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B31J – 2017 and FEATools™
Introduction and FAQs

With the recent publication of ASME B31J – 2017 and the release of FEATools v3.1, PAULIN Research Group wanted to take the opportunity to provide all piping system designers and analysts with a brief technical primer on the changes to the Code (as per B31J - 2017). We will demonstrate how FEATools can be used to capitalize on these changes to achieve a more accurate pipe stress analysis, in less time, and with far less complexity than in the past.

Before getting into the nuts and bolts of what B31J - 2017 is and how PRG's technology, in conjunction with CAESAR II, can be used to take advantage of B31J, we provide the Q&A contents below for those who are new to FEATools, B31J - 2017, or both.

B31J and FEATools™ FAQs

Q: What is B31J - 2017? ***(Herein referred to as B31J)***

A: B31J is a formally published ASME Standard that provides an update to the calculations of flexibility factors (k-Factors), Sustained Stress Indices (SSIs), and Stress Intensification Factors (SIFs) for specific types of piping components and geometries. The application is mainly for what are commonly called the "standard" B31 intersection types.

The official title of the B31J Publication is:

Stress Intensification Factors (i-Factors), Flexibility Factors (k-Factors) and Their Determination for Metallic Piping Components

https://www.asme.org/products/codes-standards/b31j-2017-stress-intensification-factors-ifactors

These updated calculations, in keeping with the history and traditions of the ASME publications, have been provided as written formulas and tables of factors that can be used by the designer, engineer or analyst to apply to their design without the need for a specific vendor's software application. For example, if you would like to find a more accurate flexibility factor for a standard branch connection on a large "run" pipe, you can use one of the new formulas in B31J, look up the factors to use in that equation based on the diameters, thicknesses, and other geometry data for your specific design, and then calculate a new, more accurate flexibility factor, SSI, or SIF for this intersection.

EXAMPLE

An example of (or "form") of one of the new formulas in B31J that can be used to calculate a more accurate k-Factor is as follows (*formatted slightly for greater readability*):

$$kib = (n.nn(d/D) - m.mm(d/D)2 + a.a(d/D)3)\ (R/T)\ b.bb\ (d/D)\ c.ccc\ (t/T)$$

Where

n.nn, m.mm, a.a, b.bb, and c.ccc are constants *(provided in a lookup table)*
D,R = the run pipe diameter and radius, respectively
d = the branch pipe diameter
T = the run pipe thickness
t = the branch pipe thickness

This particular formula is for the in-plane flexibility factor of a branch (Nozzle), or kib.

For some types of intersections, depending on the relative diameters, thicknesses, and other factors, the new k-factor calculated by this equation can easily be **2 to 8 times the old k-factors**. This can significantly impact the calculated displacements in the piping system, thus greatly impacting the calculated stresses and loads for the intersections impacted by this more accurate flexibility model.

Q: What is the main reason for B31J being published? Why should I care about B31J?

A: The main reason to use B31J is to improve the accuracy of the k-factors, SSIs, and SIFs used in piping design and pipe stress analysis. In simple terms, the flexibilities used for piping and nozzle connections by most piping and pressure vessel designers or stress analysts are based on 1950's technology. These flexibilities have a significant impact on displacements, forces, and stresses, often skewing results from reality.

If you want your designs to be more accurate AND simultaneously safer, while providing many opportunities to reduce design time, construction costs, analysis time, and lifecycle maintenance costs, you should use the new B31J methods - and the Code now directs you to do so.

Q: What is FEATools™?

A: FEATools is a companion product to CAESAR II that will automate the process of applying B31J to your entire CAESAR II model. When purchased, it is integrated to be kicked off from within the CAESAR II program to seamlessly incorporate this new technology. Using FEATools, you can improve the k-factors, SIFs, and SSIs of your piping design with just a few clicks of the mouse.

In addition, FEATools will go beyond B31J in terms of applying the exact kinds of improvements that B31J offers, but for many more types of commonly used piping components and designs. Whereas B31J is only used to improve specific types of piping intersections, and only within a limited range of geometries, FEATools allows you to use the concepts in B31J and apply them to virtually any piping design you come across.

For more on this, please see the complete FEATools™ functionality list on the last two pages of this document.

Q: How does FEATools™ help a typical piping designer apply B31J to their designs? Is it complicated?

A: Because it is "built-in" to the CAESAR II program, the end user can apply the FEATools technology to their CAESAR II model without having to do any complicated, time-consuming FEA modeling and analysis. It does not require the end user to be an expert, or even a novice, in the application of FEA to a piping model. All of the complexity is taken out of the process. The CAESAR II user can simply take their completed (or in process) piping design, run FEATools, and see how the calculated displacements, loads, and stresses change in the model, node-by-node, in a very efficient and easily understandable way. Graphs allow you to very quickly see if, and by how much, your results changed by applying the B31J and the full FEATools methods.

Q: What are the main benefits of using B31J and FEATools™?

A: The main benefits are:

1. Because the accuracy of the flexibility factors for the entire piping design are improved, the calculated displacements, loads, and stresses in the piping system are much closer to what will actually take place in the as-built system. Current methods often result in designs that are either over-designed and overbuilt, or under-designed and underbuilt (on an intersection by intersection basis). This results in either added costs or added risk to the plant due to underestimated cyclic fatigue.
2. This technology can be applied, quickly, and easily, and can give the piping designer a better understanding of the design that is just not possible using only instinct or experience. The interactions between piping intersections, supports, vessels, etc., are enormously complicated once you get away from a simple "anchor-anchor" piping segment. The real world has very few true anchors, and treating them as such normally results in an improper (incorrect) design.

Q: Are there other benefits to using FEATools™, even if I choose not to apply B31J?

A: If you are hesitant to apply B31J and FEATools to your entire piping design, you can still use FEATools to compare multiple piping designs (with changes in the design) to quickly see how these changes affect the resulting stresses and loads. This can be done without having to scan through tabular results. You can also use the individual programs in FEATools to perform an in-depth FEA analysis of a single component in your system to gain confidence in the design of that single component or intersection. Again, the programs are very easy to use, allowing you to model an intersection in a few minutes, and then perform a complete FEA analysis.

Q: Can I see some real-world examples on the impact of applying B31J and FEATools™?

A: If you would like to receive a document that has multiple examples of how FEATools has been applied to real world piping models/systems, please send a request to sales@paulin.com. Please also plan to attend our upcoming webinars to see new examples. More information on upcoming webinars can be found on our web site at www.paulin.com.

Q: Who do I contact to purchase a license of FEATools™?

A: FEATools is currently sold exclusively through Hexagon, *formerly Intergraph*. Contact your current Hexagon-CAESAR II representative for licensing questions. PRG staff is available at sales@paulin.com to answer your questions or put you in touch with the appropriate person at Hexagon.

Customer Quotes & Testimonials on FEATools™

Xodus Group Direct Quote

"Where in the past WRC, Kellogg, or ASME attachment calculations had proved to be onerous to use and, in fact, resulted in 'apparent' failures, FEATools delivered accurate and acceptable results that validated the designs without having to modify the pipework. The use of FEATools has greatly benefited Xodus and our clients!" – Stephen Fox, Xodus Group

Canadian EPC company validation of FEATools™

A Canadian engineering firm recently completed a project where the CAESAR II analysis, based on the standard code calculations and parameters, showed overstressed conditions. This resulted in a redesign and addition of piping loops to add additional flexibility to the system. This firm used FEATools after the conclusion of the project to confirm that the use of more applicable data (FEATools' FEA-based improved flexibility model and more applicable k-factors) showed the original design was NOT overstressed. Had they used FEATools on the original project, they conservatively estimated they could have saved $50,000 in project costs and completed the project much sooner!

Other Customer Comments

"It takes virtually no time to use, and when you need it you really need it."

"Using FEATools has made me a better pipe stress analyst. I am more aware of weaknesses in the code and of weaknesses in my own designs."

"I run [FEATools] on every piping system that has tees."

"I need to get the right answer and I need to satisfy the code and that's what more applicable data is all about."

FEATools™ v3.0 & v3.1
Major Feature Summary

FEATools™ v3.0 and v3.1 introduced new capabilities that elevate pipe stress analysis to state of the art and provide improved workflow features for use with CAESAR II Version 8.0 and higher.

FEATURES included AUTOMATICALLY into the CAESAR II Model

1. Pressure Vessel and Heat Exchanger Nozzle Flexibilities and SIFs
   - Differentiation between Heat Exchanger and Pressure Vessel Nozzles
   - Nozzles on Spheres, Ellipses, Cones, Dished, or Flat Heads
   - Nozzle Offsets
   - Hillside or Lateral Branch connections with repads on Cylindrical Shells
   - Trunnion Supports with and without repads. (Pressure boundary not penetrated)
2. Allowable Loads on Pipe Shoes and Saddles
   - With or without repads
   - With or without stiffening rings
3. Bends with trunnions or structural steel attachments are inserted into the CAESAR model.
4. Corrections for Major Bend SIF and Flexibility Errors
5. API 661 Header Boxes
6. Extended B31 SIF and Flexibility Factor Library
   - Includes weld thickness (can be critical for stainless steel branch connections)
   - European Style Welding Tees to EN-10253 Type A or B
   - "No Basis Copied" Olet Library -Laterals and laterals with repads
   - Increased Control for B31.3 Sustained Stress Indices
   - Increased Control for non-B31.3 0.75i more applicable data
7. Postprocessing and Automated Comparisons of Results from Multiple CAESAR Outputs

Major New Technical Capabilities

1. Expansion of B31 Piping Branch Connection Library
   - User may input weld thicknesses for fabricated branch connections - important for stainless branch connections.
   - User input of reinforcing pad properties including pad width and weld size
   - Weld improvement per ASME VIII-2. Don't reroute pipe when a more accurate SIF can solve the stress problem.
   - SIFs and flexibilities for pipe trunnion supports - pipe as a support where pressure boundary is not penetrated
   - Options copied olets with no design basis - see technical discussion for pressure and fatigue affect.
   - Ability to provide branch connection details only for connections that are overstressed
   - European Standard welding tees (EN-10253 Type A and B welding tees).
   - Olets per WFI and Bonney Forge. All ASME SIF tests were performed on WFI and Bonney Forge fittings.
2. Bends with and without Supports
   - Bends with round trunnion supports with and without repads have been added to the SIF and Flexibility FEA library.
   - Bends with structural steel supports with and without repads have been added to the SIF and Flexibility FEA library.
   - SIFs and Flexibilities for refractory lined bends (k-factors can be reduced by an order of magnitude)
   - Bend k- and i-factors based on the bend angle and length of attached pipe
     This corrects significant error in pipe stress analysis today. Bend k-factors and i-factors are a strong function of the bend angle and attached straight pipe.
   - Intrados and extrados thicknesses may be entered and considered. (Code SIF and k-factor equations in use today do not incorporate variations in intrados and extrados.)
   - Tapered bends

3. Vessel and Heat Exchanger Nozzle Flexibilities and Stresses
    - Flexibilities for vessels and heat exchangers are computed automatically and entered into the model.
    - Highlighted differences between heat exchanger and vessel nozzles boundary conditions
    - Spherical heads, Conical Heads, Dished Heads, Flat Heads, or Elliptical Heads may be entered.
    - Lateral or Hillside Offsets for nozzles on Cylinders are supported.
    - Offset Nozzles on Heads are supported.
    - Barrel and pad reinforced nozzles are supported.
4. API 661 Rectangular Header Boxes and Other Rectangular Structures
    - Minimal input required for API 661 header boxes which include tubesheet properties and locations of partition plates.
    - Generated flexibility and SIF models are inserted into the CAESAR II model automatically.
    - Any rectangular, symmetric heater geometry with branch connections can be entered
5. Pipe Shoe and Saddle Evaluation
    - Allowable Loads from a NozzlePRO evaluation of pipe shoes or Saddles used with CAESAR to evaluated loads on pipe shoes and saddles for all load cases.
6. Increased Control for Sustained Stress Analysis
    - With the new B31.3 requirements for sustained loads incorporated in CAESAR II V8.0, more sustained and occasional analyses will be overstressed due to known gross overconservatisms at branch connections. Corrections for nonconservative, and overconservative conditions are provided.