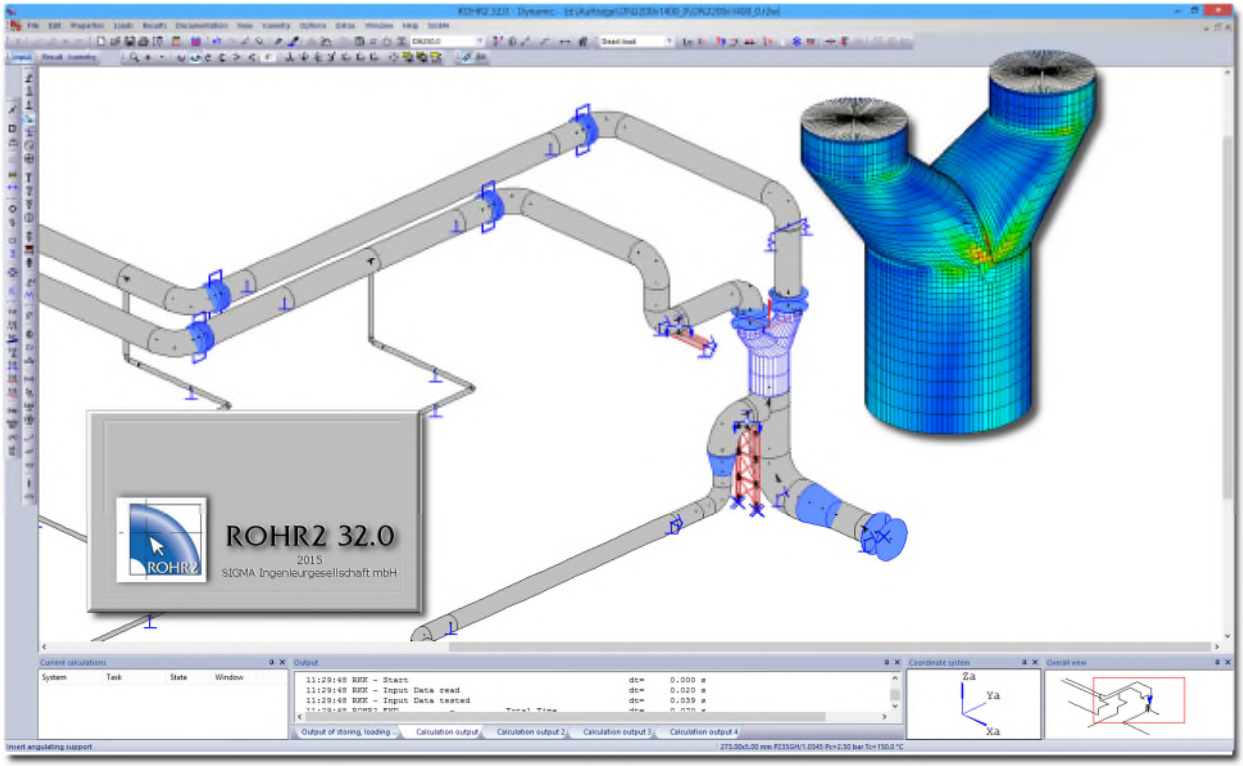
SIGMA INGENIEURGESELLSCHAFT



ROHR2

Program System for Static and Dynamic Analysis of Complex Piping and Steel Structures

SIGMA Ingenieurgesellschaft mbH

Content

Release 17.03

1 The program system ROHR2

ROHR2 the CAE-system for component analysis, construction and structural analysis of complex piping systems

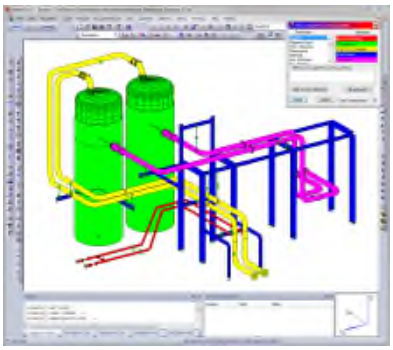
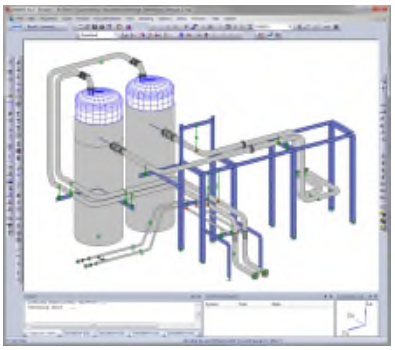
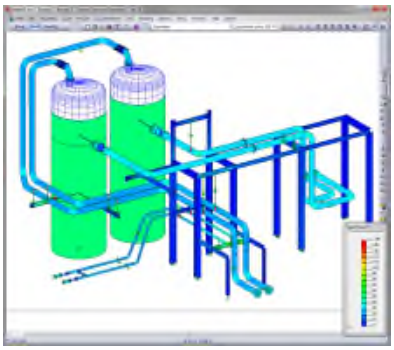
ROHR2 is the leading European Software for Pipe Stress Analysis, a standard tool for static, dynamic piping and framework analysis.

The main tasks of ROHR2 are component analysis, construction and structural analysis of complex piping systems and associated steel structures.

The **static analysis** includes the analysis of any loads and load combinations according to first and second order theory for linear and nonlinear boundary conditions (friction, gap of supports, support uplift) and coupling conditions (nonlinear regulation powers of expansion joints).

The **dynamic analysis** includes the calculation of eigen values and mode shapes and their analysis by means of different modal response methods or direct integration method (e.g. analysis of fluid hammer forces). Earthquake analysis based on the method of Time - History.

An efficient superposition module enables a versatile selection and combination of static and dynamic results as well as the generation of extreme values for loads on supports, components and nozzles.

Stress analyses of pipe components can be done by in accordance with a variety of specifications like **ASME**, **EN**, **ISO14692**, **KTA**, **CODETI** or **RCCM.**
ROHR2 creates the load case superposition and the equations automatically according to the selected stress specification.
ROHR2 compares existing and allowable stresses. The results will be documented in lists and graphical presentations. The range of applications is completed by internal pressure analysis and flange and nozzle calculation modules.

The software may be extended by a range of additional features and add on modules, enhancing an facilitating the engineer's daily job:

a wide range of interfaces covering market leading CAD/CAE systems,
ROHR2fesu for detailed component FE analysis,
ROHR2iso - isometric drawing capabilities

ROHR2 users

For more than 40 years ROHR2 supports you with continuously developed program versions for pipe stress analysis tasks. Many leading national and international plant construction companies as well as operators in the energy- , chemical - and petrochemical industry trust in the quality of ROHR2.

GENERAL ELECTRIC/ALSTOM POWER - AIR LIQUIDE - ANDRITZ - AREVA - AXIMA - BABCOCK BORSIG - BABCOCK & WILCOX - BASF - BAYER - BHEL - BGR BOILERS - BILFINGER PIPING TECHNOLOGIES - BP - BURMEISTER & WAIN - CHINA KUNLUN CEC - CIMTAS - CITEC - COVESTRO - COWI - DDTEP - DEKRA - DONGFANG TURBINE CO. - DOOSAN BABCOCK - DP CLEAN TECH - DSD - ESKOM - ESTEQ - ENBW - E.ON - EVONIK - FERCHAU - FISIA - FIVES NORDON - FMT - FOTAV RT - GASCADE - GEA Energietechnik - GRONTMIJ - GUANGDONG ELECTRIC - IDEA LTD - IHI CORPORATION - IMTECH - INFOSYS - INFRASERV - ISRAEL ELECTRIC - JACOBS - J&P-AVAX - J. CHRISTOF - KAE - KRAFTANLAGEN HEIDELBERG - KRAFTANLAGEN MÜNCHEN - Kramer & Best - KRÜGER A/S - LAHMEYER - LENZING TECHNIK - LEWA - LURGI LENTJES - M+W GERMANY - MAN DIESEL - MAN FERROSTAAL - MEYER WERFT - MITSUBISHI HITACHI - NOELL - NORDON INDUSTRIES - OUTOTEC - OSCHATZ - OMV AG - PAUL WURTH - PÖYRY ENERGY - PETROBRAS - RAMBØLL - RAFAKO - RWE - SENER - SEONGHWA LTD - SHELL - SIEMENS ENERGY - SMS SIEMAG - SPX COOLING SYSTEMS - STANDARDKESSEL - STEAG - STEELFLEX S.r.l. - STEINMUELLER - STRABAG - Sweco Projekt AS - TGE Marine Gas - THYSSENKRUPP UHDE - TECHNIP - TÜV NORD - TÜV SUED - TÜV AUSTRIA - VATTENFALL - VEBA RUHR OEL - VAM - VOESTALPINE STAHL - WESTINGHOUSE - ZRE

and National technical control boards (TÜV), Power stations, Local energy suppliers, Manufacturers of pipe components , universities and a large number of engineering companies.

Software Development, Sales and Support

SIGMA, established in 1989 in Dortmund, Germany has emerged as the partner of choice for leading international companies with its software and wide variety of engineering services.
SIGMA is known as one of the leading engineering specialists in the Pipe Stress Business in Europe, offering field tested products, strongly adapted to the user´s needs.

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2 ROHR2 Program version and scope of delivery

2.1 ROHR2 Static and Dynamic for Windows

Program System for Static and Dynamic Analysis of Complex Piping and steel Structures
Stress analyses according to a great number of standards like **ASME, EN, ISO14692, KTA, CODETI** and **RCCM.**

Flange analysis considering gaskets and screws acc. to **EN 1591-1, EN 13445-3, ASME VIII**, **Div.1** including stress analysis following several standards.

Internal pressure analysis as well as generation and administration of pipe classes including pipes, bends, reduces and branches)

Nozzle analysis acc. to standards like **API, NEMA, EN ISO**

Included and optional interface modules enable you to integrate ROHR2 perfectly into your workflow.

The graphical user interface ROHR2win can be used in German or English.
Results may be printed in German, English or French.
Country specific program versions or floating licenses may differ from this specification.
Please refer to offer/quotation.

Stress codes in ROHR2 listed by their fields of application

Steel pipes	
Pipelines , general	ASME B31.1, ASME B31.3, ASME B31.4, ASME B31.5, ASME B31.8 EN 13480 CODETI STOOMWEZEN D1101 FDBR VGLSR Equivalent stresses according to von Mises and Tresca
Nuclear Power	ASME Cl. 1, ASME Cl. 2, ASME Cl. -3 ASME Cl. 1, Fatigue analysis KTA 3201.2, KTA 3211.2 RCC-M Cl.1, RCC-M Cl.2, RCC-M Cl.3
Buried piping	EN 13941 AGFW, AGFW FW401
Offshore	B31.4 Chapter IX B31.8 Chapter VIII
GRP Pipes	ISO 14692 KRV WAVISTRONG GFK British Standard 7159
Steel frameworks	VGLSP (Stress analysis for Structural Steel Sections) following DIN 18800 EN 1993

Note: spec. program version may include a reduced no of stress codes, ref. to specification or offer

2.2 ROHR2 Interfaces

A comprehensive number of interface modules is part of the ROHR2 standard package.

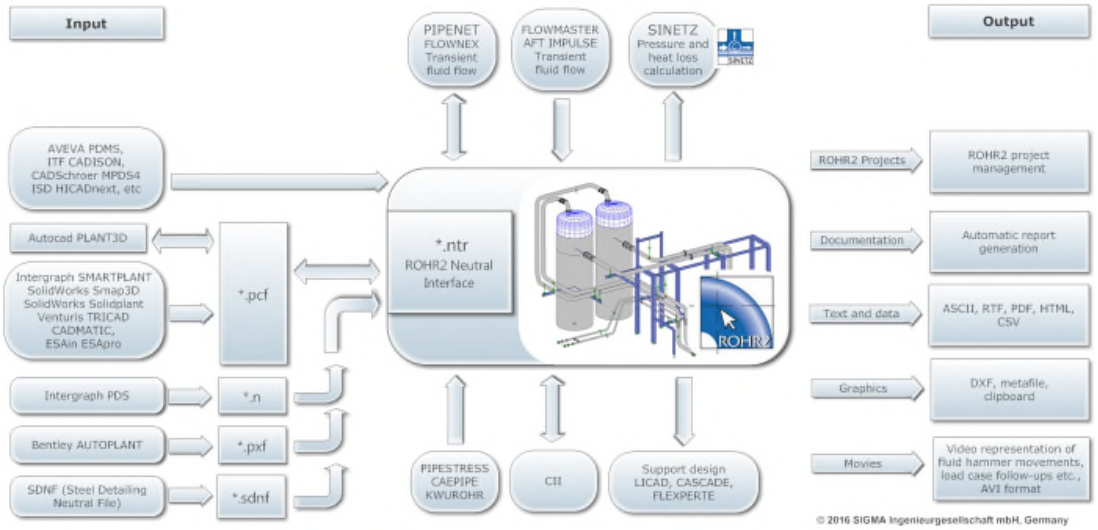
- Neutral CAD Interface including Export AVEVA PDMS/E3D - ROHR2
- DXF format Import
- CSV format Import
- Export Interface into the Support Design Programs LICAD, FLEXPERTE, CASCADE

- CAESAR II Import
- PIPESTRESS Import
- CAEPIPE Import
- KWUROHR(SIEMENS) Import

- SINETZ Export
- PIPENET Import Export
- FLOWNEX Import Export
- Load-time-functions e.g. FLOWMASTER, AFT Impulse Import

Optional interfaces are available to integrate ROHR2 into your workflow.
- ROHR2 CAD Interface package: PCF, PDS, PASCE, PXF, SDNF Interface
- ROHR2 CAESAR II Export

Please refer to the **ROHR2 Interface Brochure** or contact us for further details.



ROHR2 Interfaces, Standard equipment and optional modules

Regarding the optimization of your workflow our staff of specialists will be happy to advise you individually upon request, especially regarding the data import and export to ROHR2.

Third Party Interfaces

The integration of ROHR2 is supported by third-party interface products. In case of questions or information requests, please contact the manufacturer. We will be pleased to advise you regarding the data import and export to ROHR2.
For current information and links to software companies, pls. refer to www.rohr2.com or the ROHR2 Interface Brochure.

2.3 Licensing

The program license is available as a single user license or network license, perpetual or rental. Licensing a program requires the acceptance of the terms of use by signing a System Contract. Contract samples are available upon request.

Single user license	The single user license allows the installation of the program on the PC-systems of the licensee and the use by means of a license key (dongle) on one PC system simultaneously.
Network license	The network license enables the access to the program system by any PC in the network, limited by the number of users.
WAN	Wide area network Option Expanding the network license by an additional location

License duration	
Time unlimited /perpetual license (purchase)	Allows the **time unlimited use of the program.** Maintenance and user support are included during the first six month after delivery. In order to receive continued maintenance and user hotline, the signing of a maintenance contract is recommended.
Time limited program use (rent)	Time limited use of a program license. Minimum rental time is three month. Support and maintenance are included. Fees may be partially reimbursed in event of a purchase of the rented license(s) during the rental period.
Payment by installments (leasing)	Time limited single user program license including maintenance and support. Payable by monthly rates. After finishing rates the license will be converted into a time unlimited program version. Maintenance is included.

2.4 Scope of supply and license key

The programs´ scope of delivery contains
- the program data (by download or CD)
- the program documentation, html and pdf - format
- the ROHR2 license key (USB key , dongle).

The software does not run without the license key.
In case of updates/ upgrades the license module will be replaced or updated.

2.5 System requirements

The system requirements of all ROHR2 program versions are as following:

System requirements of single user licenses and PC-workstations in the network

- PC with min. 8 GB RAM
- Windows 10, Windows 8, Windows 7 (32-/64-bit)
- Screen resolution minimum 1024 x 768 pixels
- Connection via Internet for activation of the program license *) and program updates

*) Activation of license by phone/email or internet

System requirements of the network server

- Installation of the HASP license manager on a Server PC accessible by all users in the network, running under
- Windows 10, Windows 8, Windows 7 (32-/64-bit), Windows Server 2008/2012.

In case of integrating ROHR2 into company-wide or country-wide networks (WAN) please contact us.

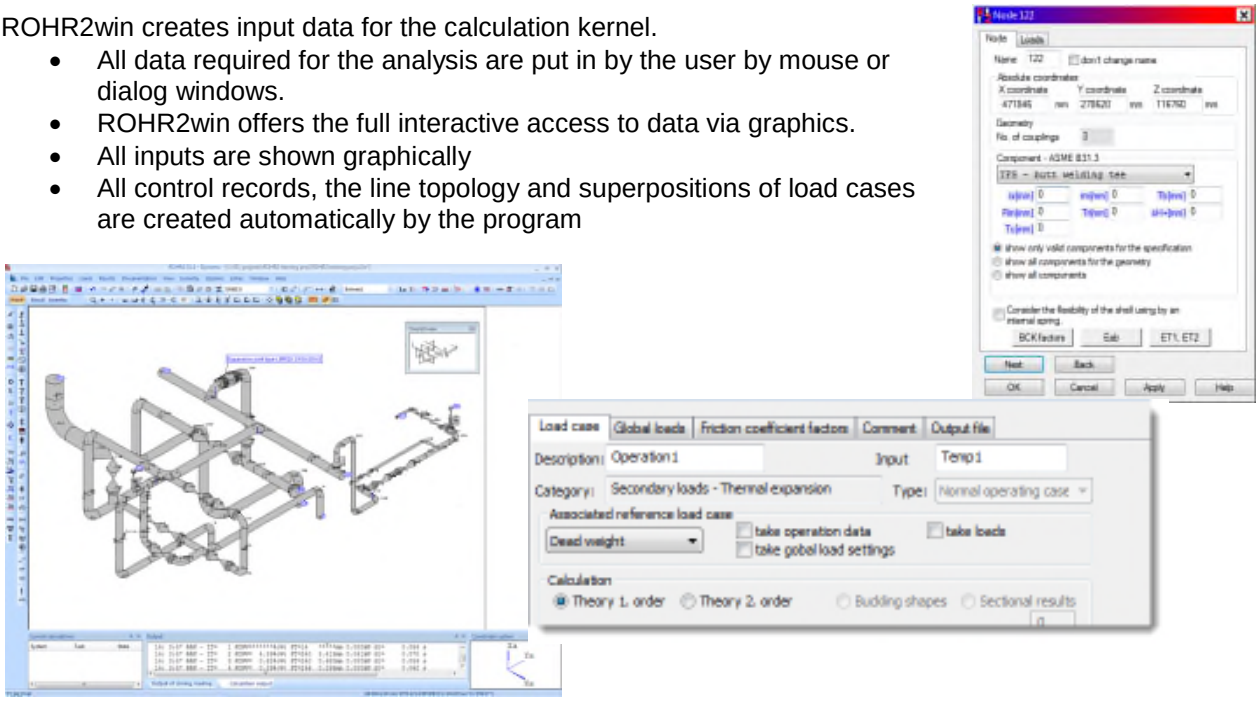
3 ROHR2 - Input of the piping system, results and documentation

The graphical user interface **ROHR2win** is the pre- and postprocessor of ROHR2. All inputs can be generated by using ROHR2win.
A wide range of control functions enables the user to check the input data easily. In addition all results may be displayed and checked both graphically and/or numerically in tables, detailed customized printed reports may be generated.

3.1 System and load case input

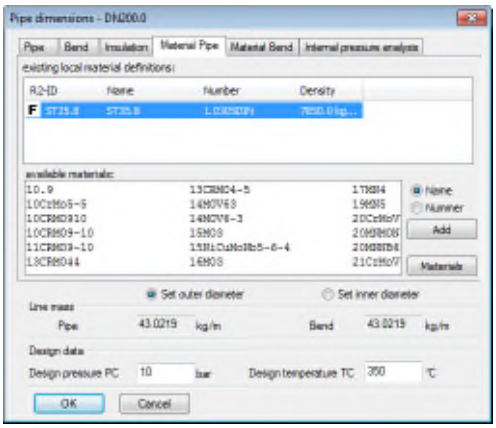
ROHR2win creates input data for the calculation kernel.

- All data required for the analysis are put in by the user by mouse or dialog windows.
- ROHR2win offers the full interactive access to data via graphics.
- All inputs are shown graphically
- All control records, the line topology and superpositions of load cases are created automatically by the program

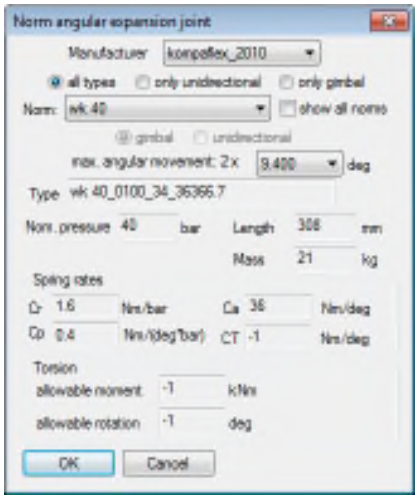


Databases

During the process the user is supported by comprehensive integrated databases.



Material database

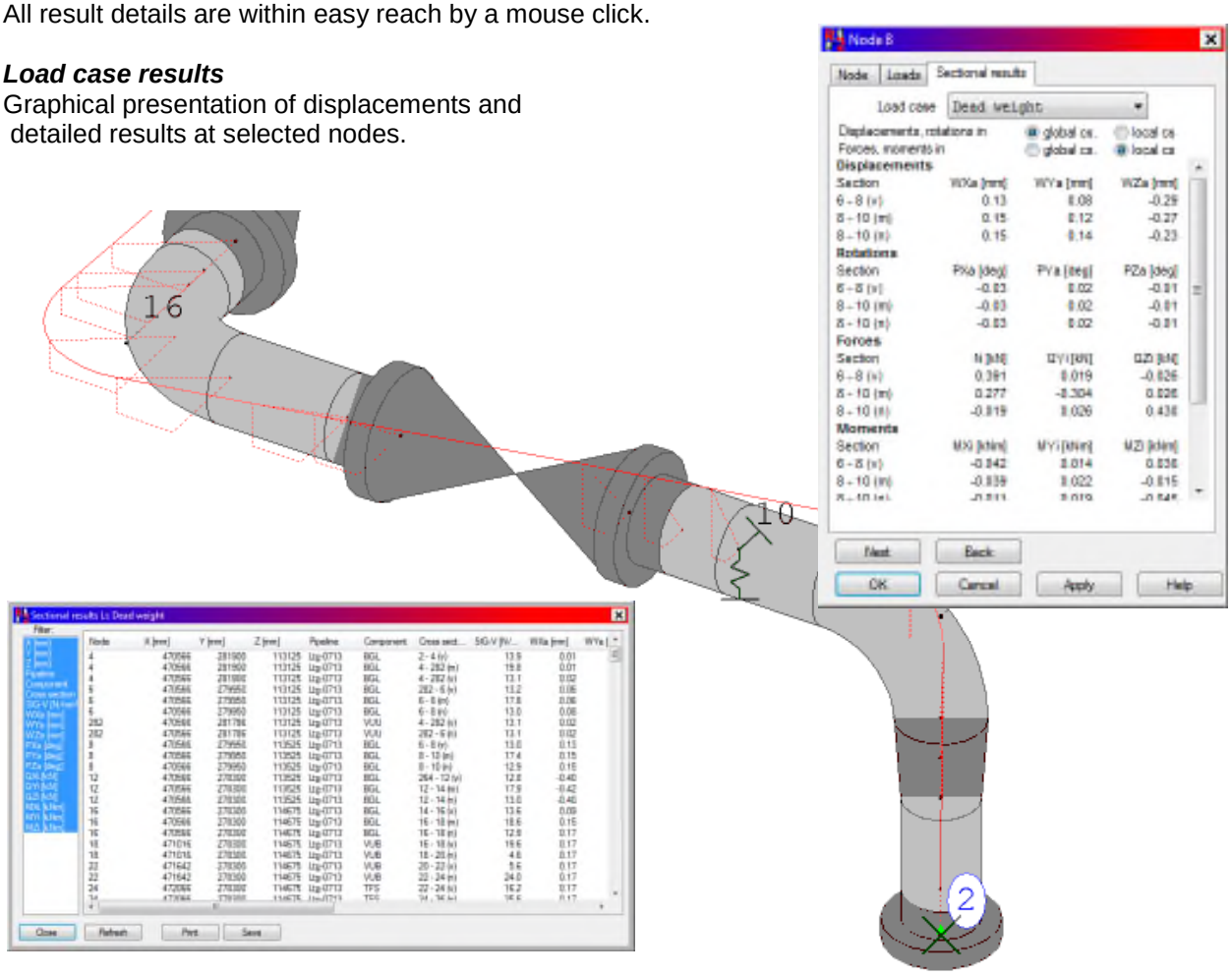


Database angular expansion joints

3.2 Documentation and presentation of the results

Analysis results are shown tabulated and graphically.
All result details are within easy reach by a mouse click.

Load case results
Graphical presentation of displacements and detailed results at selected nodes.



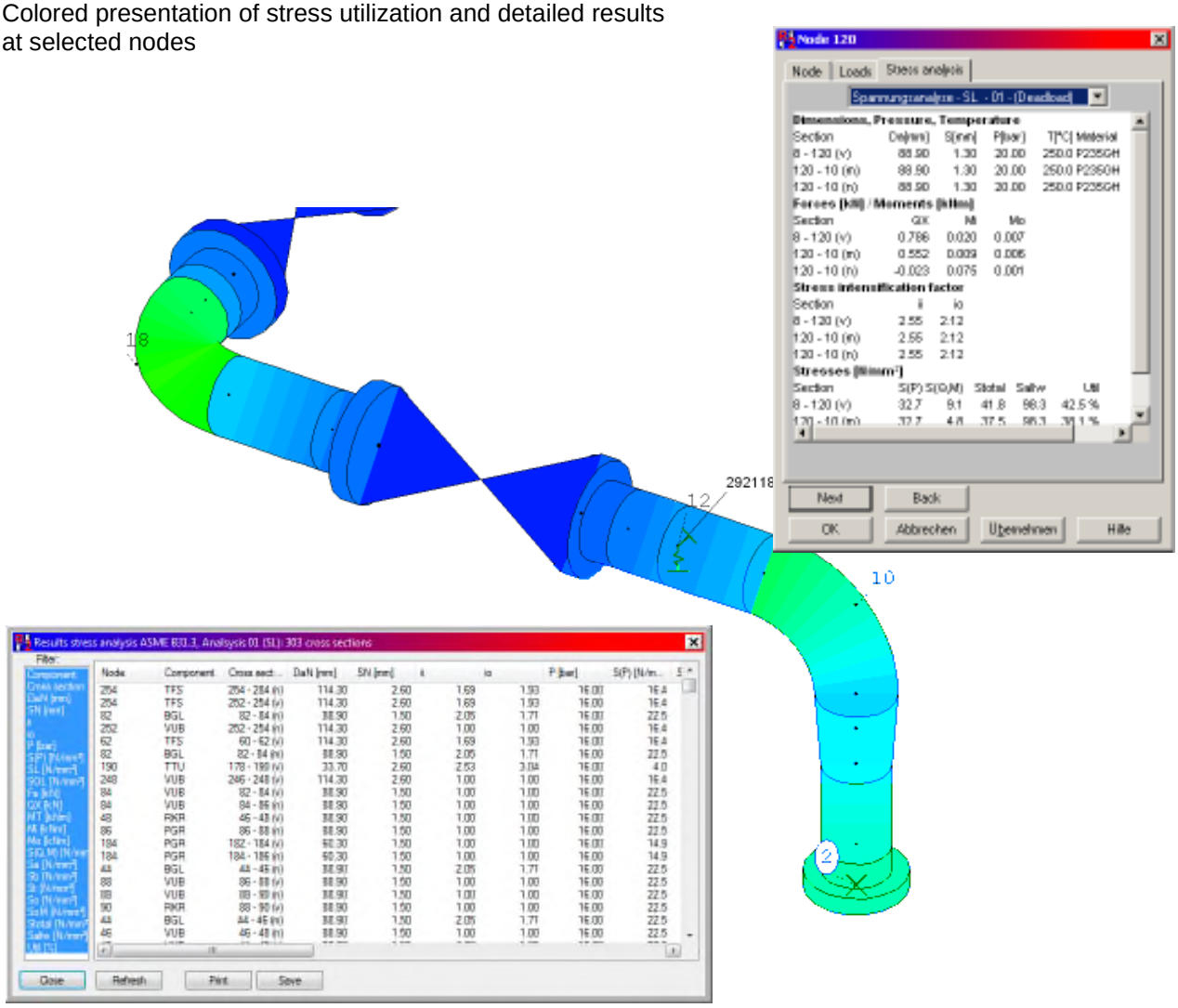
Tabulated overview of displacements

- Graphical representation of displacements, rotations, forces, moments and equivalent stresses for calculated load case and load cases created by superposition
- spatial presentation only for x, y or z direction
- zoom, pan and rotate-function available
- graphical representation of results is scalable
- detailed results for a selected node by mouse-click
- results in global or local coordinate system
- results can be printed out or saved in rtf- , html or csv format (e.g. MS Office)

- tabulated overviews can be modified by user using filter functions
- sort results by a click on the table header
- Interaction between table and graphics, selected node in graphics is highlighted in table and vice versa

3.3 Stress analyses

Colored presentation of stress utilization and detailed results at selected nodes



Tabulated overview of stresses

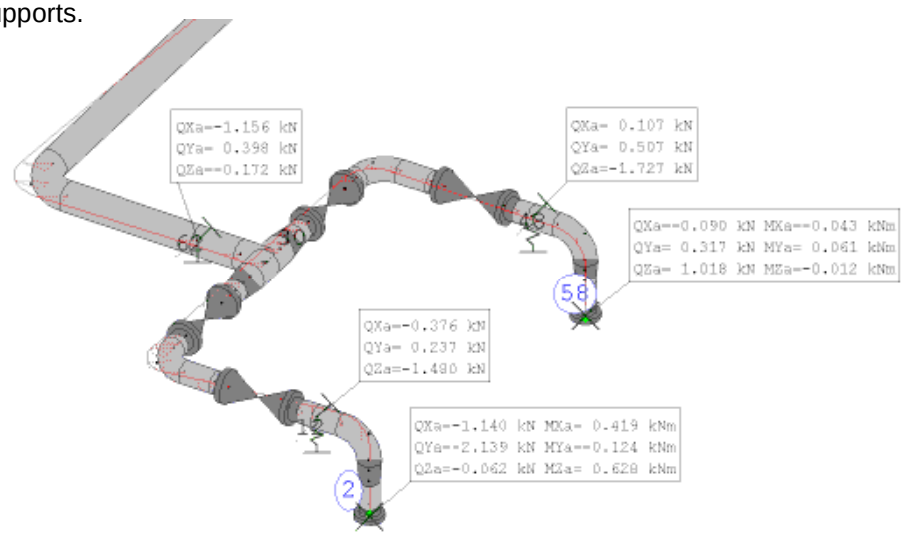
- graphical representation of stresses for the selected equation, equations are defined automatically depending on the defined load cases
- stress analysis according to different specifications for different parts of the piping system
- stress analysis may be limited to selected parts of a piping system

- detailed results for a selected node by mouse click
- results may be printed or saved in rtf- , html or csv format (e.g. MS Office)

- tabulated overview may be modified via filter functions
- sort results by mouse click e. g. acc. to utilization or node number
- interaction between table and graphics, selected node in graphic is highlighted in table and vice versa

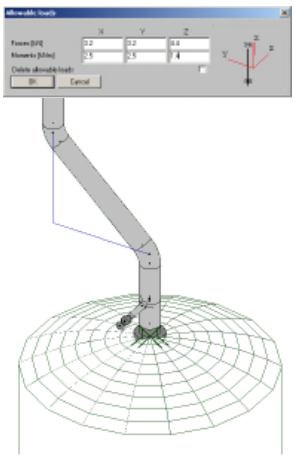
3.4 Loads on nozzles and supports

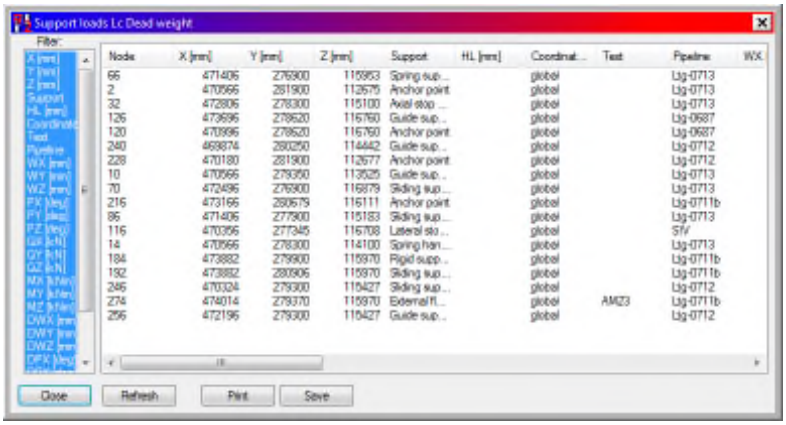
Graphical presentation of loads on nozzles and/or supports and detailed results at selected supports.



Nozzles at vessels

- Possibility to define and document allowable loads at nozzles
- Consider vessel flexibility in pipe stress calculation
- Nozzles with support conditions, spring rates, allowable loads and specific coordinate systems





Tabulated overview of loads

- graphical representation of loads for the selected load cases
- graphical presentation for all or for selected supports

- detailed results for a selected node by mouse-click
- documentation in global, local or user defined coordinate system
- results may be printed ~~out~~ or saved in rtf- or csv format (MS Office)
- tabulated overview may be modified by user using filter functions
- sort results by click e. g. acc. to load in any direction or displacement in any direction
- interaction between table and graphics, selected node in graphics is highlighted in table and vice versa

3.5 Additional results

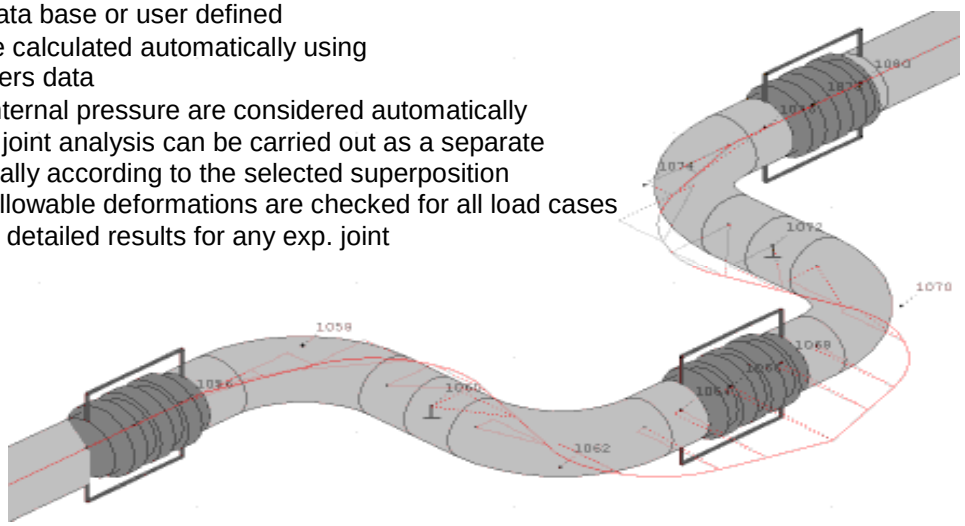
In addition to the analysis of stresses and loads at supports and connections, ROHR2 provides, among others, the results of:

- Expansion joint analysis
- Internal pressure design
- Spring design

Expansion Joints

Database with lateral, angular and axial exp. joints

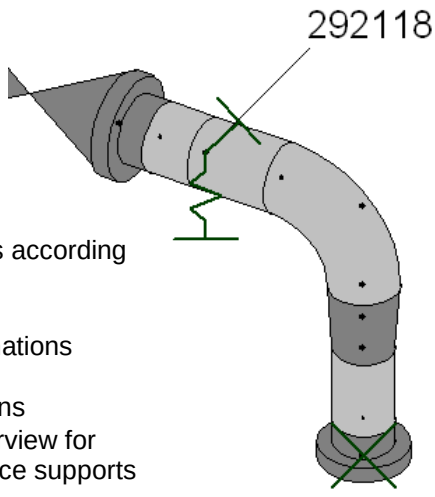
- data input by data base or user defined
- spring rates are calculated automatically using the manufacturers data
- forces due to internal pressure are considered automatically
- The expansion joint analysis can be carried out as a separate task automatically according to the selected superposition specification: Allowable deformations are checked for all load cases
- data sheet with detailed results for any exp. joint

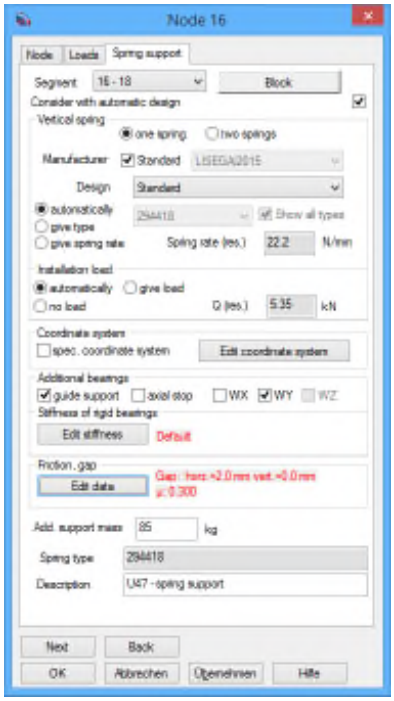


Spring design

Database with spring supports according to manufacturer's data

- spring design, estimation
- check of allowable deformations for all load cases and for load case superpositions
- data sheet with result overview for all spring and constant force supports





Definition of spring support,
Calculation with given spring data or auto spring design

3.6 Internal pressure analysis

The internal pressure analysis of pipe components is part of the ROHR2 program system. The internal pressure analysis is carried out by the module ROHR2press. ROHR2press is part of the ROHR2 standard package.

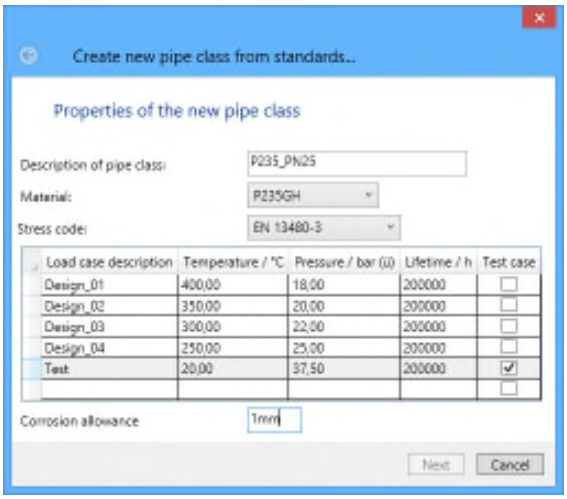
Generally there are two options to carry out the internal pressure analysis

- Dimensioning : Generation of a pipe class
- Recalculation: Checking specified components

The current program release analyzes these components according to the following standards:

- Straight pipes, e.g. acc. to EN 13480, ASME B31.1, B31.3, AD 2000 B1
- Bends and bows e.g. acc. to EN 13480, ASME B31.1, B31.3, AD 2000 B1
- Tees and nozzles acc. to EN 13480, ASME B31.1, B31.3, AD-2000 B9
- Reducers acc. to EN 13480

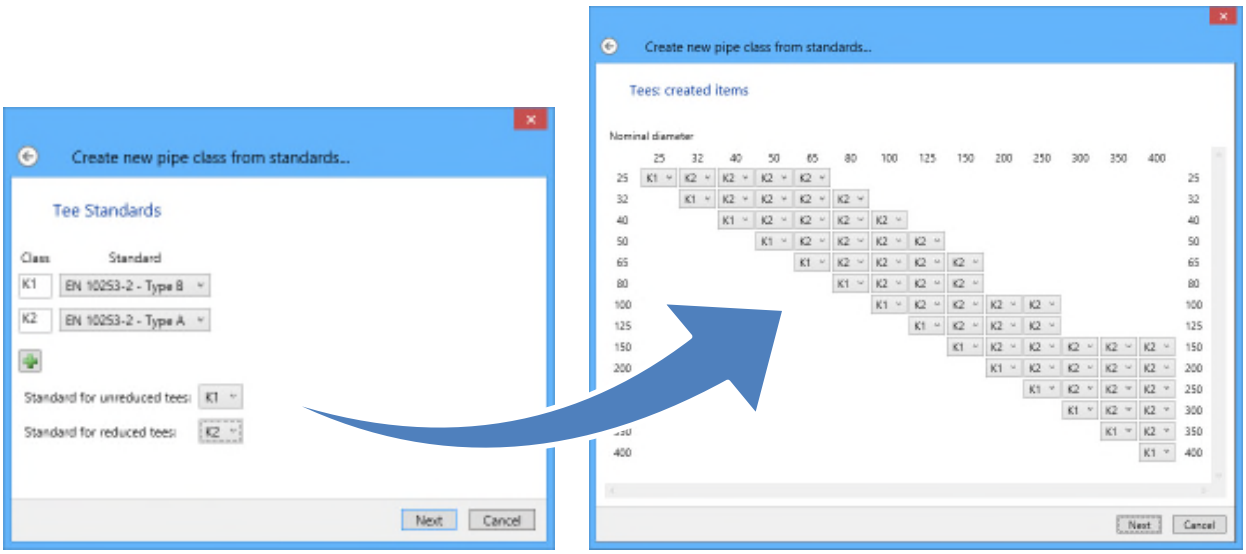
Generated pipe classes may be used to create a piping model.
Alternatively the components, integrated in a ROHR2 piping model may be checked.
The internal pressure analysis may be carried out independent from the analysis of the ROHR2 project.



The generation of pipe classes bases on the standards which are stored in the ROHR2 databases.

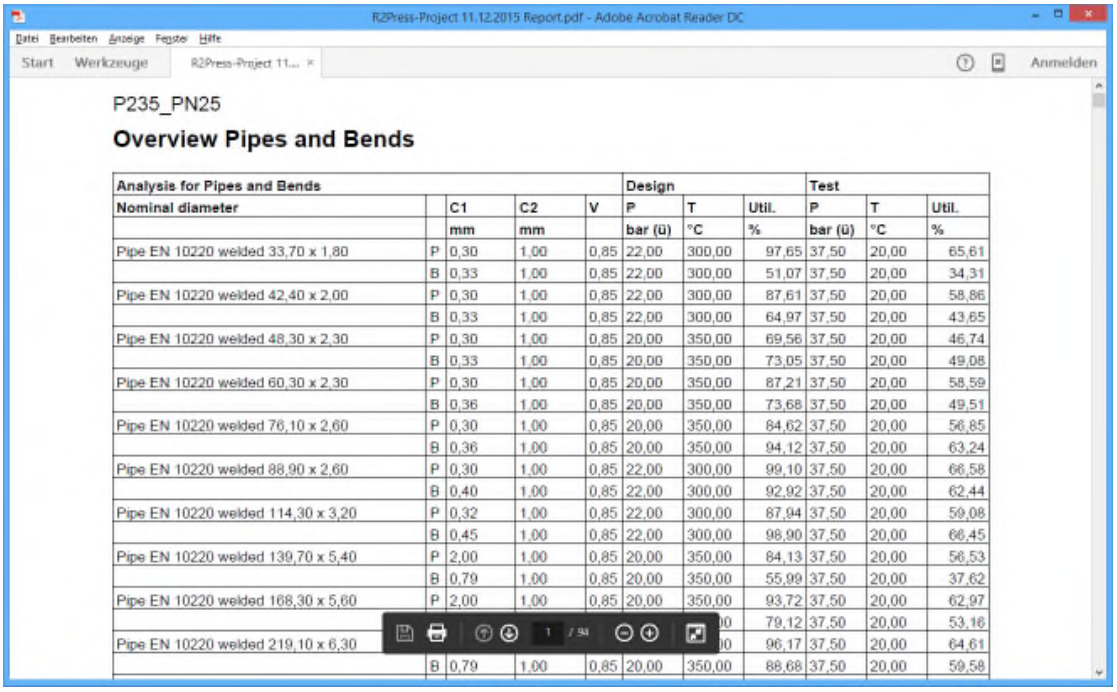
Several pressure and temperature combinations may be considered .

Various classes may be defined for tees and reducers.



Documentation of the internal pressure analysis

- Detailed warnings and error messages
- Clearly presented documentation of the pipe class

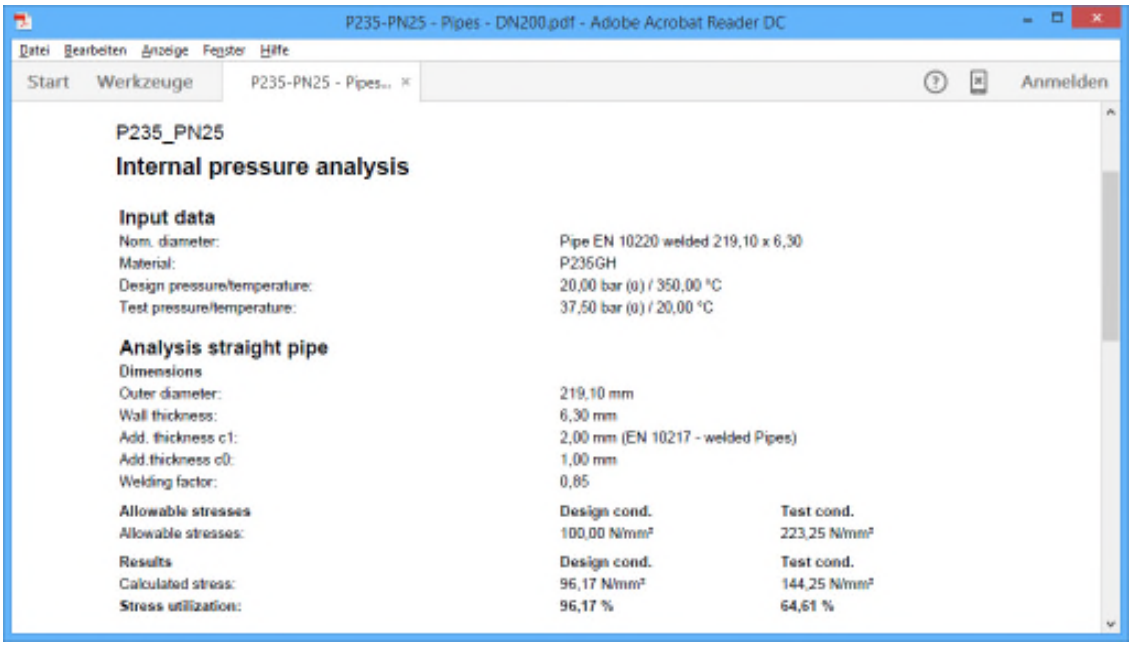


P235_PN25

Overview Pipes and Bends

Analysis for Pipes and Bends					Design			Test		
Nominal diameter		C1	C2	V	P	T	Util.	P	T	Util.
		mm	mm		bar (ü)	°C	%	bar (ü)	°C	%
Pipe EN 10220 welded 33,70 x 1,80	P	0,30	1,00	0,85	22,00	300,00	97,65	37,50	20,00	65,61
	B	0,33	1,00	0,85	22,00	300,00	51,07	37,50	20,00	34,31
Pipe EN 10220 welded 42,40 x 2,00	P	0,30	1,00	0,85	22,00	300,00	87,61	37,50	20,00	58,86
	B	0,33	1,00	0,85	22,00	300,00	64,97	37,50	20,00	43,65
Pipe EN 10220 welded 48,30 x 2,30	P	0,30	1,00	0,85	20,00	350,00	69,56	37,50	20,00	46,74
	B	0,33	1,00	0,85	20,00	350,00	73,05	37,50	20,00	49,08
Pipe EN 10220 welded 60,30 x 2,30	P	0,30	1,00	0,85	20,00	350,00	87,21	37,50	20,00	58,59
	B	0,36	1,00	0,85	20,00	350,00	73,68	37,50	20,00	49,51
Pipe EN 10220 welded 76,10 x 2,60	P	0,30	1,00	0,85	20,00	350,00	84,62	37,50	20,00	56,85
	B	0,36	1,00	0,85	20,00	350,00	94,12	37,50	20,00	63,24
Pipe EN 10220 welded 88,90 x 2,60	P	0,30	1,00	0,85	22,00	300,00	99,10	37,50	20,00	66,58
	B	0,40	1,00	0,85	22,00	300,00	92,92	37,50	20,00	62,44
Pipe EN 10220 welded 114,30 x 3,20	P	0,32	1,00	0,85	22,00	300,00	87,94	37,50	20,00	59,08
	B	0,45	1,00	0,85	22,00	300,00	98,90	37,50	20,00	66,45
Pipe EN 10220 welded 139,70 x 5,40	P	2,00	1,00	0,85	20,00	350,00	84,13	37,50	20,00	56,53
	B	0,79	1,00	0,85	20,00	350,00	55,99	37,50	20,00	37,62
Pipe EN 10220 welded 168,30 x 5,60	P	2,00	1,00	0,85	20,00	350,00	93,72	37,50	20,00	62,97
							79,12	37,50	20,00	53,16
Pipe EN 10220 welded 219,10 x 6,30							96,17	37,50	20,00	64,61
	B	0,79	1,00	0,85	20,00	350,00	88,68	37,50	20,00	59,58

- Detailed documentation for each component



P235_PN25

Internal pressure analysis

Input data

Nom. diameter:	Pipe EN 10220 welded 219,10 x 6,30
Material:	P235GH
Design pressure/temperature:	20,00 bar (ü) / 350,00 °C
Test pressure/temperature:	37,50 bar (ü) / 20,00 °C

Analysis straight pipe

Dimensions

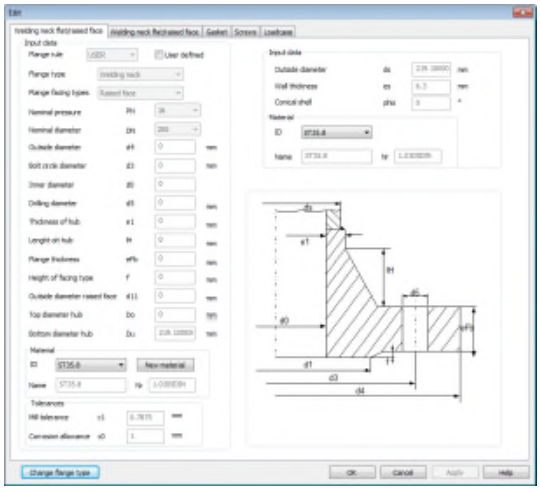
Outer diameter:	219,10 mm
Wall thickness:	6,30 mm
Add. thickness c1:	2,00 mm (EN 10217 - welded Pipes)
Add.thickness c0:	1,00 mm
Welding factor:	0,85

Allowable stresses	**Design cond.**	**Test cond.**
Allowable stresses:	100,00 N/mm²	223,25 N/mm²

Results	**Design cond.**	**Test cond.**
Calculated stress:	96,17 N/mm²	144,25 N/mm²
Stress utilization:	**96,17 %**	**64,61 %**

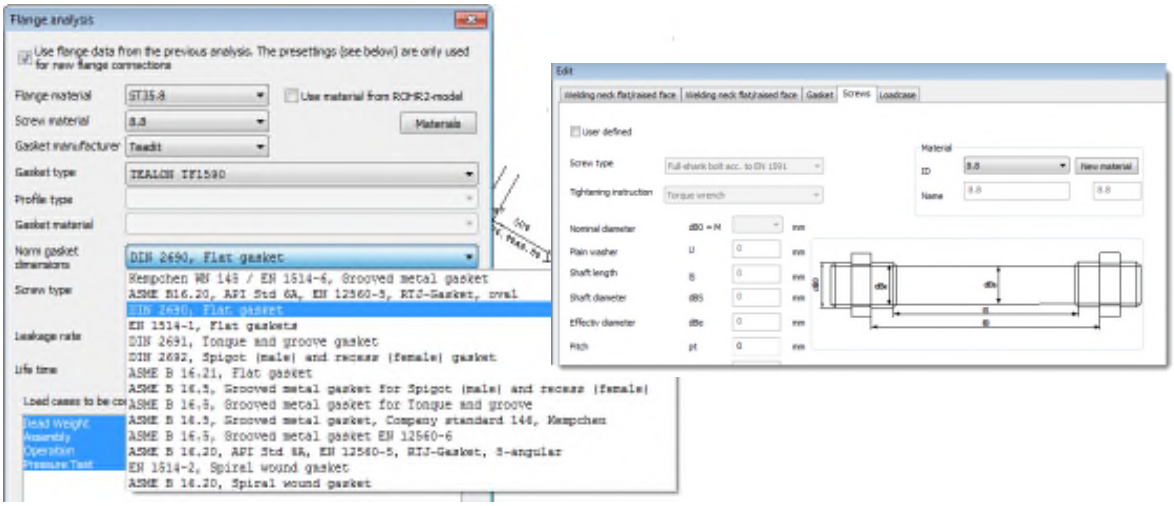
- The documentation is transferred into the ROHR2 calculation report

3.7 Flange analysis

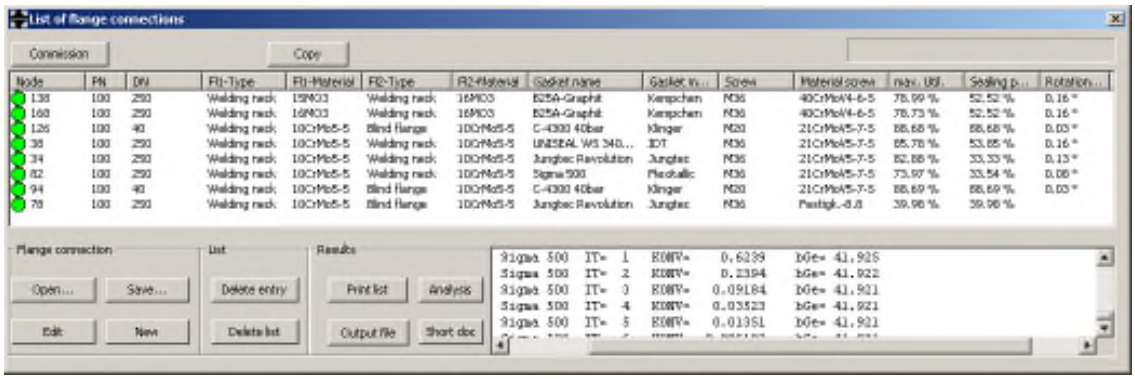


Flange analysis with the module ROHR2flange.
ROHR2flange is part of the ROHR2 standard package.

- Flange analyses acc. to
  - EN 1591-1:2011,
  - EN 13445-3:2010 Annex G,
  - ASME VIII, Div.1:2010
- Automatic analysis of all flanges in the system taking into account all load cases. The number of load cases can be reduced by the user.
- Automatic generation of load case combinations required for the analyses.
- Simple pre-settings of the flange parameters by means of standard values for flanges, screws and gaskets.
- The flanges may be modified individually and in detail.



- Report of the calculation results in a list



- Automatic generation of a calculation report in German or English

3.8 Nozzle analysis

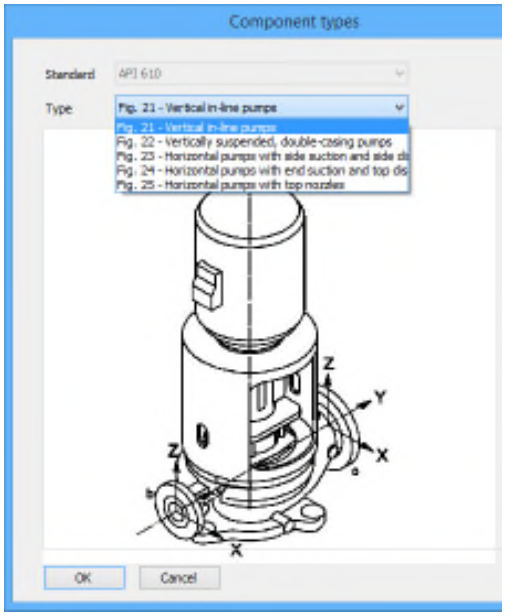
Analysis of the loads following several standards for nozzles at a pumps and vessels which are part of the ROHR2 project. The nozzle analysis is carried out by the module ROHR2press. ROHR2press is part of the ROHR2 standard package.

Currently the following standards are part of the nozzle analysis:

- API 610 /
- API 617
- API 661
- DIN ISO 9905
- NEMA SM23
- Nozzle Spec
- EN ISO 5199
- DIN EN ISO 10437
- DIN EN ISO 10440
- DIN EN ISO 13709
- Allowable loads acc. to manual input in ROHR2

The first step is the definition of nozzle analyses in ROHR2 and the selection of a standard.
Depending on the standard one or more nozzles in the ROHR2 model may be assigned.

A sub-type can be selected according to the standard, too. The subtypes are defined in the standards.



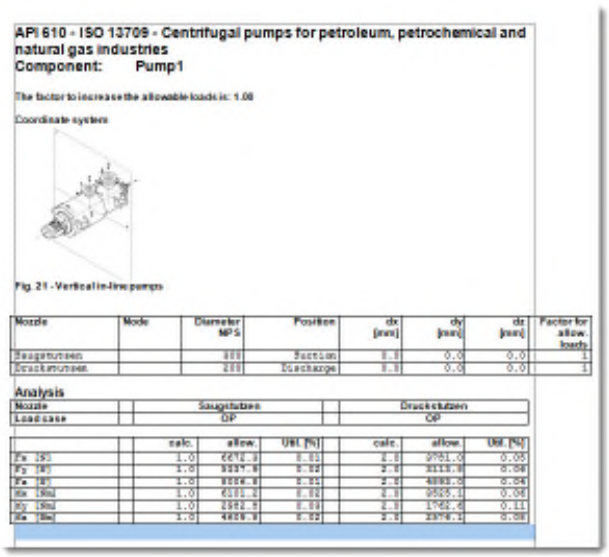
Example: Sub-Types according to API 610

Depending on the chosen standard additional input may be required.

Calculated loads are transferred from the ROHR2 calculation. The allowable stresses are determined depending on the standard.

The stress utilization will be analyzed and documented

In addition the nozzle analyses may be carried out independent of the ROHR2 model. In this case the maximum occurring loads need to be inserted manually..



Report

A documentation in *.rtf format is generated for all calculated components. The document is shown in the associated text processor.

If ROHR2nozzle has been started inside a ROHR2 Project the output can be made part of the ROHR2 report.

3.9 Documentation

ROHR2 Standard Documentation

Text

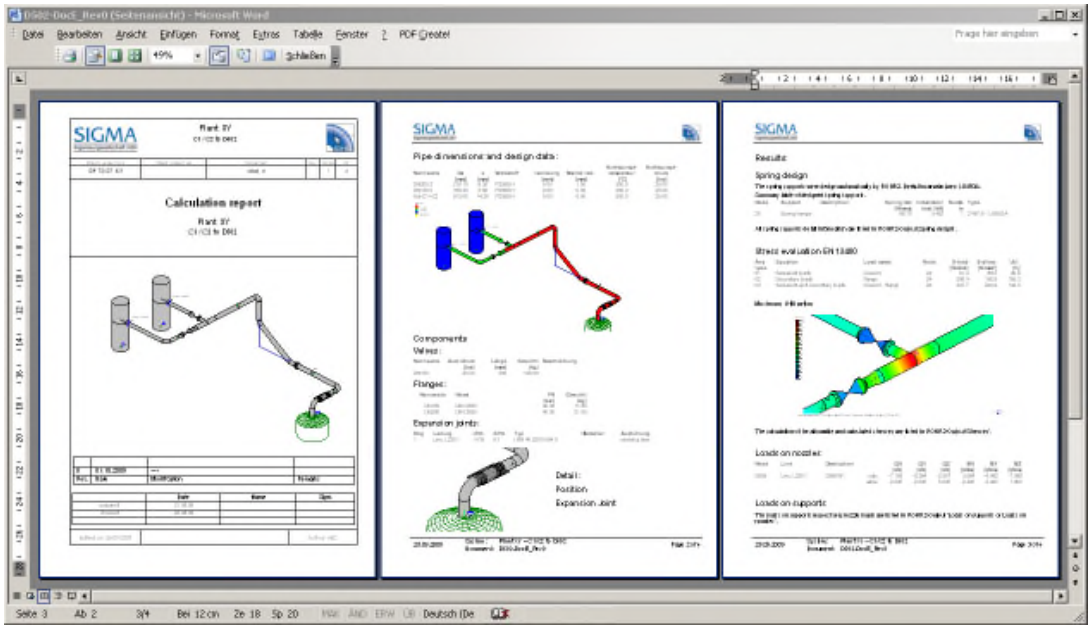
- Individually determined content of output files, results tables may be included/excluded by the user
- Output files in ASCII format
- Data can be stored in pdf or rtf format, e.g. for further processing in MS Word
- Headers and footers may be added
- Data export for further processing in a spreadsheet program like MS Excel

Graphics

- Selection of arbitrary views
- Graphic representation of the entire system, of system parts or of specified pipes
- Framework graphics or volume model
- Assigned parameters like dimensions, materials, operation data may be shown graphically (colored representation)
- Graphical presentation of results, e.g. deformations or stresses
- Graphical presentation of loads

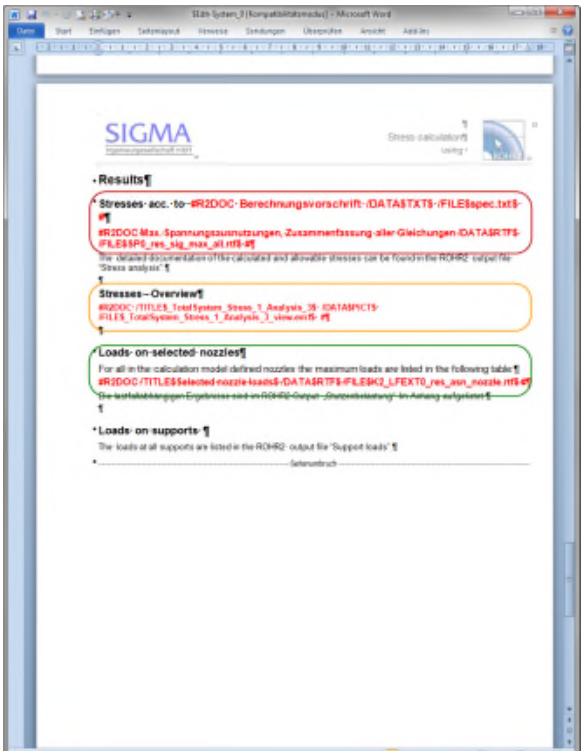
ROHR2 Report generation

ROHR2 offers functionality for customized report generation. Certain predefined templates for the generation of reports are included in the scope of delivery of ROHR2. These template may be used and changed to customize result reports fulfilling the specific needs of the user.
An additional appendix to the report may be defined e.g. for printing complete calculation results
The report capabilities include free formatting of ROHR2 text modules and the refreshing of the report when input changes are made and the analysis is redone the calculation changes.



ROHR2 Report generation

Creating a ROHR2 report



The report template includes links to ROHR2 text and graphic output of

general data

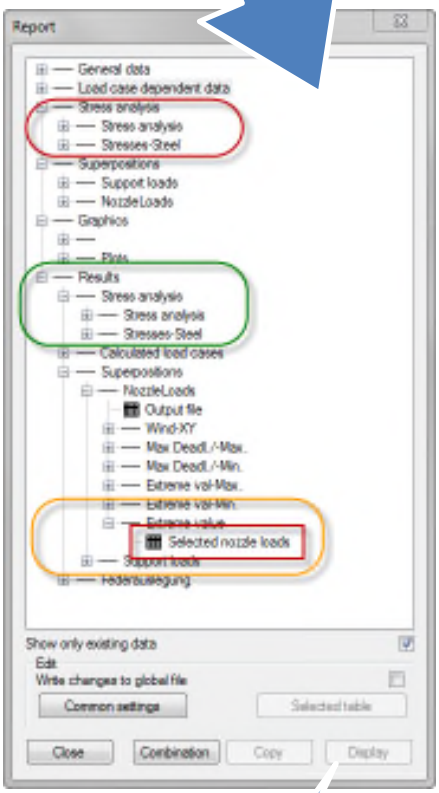
load cases

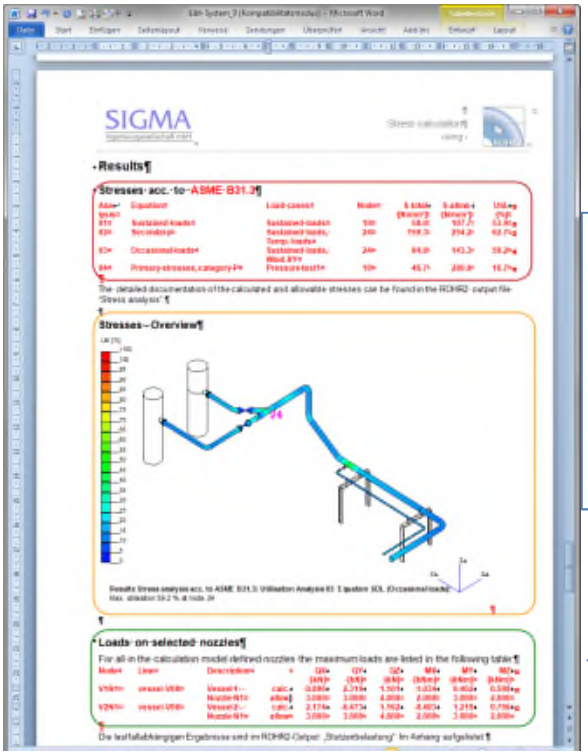
stress analyses

extreme value calculations

graphics

results





After re-calculating the piping system the modifications of the current analysis are taken over into the report.

Automatically refreshed after re-calculation

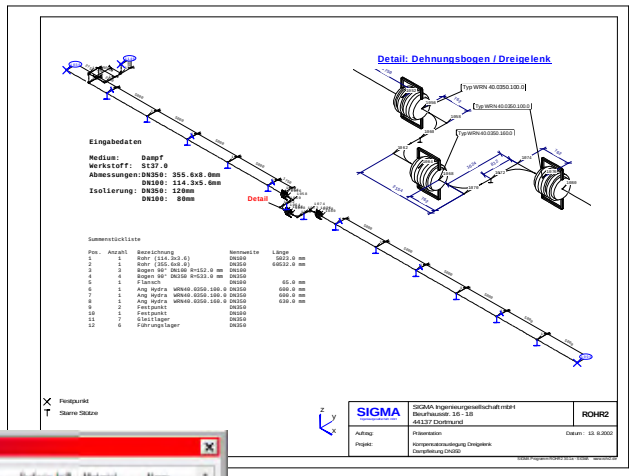
4 ROHR2 Optional available programs

The usability of ROHR2 Static and Dynamic program system may be even further extended by a number of add-on modules. We will be happy to provide more detailed information including examples for the following add-on modules.

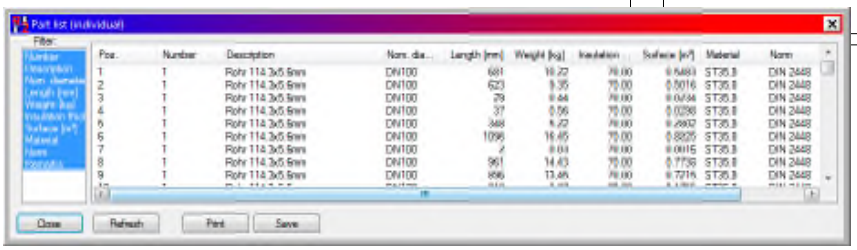
4.1 ROHR2iso

Program module to create dimensioned isometric graphics

ROHR2iso completes the graphical user interface ROHR2win by isometric drawing functionality. ROHR2iso creates scaled and not-scaled pipe isometrics. The module allows to add dimensions, welding nodes and additional parameters like height data or user defined texts and graphics.
The creation of single- and cumulative part lists is implemented.



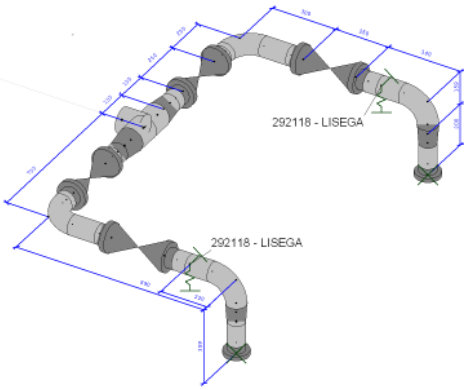
After entering data, the static or dynamic ROHR2 calculation may be carried out with the full scope of functionality of ROHR2win.



Using ROHR2iso benefits:

Minimal effort for the training of users

The separate available program module ROHR2iso is integrated into ROHR2win. Multiple inputs are not required: each data entry is made for calculation and isometric drawing.



Significantly reduced effort of data input and editing

Enormous advantages arise when performing system optimization or system changes. If there are changes in geometry or in technical requirements, the calculation and isometrics may be adapted in one step.

- Automatic creation of simply dimensioned isometrics.
- Adapt isometrics to the user's needs.
- Creation of single- and cumulative part lists with general system information "at the touch of a button".
- Export of graphics and part lists in various file formats

For detailed information see specific ROHR2iso brochure.

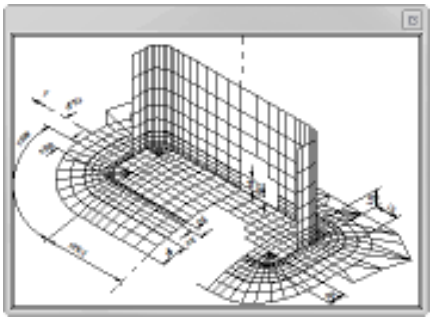
4.2 ROHR2fesu

Finite Element Analysis of Sub-structures in ROHR2

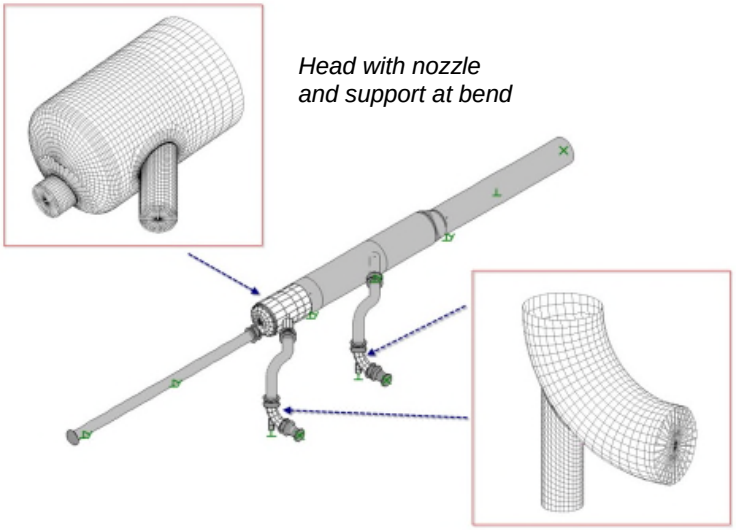
ROHR2fesu is an add-on module ROHR2 for detailed analysis of local segments in pipes and vessels. ROHR2fesu offers an easy-to-use modeling of shell element sub-structures, fully integrated in the ROHR2 framework. This enables the user to carry out detailed analyses of critical segments while maintaining the framework of the entire model.
The shell analysis is carried out in accordance with the widely accepted method of finite elements.
The mesh generator of ROHR2fesu automatically integrates intersections of branches, trunnions, nozzles with and without reinforcement. ROHR2fesu enables the user to easily control the mesh size and distribution.
ROHR2fesu has been extensively verified in accordance with the present the state of technology.

ROHR2fesu offers:

- Complete integration of the FE structure(s) into the connecting frame work
- easy-to-use parameter controlled model generation and meshing
- short solution time
- automatic stress analysis and documentation
- stress analyses following **EN 13445**, Appendix C, **ASME Section VIII**, Div. 2, Part 5 and **AD S4**

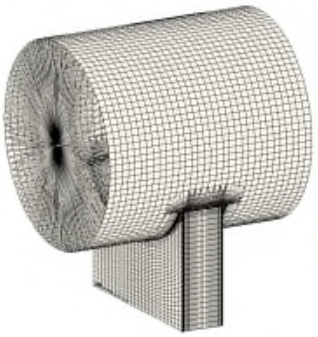


ROHR2 model with non-regular components



Head with nozzle and support at bend

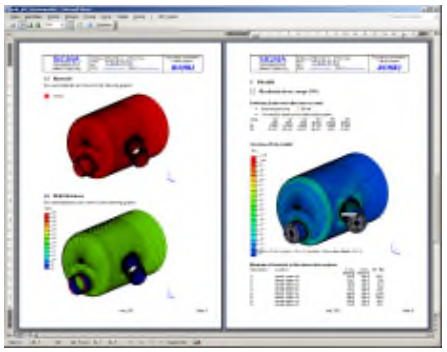
ROHR2fesu model rectangular lug



ROHR2fesu Documentation

The ROHR2fesu documentation can be modified by the user. Input data and results are taken into a report template as text as well as graphics.

A separate detailed ROHR2fesu program description is available.



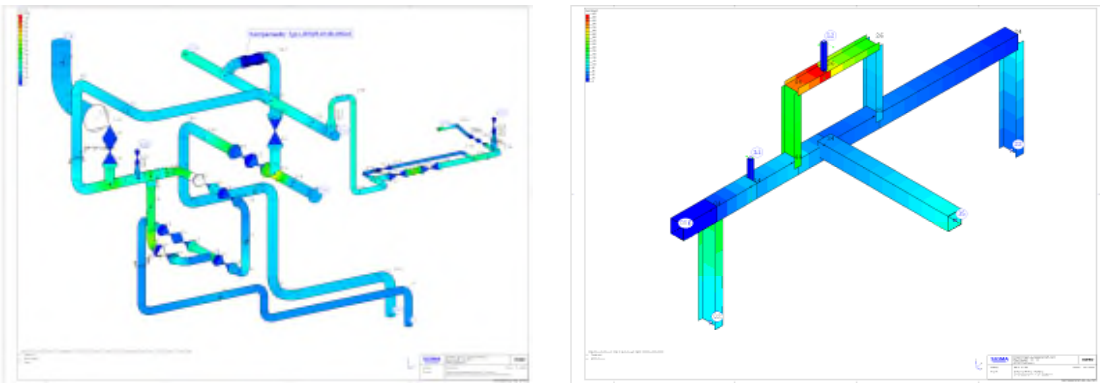
5 ROHR2 - Detailed features

5.1 Overview

All ROHR2 program versions include

- ROHR2win graphical user interface
- ROHR2 calculation program
- ROHR2fed spring hanger design
- ROHR2flange flange design acc. to EN 1591-1, ASME VIII, Div.1
- ROHR2press internal pressure analysis
- ROHR2nozzle nozzle analysis

- Neutral CAD Interface including Export AVEVA PDMS/E3D - ROHR2
- CAESAR II Import interface
- PIPESTRESS Import interface
- CAEPIPE Import interface
- SINETZ Export interface
- FLOWNEX Export interface
- PIPENET Import interface
- PIPENET Export interface
- DXF format Data import interface
- Export Interface into the Support Design Programs LICAD, FLEXPERTE, CASCADE



Equivalent stresses are calculated at common beam elements.

5.2 Input features

System input

- Pre-settings for new models (e. g. standard, …) can be defined individually by the user
- Input of system geometry by mouse and keyboard
- Zoom, pan and rotate functions with individual assignment of the mouse functions
- UnDO and ReDO
- Quick access to frequently used commands by context menu
- Copy, insert, rotate, reflect(mirror) commands

Detailed Input features

- Definition and assignment of boundary conditions and loads with the mouse by means of dialog windows.
- Different support conditions such as sliding support, guide support, axial stop, anchor point etc. are available. The according support directions are determined automatically.
- Input of internal supports and hangers (i.e. Supports and hangers where the base point is a system node). Internal spring hangers and supports are analyzed like “normal” spring hangers and –supports.
- Input of angulating supports with any arbitrary spring characteristics.
- Local coordinate systems for boundary conditions are produced automatically if required.
- User input of dimensions of pipes and structural steel sections, alternatively data may be retrieved from the enclosed databases. The line masses of pipes, insulation and medium are determined.
- Sectional data of the common structural steel sections are determined automatically or retrieved from a section data file (DIN).
- Material properties like Young´s modulus, α_t and allowable stresses may be taken from the ROHR2 database MATDAT (may be extended by the user).
- For EN13480, ASME B31.1 and ASME B31.3 a reduction factor for allowable stresses at welds may be considered (e.g. “Weld Joint Strength Reduction Factor“ according to ASME B31.3).
- Input of components like instruments, expansion joints and flanges.
  The increased stiffness of the instruments is considered by $3 \cdot s$ of the associated diameter. Expansion joints are integrated into the piping model considering type and orientation of the tension and nonlinear regulating powers.
- The stiffness of supports may be input by the user. Data may be retrieved from database (VDI 3842/2004) or manually entered.
- Management of pipe names
- Modeling of soil restrained pipes with non-linear soil properties acc. to AGFW FW401 or EN 13941
- Modeling of jacket piping, considering the connections of inner and outer pipe via couplings.

Databases

Component databases, included in ROHR2

Databases with data e. g. of pipes, bends, flanges or expansion joints according to technical standards or according to manufacturer's data. Databases are extendable by the user.
The ROHR2 standard version includes:

Pipes:	ASME B36.10, EN 10220, DIN 2448, DIN 2458
Bends:	EN 10253-2, ASME B16.9, DIN 2605 part 1, DIN 2605 part 2
Flanges:	EN 1092-1, ASME B16.5, DIN 2627 - DIN 2638
Blind flanges:	EN 1092-1
Reducers:	EN 10253-2, DIN 2616 part 1, DIN 2616 part 2, ASME B 16.9
Tees:	EN 10253-2, DIN 2615 part 1, DIN 2615 part 2, ASME B 16.9
Expansion joints:	HYDRA (Witzenmann), BOA (IWK), KOMPAFLEX, FLEXOMAT, HaTecFlex, HKS and Dilatoflex
Heads:	EN 10253-2, DIN 28011, DIN 28013, DIN 2617
Visco dampers:	GERB, type VES, RHY and VISCODA type VD, VM
Spring hangers /supports:	ANVIL INTERNATIONAL GB-China, Grinnel, Hesterberg, LISEGA, Petrochemical-CN, PipeSupportsGroup, Pipingtech, PSS, Seongwha, SSG, Witzenmann (HYDRA)
Constant hangers /supports:	LISEGA
Stiffness of supports according to	VDI 3842/2004

- Databases for rigid supports, couplings (jacket pipes) and instruments may be created by the user.

Material databases, included in ROHR2

- Material database containing material according to EN / ASME / DIN etc.
- Direct access to ASME Stress table data from ASME BPV Sec. II
- Temperature and wall thickness depending values for Young´s modulus, coefficient of expansion, tensile strength, yield strength and code depending allowable stresses
- The material database may be extended by the user
- Material database allows the administration of various norms and revisions
- Control the form of manufacturing
- Consideration of creep range parameters
- Automatic determination of allowable stresses depending on the life cycle
- Automatic determination of reduction factors at cryogenic temperature according to AD 2000 W10 or ASME B31.3
- For EN13480, ASME B31.1 and ASME B31.3 a reduction factor for allowable stresses at welds can be considered (e.g. "Weld Joint Strength Reduction Factor" according to ASME B31.3).
- GRP materials with anisotropic properties may be defined.
- Youngs modulus and creep modulus can be defined at plastic pipes to consider long time and short time values

Load cases and loads

- Definition of load cases in dialog boxes.
- Alternative: Simplified user interface with load case and loads standard settings
- Load case superpositions for stress analysis and extreme value calculation are created automatically depending on the selected stress code.
- Load case superpositions of extreme value combinations are created automatically and may be modified by the user).
- Automatic generation of wind loads according to DIN 1055 part 4, DIN 4133, EN1991, NV65, UBC, ASCE 7, IS875 or by user defined wind pressure tables.
- Automatic generation of snow loads and ice loads according to DIN 1055
- Automatic generation of seismic loads acc. to EN 1998,1997, UBC, 1997 and ASCE 7, 2010
- Automatic generation of fluid hammer loads (Joukowsky)

5.3 Documentation

- Display of assigned parameters, loads and results in the graphics and dialog boxes.
- Certain results may be displayed as animations and stored in a video file format.

Tabulated outputs

- standard calculation outputs with
  - easily understandable result tables with table header
  - result tables may be enabled or disabled for user customized documentation
  - customizable documentation content
- output of calculation files and results in fixed format into a universal file (for transfer to database)
- additional and user defined extreme value calculation for arbitrary sections ~~as you like~~, selection by filters. Selection of these sections by direct access via graphics
- wide range of options to display input data, loads or results in lists and to create individual outputs by printing out these lists
- selection of data by filters
- results may be presented in any coordinate system.

Graphical presentation

- line- or volume presentation, user defined colored presentation
- display options to modify the view by enabling or disabling the different options
- selection of partial structures using a wide range of filter functions
- predefined isometric views, in addition front and side-view
- generation of arbitrary views using zoom, pan and rotate-functions

Input data

- graphical representation of the structure
- Inputs in SI or US-units
- color presentation of the assigned properties (dimensions, pressure, temperature, material, ...)
- color presentation of the assigned loads
- clear labeling of names of lines and nodes (supports, valves, ..)
- stress analysis of partial systems enabled by the inclusion / exclusion of selected lines

Results

- entering of any texts and additional graphics into the graphics
- results in SI or US-units
- results (deformations, rotations, forces, moments, stresses) of any calculated load case may be displayed in the graphics
- deformations from natural frequency calculations and dynamic fluid hammer calculations are displayed as an animation time dependently
- the stress distribution may be displayed in colors
- creation of structure plots and result plots of the entire system or details

Export of results

- output of graphics and text by printer and plotter (large format printers up to DIN A0)
- Export graphics in PDF, HPGL, DXF or metafile format.
- export text in PDF or RTF format
- export of selected data (from dialog boxes, listings) into RTF, HTML or CSV format (csv for use with spreadsheet programs, e.g. Microsoft Excel)
- Automatic report, plus appendix based on individual configurable templates.

5.4 ROHR2 calculation program

The ROHR2 calculation program contains static and dynamic calculation capabilities.
ROHR2 Static and Dynamic in addition to the features of ROHR2 Static includes the possibility to calculate dynamic effects like earthquake (frequency-dependent) or fluid hammer / pressure surge (time-dependent).

Core Module - Static

- Calculation of piping structures considering any static loads following the standard rules of linear static theory
- It may be considered
  - shear deformation,
  - continuous elastic foundation.
- Automatic generation of the equation system with an optimum line topology path (band width optimization). This enables problem-free transfer of data from other CAD-systems.
- Input via graphical user interface or text editor
- General properties of components such as constant hangers, spring supports or dampers may be altered by simple switching.
- stress analyses according to von Mises yield criterion
- Stiffness calculation for vessel connections (BS5500/WRC 297)
- consideration of pre-stressed springs
- spring hangers and spring supports can be designed automatically
- check of the movement of the expansion joints and overloading in consideration of the reducing coefficients for compression, temperature and number of load cycles
- check of difference in deformation for jacket piping

Nonlinear Boundary Conditions

- Calculation of pipe structures with nonlinear boundary conditions such as
  - friction
  - gap in supports and uplift
- Consideration of restoring forces due to skewing and internal friction for rigid hangers, springs and constant hangers.
- Analysis of the nonlinear behavior of braced expansion joints
- Consideration of geometric non-linearities

Second Order Theory

- Calculation of spatial frameworks in general, with consideration of any static loads, according to the standard rules of linear or nonlinear static second order theory
- Calculation of buckling load and stress results according to the second order theory for analysis in accordance with DIN 4114 and DIN 18800 part 2

Superposition module

- Different options for the selection, combination, calculation and analysis of extreme values of results. Superposition of any static and dynamic load cases and output of resultant loads.
- Nearly complete automatic superposition of defined load cases with additional options for customization.

Check of input data / verification

- Error check during data input
- Internal pressure analysis of newly added dimensions
- Graphical presentation of assigned parameters for verification
- Calculation includes formal error checking with listing of input files
- Additional safeguards for input data are provided by printing control values such as
    - absolute coordinates, angles of bends, lengths in space, overall length, total weight, overall center of gravity and sum of support loads
- listing and error messages with link to the concerning nodes or sections in the graphics for easy error checks
- context sensitive link to user manual
- warnings / warning levels for advanced check of input data

Internal pressure analysis

- According to TRD 301, AD 2000, EN 13480, ASME B31.1, B31.3
- Straight pipes, bends, tees with or without reinforcing pad
- Internal pressure analysis at reducers according to EN 13480
- Generation and administration of pipe classes for the above mentioned components

Flange analysis

- According to EN 1591-1:2014, EN 13445-3:2010 Annex G, ASME VIII, Div.1:2010
- Automatic analysis of all flanges in the system under consideration of all load cases. The number of load cases can be reduced by the user
- Automatic generation of load case combinations required for the analyses
- Simple presettings of the flange parameters by means of standard values for flanges, screws and gaskets
- The flanges can be modified individually and in detail
- Generation of a calculation report in German or English

Nozzle analysis

- According to API , NEMA, DIN EN , BAYER company standard
- Automatic analysis of all nozzles in the system considering all load cases of the system. The selection of the load cases may be changed by the user.
- Comparison of calculated loads and automatically determined allowable loads
- Detailed modification of selected nozzles
- Automatically generated report in German or English.

Core Module - Dynamics

The core module Dynamics includes additionally:

- Calculation of natural frequencies and mode shapes for any pipe structures as well as for anframework structures
- Modal analysis for support excitation, which is defined in terms of floor response spectra (e.g. earthquake spectra). Higher mode shapes are taken into consideration by means of a residual mode approximation
- The dynamic model is based on point masses. ROHR2 includes the automatic mass distribution in relation to the defined cut off frequency

Excitation Forces

- Consideration of any dynamic excitation forces (particularly fluid hammer) according to the modal time-history-method
- The influence of higher mode shapes is taken into account by use of residual mode approximation. Inaccuracies in the dynamic model may be covered by using the frequency shift method

Harmonic excitation

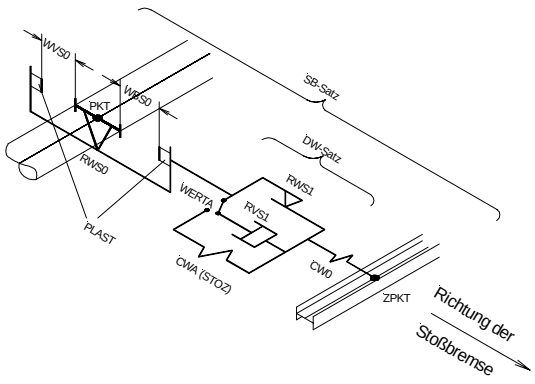
- Special solution for the calculation of any harmonic loading in conjunction with the pipe static core module. Results are harmonic stress resultants

Structure Analysis of Fluid Hammer using Direct Integration

- This analysis is used to consider **non-linear** boundary conditions and couplings.

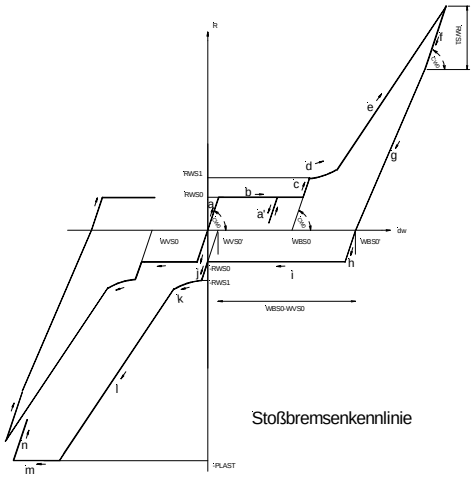
This method is an alternative to the modal Time-History-Analysis. It allows integrating the full range of non-linear piping components like shock absorbers or dampers into the dynamic analysis.
Nonlinear boundary conditions may be used to model shock absorbers or visco dampers

- ROHR2fun is included for the graphical representation of functions and results.



Stoßbremsen-Schaltbild

Shock Absorber - Diagram



Shock Absorber - Load displacement function

5.5 Stress codes in ROHR2 Static and Dynamic

The following ROHR2 program features apply to all stress codes listed below:

- Conformity check of pipe components
- Processing of flexibility factors in accordance with the structure calculation.
- Stress analyses.
- Comparison of stresses
- Listing of components with the highest stress utilization.
-

Title	Content, keywords and source	Chapter	Edition
EN 13480 [1])	DIN EN 13480-3 Metallic industrial piping - Part 3: Design and calculation; German Version EN 13480-3:2012	11	2013
FDBR	Power Piping Fachverband Dampfkessel-, Behälter-, und Rohrleitungsbau e.V., Essen	21	1/1987
Stoomwezen D1101	Stress Analysis according to Stoomwezen D1101 /78-10	22	7/2003
AGFW	Stress Analysis of District heat Piping AGFW "Richtlinien für die Festigkeitsberechnung von Fernwärmeleitungen"	23	1988
AGFW401	Stress Analysis of District heat Piping AGFW / FVGW Regelwerk Arbeitsblatt FW401 - Teil 10 - Verlegung und Statik von Kunststoffmantelrohren (KMR) für Fernwärmenetze	24	12/2007
EN 13941	Design and installation of preinsulated bonded pipe systems for district heating	25	12/2010
CODETI	Code de Construction des Tuyauteries Industrielles	26	2014
ASME B31.1	Power Piping ASME Code for Pressure Piping, The American Society of Mechanical Engineers, New York	31	2014
ASME B31.3	Chemical Plant and Petroleum Refinery Piping ASME Code for Pressure Piping The American Society of Mechanical Engineers, New York	32	2014
ASME B31.4	Liquid Transportation Systems Piping ASME Code for Pressure Piping The American Society of Mechanical Engineers, New York	33	2012
ASME B31.5	Refrigeration Piping ASME Code for Pressure Piping The American Society of Mechanical Engineers, New York	34	2013
ASME B31.8	Gas Transmission and Distribution Piping Systems ASME Code for Pressure Piping The American Society of Mechanical Engineers, New York	35	2014

Title	Content, keywords and source	Chapter	Edition
KRV	GRP-pipes Verlegerichtlinien für Rohrleitungen aus textilglasfaserverstärkten Reaktionsformharzen - „Planungs- und Konstruktionshinweise“, Ausgabe Juli 1993 des Kunststoffrohrverbandes e.V., D-53113 Bonn	41	7/1993
WAVI-STRONG	Engineering Guide for Wavistrong glass fiber reinforced pipe systems	42	1994
BS 7159	Stress Analyses for GRP pipes according to British Standard 7159	43	1989
ISO 14692	Stress analysis for GRP pipes acc. to DIN EN ISO 14692-3	44	2002
VGLSP	Stress Analyses for Skeletal steel structures (VGLSP)	51	2004
VGLSR	Stress Analyses for pipes (VGLSR), according to General stress hypothesis von Mises/Tresca	52	---
ASME CL1 [2])	NB-3600 "PIPING DESIGN" in ASME-BOILER AND PRESSURE VESSEL CODE SECTION III SUBSECTION NB CLASS 1	71	2013
ASME CL2 [2])	NC-3600 "PIPING DESIGN" in ASME-BOILER AND PRESSURE VESSEL CODE SECTION III SUBSECTION NC CLASS 2	72	2013
ASME CL3 [2])	NC-3600 "PIPING DESIGN" in ASME-BOILER AND PRESSURE VESSEL CODE SECTION III SUBSECTION ND CLASS 3	73	2013
KTA 3201 [2])	Nuclear Safety standards commission (KTA) Komponenten des Primärkreises von Leichtwasserreaktoren Sicherheitstechnische Regel des KTA, Edition 6/96	74	2013
KTA 3211 [2])	Nuclear Safety standards commission (KTA) Druck-und aktivitätsführende Komponenten von Systemen außerhalb des Primärkreises Teil 2: Auslegung, Konstruktion und Berechnung Sicherheitstechnische Regel des KTA3211.2, Edition 6/92	75 76	2013
RCC-M CL1 [2])	B-3600 "DESIGN" in RCC-M SECTION I SUBSECTION B CLASS 1	77	2002
RCC-M CL2 [2])	C-3600 "PIPING DESIGN" in RCC-M SECTION I SUBSECTION C CLASS 2	78	2002
RCC-M CL3 [2])	D-3600 "PIPING DESIGN" in RCC-M SECTION I SUBSECTION D CLASS 3	79	2002

[1]) EN 13480: stiffening from internal pressure is considered in the calculation of k-factor and i-factor according to EN 13480 DRAFT 2011.

[2]) Not available in program version ROHR2 Static

optional available program ROHR2fesu

Title	Content, keywords and source	Chapter	Edition
EN 13445-3	Stress Analysis of FESU structures acc. to EN 13445-3 Appendix C	61	2010
AD 2000 S4	Stress Analysis of FESU structures acc. to AD 2000- S4	62	2008
ASME VIII Div 2	Stress Analysis of FESU structures acc. to ASME VIII Div 2 Part 5 (Elastic Stress Analysis Method)	63	2013

6 Software Services

6.1 Program maintenance and updates, User support

The program system ROHR2 and its add on modules are delivered with detailed application documentation. For any questions about ROHR2 you may contact the ROHR2 hotline to get direct support from our hotline staff which consists of ROHR2 developers and engineers using ROHR2 every day. You may send the project file you are currently working on, to discuss your questions with our development and engineering team with 40 years of pipe stress analysis experience.
This direct link to the hotline guarantees an effective use of ROHR2 and assures that you receive competent help in a timely manner.

ROHR2 continuously developed analysis software

Updating the software by periodical releases is an essential component of the maintenance agreement. The software is developed continuously in order to incorporate the ongoing changes in the stress calculation codes and norms, but also to improve the user interface and extend the capabilities of ROHR2 according to the user's needs. The material and component databases are regularly extended and adapted to include upcoming changes in specifications. The technical regulations for the calculation of pipes are subject to a permanent change. These changes are monitored by our development team and implemented in the program system ROHR2 in a timely manner. Updates are available via internet download.

This assures the user of ROHR2 that the software always is updated to most recent editions and changes of the codes which is required by the legislator of the current norms and laws.
The technical development in software programming as well as the adaption to technical prerequisites, such as operating systems, are also considered and part of the update service. This ensures a long-term safeguarding of the investment of soft- and hardware.

6.2 ROHR2 trainings

In order to boost the efficiency of the ROHR2 users, SIGMA proposes a concept of user training courses, which have proven their effectiveness for many years.

Possible training courses are:

- Basic courses
- Courses for users with experience from other pipe calculation software
- Expert trainings, advanced courses
- Courses covering program updates
- Courses for special topics on demand

Basis of the courses are our field-tested training examples or examples provided by the user.
The theoretical part with explanation of the graphical user interface and information about the ROHR2 environment as well as hands on solution of selected examples, are part of the training.

SIGMA training courses

Individual Program Training	The small group size of 1 to 6 persons per course allows an effective personalized training. The training may be adapted to your personal need, e.g. for the clarification of ~~open~~ questions arising in your everyday work with ROHR2. We encourage you to bring the project examples you are currently working on and make them the subject of your training so that the questions relevant to your situation are discussed and answered. Training language is German, English or French. Training dates may be arranged individually. Venue for the training course may be the trainees company office or our corporate center in Unna
ROHR2 Group training course	Basic program training in groups of up to 6 participants, coming from different companies. The participants list is filled by appointment. The small group size allows an effective personalized training. Venue for these scheduled courses is our corporate center in Unna. The training language is English or German. The training dates are published on the website www.rohr2.de or may be provided from our sales department
ROHR2fesu training course	1-day training for the add on module ROHR2fesu ROHR2fesu introduction, modeling of a substructure, interaction with ROHR2/framework, modeling details, report, results analysis, stresses
Group Training course ROHR2 add on modules	ROHR2 modules ROHR2flange, ROHR2nozzle, ROHR2press, Introduction into ROHR2iso and ROHR2fesu. 1-day group training group training, training dates subsequent to ROHR2 group training courses.
Internet training sessions	In case of urgent questions or project related needs which do not justify the organization of a complete one or two-day training we propose internet based training as an alternative. All you need to do is to install a local viewer client (VNC) and log into our training PC. Using the telephone line and the internet connection you will follow the training session on your screen, interact using your mouse and discuss the difficulties and questions with our training staff.

Don´t hesitate to ask for an individual training offer!