Expansion Joint Design

Ancillaries Design - Design Software User Manual

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Introduction

This User Manual is for the expansion joint ancillaries design and support programs. These programs do not have dedicated help files. In general programs are easy to use and understand.

This manual gives a good overview of the program use but also some smaller details, advise and warnings in the use of them.

Manual covers the following programs:

BracketMaster

FlangeTool

Gimbalmaster

PinMaster

RodMaster

In addition sections of the manual has information for:

HeatMaster

AxMovTool

HinMovTool

Manual describes common items applicable for all the programs first. These include installation, registration, setting up and common features. After these there are separate Chapters for each of the programs.

Installation and Uninstallation

All programs have 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):

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

Ancillary program installations are limited. They do not include material database or possibility to set up the material database. To use the programs you have to install also MatTool II. Only exceptions to this are HeatTool, AxMovTool and HinMovTool, which do not require a material database.

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".

Program uninstallation is done via program uninstallation option in Control Panel.

Program registration

All of the programs require registration before they can be used. Licenses are computer and partly 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 two step process. The first step is to request a license. 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 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 notepad program to transfer the license request to another computer. Notepad is part of each Windows operating system and makes simple text files *.txt. Save the file onto a disk 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.

With the exception of HeatTool licenses for the listed programs are Site License type. This means that the programs can be installed on multiple computers within one company. However, license has to be requested separately from each of the computers. License issued for one computer will not work on another.

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. 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 malware.

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:

Old Type:

Key:
3BT74OHO-QOOQEK6C-E36GIOOE-K2NJB527-MVVZ7WNO-TUFABXYV-7XRFB
ARQ-CPQR6EYA-2UUOOCQ2-73RAEAKQ-RATRZ3SZ-TMBRHLIA-ABSMWQPG-G
AWAEFAN-UEJ6HA4M-VPINDA7A-P4YEKZXJ-BLISLSYC-CRCEOT2U-OZLVQQQ
M-6YMIZOM3-DW6CSKH2-KMERQBPT

If you receive the old type, you need to be careful when copying the license. Cursor has to be just after the last character and not on the next line. Allowing the cursor to be on the next line you may copy invisible character and the license entry fails.

New Type:

Key:
*begin_data*FT45RY6J-ZOWLYTDF-GDM4Q6CP-4K72QIYS-IMG6ITUX-VLAIBDJ
3-CAAON7P2-4ICE72WH-AMO6CFPL-KCJWABQA-7H4PPOYF-NAHQB44H-BR4P

BAID-AQEGFEYG-B5DJWQOH-NAGTALIC-CR5AC7H3-36G6QH7X-AQG2J35U-NBI3C3J5-54BBKAEY-G4VAMRJW-XHP3D2EW-PXNWIJAB-AHBXMHIP*end_data*

New key type is implemented fully as the programs are updated. Initially user is required to copy the licence between special markers *begin_data* and *end_data* without including any part of the markers. Later when the programs are updated 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 consider first the Old and New type license issues. After that close the program and try again. If the second time fails 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.

Program Settings

Listed programs require minimal initial settings. This Chapter describes the minimum steps you are required to do.

Material Database

Not one of the programs requiring material data for the calculations has any access to such if the programs do not know where the material database is located. Installations do not have the material database included and the programs do not even have a facility to point the programs to such material database.

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 need registered MatTool II program and material database.

MatTool II program is a free add on program. When it is installed, a small demo material database is also installed. However, your company may have purchased an additional material database with upto date materials.

Registration of the MatTool II is similar to the registration steps described above. To use the program for the setting is safe if only the program main form is opened. Opening any one of the material entry forms is risky before reading the help file and document "How to enter new materials" from www.jat.co.za/bmsupport.html

Demo material databases are named like EJMA Materials_5_*.adb. Your operating system may hide the part ".adb". Star "*" indicates the material file edition. For instance file name EJMA Materials_5_R2.adb shows that the demo database is Revision 2.

Additional material databases are named slightly differently. For instance database file name: EJMA_2019_Mat_R10_5.adb is based on 2019 edition ASME II D, it is Revision 10 and number 5 identifies the database engine version used.

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 database 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.

Programs have very minimal checking that you have actually selected 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: C:\Users\User\AppData\Roaming\J Tolonen Services cc\BelData.

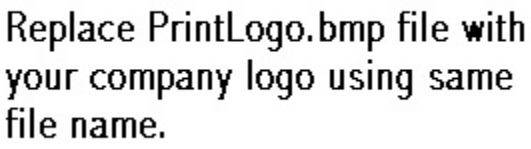
"User" is replaced by the current user's name.

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.

HeatTool, AxMovTool and HinMovTool programs do not require any material database.

Company Logo

All of the programs have a possibility to print a calculation report. Reports have a place for the company logo. Installations include the file but the content is just text like:



The logo file is old bitmap image type. The file name must be PrintLogo.bmp where ".bmp" might be hidden by the operating system (Windows). Location of the file after the installation is the default material database location, see above, for those programs that require material database and the program EXE file location for the rest.

During the use of the programs for programs requiring the material database the print logo must be in the same folder as the active material database is. For HeatTool, AxMovTool and HinMovTool the file must be in the same folder where the program EXE file is located.

Logo area reserved on the reports is rectangular 230 x 60 pixels. Maximum logo width is 350 pixels. When the report uses the logo file, it is stretched to fill the reserved area on the report. To prevent deformation of the logo width to height proportions should be about the same as the default logo and therefore for the maximum width logo the height should be about 90 pixels.

Use any image handling program to capture your company logo and using crop and white space options it is relatively easy to prepare the correct size. When preparing the logo always check the resulting file size. A well-prepared logo file is few kb but badly prepared can be more than one Mb. Using color is possible but it increases the file size and can be expensive if a lot of the calculation reports are printed in color. If you use color logo always test print some reports in black and white as it is highly likely that your customers will use black and white printers.

Common Calculation and Program Issues

The following points apply mainly to actual ancillary design programs but in some cases also for the movement calculations and HeatTool.

Most of the programs have two windows. One is for the main program where entries are done and the other has an image of the design you are busy with. Both window types are "sticky", e.g. they remember their position, size and basic settings after you close the program. Window sizes can be changed by normal operating system methods. Calculation windows should always have a visible logo in the bottom right-hand corner. If the logo is not visible, you may have also other items hidden. Simply resize the window. You should never use the option to fill up the whole screen.

Position the windows to suit your use of the program.

All programs have few common buttons. One is for registration, one to close the program, calculation, print and about buttons. About button is important if you need to find out which version the program is.

Basic settings

Before starting the calculations you should always check and set the following items:

Pressure test calculation: Yes or No. Difference between the two types is in the result evaluation. "No" is the normal calculation where design values are used and evaluation is against the allowable stress value or Yield divided by a reasonable built in safety factor, see below.

"Yes" is a pressure test calculation where the temperature is the test temperature and the pressure is the specified pressure test pressure. This calculation is always against material's Yield value reduced by a small margin.

Evaluation criteria: Normally use "Allowable" option. Stresses are evaluated against the Allowable stress value entered into the material database.

Yield option is an old European generic design method where Yield at the design temperature was divided by a safety factor typical for the application. This is not used in any common design standards today but is a handy calculation in some specific cases. Safety factors are built into the programs, users cannot change them and the values are not published.

Units systems that can be used are SI and Imperial. Imperial term used is somewhat misleading as units are actually those used in USA. Simply select the unit system required.

Printing

All programs have a report printing facility. After entries and calculation you can print the report. Reports ask two entries that are shown on the report. You can enter details as you prefer.

When you click the print button, new form opens. All other buttons are self explaining but the Save button requires some additional explanation. Behind this button is the possibility to save the report in PDF format. You do this as follows:
- Click the Save button
- New form opens
- Change "Save as Type" to PDF
- Navigate to a folder where you like to save the file. The window is a standard operating system "Save as" window
- Enter a file name
- Click the button save

A file is generated. Close both additional windows.

Program Entry and Result Field Hints

On all programs holding the mouse cursor/pointer over any field will show hint giving additional information what that field is for.

Pressure Force

Pressure force is the pressure thrust value from the bellows element calculation.

Additional Forces

Additional axial force is sometimes present where the pipe is vertical and the pipe below the expansion joint is hanging. Lateral force can be for instance resulting from a wind load.

In some designs like pin and bracket additional force can come from a torsion moment. The moment is "converted" to a force at the required point. Such consideration doesn't exclude the need to check the element for the same torsion moment!

Force values are the same between various ancillary designs.

Temperature Entries

In many cases the metal temperature is not necessarily the fluid temperature, which is often the design temperature. Where design standard allows use of actual metal temperature then it should be used for the design. Generally the lower design temperature has to be justified by calculations or actual measurements of similar construction.

Material Search Button

Next to the material drop down lists there is a small button. It is to search material where material list is long. Clicking the button search field entry opens. Enter partial description of the full material description. Search is case sensitive so for instance b7 will not find the bar material ASME SA 193 B7 2019 ed but B7 will find it.

After clicking OK button all materials found will be listed in a grid. Click the material you wish to select and then click OK button. Selected material will be entered into the entry field.

Note that you can select the material also from the drop down list and you do not need to use the search button.

Calculated Stress

In several programs calculation result is a stress. Value is given and evaluated. On standard Windows setting the field is Green if the stress is below the maximum allowed and red if the stress is too high.

Vanishing Images

Several of the programs have a separate form/window, which shows image of the designs that the user has selected to design. These forms/windows have sticky memory to remember their position, size and type when they are closed. If the user closes these image forms on their own they will not show up when the program is started again. The only way to get them visible is to delete Registry Keys using RegEdit. If you have never used this program ask help from a person familiar with the program.

This behavior may be changed at a later editions of the programs.

Registry keys to delete:

- FlangeTool: Computer\HKEY_CURRENT_USER\SOFTWARE\J Tolonen Services cc\Flange\ImageForm
- PinMaster: Computer\HKEY_CURRENT_USER\SOFTWARE\J Tolonen Services cc\Pin\ImageForm
- BracketMaster: Computer\HKEY_CURRENT_USER\SOFTWARE\J Tolonen Services cc\Bracket\ImageForm
- GimbalMaster: Computer\HKEY_CURRENT_USER\SOFTWARE\J Tolonen Services cc\Gimbal\ImageForm

BracketMaster

BracketMaster is a design program, which calculates stresses in the connection between ancillary that holds the rod or hinge plate and is attached to the pipe, duct or vessel. Forces affecting are external loads and pressure thrust.

The program has two Tabs to use. The most often used tab is for the bracket and lug designs welded to the pipe. Such connection results in forces and moments impacting the pipe wall. Less often used is a ring design where the attachment is causing only shear loading on the pipe.

Especially the bracket and lug calculation results have been verified by use of FEA. Calculated results are very close to the linear FEA results.

Known limitations

There are no known design calculation limitations on the design types included. Main limitation of the brackets and lug designs are related to creep. At high metal temperatures thermal and other stresses result in creep damage and then failures. In such cases floating ring designs have to be considered. Ring design, which is included into the program can be used in such a case at least during the tender time. It is a normal requirement that in the high temperature designs FEA has to be used for the final design.

The program doesn't have a reinforcing ring option. There are no known reliable analytical design calculation methods for such design. Where the bracket design results in too high pipe stress the simplest and most of the time cheapest design option is to use thicker pipe ends.

Reinforcing pads are not supported by the program. Such designs have a high failure rate and therefore are not recommended.

Ring design

The ring can be welded to the pipe in low temperature applications but where the pipe has high metal temperature then ring has to be locked in place by lugs, which prevent the ring rotation and axial movement. BracketMaster doesn't calculate lugs, welds used to attach them or any heat expansion clearances between the pipe and the rings. Welds joining the ring elements are assumed to be same strength as plates used.

The program calculates the maximum stress in the ring construction.

Dimensional entries are self explaining.

The program has only the rod option but hinge plate design is also possible. Hinge plate center is at the center of the rod center.

Maximum stress field will show the stress calculated and it is evaluated.

Rod and Hinge Plate Bracket Design

Two designs differ slightly but the designs are basically the same. Maximum stress is calculated and evaluated in the pipe wall. In addition minimum thickness of the front plate in case of a rod design type is given.

All bracket welds are assumed to be sufficiently large. The program doesn't evaluate any weld stresses.

Lug Design

Lug design is for the simple lug as shown on the image. Pipe wall stress and moment on the pipe wall are calculated and evaluated. If either one of the two is over the allowable limit the design fails.

Lug design is relatively new addition. Bracket design has been used more than 30 years and has therefore a long history. No known failures excluding the creep related issues and failure of reinforcing pads are known. Lug design is well-established calculation method but has not been used extensively on expansion joints. Program developers recommend some caution in the use of the simple lugs.

FlangeTool

FlangeTool is to calculate minimum flange thickness of various configurations. Original calculation was developed for oval flanges but for fabrication cost reasons round flange plus lug design is shown in the images. Oval flanges where the "lug" is an integral part of the flange can be calculated.

Important Note: FlangeTool program is not designed to calculate flange bolts or flange thickness for the design pressure! Before using the program minimum flange rating, material, flange thickness, number of bolts and their sizes have to be established based on the line design pressure and temperature using the applicable design code. FlangeTool is then used to establish if the flange is sufficiently thick for the additional loads from the expansion joint pressure thrust. Original design method calculates with high accuracy the primary stress on the pipe wall where there are no connection bolts. This bending stress is most of the time the limiting factor.

Known Limitations

There are few limitations. Number of rods can be only 2, 3, 4 or 6.

The program doesn't calculate deflection of the oval flange. This is a problem especially in case of the outer rod flanges in an axial inline pressure balanced expansion joints. Rod distance from the pipe outside diameter can be large. As the bending moment on the flange can be substantial, the deflection can be too high even where the stress level is low. Program developers found a reasonably accurate analytical calculation method to calculate the deflection but it has not been included into the program as it can be problematic in some design cases. Program users should calculate the deflection in cases where it can be considered critical. Developers have identified several designs by others where the deflection has not been considered. It is definitely not acceptable to have higher deflection than the axial design movement of the unit.

FlangeTool doesn't consider gasket sealing related issues. Where bolted flange is used it has to comply with the flange pressure rating at the design temperature and pressure.

Some users have complained that the calculated flange thicknesses are too big. All verification calculations using FEA have shown that the calculated thicknesses are correct.

Flange and Lug Designs

Flange type image shows the type designed. Images show designs where welded on lugs are used. Designs are also valid for the integrated lug type, e.g. oval flange.

Where welded lugs are used the lug thickness is limited to the flange thickness.

The most critical issue in all of the FlangeTool design calculations is to remember

that where weld on lugs are used the weld between the lugs and the round flange is a full penetration weld and not fillet welds. Using any other weld type than full penetration weld can result in a catastrophic weld failure. Smaller welds can be used in some cases but such have to be separately calculated.

It is critical that the weld symbol and the size used are shown on the manufacturing drawings.

The program calculates the minimum flange and lug thicknesses. It is then the designer's duty to make sure that the drawings have at least these material thicknesses.

GimbalMaster

GimbalMaster is for the design of three types of gimbal rings. These are solid and hollow round types and rectangular solid type.

Known Limitations

Round gimbal ring can collapse between the two gimbal pins. In this case the ring rotates upto 90 degrees and understandably becomes very weak. This type of collapse is not evaluated by the program. Large diameter solid rings have the highest risk. Designer should consider the risk.

Hollow ring design doesn't have hole area reinforcing option. This could be done using thicker or additional plate.

Deflection of the ring is not calculated.

Above limitations are not serious. Possible solutions are:

- Use FEA in case of critical applications to calculate the deflection and any additional reinforcing. Deflection has not been an issue in any designs the developers have done.
- Some guidance of the required reinforcing can be established by changing plate thicknesses and pin diameters. In most cases this is sufficient. Highest bending stress is where the pins are located.

Gimbal Ring Designs

The program calculates maximum stress and evaluates this against the allowable. Stress components are shown for information.

In case of a solid ring design highest torsional shear stress is either in the middle of the ring end or where the pin is depending on the dimensions. Where required by the dimensions the combined shear stress is evaluated in the pin area separately from the combined bending and shear stress on the edge of the ring.

Shear stress calculation was changed in version 3.8. The new calculation can be more conservative in some cases.

Reinforcing on the pin hole area was added into the program in version 3.8. Entering zero dimension values means that no reinforcing exists. The program doesn't ask or assume any length of the reinforcing. Designers recommend at least four times the pin diameter to use. No calculation is included for the size of the weld used between the reinforcing and the ring. A full penetration weld is always safe but smaller welds could be used if additional calculations are done by the designer.

PinMaster

PinMaster is for the design of hinge pins used in hinge and gimbal expansion joints.

Known Limitations

There are no known limitations when considering what the program is designed to calculate. The program doesn't have one-sided pin design, e.g. single shear pins. Such are normally used in small size lightly loaded designs.

Engineers have two basic theories how the pins should be designed. One theory considers pin bending and the other not. Both options are included into the program. It is the opinion of the developers that it is better to consider bending. European expansion joint standard EN 14917 specifically states that bending shall be considered. American Air Force pin calculation method also states that bending shall be considered. The cost difference between the two pin designs is minimal. There is no reason to take a risk by excluding the bending.

Some users have stated that the calculated pins are too big-diameter. Pins might be slightly conservative but not a lot. Calculated pin sizes pass all design reviews developers have seen.

Pin Design Calculations

Calculation considers Shear, Bending, Bearing on all plates and also on the pin. Bending and shear stress are combined and all stresses are evaluated against the allowable stress limits. The largest calculated pin diameter is given as the minimum pin diameter.

Designer has an option which allowable stress is used for the bending.

RodMaster

RodMaster is used for the calculation of tie and limit rods or any rod for that matter where the load is known. Loading can be tension or compression. In case of expansion joints rods are under compression in case of external pressure case, normally called vacuum case.

Known Limitations

There are no known limitations.

Rod Design

A minimum rod diameter is calculated. This diameter is based of stress but doesn't consider general stability. Next to the calculated rod size field there is a button which shows the recommended rod sizes given in EJMA. Those sizes are based on stability and long experience.

Program also includes compression load option. This calculation uses Euler's critical load and Johnson's parabolic formulae. The following points need to be considered:

- Program has no built in safety factor what calculating compression load, e.g. buckling case. Maximum total force for all rods is given, e.g. it is the critical force without any safety margin. Designer should consider what safety margin should be used between the critical load and the total rod load.

- Program asks for the rod diameter. This diameter is used for the calculation. Part of the calculation is also compression stress evaluation. Designer must evaluate if the diameter given is the thread root diameter or the rod outside diameter.

RodMaster calculates also strain per meter/per inch. Total length increase of the rod is the given value times the free length of the rod. Strain calculation was added because there was stress calculation performed by others where the rod strain under a load became critical issue.

When doing rod design thermal expansion issue can be critical. It is required that the nipple (center pipe) expansion has to be added into the element design calculation as axial movement in case of a universal expansion joint. However if the rods are inside insulation and close to the temperature of the center pipe then the axial movement can be less. Expansion joint designer should consider this and verify what the pipe stress engineer assumed (in critical applications).

HeatTool

HeatTool is for the calculation of the bellows element actual metal temperature. The program has a dedicated help file. It is activated using key F1. Please use the help file for additional information. Installation, registration and printing are the same as described in this manual. There is no material database linked to the program.

Movement Programs

There are two movement calculation programs. AxMovTool is for the calculation of axial expansion joint movement but it can be used even for the calculation of heat expansion of a tie rod or pipe or structural steel section etc. HinMovTool is to calculate angular movements of hinge or gimbal expansion joints in three pin systems.

Installation, registration and printing are the same as described in this manual. There is no material database linked to the programs. Both programs include a list of typical pipe materials with generic heat expansion coefficients.

Revisions

May 2020: Material search button was added
April 2023: RodMaster compression load case explanations added