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Experimental Validation shows that FE-107 Provides More Accurate Results than WRC-107

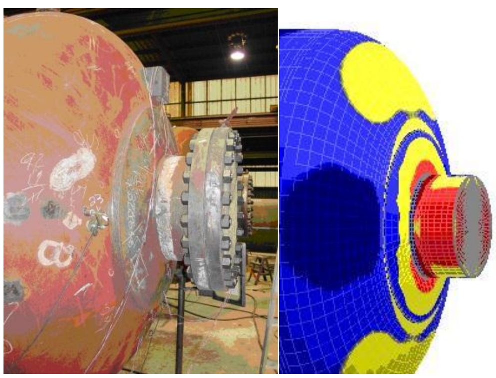
FE-107 Experimental Validation

Has your finite element analysis (FEA) software been validated against real-world pressure vessel problems? FE-107 and other PRG software are continuously validated against actual problems faced by practicing engineers. Follow this link for to learn more about an experimental validation of the FE-107 solutions and see how WRC 107 fails to predict accurate stresses in a real world application.

Real-world validation of PVP Designs

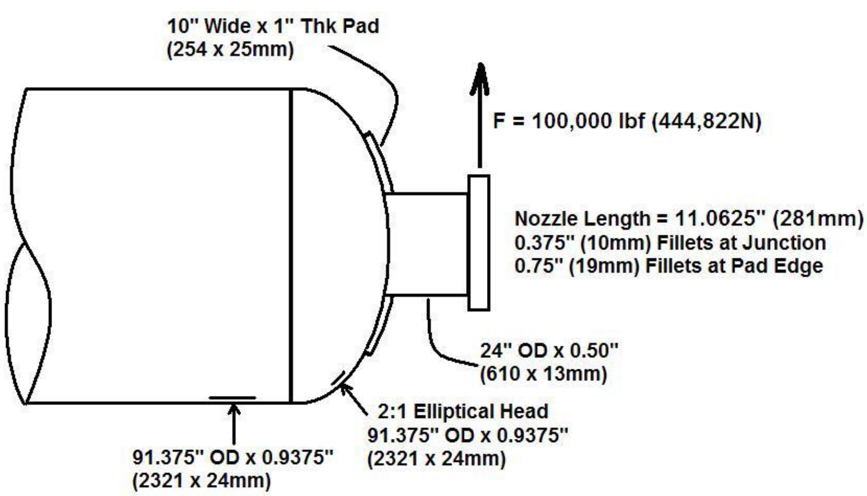
Validation comes in two forms: numerical validations and real-world validations. All FEA programs are numerically validated…few are validated against problems you face everyday in the pressure vessel and piping industry.

An external load was applied to the nozzle located in an elliptical head as shown below. Strain gauges were placed on the head adjacent to the pad and in the nozzle neck to validate the finite element solution.



Details of the Experiment

The horizontal vessel was lifted from the bolted cover, resulting in a load of 20,000 lbf. Details of the pressure vessel and nozzle are given below.

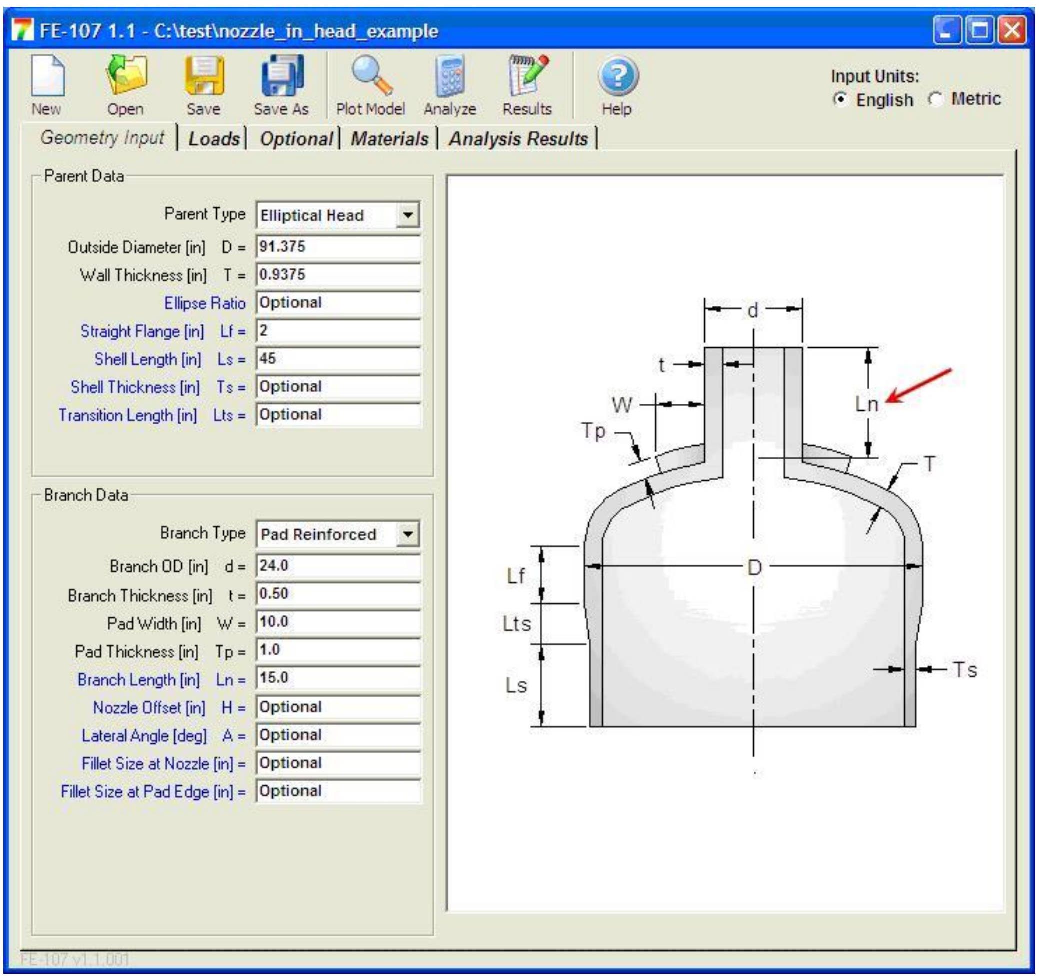


The next step is to input the model in the FE-107 input screens.

FE-107 Input

FE-107's input is specifically designed to make the design and analysis of typical pressure vessel and piping (PVP) geometries with nozzle very easy. Unlike general FEA programs that require the user to create models from scratch, FE-107 creates the model for you using input that is familiar to all PVP engineers.

In this case, the geometry can be defined using just 11 input fields as shown below. The required input accompanied by a drawing for each type of model available in FE-107. This makes it very easy to understand the input.



Next, the orientation and loads are defined. FE-107 can accommodate any orientation of the head and nozzle.

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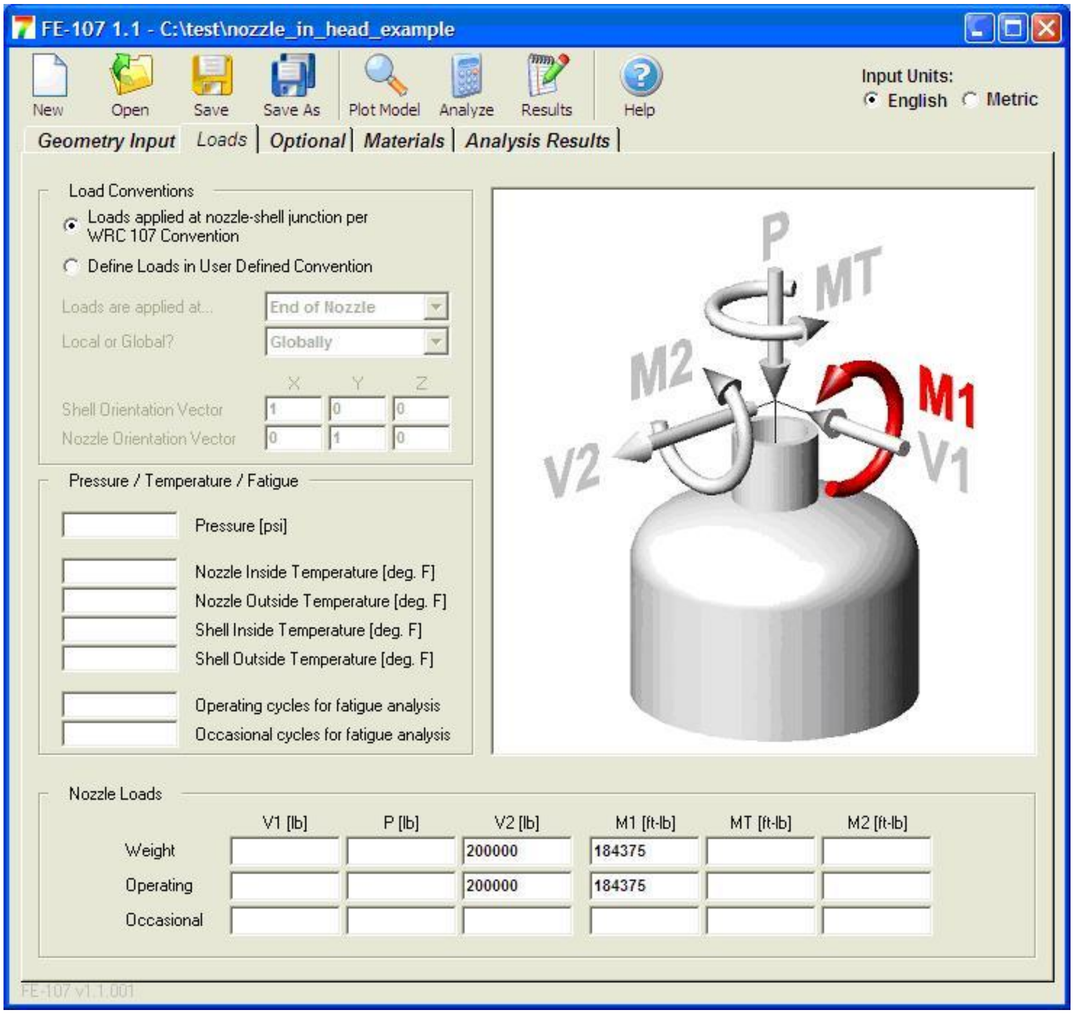
Some other features:

1. Loads can be specified using WRC conventions or in a user defined convention.
2. Loads can be defined at the centerline, nozzle-shell junction, or end of the nozzle.
3. Input for weight, operating, and occasional loads.
4. Specify the number of fatigue cycles for an automatic fatigue analysis of external loads and pressure.



Run the Analysis

To start the analysis, the user clicks the "Run" icon located on the FE-107 toolbar. FE-107 will automatically construct the model, apply the loads, and boundary conditions based on the user's input. You don't need to be an FEA expert to use FE-107.

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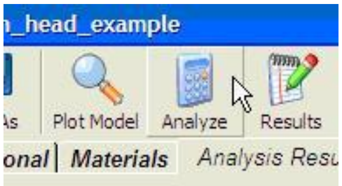
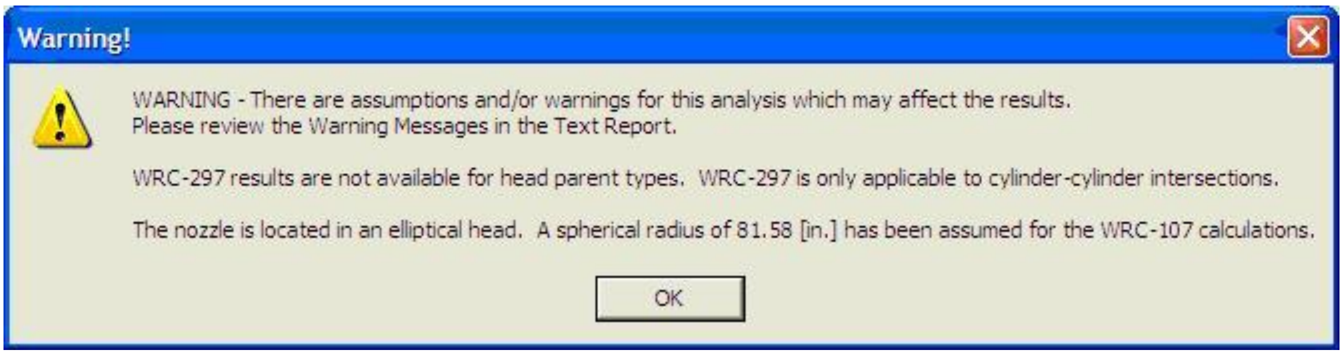


During the analysis, FE-107 will give the user useful information and provide alerts when assumptions must be made. In this case, neither WRC-107 nor WRC-297 methods are ideally suited for the analysis since the nozzle is located in an elliptical head.



Analysis Results – WRC 107 FAILS

The following are the comparative results between the experimental stresses, FE-107's FEA solution, and the WRC-107 & WRC-297 comparisons.

As shown below, FE-107 predicts conservative and accurate stresses in all cases.

WRC-107 fails the validation by significantly over predicting the stresses in the pad and not providing any stress calculation for the highest stresses which occur in the nozzle neck. This clearly shows why the WRC methods are not adequate for PVP designs.

Can you afford to miss the highest stress by a factor of 4.0 using outdated analysis methods?

Location	Strain Gage Results	FEA Results	WRC-107	WRC-297
Shell near pad weld	7000 psi (48 MPa)	6350 psi (44 MPa)	32140 psi (109 MPa)	Not applicable
Pad near nozzle weld	23440 psi (162 MPa)	20240 psi (140 MPa)	31882 psi (109 MPa)	Not applicable
Nozzle neck near nozzle weld	51500 psi (355 MPa)	64750 psi (446 MPa)	Not available	Not applicable

FE-107 Output

The FE-107 results are presented in an easy to use interface and include ASME Code compliance reporting.

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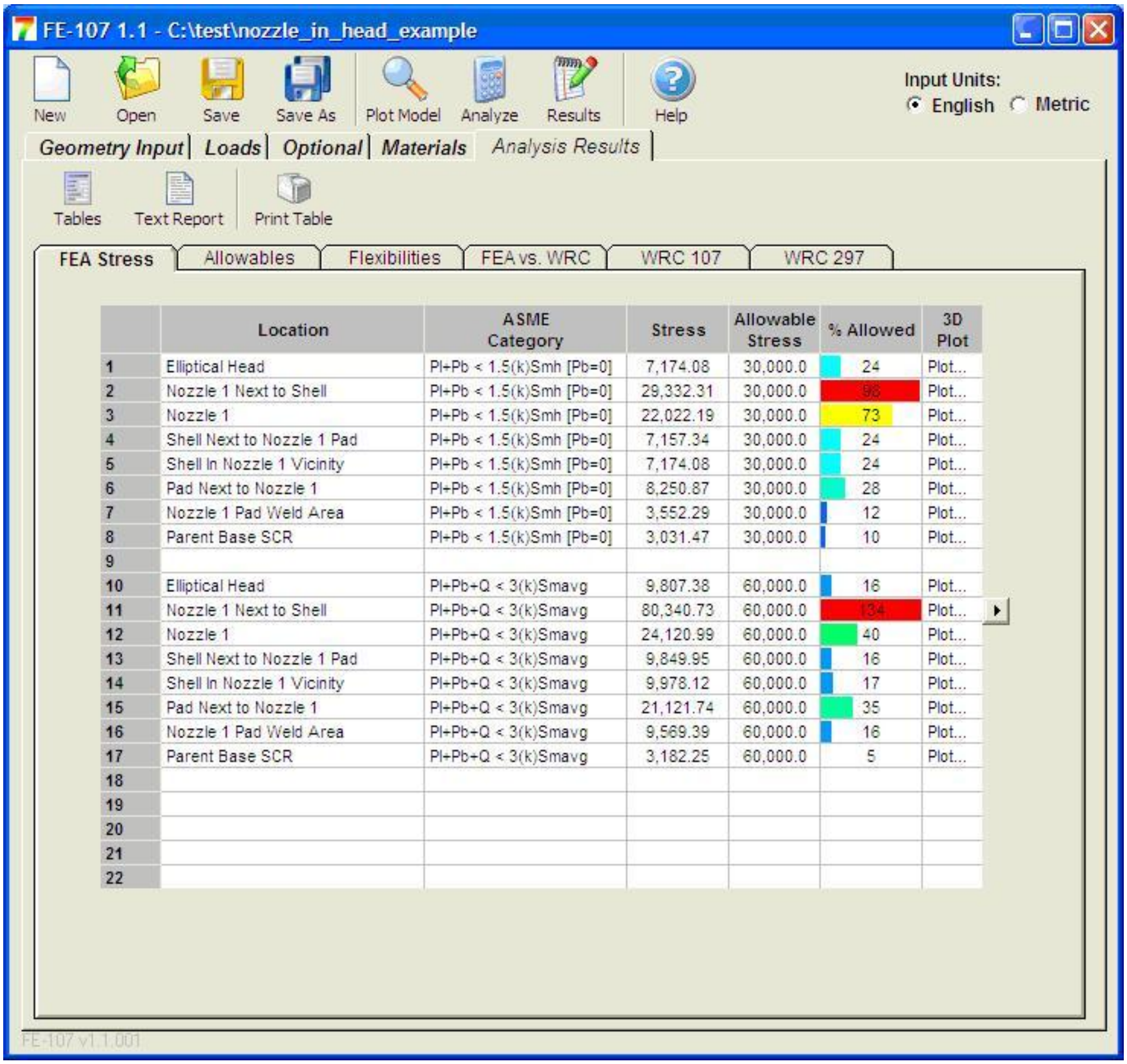
Some features of the FE-107 output:

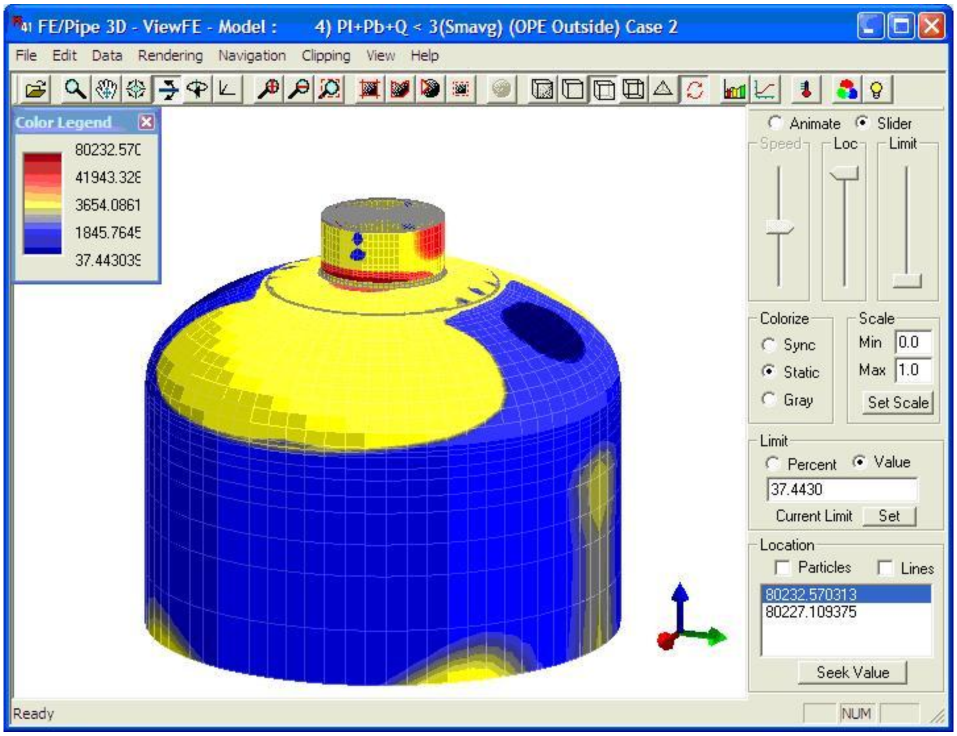
1. Finite element results are given in three easy to use formats (spreadsheets, printable reports, 3D interactive graphics)
2. Automatic ASME stress classification – no other FEA software offers this for shell elements.
3. Automatic ASME Code compliance reports
4. Comparisons against WRC-107 and WRC-297 methods



	Location	ASME Category	Stress	Allowable Stress	% Allowed	3D Plot
1	Elliptical Head	Pl+Pb < 1.5(k)Smh [Pb=0]	7,174.08	30,000.0	24	Plot...
2	Nozzle 1 Next to Shell	Pl+Pb < 1.5(k)Smh [Pb=0]	29,332.31	30,000.0	98	Plot...
3	Nozzle 1	Pl+Pb < 1.5(k)Smh [Pb=0]	22,022.19	30,000.0	73	Plot...
4	Shell Next to Nozzle 1 Pad	Pl+Pb < 1.5(k)Smh [Pb=0]	7,157.34	30,000.0	24	Plot...
5	Shell In Nozzle 1 Vicinity	Pl+Pb < 1.5(k)Smh [Pb=0]	7,174.08	30,000.0	24	Plot...
6	Pad Next to Nozzle 1	Pl+Pb < 1.5(k)Smh [Pb=0]	8,250.87	30,000.0	28	Plot...
7	Nozzle 1 Pad Weld Area	Pl+Pb < 1.5(k)Smh [Pb=0]	3,552.29	30,000.0	12	Plot...
8	Parent Base SCR	Pl+Pb < 1.5(k)Smh [Pb=0]	3,031.47	30,000.0	10	Plot...
9						
10	Elliptical Head	Pl+Pb+Q < 3(k)Smavg	9,807.38	60,000.0	16	Plot...
11	Nozzle 1 Next to Shell	Pl+Pb+Q < 3(k)Smavg	80,340.73	60,000.0	134	Plot...
12	Nozzle 1	Pl+Pb+Q < 3(k)Smavg	24,120.99	60,000.0	40	Plot...
13	Shell Next to Nozzle 1 Pad	Pl+Pb+Q < 3(k)Smavg	9,849.95	60,000.0	16	Plot...
14	Shell In Nozzle 1 Vicinity	Pl+Pb+Q < 3(k)Smavg	9,978.12	60,000.0	17	Plot...
15	Pad Next to Nozzle 1	Pl+Pb+Q < 3(k)Smavg	21,121.74	60,000.0	35	Plot...
16	Nozzle 1 Pad Weld Area	Pl+Pb+Q < 3(k)Smavg	9,569.39	60,000.0	16	Plot...
17	Parent Base SCR	Pl+Pb+Q < 3(k)Smavg	3,182.25	60,000.0	5	Plot...
18						
19						
20						
21						
22						

More FE-107 Output Screens

Interactive 3-D graphical results for evaluating results.



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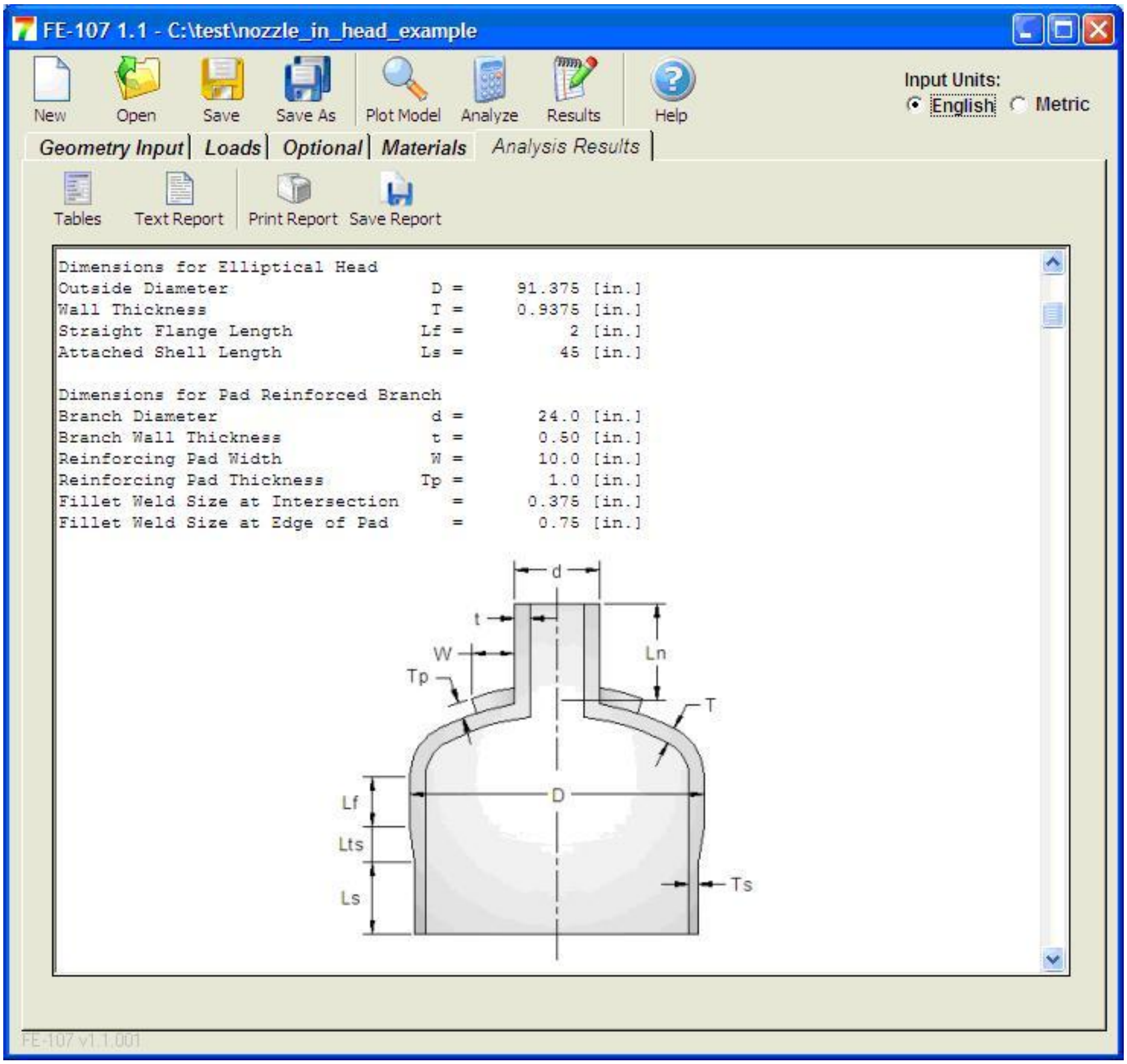
Experimental Validation shows that FE-107 Provides More Accurate Results than WRC-107

A text report is provided for documentation and distribution to clients and inspectors. The report includes drawings, dimensions, tabulated stresses, and graphical results



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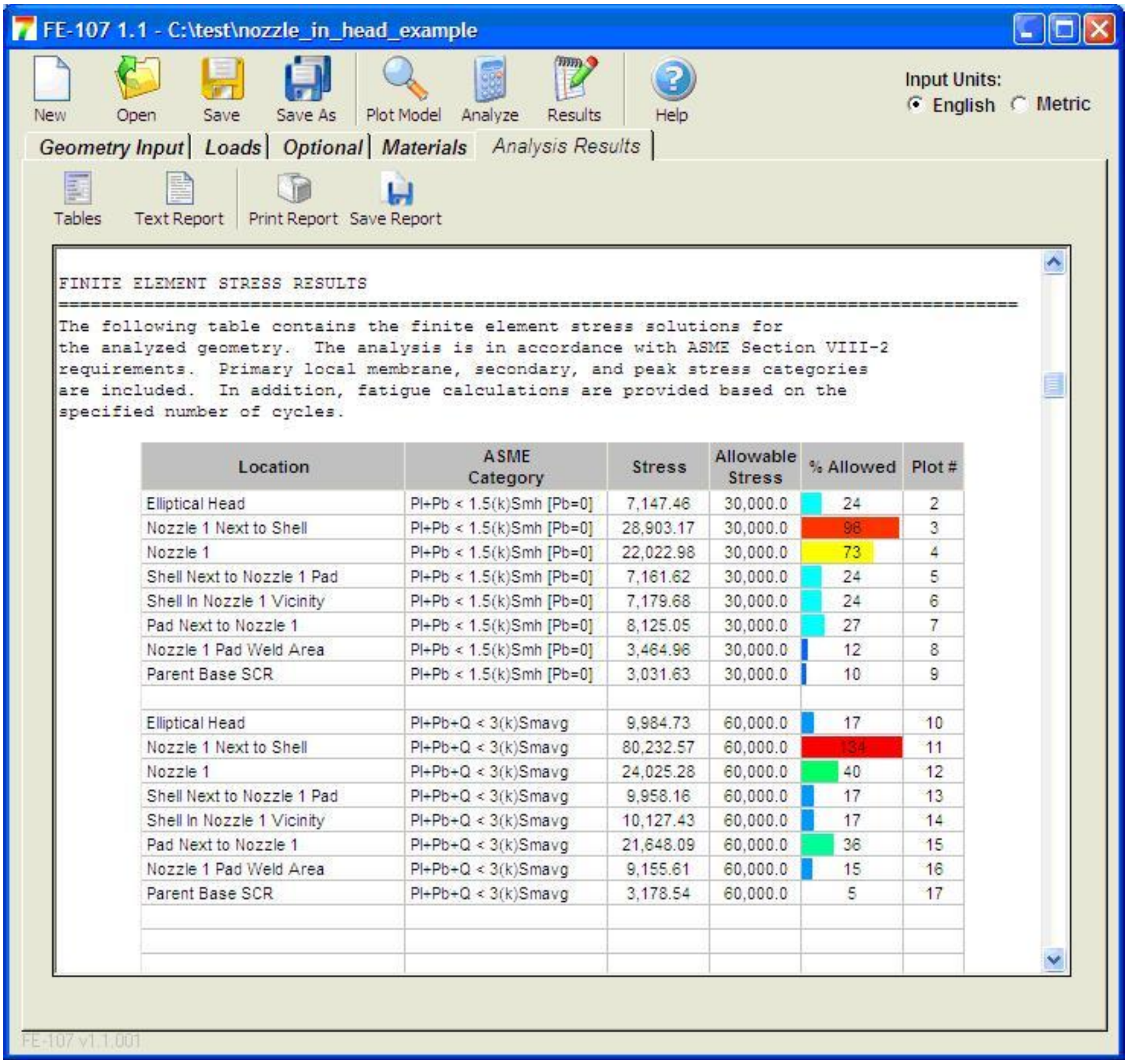
Experimental Validation shows that FE-107 Provides More Accurate Results than WRC-107

A text report is provided for documentation and distribution to clients and inspectors. The report includes drawings, dimensions, tabulated stresses, and graphical results (contd.)



FINITE ELEMENT STRESS RESULTS

The following table contains the finite element stress solutions for the analyzed geometry. The analysis is in accordance with ASME Section VIII-2 requirements. Primary local membrane, secondary, and peak stress categories are included. In addition, fatigue calculations are provided based on the specified number of cycles.

Location	ASME Category	Stress	Allowable Stress	% Allowed	Plot #
Elliptical Head	Pl+Pb < 1.5(k)Smh [Pb=0]	7,147.46	30,000.0	24	2
Nozzle 1 Next to Shell	Pl+Pb < 1.5(k)Smh [Pb=0]	28,903.17	30,000.0	96	3
Nozzle 1	Pl+Pb < 1.5(k)Smh [Pb=0]	22,022.98	30,000.0	73	4
Shell Next to Nozzle 1 Pad	Pl+Pb < 1.5(k)Smh [Pb=0]	7,161.62	30,000.0	24	5
Shell In Nozzle 1 Vicinity	Pl+Pb < 1.5(k)Smh [Pb=0]	7,179.68	30,000.0	24	6
Pad Next to Nozzle 1	Pl+Pb < 1.5(k)Smh [Pb=0]	8,125.05	30,000.0	27	7
Nozzle 1 Pad Weld Area	Pl+Pb < 1.5(k)Smh [Pb=0]	3,464.96	30,000.0	12	8
Parent Base SCR	Pl+Pb < 1.5(k)Smh [Pb=0]	3,031.63	30,000.0	10	9
Elliptical Head	Pl+Pb+Q < 3(k)Smavg	9,984.73	60,000.0	17	10
Nozzle 1 Next to Shell	Pl+Pb+Q < 3(k)Smavg	80,232.57	60,000.0	134	11
Nozzle 1	Pl+Pb+Q < 3(k)Smavg	24,025.28	60,000.0	40	12
Shell Next to Nozzle 1 Pad	Pl+Pb+Q < 3(k)Smavg	9,958.16	60,000.0	17	13
Shell In Nozzle 1 Vicinity	Pl+Pb+Q < 3(k)Smavg	10,127.43	60,000.0	17	14
Pad Next to Nozzle 1	Pl+Pb+Q < 3(k)Smavg	21,648.09	60,000.0	36	15
Nozzle 1 Pad Weld Area	Pl+Pb+Q < 3(k)Smavg	9,155.61	60,000.0	15	16
Parent Base SCR	Pl+Pb+Q < 3(k)Smavg	3,178.54	60,000.0	5	17

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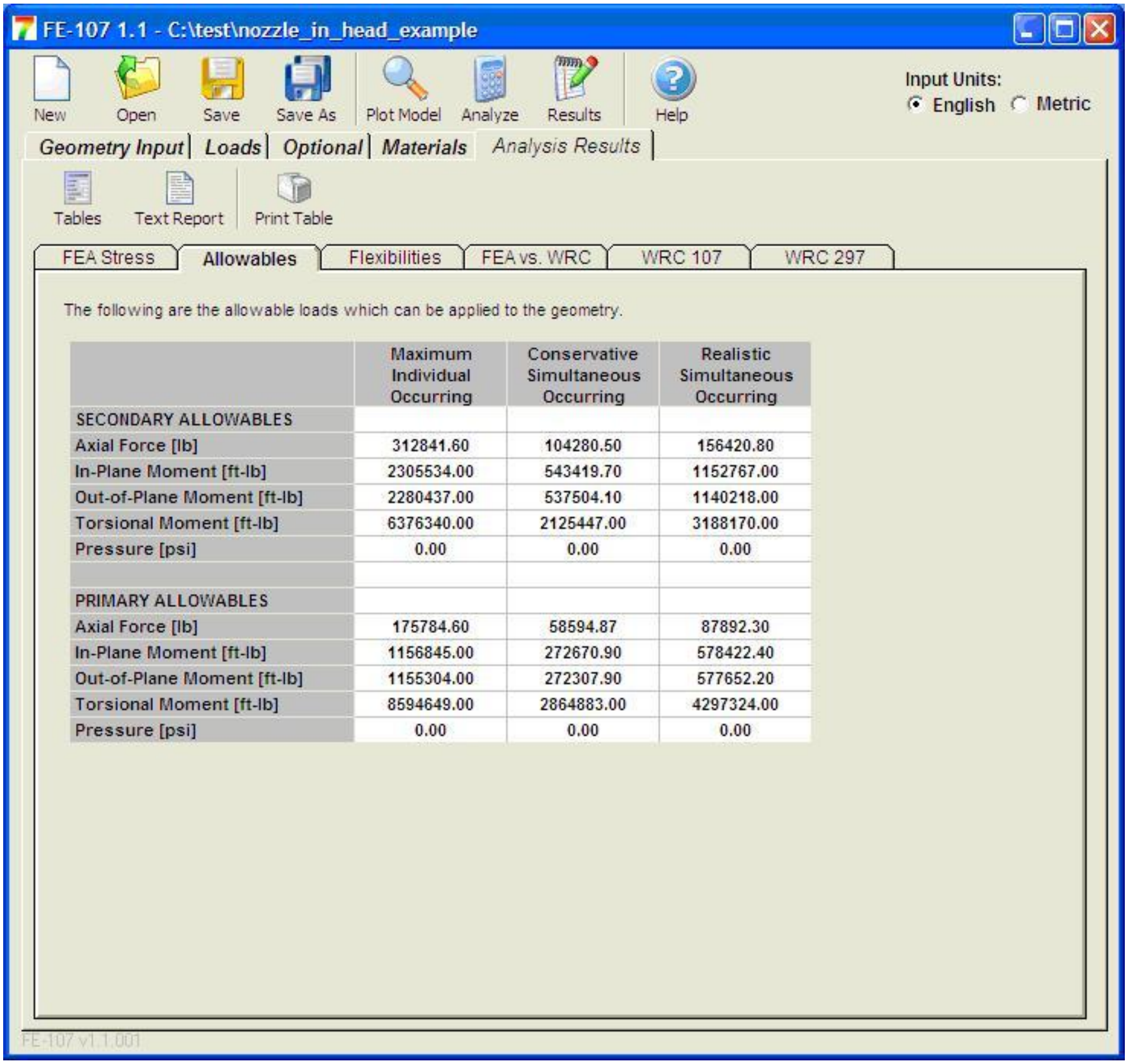
FE-107 also provides allowable loads and flexibility results for the nozzle. Flexibilities can be used by piping engineers for more accurate piping analysis.



	Maximum Individual Occurring	Conservative Simultaneous Occurring	Realistic Simultaneous Occurring
SECONDARY ALLOWABLES			
Axial Force [lb]	312841.60	104280.50	156420.80
In-Plane Moment [ft-lb]	2305534.00	543419.70	1152767.00
Out-of-Plane Moment [ft-lb]	2280437.00	537504.10	1140218.00
Torsional Moment [ft-lb]	6376340.00	2125447.00	3188170.00
Pressure [psi]	0.00	0.00	0.00
PRIMARY ALLOWABLES			
Axial Force [lb]	175784.60	58594.87	87892.30
In-Plane Moment [ft-lb]	1156845.00	272670.90	578422.40
Out-of-Plane Moment [ft-lb]	1155304.00	272307.90	577652.20
Torsional Moment [ft-lb]	8594649.00	2864883.00	4297324.00
Pressure [psi]	0.00	0.00	0.00

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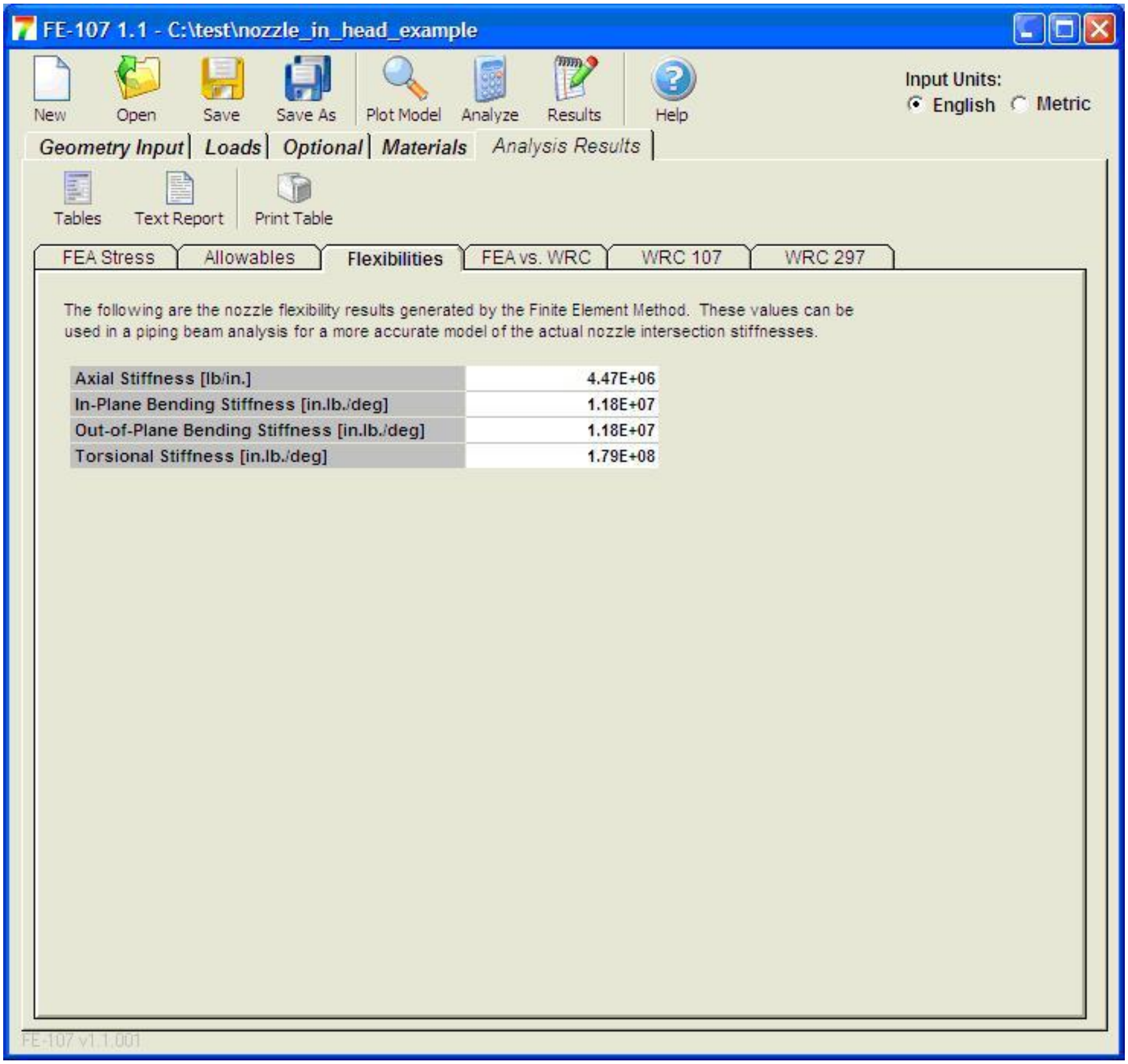

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Automatic comparisons between FE-107, WRC-107, and WRC-297 are given to show when the WRC methods are not appropriate.