PROBAD

Code-based Strength calculations of Pressure parts

PROBAD 01/2020
New Features and Improvements

The program system PROBAD is checked and modified continuously within the scope of the maintenance agreement.

List of innovations, improvements and corrections of the new PROBAD-Releases

EN 12952	Water-tube Boilers	Release 4.08
EN 13445	Unfired Pressure Vessels	Release 3.07
EN 13480	Metallic industrial Piping	Release 2.07
EN 1591	Circular Flange Connections	Release 5.04
EN Piping Series	Serial Piping Calculations	Release 4.08
AD 2000	Pressure Vessels	Release 7.08
TRD	Steam Boilers	Release 8.08
WRC 107 / WRC 537	External Nozzle Loads	Release 8.08
WRC 297	External Nozzle Loads	Release 5.08
FEZEN	Material Information System	Release 4.12

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FEZEN – Information System, Version 4.12:

The following new editions of standards and codes were inserted into the material database FEZEN:

Reference standard EN:

EN 10217-1	Edition 04/2019	Welded steel tubes for pressure purpose
EN 10217-2	Edition 04/2019	Welded steel tubes for pressure purpose
EN 10217-3	Edition 04/2019	Welded steel tubes for pressure purpose
EN 10217-4	Edition 04/2019	Welded steel tubes for pressure purpose
EN 10217-5	Edition 04/2019	Welded steel tubes for pressure purpose
EN 10217-6	Edition 04/2019	Welded steel tubes for pressure purpose
EN 13445-2	Edition 12/2018	Unfired Pressure Vessels – Materials

Reference standard DIN:

- AD 2000 - W 9 Edition 07/2019 Steel flanges
  AD 2000 - W 10 Edition 07/2019 Ferrous materials for low temperatures
  AD 2000 - W 12 Edition 07/2019 Seamless tubular products for pressure vessel shells
  AD 2000 - W 13 Edition 07/2019 Forgings and rolled components

- The following modified VdTÜV-Material sheets were entered into the material database FEZEN:
  007/2, 109, 236,
  350/3, 352/2, 354/1, 354/2, 357/1, 357/3, 377/1, 399/3,
  400, 404/3, 418, 421, 424, 440/1,
  511/2, 511/3, 547, 550, 555, 587, 588

Dimensions Standards:

- By user request the following dimensions standards were entered into the database:

DIN 11866, 11/2016:	Stainless steel pipes for aseptic purpose
DIN 11865, 11/2016	Stainless fittings for aseptic purpose
DIN 28033, 04/2019	Weld-on flanges for pressurized process equipment
DIN 28034, 09/2013	Welding-neck flanges for pressurized process equipment
DIN 28040, 09/2013	Flat gaskets for process flanges
Kempchen WN 104	Spiral gaskets according to Kempchen standard WN 104
Kempchen WN 157	Corugated gaskets according to Kempchen standard WN 157

- The dimensions database was updated according to the following new editions of standard:

EN 10217-1,	04/2019:	Welded steel tubes for pressure purpose
EN 10217-2,	04/2019:	Welded steel tubes for pressure purpose
EN 10217-3,	04/2019:	Welded steel tubes for pressure purpose
EN 10217-4,	04/2019:	Welded steel tubes for pressure purpose
EN 10217-5,	04/2019:	Welded steel tubes for pressure purpose
EN 10217-6,	04/2019:	Welded steel tubes for pressure purpose
EN ISO 3183,	09/2018:	Steel pipe for pipeline transportation systems
EN 1092-1,	04/2018:	Steel flanges for pipes, valves, fittings

Result Template:

In the new release a company specific Word or PDF template may be defined under menu ‚Settings > Printer‘. On demand the results are created in this template as Word or PDF document.

EN 12952: Water-Tube Boilers, Release 4.08

Adjacent Branches:

By default adjacent openings are checked via a common reinforcement calculation according to EN 12952-3, 8.3.4.
In the new release this check can be alternatively requested via efficiency factor vm according to EN 12952-3, 8.2.4. In most cases this leads to more conservative results.

Hemispherical Heads without cylindrical Skirt:

By default hemisperical heads without cylindrical skirt are regarded as complete hemisphere.
In the new release in case of a non-complete hemispherical shell the diameter of the spherical segment can be entered. This input is used to determine the height of the head, the inside volume and the weight correctly.

Correktions:

- Nozzles:
  The differences between text and graphic helps regarding the inside and outside projection have been eliminated.

EN 13445: Unfired Pressure Vessels, Release 3.07

Reducers:

- Nozzles on eccentric Reducers:
  Up to now the reinforcement calculation of nozzles on eccentric reducer was done under the as-sumption, that the opening was placed on the conical shell with maximum cone angle.
  In the new release openings with
  - circumferential position 180° are placed at the conical part with maximum cone angle
  - circumferential position 0° are placed at the cylindrical part of the cone.

- Reducers with short run-out area:
  If the run-out length of the reducer is smaller than required according to EN 13445-3, the strength calculation for this area is done with an effective run-out thickness according to EN 13445-3, figure 7.6-1 or 7.6-4 respectively. Now this proceeding is only reported by a hint.

- Reducers without cylindrical run-out area:
  Entering a cylindrical run-out length L1 = 0 mm, the cylindrical run-out area is no longer checked in the new release. A corresponding hint is displayed.

Support Skirt:

Up to now for support skirts with opening in section 4-4 or section 5-5 the relevant parameters residual cross sectional area A, section modulus W and centroid deflection yG had to be entered.
Now for an opening in the section the outside diameter det of the opening may be entered.
Using a stiffening ring the thickness ent, the total length lt and the outer projection ht of the ring must be entered additionally. In this case the residual cross sectional area A, section modulus W and centroid de-flection yG are determined internally according to EN 13445-3, section 16.12.4.4.

Corrections:

- T-Fittings:
  For T-fittings up to now the allowable stresses of main pipe and nozzle were always determined se-parately. In the new release for forged or extruded T-fittings a lowwe allowable stress of the main pipe is also used for the nozzle.

- Reducers:
  If the cylindrical run-out length L1 is entered explicitely, the increased wall thickness e1 is taken into account over this length calculating the effelcive thickness. For the remaining length Lcyl-L1 the connection thickness ecyl is used.

- Flat Heads:
  For bolted flat plates with gasket within the bolt circle now also a warning is displayed, if the thick-ness of the flange ring is less than the required thickness eA for assembly condition.

- Flat Heads:
  Up to now a warning was displayed, if the ratio es/Di or p/fmin was out of the range of EN 13445-3, figure 10.4-2 or figure 10.4-5 respectively.
  Since the factors C1 and C2 are not determined from these figures, but from the corresponding for-mulas, the warnings are ommitted in the new release, if the parameters are out of range of the figu-res.

EN 13480: Metallic industrial Piping, Release 2.07

Reduzierungen:

- Nozzles on eccentric Reducers:
  Up to now the reinforcement calculation of nozzles on eccentric reducer was done under the assumption, that the opening was placed on the conical shell with maximum cone angle.
  In the new release openings with
  - circumferential position 180° are placed at the conical part with maximum cone angle
  - circumferential position 0° are placed at the cylindrical part of the cone.

- Reducers with short run-out area:
  If the run-out length of the reducer is smaller than required according to EN 13480-3, the strength calculation for this area is done with an effective run-out thickness according to EN 13480-3, figure 6.4.2-1 or 6.4.8-1 respectively. Now this proceeding is only reported by a hint.

- Reducers without cylindrical run-out area:
  Entering a cylindrical run-out length L1 = 0 mm, the cylindrical run-out area is no longer checked in the new release. A corresponding hint is displayed.

Corrections:

- T-Fittings:
  For T-fittings up to now the allowable stresses of main pipe and nozzle were always determined separately. In the new release for forged or extruded T-fittings a lowwe allowable stress of the main pipe is also used for the nozzle.

- Reducers:
  If the cylindrical run-out length L1 is entered explicitely, the increased wall thickness e1 is taken into account over this length calculating the effelcive thickness. For the remaining length Lcyl-L1 the connection thickness ecyl is used.

- Flat heads:
  For bolted flat plates with gasket within the bolt circle now also a warning is displayed, if the thickness of the flange ring is less than the required thickness eA for assembly condition.

- Flat heads:
  Up to now a warning was displayed, if the ratio es/Di or p/fmin was out of the range of EN 13480-3, figure 7.2.3-2 or figure 7.2.3-4 respectively.
  Since the factors C1 and C2 are not determined from these figures, but from the corresponding formulas, the warnings are ommitted in the new release, if the parameters are out of range of the figures.

EN 1591: Circular Flange Connections, Release 5.04

Surface Pressure of Gasket:

Calculating flange connections according to EN 1591 considerable differences occur oftenly between designing (i.e. determination of the nominal bolt force FB0nom) and control calculation according to EN 1591-1, section 5 (with entered bolt assembly force FB0,spec. or entered bolt assembly torque Mt0,spec.).
To achieve comparable results, the calculation was modified in several points in the new release. The corresponding modification of formulas were partially taken over into the current draft of EN 1591.

- Up to now the minimum gasket force at assembly FG0min was determined according to formula (103) using the gasket pressure QA prior to unloading (listed in the corresponding gasket sheet): FG0min = AGe * QA
  Now deviating from formula (103) FG0min is determined using the required minimum gasket pressure Qmin(L) in assemly condition: FG0min = AGe * Qmin(L)
  Qmin(L) is determined by the program but can also be entered explicitely.

- Instead of QA now the mean effective compressiv stress QG0 = FG0 / AGe according to formula (57) serves for the determination of the required minimum surface pressure Qsmin(L) in subsequent conditions.
  Also in control calculations QG0 is determined using formula (57). However here FG0 is determined according to formula (1) and stays fix during the iteration.

- The formulas to determine the gasket force FG0d, taking into account all subsequent conditions, were modified as follow:

Design:	Formula (119)	: FG0d = max {FGDelta ; 2/3 * (1-10/NR) * FB0max – FR0}
	Formula (119-mod)	: FG0d = max {FG0req ; 2/3 * (1-10/NR) * FB0max – FR0}
Control:	Formula (2)	: FG0d = max {FB0min-FR0 ; 2/3 * (1-10/NR) * FB0max – FR0}
	Formula (2-modif.)	: FG0d = max {FG0 ; 2/3 * (1-10/NR) * FB0max – FR0}

Maximum Bolt Assembly Torque:

- Up to now also for design calculations the determination of the maximum allowable bolt assembly torque Mt0,nom could be requested in PROBAD. But oftenly this value entered as Mt0,spec for a control calculation according to section 5 led to overload or turned out to be too small.
  For this reason now the determination of the maximum allowable bolt assembly torque can only be requested for control calculations (i.e. for entered bolt assembly force FB0,spec. or entered bolt assembly torque Mt0,spec.). In this case PROBAD determines the maximum allowable bolt assembly torque Mt0,spec. according to EN 1591-1, section 5 iteratively.

- Also an entered minimum load ratio PhiB0min of the bolts is now checked only, if the bolt assembly force FB0,spec. or the bolt assembly torque Mt0,spec. are entered.
  If the determined load ratio of the bolts in assembly condition is lower than PhiB0min, a corresponding warning is displayed.

Friction Factor of Gasket:

The friction factor miG of the gasket is now determined according to EN 1591-1, Draft 2019, Table E.1 depending on the type of gasket, because the friction factors listed in EN 1591-1, Edition 2013 in Annex E, Table E.1 turned out to be to low.
In case of lateral forces or torque this has a significant impact on the results.

Bolts in Creep Range:

- Since the bolts are usually changed during the operational lifetime for flange connections in creep range, a lifetime different from that of the flanges may be entered for the bolts using the switch ‚Change of safety factors and lifetime‘.
  According to EN 1591-1, 4.3 the nominal design stresses of the bolts are determined on basis of the same rules as for flange and shell, for example using the same safety factor for yield strength.

Corrections:

- Blind flange:
  For blind flanges with tongue the inner plate thickness was regarded icluding the height of the tongue. The bug has been fixed.

- Gaskets in by-pass:
  Up to now for by-pass gaskets the maximum possible contact area of the flange plates was regarded as effective gasket area in the calculation.
  In the new release only the contact area outside of the O-ring is taken into account.

- Washers:
  The inside diameter dW1 of washers was shown wrong In the graphic helps. This was corrected.

- Flange connection with 2 tongues:
  In the new release it is now possible to calculate flnge connections with tongues in both flanges. This combination makes sense, if a plate clamped between has a groove on both siedes.

AD 2000: Pressure Vessels, Release 7.08

AD-S3/7: New Edition 05/2019

According to the new edition of AD-S3/7 instead of the mean wall temperature theta now the difference temperature Delta theta = wall temperature – manufacturing temperature enters into the calculation of the thermal stresses. The programs were modified, with manufacturing temperature set to 20°C.

Tubesheet:

During the determination of the maximum usage ratio the tube-to-tubesheet connection was not taken into account up to now.
In the new release the ratio ‚actual / allowable load of connection' enters into the determination now.

Support Skirt:

Up to now for support skirts with opening in section 4-4 or section 5-5 the relevant parameters residual cross sectional area A, section modulus W and centroid deflection epsilon had to be entered.
Now for an opening in the section the outside diameter det of the opening may be entered.
Using a stiffening ring the thickness ent, the total length lt and the outer projection ht of the ring must be entered additionally. In this case the residual cross sectional area A, section modulus W and centroid deflection epsilon are determined internally according to EN 13445-3, section 16.12.4.4.

Corrections:

- Tubesheet:
  Caused by a bug the number of load bearing tubes was not increased, even if they were overloaded by buckling. This bug was fixed.

DIN/EN-Piping Series, Release 4.08

Calculation against internal and external Pressure:

In the new release it is now possible to enter an internal pressure Pi and an external pressure Pe. In this case in addition to the internal pressure calculation the straight pipes and nozzles are also calculated against external pressure.

4 Ranges:

In the new release up to 4 ranges can be defined for the single components.
In this way it is now possible, to devide for example the straight pipes into non-overlapping ranges
- seamless, material A
- seamless, material B
- welded, material C
- welded, material D.

Defined ranges are now marked in color in the input panels.

Documentation of Results:

Wall thicknesses and allowable stresses, which did not change compared to the previous table line, are not displayed in the result tables. This is also valid for the diameter and the wall thickness of the main pipe in the nozzle results. This makes it easier to read the results and to recognize differences in wall thicknesses etc..
On user request in the print-, PDF- or Word-documents the result tables are now completely filled in the new release.

Nozzle Scheme:

Main pipe and nozzle are now documented with increasing diameters in the nozzle scheme.

Corrections:

- Extruded Nozzles:
  Up to now the the stress loaded areas of extruded nozzles were reduced by 10% only for the ruling codes EN 12952, AD 2000 and TRD. Now this reduction is done for all ruling codes
  (see for example EN 13480-3, 8.3.8).

- T-Fittings:
  Up to now for the pipe connections of reinforced T-fittings a chamfer length Lf equal to the connection thickness e1 was assumed internally. Now the wall thickness difference to the reinforced thickness e3 is regaded additionally, thus Lf = Minimum {e1 ; e3-e1}.

- Individual Diameters:
  Up to now diameters entered via the button NEW could not be revised on the input panel.
  Now in the new release this is possible.

WRC 107: Local Stresses at cylindrical and spherical Shells, Release 8.08
WRC 297: Local Stresses at cylindrical Shells, Release 5.08

Stress Evaluation:

The determined maximum stresses of the overlay must be lower than the allowable local equvalent stresses. These allowable local equvalent stresses are determined internally depending on the selected method of ‚stress evaluation‘. For stress evaluation according to AD-S4 now a distinction is made between:

- **Primary- and secondary stresses according to AD-S4:**
  It is assumed, that the stresses, resulting from the combined local stresses, may be categorized as secondary stresses according to AD-S4, Table 1-3.
  The evaluation happens according to AD-S4, section 6.2 und 6.3.
  Local membrane stress: sig allow = 1.5 * K/S
  Local membrane and bending stress: sig allow = 3.0 * K/S

- **Primary stresses according to AD-S4:**
  The evaluation happens according to AD-S4, section 6.2 and must be selected for combined primary stresses as listed in AD-S4, Table 1-3:
  Local membrane stress: sig allow = 1.5 * K/S
  Local membrane and bending stress: sig allow = 3.0 * K/S

Unification of Calculation Parameters:

- **WRC 107: Stresses resulting from internal pressure:**
  In PROBAD WRC 107 the stresses resulting from internal pressure are determined
  - for cylindrical shells via the formula σ = p / (da/di -1),
  - for spherical shells via the formula σ = p / (da^2/di^2 -1).

  In the new release (conform to the other PROBAD modules) the stresses resulting from internal pressure are now determined
  - for cylindrical shells via the formula σ = p * Dm / (2 t)
  - for spherical shells via the formula σ = p * Dm / (4 t).

- **WRC 107: Allowable effectve stress in the nozzle:**
  In PROBAD WRC 107 up to now the actual combined stress in the nozzle was checked against the allowable value K/S. In the new release (like in WRC 297) the actual cobmined stress in the nozzle is checked against 1.5 K/S.

- **WRC 297: Input of pressure data:**
  In PROBAD WRC 297 pressure data was entered in (bar) up to now.
  In the new release the input (like in WRC 107) is expected in (MPa) now.

- **WRC 297: Proof of the nozzle:**
  In PROBAD WRC 297 up to now the internal pressure did not enter into the proof of the nozzle.
  In the new release this is managed via the ‚type of attachment‘:
  Tube plug: Without opening in the main shell
  Nozzle: With opening in the main shell.

- **WRC 297: Shear forces VL and VC:**
  In PROBAD WRC 107 and WRC 297 the shear stresses tao = 2 Vi / (pi * d * t) resulting from the shear forces Vi are taken into account during the calculation.
  Additionally in PROBAD WRC 107 the shear forces via the lever arm h1 are converted into bending moments, which are taken into account in the futher calculation.
  In the new release a corresponding lever arm h1 can also be entered in PROBAD WRC 297 now.
  In this case the corresponding neding moment h1*V is regarded like in WRC 107.

- **WRC 297:Control calculation:**
  Also in the helps of PROBAD WRC 297 a control calculation is now available for the input file:
  Example_Tube_Plug (Order: A_Hand1 Drawing: Z_Hand1)

- **WRC 297: Nomenclature:**
  In PROBAD WRC 297 German symbols were used up to now (e.g.: Dz, Tz, ds, ts etc.)
  In the new rlease English symbols are used now (e.g.: Ds, Ts and db, tb etc.)

- **Axial force in the nozzle:**
  In WRC 107 a positive axial force P is regarded as pressure force (see e.g. WRC 107, Table 1), in WRC 297 as axial tensile force (see WRC 297, figure 1).
  This is clearly documented in the corresponding input fields and helps.