

# Expansion Joint Design

Bellows Element Design - Design Software User Manual  
BellowsMaster II EN

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# Introduction

This Manual is for the BellowsMaster II EN (BM II EN) program and how to use it to design bellows elements to European standards. In addition program has an option to use ASME material database with EN calculation method. This manual explains how it is used and why.

## Additional resources

There are additional documents to read:

- Program help file. Press F1 key to activate it. Help file is context sensitive so where the cursor is the help file opens for that entry or result. All images and formula have hot spots. Click any parameter in a formula and additional details are available
- Installation of Bellows Software.pdf
- How to use Software.pdf
- NewComputer
- Registration.pdf
- Logo creation
- Several technical papers
- How to enter new material at <http://www.jat.co.za/bmsupport.html>
- Contact developers

# Installation and Uninstallation

BMII EN has a standard Windows installation file. After downloading the installation file into a temporary folder simply double click the installation file in Windows Explorer. It is also known as File Explorer and My Computer. In Windows 10 it is known as File Explorer.

Installation programs install the program files into a folder (WIN 10/11):

C:\Program Files (x86)\J Tolonen Services cc\Bellows\Design2

Installation includes an EN based material database. Where the order includes additional module to use ASME materials there is a second material database sent via e mail. It is the best to save the ASME material database to the same folder where the EN material database is located.

All of the programs are "low volume" and this is causing problems with some virus protection programs. Developers are signing the installations using agreed system by the virus protection program developers. Not all of the developers use the system and even those who work with the system have false reporting from time to time. Unfortunately even this system has been discontinued. There has never been any confirmed report or detection that bellows design software has virus or other unwanted code. Many developers have similar problems with "low volume" software or software updated regularly. Sometimes programs have been in use for more than 20 years without any issues and suddenly they are removed as "dangerous". The best solution is to ask your virus protection supplier to double check. They will add the software to be accepted and on a safe product list.

Warning: Windows Vista and later versions have increased security. You need to have administrator rights to do the installations. Sometimes even this is not sufficient depending on your company's IT policies. The first trick is to try to run the installation program by right clicking on the installation file and selecting "Run As Administrator".

The program uninstallation is done via the program uninstallation option in Control Panel.

# Program Registration

BM II EN requires registration before it can be used. Licenses are a computer and partly a user specific. Each computer requires own dedicated license per program. License is locked to the computer identification collected during the licensing procedure, see below. Because the licensing information is saved into the Registry under Current User key, the license has to be entered for every user where the computer is used by multiple users having different user names.

Registration is a two step process. The first step is to request a license. The second step is to enter it after the license is received.

Terms License, Key and Certificate mean the same thing.

## License Request

Steps to follow to request the license:

1. Install the program on the computer you are going to use for testing or for permanent installation. We recommend you use the standard installation and default file locations.
2. Start the program.
3. New form opens. This is for registration.
4. Click the last button with a hint "Request for license"
5. New form opens
6. Enter requested information
7. Click the second button "Collect information"
8. Click the last button "Copy to clipboard"
9. Open your e mail program and start a message to us
10. Paste the clipboard content into the e mail. The result looks something like the following:

```
-----Do not change the following-----  
Jouko Tolonen jouko@jatsa.biz
```

```
PinMaster 1.0.0.0
```

```
41940
```

```
1057-4E4B-5E3C-9DA0-7F93-C26B-D383-30F8
```

```
-----End of request----- Comments to developers:
```

## 12. Send the e mail to developers

If the computer you are using has no E mail possibility then you can use a notepad program to transfer the license request to another computer. The notepad is part of each Windows operating system and makes simple text files \*.txt. Save the file onto a disk, network, stick or any other media for the transfer.

If you are installing multiple programs on the same computer, you do not need to issue the request for all of them. Simply create one request and in the e mail list the programs for which you require the license.

BM II EN is sold per license. License issued for one computer will not work on another. License can be transferred on request to a new computer or to another user.

## Entering the License

After receiving the license, which is sent via e mail in \*.txt file format it has to be entered to the program the license is for. A license file name identifies for which program the license is for. License file for PinMaster is named PinMaster\_License.txt. Depending on the Windows settings you may not see the file name part ".txt". As a default it is hidden by the operating system. This is a serious security issue and you should always change the setting to prevent unintended installation of dangerous viruses and mal ware.

To enter the license start the program. If the licensing form doesn't open automatically simply click the button or menu item to open the entry form. After the license entry form is open follow the steps:

1. Copy the license from the first to the last character as describe below using copy command or key combination CTRL plus key C. Typical license file looks like:

Key:

```
*begin_data*FT45RY6J-ZOWLYTDF-GDM4Q6CP-4K72QIYS-IMG6ITUX-VLAIBDJ  
3-CAAON7P2-4ICE72WH-AMO6CFPL-KCJWABQA-7H4PPOYF-NAHQB44H-BR4P  
BAID-AQEGFEYG-B5DJWQOH-NAGTALIC-CR5AC7H3-36G6QH7X-AQG2J35U-N  
BI3C3J5-54BBKAEY-G4VAMRJV-XHP3D2EW-PXNWIJAB-AHBXMHIP*end_dat  
a*
```

All characters can be copied and licencing system excludes automatically characters that are not part of the licence.

2. Click second button from left on the registration form. This has a hint "Load license from clipboard"

3. Click button Activate Program

4. Read all messages. You should get information that the program is registered. If you receive an error message write it down (each error) or preferably take an image and send them to us.

If the license entry fails please close the program and try again. If it fails a second time contact the supplier via e mail and send images of all error messages you get. Entry may fail due to misunderstanding, company security policies or by some other reason. All cases have been solved.

Access to the additional ASME material module is part of the license. Registration process is the same with or without the module. Where the module access is purchased afterwards the registration is the same as the initial process but to open the registration for go to menu: Help - Register Program...

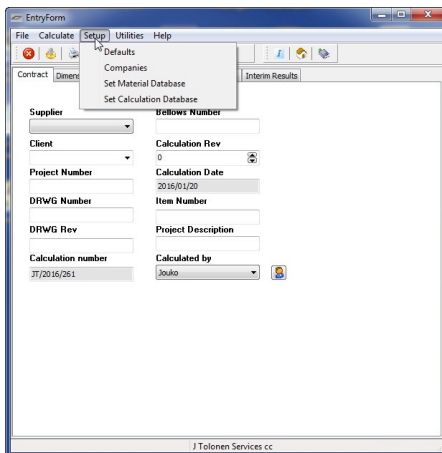
# Program Settings

BM II EN has number of initial settings. This Chapter describes the minimum steps you are required to do.

## Material Database

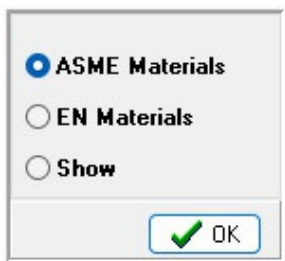
BM II EN requires material data for the calculations. After an installation and registration program doesn't know which material database to use or where it is located. The user has to set this up.

When the program restarts after the registration and gives a warning that the material database is not set you will not be able to use the program before this setting is done. To do the setting you use BM II EN Menu: Setup - Set Material Database, see the images how to do this:



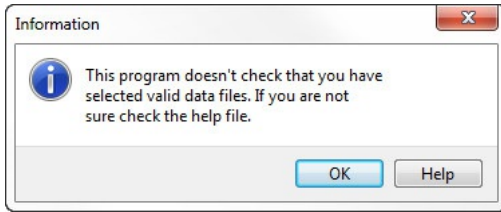
**Figure 1** Setting databases

Which form opens next depends if the program is standard or includes access to ASME material module.



**Figure 2** With ASME option



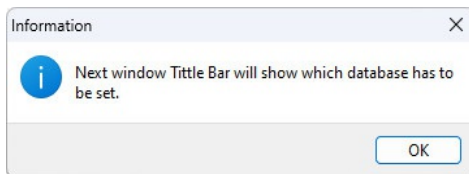


**Figure 3** Click Help button for additional details

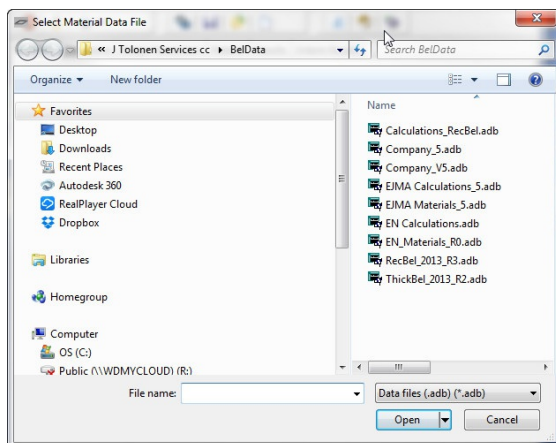
Where the ASME option is active selection form opens. Just select the option you require. Next form is the same for standard edition and where the ASME option is included.

Material database name indicates if it is for EN or ASME. For ASME option will work only with material database EJMA\_2023\_Mat\_R1\_5.adb or later. EJMA refers to EJMA and ASME calculations. 2023 gives the ASME edition and R1 is the revision of the 2023 database. The latest EN database at the time of writing is EN\_Materials\_R9.adb.

Where ASME option is active information form opens:



**Figure 4** Information for the selection



**Figure 5** List of databases in the default location opens.

Click the database you wish to use and click Open button. Selection of the database is only activated after restarting the program.

Depending which programs, your company has purchased you may find different database names. Some of those are for calculations or material values for different design codes. In addition your company may have modified or created own databases with different naming convention.

Database locations are saved into the registry. If the registry would get corrupted or you have reinstalled Windows you need to reset the file locations.

BM II EN has very minimal checking that you have actually selected the correct database. After setting the database if you get strange errors, you do not see expected results or materials you may have totally wrong or outdated file in use. If you keep changing the database establish some form of revision control so that you know what is the file you should use.

If you purchased an additional database, you can either save it to the same location as the one supplied with the program or any other location you wish to use. You just need to point the program to the correct file. Which material database is used can be changed at any given time but it requires restarting the program.

Default material database locations are:

NT/2000/XP: C:\Documents and Settings\User\Application Data\J Tolonen Services cc\BelData

Vista/7/8/10/11: C:\Users\User\AppData\Roaming\J Tolonen Services cc\BelData.

"User" is replaced by the current user's name.

You can have the databases in any other location. If they are on the server then the path to the server folder has to be permanently captured.

## **Calculation Database**

Steps to set up the calculation database are the same as the material database. Default name for the database is EN Calculations.adb.

This database is the one you have to back up. If you lose it, you lose all of your saved calculations. The database can be located on the company server or any other location.

## **Company Logo**

BM II EN uses the same Company file as BellowsMaster II and RecBel and some other programs from the developers so if you have any one of them the setting needs to be done only one time by any one of the programs.

The program can have unlimited number of company logos. Most need only one but consulting company may have very many. Set up is via program Menu Setup - Companies. When the entry form opens click key F1. In the help file there is an image. Click each entry field (white areas) and read the details.

Recommended logo size is given in the help file. The program is designed for a rectangular logo. If your logo is different shape use some image program and allow white space where required to get rectangular shape. A logo file must be in BMP format.

Unfortunately Paintbrush, which is part of Windows doesn't work here. There can be other programs with the similar problem. If the logo vanishes when you click "Post" (Save) button the image program is not suitable. BM II installation includes Frequently Asked Questions (FAQ) document. Solution to this issue is described there and the same details are given here:

There is a known issue concerning the creation of company logos for printing purposes. Logo files saved using some versions of Windows Paint programs are not compatible with the graphical module used in Bellows Master II and other programs using Company.adb. If you experience a problem that after entering your logo file into Bellows Master II it vanishes, e.g. will not print or show your logo file is in wrong format. The solution is to open the logo file (\*.bmp) in and other program and use "SaveAs" command. One program tested to give the correct result (File format) is freely available IrfanView (<http://www.irfanview.com/>).

The easiest way is to open the BMP logo file in IrfanView and then use menu Edit - Copy. When this is done and you have the company logo entry form open simply do the following steps:

- Click a small button with + sign
- Enter short company code
- Enter a company name
- Click 2<sup>nd</sup> button on top to paste the logo
- Click the Post button with a Tick image

Done

Entry form is for a database. Database programs work differently to programs like Excel and MS Word. One big problem is the use of many buttons in the bottom. Saving is called Posting etc. Each button is described in the help file. Just click each button in the help file image and there is description.

## **Program Defaults**

Using the program is much easier if the program settings are done. The program defaults are in Menu Setup - Defaults.

Defaults form has two Tabs "Entries" and "Other". Go into any of the entry fields and press key F1. Images open and by further click on the image explanation is given. Please read additional details on each entry from the help file.

Note that the "Calculated By" drop down list is empty until you have entered name or names on the main program.

Couple recommendations:

- Consider entering calculation prefix. In the long run it is handy
- Consider selecting "Show working spring rates"
- Note "Clear display on new calc"
- Consider hiding tabs you do not need

All of the settings can be changed at any time - even in the middle of a calculation.

When completed click OK button and all entries are written into the registry. Clicking Cancel doesn't change entry entries in the Registry.

To get additional details click any of the default entries and then press key F1. Help file opens showing two images. Using mouse click fields in the images and most of them have detailed information what they are for.

# The First Design

Programs have many Tabs. Entries can be done in any sequence but recommended is the listed Tab sequence and entering from left top corner down and next column from top.

- Contract
  - Dimensions
  - Design Parameters
  - Material
- Calculate

## Contract Tab

On the Contract Tab you have several entries. You do not need to enter any one of them but it is highly recommended to use them. Entries are used on the reports. The program has revision control. You can save unlimited number of calculations. Only the entries are saved and no calculation results.

Revision control is handy. You use it as you would use drawing revisions. It is recommended that you do not use the revision control of the design case calculation for pressure test calculation. Rather, use separate calculation number. After you are happy with the design condition calculation make sure that the tick mark is not on in the program defaults on "Clear display on new calc". Then make sure your calculation is open and click "New calculation" button. Change the calculation to Pressure test calculation and then change the temperature, pressure and movement entries. Save and calculate.

## Dimensions Tab

Most of the entries are clear. Using key F1 you do get detailed information. If your defaults were set, you have pre-filled entries. You can change any of the entries as required.

A nipple is the duct/pipe section between two elements. Number of convolutions is always per element.

Nominal bore entry cannot be a decimal number. Entry is used only to select hydro forming tools.

## Design Parameters

Entries on this tab are critical and require some additional explanations.

### Externally pressurized

If the inside pressure is higher than the outside then select No. This is the normal

case. In some cases you have lower internal pressure than the pressure outside. Sometimes this case is called "vacuum". BM II EN entries do not work on negative pressures on the externally pressurized case. The program uses absolute pressure values.

Designers tend to get confused with absolute, gauge and negative pressures:

- Absolute standard pressure on sea level is 101.325 kPa
- Standard gauge pressure on sea level is 0 MPa and also 0 kPa
- Where vacuum pressure is given as a negative value like -20 kPa then the absolute value to use ON SEA LEVEL is  $(101.325 - 20) \text{ kPa} = 81.325 \text{ kPa}$  or 81 kPa

Atmospheric pressure depends on the elevation. In some cases you can use the standard pressure at the plant location. Only thing that changes is the value of 101.325 kPa.

When using the external pressure option note the units used. Assuming the customer has asked a full vacuum and the duct is on free air then the inside pressure entry is zero and the design pressure 0.101 MPa (a) for the sea level.

## **Movements**

Program has 6 movement entries. It is important to understand stress range principle. If for instance the design specifies axial movement 10 mm compression and 7 mm expansion the calculation may not be done only on 10 mm compression. Both values have to be entered to get the correct fatigue result.

When there are multiple movements (axial, lateral and rotation) then the entries must be paired correctly. Lateral or rotation movement that happens at the same time as the axial compression have to be entered to the fields where there is "Comp" mentioned.

If there are different design conditions like bad starts, good starts, emergency shut downs and different movements and other design conditions are given then each such case is calculated separately and the results are combined outside the program using cumulative fatigue.

## **Fatigue Design**

### *Fatigue Safety Factor*

From the help file:

A fatigue safety factor is an additional factor you can use to change the design evaluation. Normally you enter one. Value below one means that your design is less stringent than standard calculation. Value above one gives you additional safety against fatigue. This factor is not considered if calculated allowed cycles are above the maximum cycle limit set for the material. By double clicking the field default value is automatically entered.

## Design Code

You have two design codes to choose. They are EN 14917 and EN 13445. The first is general purpose design code and the other is primarily for pressure vessels.

## Basic Stress

This selection is only available if the ASME add on module is included. Just select which material data bases should be used. Material lists update automatically and there is no need to restart the program.

## Material Tab

On the material tab you select the bellows element, nipple and pipe end materials as required. The fastest way to find the correct material is to use the search button. Search string is case sensitive and is searching the full material descriptions.

Programs enters the minimum elongation value as given in the material standard. Entered value can be overwritten but such have to be justifiable change.

## Result Tab

Result Tab shows the calculated results. There are different fields for the stresses. Pressing key F1 will show the formula used. In the formula you can click any of the parameters to drill down what is behind that specific parameter.

It is important to note that depending on the design some stresses are set to zero. Exact rules are given in EN 14917 standard.

All designs are evaluated and any warning or failure is shown in the Error Messages.

## Calculation

Program has calculation button, which is set for default calculation. Of then the default is not what is required. Additional calculation options are available via Menu - Calculate

## Design Warning

EN 14917 is a problematic standard. Some areas are very complex and some stripped down. BM II EN has a large help file plus this manual. In addition the designer has to have the standard. It is also advisable to read two letters sent to the authorities. Both are available on the developers site: [https://www.jat.co.za/bmsupport\\_1.html](https://www.jat.co.za/bmsupport_1.html)

**BM II EN is not evaluating the pipe ends or the nipple.** Designer has to verify that the pipe sections are sufficiently thick. In addition in cases where there is an external pressure it is not enough to design only the element for the external

pressure. ASME VIII Div 1 UG 28 design calculation or the same in EN standards has to be performed for the full section between vacuum rings. Spectacular failures have occurred where such calculation was omitted.

## **Sleeve Clearances**

Sleeves may not clash with any other part. If they do they deform, prevent free movement and increase the effective spring rate.

## **Interim Results Tab**

This tab gives additional details you may need.



# Printing

Program has printed reports. To print them there is a button with a printer icon.

There is a possibility to make PDF out of the print report directly from the program. When the preview of the print report is shown there is a typical Save button. Click that and new form opens. First change "Save as type:" in the bottom to PDF. Enter name into "File name:" and then navigate to folder (directory) where you wish to save the report and click button "Save".

In addition to the formal report there is a possibility to print full listing of parameters used by the program. You get this from Menu Utilities - Show Variables. Original purpose of this listing was to be able to verify the correctness of the calculations. This print can be confusing and normally should not be given to a customer.

Print button has default printing set but that may not be what needs to be printed. Part of the print button is a small arrow. By clicking that additional printing options are available. Same prints are also available via Menu - File - Print.

# ASME Module

## General

ASME module was added after ASME VIII Division 1 2023 edition was published. Appendix 26 was completely revised. For the basic design calculations Division 2 bellows element designs are used. Formulae are the same as before. Older editions were strict on what the designer could do. Now there are possibilities. Where the given design rules do not cover the type of a design the designer wishes to use then U-2 (g) can be used on the approval of the inspector, see 26-1 (b) and (c).

*U-2 (g) (1): This Division of Section VIII does not contain rules to cover all details of construction. Where complete details of construction are not given, the Manufacturer, subject to the acceptance of the Authorized Inspector, shall provide the appropriate details to be used.*

*(1) Where design rules do not exist in this Division, one of the following three methods shall be used:*

*(-a) Mandatory Appendix 46.*

*(-b) proof test in accordance with UG-101.*

*(-c) other recognized and generally accepted methods, such as those found in other ASME, EN, ISO, national, and industry standards or codes. This option shall provide details of design consistent with the allowable stress criteria provided in UG-23.*

U-2 (g) (2) has limitations: *(2) The provisions of this paragraph shall not be used to justify the use of materials, joining processes (fabrication), examination, inspection, testing, certification, and over pressure protection methods other than those allowed by this Division.*

26-1 together with U-2 (g) makes it possible, with the approval of the inspector, to use higher temperature limits, use flange and flued elements with circular welds, design carbon steel elements etc. provided one of the three options above are complied with. EN 14917 is recognized international standard. As long as the stress evaluation is against ASME allowable stresses EN 14917 designs should be acceptable.

Other reasons to use BM II EN combined with ASME materials:

- TEMA has thick wall bellows element designs based on FEA. Expensive and slow. As a minimum tender designs could be done using the program.
- All thick wall element designs where ASME VIII Division 1 Appendix 5 is used or any other similar design where no EN materials are available but ASME/ASTM materials are

## Materials

EN 14917 is using EN materials. ASME requires ASME materials. EN 14917 is very theoretical. It has multiple special material factors for austenitic materials (stainless steels) which are calculated using R.p02 R.p10 values. ASME has only one yield value

and not two. For ferritic materials (carbon steels) there are no special factors.

ASME material data base is built on the following bases:

- Ferritic materials: Two entries are entered. These are not Type which is always 3 as stated in EN 14917 and Fatigue Class, which is 3 or 4. Fine grain materials are 3 and the rest are 4
- Austenitic materials where the equivalent ASME material is given in EN 14917 the special factors as per EN 14917 are simply used on ASME materials.
- Materials where either one of the above cannot be used are handled as described below. Use of these materials have to be carefully considered including if an additional safety factor should be used.

### **310S**

For the purpose of the calculation 310 and 310S are considered to be the same. The difference between the two is in carbon content. Allowable stress values in ASME are higher for 310S. ASME II D has no 310 plate but fittings etc. Rp02 and Rp10 values for 310 are from EN 10095. All factors are calculated as given in EN 14917

### **309S**

309 values as given in EN 14917 are used

### **SAF 2205**

This is a duplex steel. For the calculation it is considered as Ferritic.

### **Cor-Ten A**

This is taken as ASTM A588 A. This is ferritic carbon steel with elevated copper. In EN standards it is one of the 355 sub grades. Being structural steel there are no elevated temperature values. For the database elevated material properties are based on EN 355 GH, which is in ASME II D. Designer must consider if structural steel can be used at elevated temperature and what additional safety factor on all stresses should be used.

### **Hastelloy X**

There are no Rp10 values for this material. Rp02 value is taken as Yield in ASME. Rp10 is Yield + 30 MPa, which is a good estimate. EN factors are calculated based on these values. Designer must consider if this method is acceptable for the application.