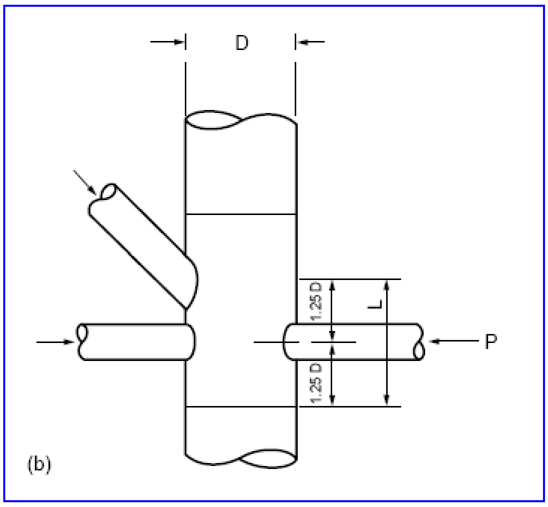
Brace Type	Select how to classify the brace type regarding geometry. Alternatives are: - manually set to YT, X, K, KTT, KTK - classify according to geometry - classify according to loadpath (and geometry) - interpolate using manual input 
Load Transfer	Select if load transfer through chord shall be used, ref. API section E.3.4.
Gap	From Structure = use the geometry as defined in the model and calculate gap values.  None = do not include gap => set gap to zero Manual = specify the gap value to be used towards neighbour braces
Through Brace	The program will propose the through brace in an overlapping joint based on: 1. Max. thickness is through-brace 2. Max. diameter is through, when 1. equal 3. Minimum angle with chord is through brace The user may change this if the situation is different from the proposal.

The joint capacity check requires that the tensile strength of the chord material is defined. If the tensile strength has not been defined, a tensile strength equal to Yield strength * 1.11 will be used. In such cases the usage factor from equation (E.3-1) will be based on Fy = 2/3 of tensile strength.

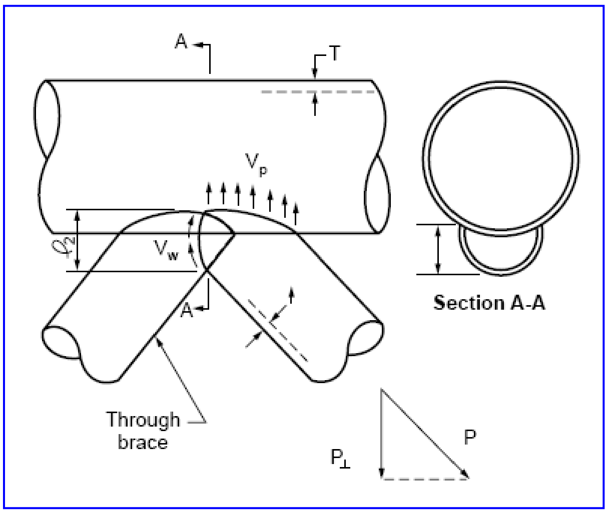
When calculating the usage factor for an overlapping brace according to Section E.3.2 “Overlapping joints” the capacities according to Section E.3.1 “Simple Joints” are also checked.

API Figure E 3-6



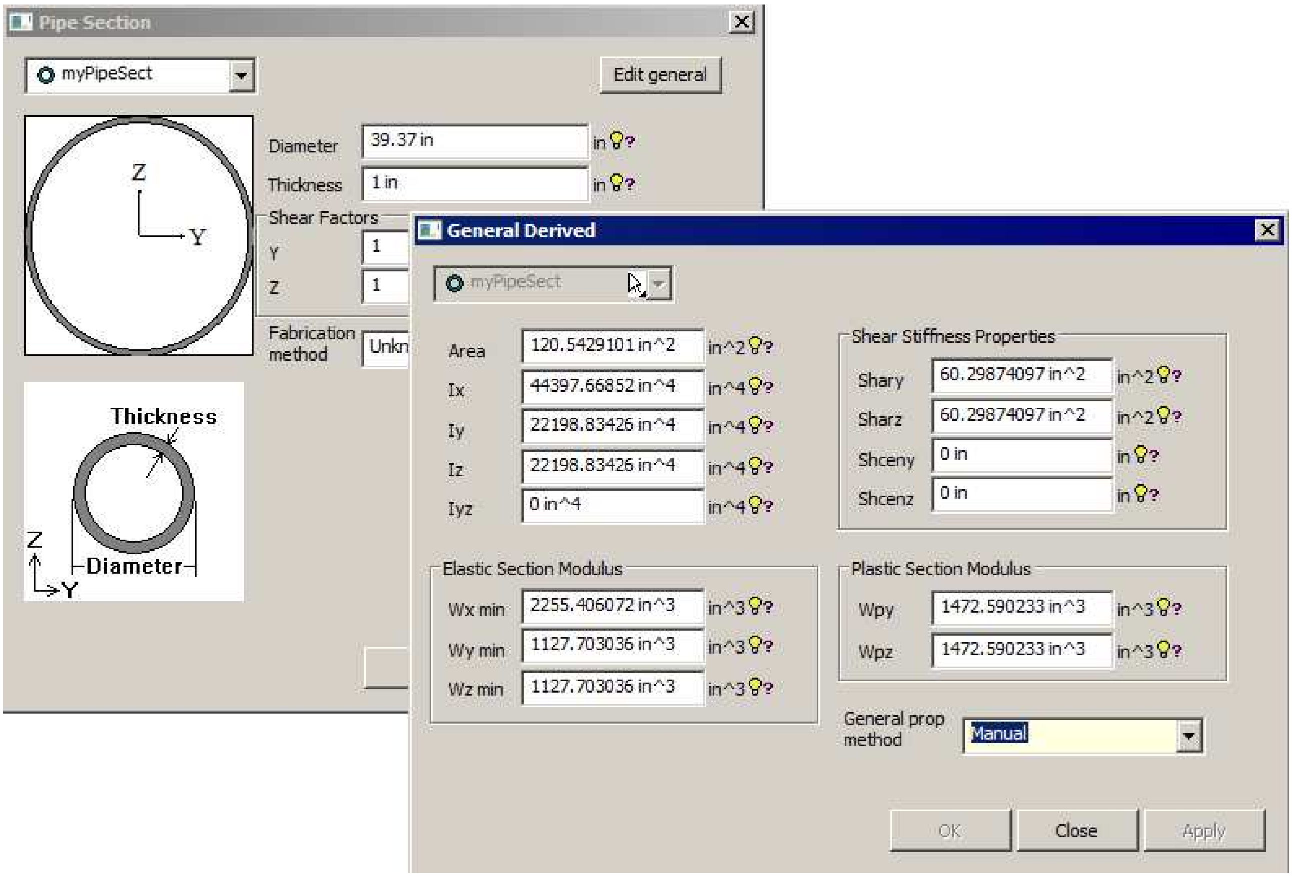


API Figure 4.3.2-1



1.4 Cross section properties for manually updated profiles

From GeniE v7.5 it is possible to manually modify/update the computed cross section properties.



Member code checks will utilize updated/modified:

- Area
- Moment of inertia, Ix, Iy and Iz
- Elastic section modulus, Wy and Wz
- Plastic section modulus, Wpy and Wpz

No attempt to calculate any equivalent diameter or wall thickness. It is strongly recommended to always update related values, e.g. if modifying Iy also update Wymin and Wpy accordingly.

No specific update for cone or joint code check has been made to utilize modified values. However, modified area and elastic section modulus will be used when calculating stress in chord member. (Stress in chord for calculation of parameter A used in chord load factor Qf.)

1.5 Nomenclature

1.5.1 Member check API LRFD 2003

The print of all available results inclusive intermediate data from the member check will report the following:

Member	Capacity model name (name of Beam(s) or part of beam representing the member)
Loadcase	Name of load case/combination under consideration
Position	Relative position along member longitudinal axis (start = 0, end = 1)
Status	Status regarding outcome of code check (OK or Failed)
UfTot	Value of governing usage factor
Formula	Reference to formula/check type causing the governing usage factor
SubCheck	Which check causes this result, here API LRFD member check
GeomCheck	Status regarding any violation of geometric limitations
ufShear	Usage factor due to shear action
ufTorsion	Usage factor due to torsional action
ufD211	Usage factor according to equation (D.2.1-1), i.e. axial tension
ufD252	Usage factor according to equation (D.2.5-2), i.e. hydrostatic pressure
ufD311	Usage factor according to equation (D.3.1-1), i.e. axial tension and bending
ufD311ax	Axial contribution to usage factor according to equation (D.3.1-1)
ufD311mo	Moment contribution to usage factor according to equation (D.3.1-1)
ufD321	Usage factor according to equation (D.3.2-1), i.e. axial compression and bending
ufD321ax	Axial contribution to usage factor according to equation (D.3.2-1)
ufD321mo	Moment contribution to usage factor according to equation (D.3.2-1)
ufD322	Usage factor according to equation (D.3.2-2), i.e. axial compression and bending
ufD322ax	Axial contribution to usage factor according to equation (D.3.2-2)
ufD322mo	Moment contribution to usage factor according to equation (D.3.2-2)
ufD323	Usage factor according to equation (D.3.2-3), i.e. axial compression
ufD331	Usage factor according to equation (D3.3-1), i.e. axial tension, bending and hydrostatic pressure
ufD341	Usage factor according to equation (D.3.4-1), i.e. axial compression, bending and hydrostatic pressure
D/t	The D/t ratio
thk	Tubular wall thickness in meter
relpos	Relative position along member longitudinal axis (start = 0, end = 1)
D	Tubular outside diameter
t	Tubular wall thickness
Fy	Yield strength
E	Young's modulus of elasticity
P	Acting axial force, negative when compression
My	Acting bending moment about local y-axis

Mz	Acting bending moment about local z-axis
Mvt	Acting torsional moment
V	Acting transverse shear force (vector sum for local y and z directions)
p	Hydrostatic pressure according to section 3.2.5.a "Design Hydrostatic Head"
Kly	Buckling length for buckling about local y-axis
Klz	Buckling length for buckling about local z-axis
stfspace	Length between ring stiffeners
Fey'	Euler stress appropriate for bending about local y-axis
Fez'	Euler stress appropriate for bending about local z-axis
lambday	Column slenderness parameter about local y-axis
lambdaz	Column slenderness parameter about local z-axis
fa	Acting axial stress, negative when compression
fby	Acting bending stress about local y-axis
fbz	Acting bending stress about local z-axis
fv	Acting torsional shear stress
fvt	Acting transverse shear stress
Cmy	Bending moment amplification coefficient for bending about local y-axis
Cmz	Bending moment amplification coefficient for bending about local z-axis
Fxe	Elastic local buckling stress
Fxc	Inelastic local buckling stress
Fcn	Nominal axial compressive strength
Fbn	Nominal bending strength
Fvn	Nominal beam shear strength
Fvtn	Nominal torsional shear strength
fh	Hoop stress due to hydrostatic pressure
gammaD	Hydrostatic pressure load factor
Fhe	Elastic hoop buckling stress
Fhc	Nominal critical hoop buckling strength

1.5.2 Cone check API LRFD 2003

The print of all available results inclusive intermediate data from the cone check will report the following:

Member	Capacity model name (name of Beam(s) or part of beam representing the member)
Loadcase	Name of load case/combination under consideration
Position	Relative position along member longitudinal axis (start = 0, end = 1)
Status	Status regarding outcome of code check (OK or Failed)
UfTot	Value of governing usage factor
Formula	Reference to formula/check type causing the governing usage factor

SubCheck	Which check causes this result, here API LRFD cone check
GeomCheck	Status regarding any violation of geometric limitations
uffTotC	Usage factor based on total stress (ref. section D.4.1.3.1), cone side of junction
uffTotT	Usage factor based on total stress (ref. section D.4.1.3.1), tubular side of junction
ufnomiC	Usage factor based on nominal stresses (ref. section D.4.1.1), cone side of junction
ufnomiT	Usage factor based on nominal stresses (ref. section D.4.1.1), cone side of junction
ufHoop	Usage factor due to hoop stress
ufD341	Usage factor according to equation (D.3.4-1), i.e. axial compression, bending and hydrostatic pressure
ufD322	Usage factor according to equation (D.3.2-2), i.e. axial compression and bending
ufD331	Usage factor according to equation (D.3.3-1), i.e. axial tension, bending and hydrostatic pressure
Alpha	One-half the projected apex angle of the cone
relpos	Relative position along member longitudinal axis (start = 0, end = 1)
D	Outside diameter of tubular (tubular side of junction)
t	Wall thickness of tubular (tubular side of junction)
Dc	Outside diameter of cone
tc	Wall thickness of cone
E	Young's modulus of elasticity of tubular section
Fy	Yield strength of tubular section
Tens	Tensile strength of tubular section
Ec	Young's modulus of elasticity of cone
Fyc	Yield strength of cone
Tensc	Tensile strength of cone
fc	Acting axial stress in the tubular section
fb	Acting resultant bending stress in the tubular section
fcc	Acting axial stress in the cone
fbc	Acting resultant bending stress in the cone
fb'	The localized bending stress at the junction, tubular side
fb'c	The localized bending stress at the junction, cone side
fh'	The hoop stress caused by the unbalanced radial line load
p	Hydrostatic pressure according to section D.2.5.1 "Design Hydrostatic Head"
fh	Hoop stress due to hydrostatic pressure
gammaD	Hydrostatic pressure load factor
Fxe	Nominal elastic local buckling strength
Fxc	Nominal inelastic local buckling strength
Fhe	Elastic hoop buckling stress
Fhc	Nominal critical hoop buckling strength

1.5.3 Tubular joint check API LRFD 2003

The print of all available results inclusive intermediate data from the tubular joint check will report the following:

Member	Capacity model name (brace name)
Loadcase	Name of load case/combination under consideration
Position	Governing brace causing highest utilisation
Status	Status regarding outcome of code check (OK or Failed)
UfTot	Value of governing usage factor
Formula	Reference to formula/check type causing the governing usage factor
SubCheck	Which check causes this result, here API LRFD joint capacity check
GeomCheck	Status regarding any violation of geometric limitations
ufE31	Usage factor according to equation E.3-1
ufE32	Usage factor according to equation E.3-2
ufE34	Usage factor according to equation E.3-4
ufE34ax	Axial contribution to usage factor according to equation E.3-4
ufE34mo	Moment contribution to usage factor according to equation E.3-4
ufPperp	Usage factor axial component perpendicular to chord for overlapping brace
beta	Value of β (= d/D), geometric limitation; $0.2 < \beta < 1$.
noTensile	Control value regarding tensile strength (0 = OK, 1 = tensile strength not defined)
D	Outer diameter of chord
T	Wall thickness of chord
d	Outer diameter of brace
t	Wall thickness of brace
Fyc	Yield strength of chord
Fyb	Yield strength of brace
g	Gap value used in calculations
theta	Angle between brace and chord
tau	Value of τ (= t/T)
gamma	Value og γ (= D/2T)
A	Factor A, i.e. the utilisation (stress level) of the chord
Qfax	Factor to account for nominal longitudinal stress in chord, axial
Qfipb	Factor to account for nominal longitudinal stress in chord, in-plane bending
Qfopb	Factor to account for nominal longitudinal stress in chord, out-of-plane bending
Quax	Ultimate strength factor dependant of joint and load type, axial
Quipb	Ultimate strength factor dependant of joint and load type, in-plane bending
Quopb	Ultimate strength factor dependant of joint and load type, out-of-plane bending
Ytfact	Brace classification, fraction as type YT behaviour
Xfact	Brace classification, fraction as type X behaviour
Kfact	Brace classification, fraction as type K behaviour

KTTfact	Brace classification, fraction as type KTT behaviour
KTKfact	Brace classification, fraction as type KTK behaviour
L	Effective length L as defined Figure 4.3.4-1
Tnom	Wall thickness for nominal chord member (not the can part if exists)
PD	The factored axial load in brace
MDipb	The factored bending moment in brace, in-plane bending
MDopb	The factored bending moment in brace, out-of-plane bending
Pu	Ultimate capacity for brace axial load
Muipb	Ultimate capacity for brace bending moment, in-plane bending
Muopb	Ultimate capacity for brace bending moment, out-of-plane bending
tw	The lesser of the weld throat thickness or the thickness t of the thinner brace (overlap)
PDperp	The factored axial load component perpendicular to the joint for (overlap)
Pujperp	Ultimate axial load component perpendicular to the joint for (overlap)
oveCap	Overlap capacity (= $2*v_{wa}*tw*l_2$)
oveRat	Ratio between overlap capacity and the acting P perpendicular to chord

Note that **Pu**, **Muipb** and **Muopb** are reported inclusive resistance factors. This because they may be calculated from interpolation for e.g. partial K and YT action, and hence also will be using different resistance factors for the different action types.

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