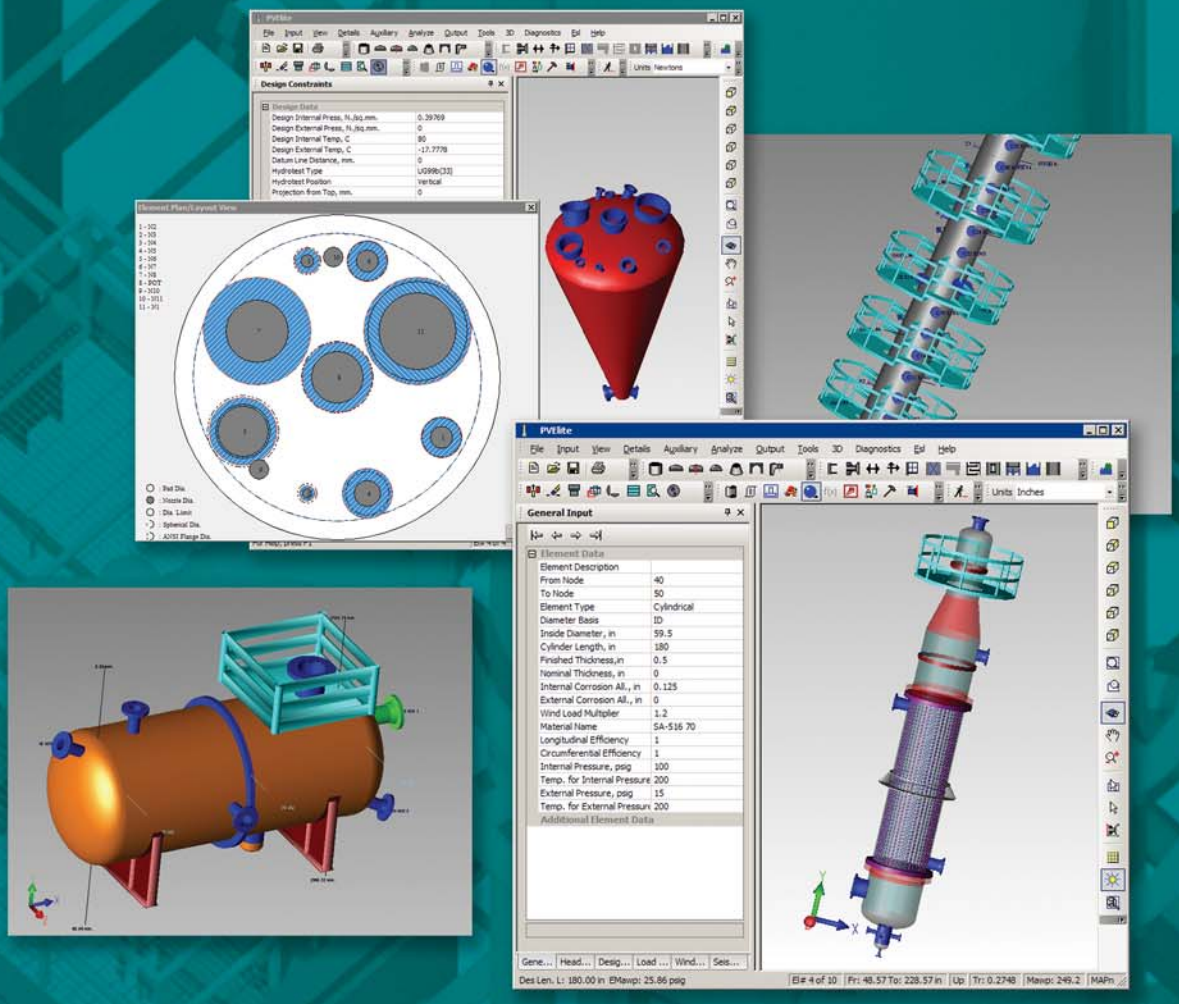
COADE®
ENGINEERING SOFTWARE

COADE PVElite®

Vessel and Exchanger Analysis



PV Elite: Rigorous Pressure Vessel Design and Evaluation Made Simple

PV Elite is a complete solution for the quick and comprehensive design of new pressure vessels for the process industry. PV Elite also evaluates and re-rates existing vessels including Fitness for Service analysis. The program considers the whole vessel, addressing all of the wall thickness rules and stress analysis requirements for vertical towers, horizontal vessels and heat exchangers. Or, individual pressure vessel components may be modeled and evaluated according to current safety codes.

PV Elite provides engineers, designers, estimators, fabricators and inspectors around the world with solutions that match their pressure vessel design requirements. Because the program is easy to learn and use, it is perfect for both full-time vessel designers and for those occasional users who require quick start up and confidence in their safety code calculations.

Whether it's a simple component check or a complete vessel design, PV Elite's input, analysis and output have been designed to be clear, accurate and concise.

PV Elite has the answer:

COMPLETE

PV Elite provides the most comprehensive mechanical design methods for the widest range of pressure vessel applications throughout the world.

EASY TO USE

Developing a model for evaluation is easy in PV Elite. Substantial interactive help is available throughout the process. Each step of the analysis is displayed as it occurs and output is clear and complete. Even for the occasional user, the process is easy.

ACCURATE

The program's 3D graphical representation of the vessel builds confidence in the accuracy of the model. Intermediate calculations clearly show the steps taken to derive the final results.

GLOBAL

PV Elite is popular around the world because it incorporates international standards and includes a great quantity of localized data.

RELIABLE

The program has been proven reliable by many years of real world use and through constant updates and enhancements. Users everywhere have confidence in the program and the results it provides.

UP-TO-DATE

PV Elite is updated annually to include the latest rules in vessel codes and standards and to offer the latest technologies available. You know you are always up-to-date with PV Elite.

PV Elite provides the following capabilities—right out of the box!

Extensive Content

- Vessel and Component Design Codes
- Local Wind and Seismic Standards
- Extensive Material Databases
- Structural Steel Databases
- Default and Carry-forward Data

Structured Data Collection

- Input Organization
- General Vessel Categories
- Defining the Vessel through Elements
- Completing the Elements with Details
- Standalone Vessel Components
- Model Display

Vessel Analysis

- Continuous On-the-fly Analysis
- Rigorous Structural Load Sets
- Design, Evaluate and Re-rate Modes
- Wall Thickness for Pressure
- Wall Thickness for Total Load
- Fitness for Service Assessment
- Special Analysis

Individual Component Evaluation

- Shells and Heads
- Conical Sections
- Nozzles
- Flanges
- Nozzle Loads
- Base Rings
- Saddles
- Vessel Attachments
- Tubesheet and Flanged Extension
- Floating Heads
- Flanged and Flued Expansion Joints
- Metal Bellows Expansion Joints
- Fabricated Piping Intersections
- Rectangular and Non-circular Vessels
- Large Openings in Flat Heads
- Half-pipe Jackets on Cylindrical Shells

Results Presentation

- Design Mode Control
- Complete Calculation Reports
- Equations with Substitutions
- Design Drawings

Links to Design and Analysis Packages

Extensive Content

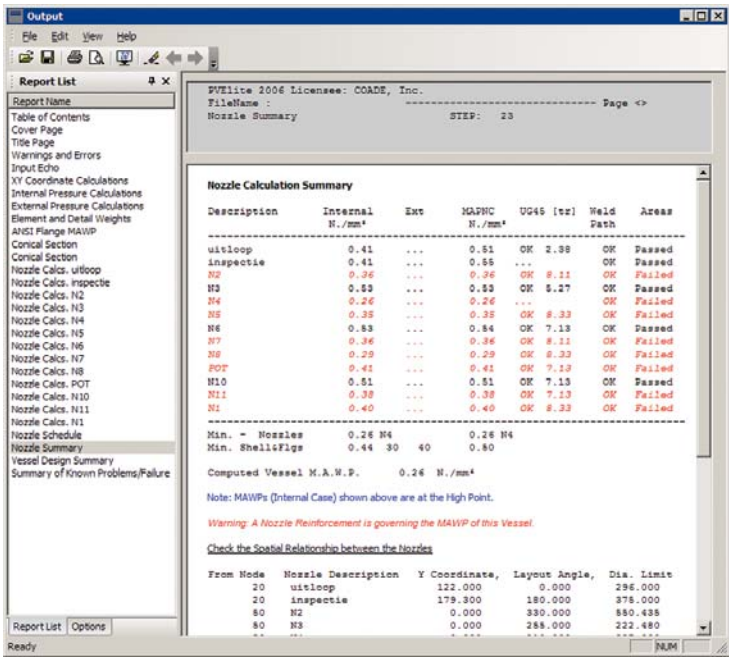
PV Elite includes a wealth of localized content to address most any vessel project. Most obvious is its application of the design rules and criteria of the world's major pressure vessel safety codes. Tables of local wind and seismic load data are ready for use in these analyses. And, detailed material and structural steel specification is simplified through database selection. Units of measure, nominal pipe sizes, flange classes and even bolt sizes can be customized to suit your needs. It is easy to turn this commercial package into a customized tool for your own application.

Vessel and Component Design Codes
PV Elite keeps pace with worldwide vessel design codes and standards, incorporating code changes as they become mandatory. All of the major codes and standards are included.

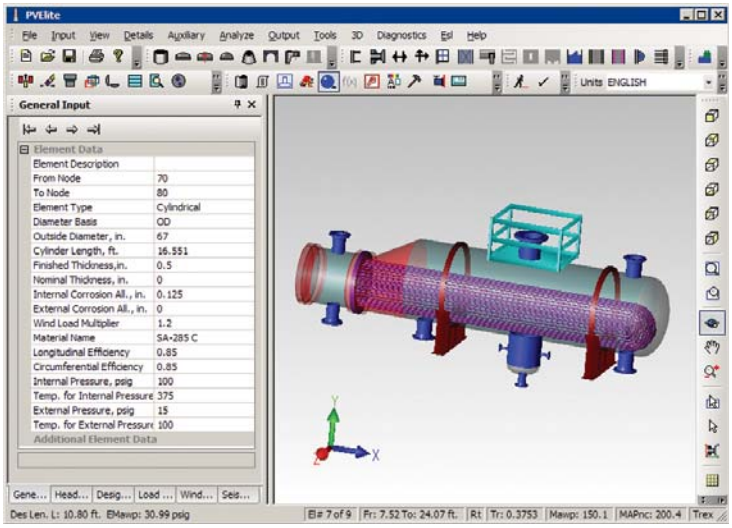
- European Norm (EN) 13445 rules for the analysis of unfired pressure vessels.
- ASME BPV Code Section VIII, Divisions 1 & 2 for the design and analysis of vessels and heat exchanger components.
- British Standard PD 5500 guidelines for the analysis of unfired fusion welded pressure vessels, heat exchanger components and tubesheets.
- ASME/ANSI B16.5 and B16.47 standards for pipe flanges and flanged fittings, including equivalent pressure due to applied loads plus pressure ratings for flanges from the DIN standard.
- ASME Section UHX, PD 5500 and Tubular Exchanger Manufacturers Association (TEMA) standards for designing and analyzing tubesheets and expansion joints in heat exchangers.
- ASME B31.3 rules for replacing area around fabricated tees.
- ASME STS code for stack analysis.
- Welding Research Council (WRC) Bulletins 107, 297, 368 and PD 5500 Annex G rules for calculating local stresses in and around vessel attachments (lugs and nozzles).

Local Wind and Seismic Standards
Many regional building codes define the magnitude and application of wind and earthquake loads for their jurisdictions. These load tables can be entered explicitly or, as a convenience, they can be selected from a standards database. Wind and/or seismic data can be selected for:

- Australia & New Zealand
- Canada (NBC)
- Europe
- India
- Mexico
- United States (ASCE 7 , UBC, IBC)
- UK (BS 6399)



Clear, Concise Output
The output from PV Elite is easy to read, review and understand. It is also color coded showing problem areas at a glance.



Heat Exchanger Analysis
PV Elite can model and analyze a variety of heat exchangers, vertical or horizontal.

Extensive Material Databases
Proper specification of material data—such as allowable stress versus temperature, yield stress versus temperature, external pressure charts, UNS number and product form—is a critical step in pressure vessel design.

PV Elite features material libraries from around the world and offers easy selection of over 3600 materials. PV Elite lists these properties just as they appear in their respective codes, all sorted alphabetically for quick search and selection. You can view all properties for a selected material at the click of a button. A database editor allows you to permanently add special materials or materials from other codes to the standard database for future use in model creation.

Structural Steel Databases
Leg supports and stiffening rings for pressure vessels are made of structural steel, and proper definition of the steel size and shape is important in designing the vessel. As structural steel shapes and sizes vary around the world, PV Elite includes the details for the national standards of:

- Australia
- Germany
- India
- Japan
- Korea
- North America
- South Africa
- UK

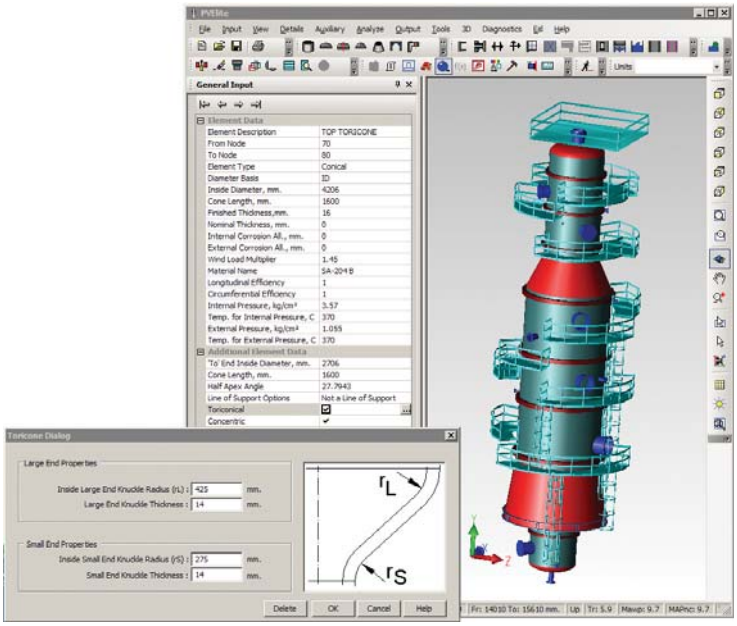
Default and Carry-forward Data
PV Elite eliminates errors and data search by offering a selection of standard values from common datasets.

PV Elite offers input for units of measure (U.S. Customary, S.I., and User-defined), pipe size and schedule and flanges by class. The program will also carry-forward entered data from one element to the next including shell diameter, finished thickness, corrosion allowance, temperatures, pressures and vessel material.

Structured Data Collection

PV Elite's input processor is organized to collect data to design, analyze and evaluate a wide range of pressure vessels and individual pressure components. As construction proceeds, PV Elite displays a 3D model to confirm the model layout. At the touch of a button, online help is always available with code references, illustrations and input recommendations.

Logical Input Organization
PV Elite segments the large amount of input into logical groups, each in its own section. Obviously, the section holding the vessel model is primary to the input. The general control of the analysis—the vessel code to apply, selecting new design versus re-rate (setting the wall thickness versus resetting the MAWP), setting the hydrotest position—is set in the *Design Constraints* tab. The comprehensive list of vessel loads consisting of various combinations of pressure, weight and wind or seismic loads can be manipulated in the *Load Cases* tab. Other sections hold the specification of wind loads, seismic loads and other selections.



Vertical Vessel Analysis
Vessels of all sizes and configurations can be modeled, including those types that have intermediate skirts.

General Vessel Categories
Pressure vessels fall into two categories—horizontal and vertical. Each vessel type has its own special considerations and PV Elite addresses these for both. For example, saddle supports are integral to horizontal vessels while leg and skirt supports are found on vertical vessels. The PV Elite input processor identifies these categories and collects the appropriate data. Vertical vessels may also include intermediate heads (to build stacked vessels) and horizontal vessels may include eccentric reducers (to model kettles).

Vessels identified as heat exchangers can include all of the major mechanical details found in those units. This integrated approach produces a complete set of calculations in accordance with ASME Part UHX, TEMA or PD 5500. Fixed, floating and U-tube arrangements can be included in the tubesheet evaluation. Components such as expansion joints and floating heads will also be analyzed. The heat exchanger can then be assessed for a variety of structural loads such as start-up, shut-down and hydrotest conditions.

Defining the Vessel through Elements
In PV Elite, all vessels can be quickly modeled from a basic set of elements. PV Elite collects these general data to build the vessel structure. These elements hold data such as material, temperature, pressure and diameter and are assembled as horizontal or vertical vessels. Elements include:

- Cylindrical shells
- Elliptical, spherical, torispherical, conical and flat heads
- Conical sections (including those with knuckles)
- Body flanges (standard and custom)
- Skirts with base ring details

Completing the Elements with Details
Details are added to each of these elements to finish out the vessel model. These details set the total weight of each element and also highlight other design and analysis concerns for the vessel. Details include:

- Stiffening rings*
- Nozzles and flanges*
- Applied forces and moments
- Platforms
- Trays and packing
- Saddles, legs and lugs*
- Fluid
- Insulation and lining
- Tubesheets*

* *PV Elite will also analyze and evaluate these details.*

Standalone Vessel Components
Vessel elements and details need not be assembled into a complete vessel to be evaluated. Individual components can be modeled alone or in groups (as in a group of flanges) for analysis. Also, PV Elite addresses special vessel components such as rectangular vessels, half-pipe jackets and fabricated pipe intersections here.

Visual Model Display
As the vessel is built, a rendered 3D presentation of the vessel model is displayed as each major element is added. The graphic includes vessel details throughout the model. By clicking on the element or detail, PV Elite will display the input data for that component. You can also drag and drop a detail to another location in the model and the graphical display updates instantly along with the data for that item. Other important geometries such as base ring layout and nozzle orientation are also displayed as their input is collected.

PV Elite's 3D graphic presentation validates the integrity of the model at any time during the design. You can turn the 3D model in any direction. Choose a 3D cutaway to see internal components, all of which are to scale. This presentation is a great help in identifying potential mistakes during the input data phase, thus saving time, money and potential problems downstream.

The 3D image can be saved and distributed as HTML, providing full graphic manipulation to the recipient.

Vessel Analysis

PV Elite performs all the calculations necessary for the stress analysis of vertical columns, horizontal vessels and heat exchangers.

Continuous, On-the-fly Analysis
PV Elite provides continuous, real-time calculations during the input session. As you construct or change an element, critical results are immediately displayed. The status bar shows the element's required thickness for both internal and external pressure, MAWP and maximum allowable pressure in the new and cold condition (MAPnc). This allows for quick on-screen "what if" calculations at any time during the design and highlights input errors. Similar intermediate results are displayed during the entry of nozzles and stiffening rings.

Rigorous Structural Load Sets
PV Elite evaluates the response of the vessel to a comprehensive list of possible load sets provided by the program. These loads are defined by the user and can have a pressure term, a weight term and a horizontal load term:

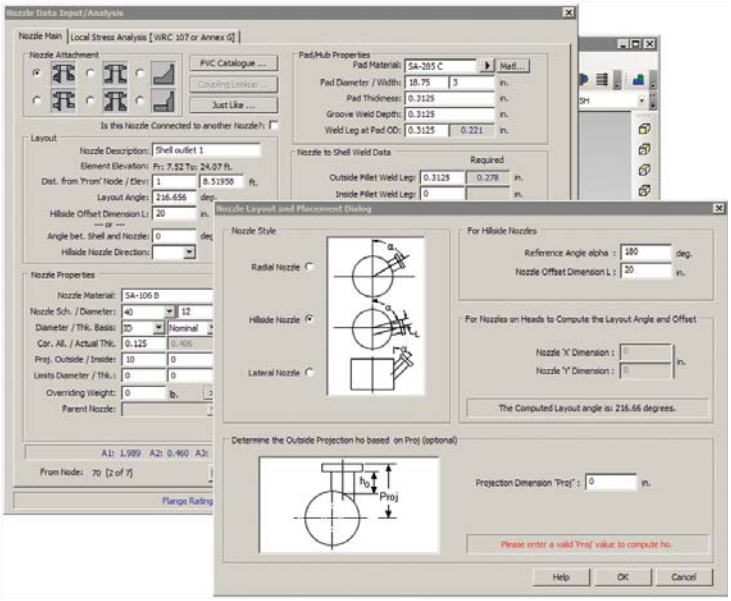
- Pressure – internal, external and hydrostatic
- Weight – new or corroded
- Horizontal – wind (including vortex shedding) and seismic

Design, Evaluate and Re-rate Modes
For a new vessel, PV Elite can identify the critical load condition for each element and set its required shell thickness. To confirm an existing vessel design, the program can simply check all existing thicknesses and stresses. To re-rate a vessel in service, you need only update the measured corrosion allowance or change the temperature and pressure requirements, and PV Elite will re-calculate the vessel's MAWP, including attached flanges.

Wall Thickness for Pressure
Establishing wall thickness is a basic task of the pressure vessel designer, and PV Elite determines required element wall thicknesses for internal pressure. To address external pressure, PV Elite also considers total unsupported shell length and strength of stiffener rings in setting wall thickness.

Wall Thickness for Total Load
Vessel elements experience more than simple pressure loads, so PV Elite will also consider overall vessel wall stresses due to the many combinations of 1) pressure (internal, external or test), 2) deadweight (erected, operating or hydrostatic test conditions), and 3) wind or earthquake loads. PV Elite sums the weights of each element and all its details to calculate the compressive stresses in the vessel wall. The program also analyzes the effects of bending due to wind and seismic loads. By basing these stress calculations on the total structural load, PV Elite ensures sufficient wall thickness for the vessel in its operating environment and proper design of the vessel supports.

Fitness for Service Assessment
PV Elite uses the API 579 approach to determine remaining operational life of pressure vessels. Taking into account the current corroded condition of the vessel, the current MAWP and the corrosion rate, PV Elite can estimate the remaining life of the unit. Where flaws are excessive, PV Elite will also compute the de-rated MAWP of the component as it currently exists.



Interactive Calculations
For many items such as nozzle design, PV Elite performs calculations as the data is typed in, allowing "what if" scenarios to be explored quickly.

Special Analysis
PV Elite performs a variety of other important calculations for evaluating vessels. These include:

- Zick analysis (horizontal drums on saddle supports)
- Natural frequency calculations and modal seismic analysis
- Critical wind speed calculations
- Wind loads due to vortex shedding
- Area and moment of inertia checks for cone reinforcement and stiffening rings
- Local shell stresses at nozzles and attachments
- Fatigue analysis of openings (e.g. nozzles) per ASME, EN 13445 and PD 5500
- Rigging analysis when the vessel is to be erected
- Thick wall (flanged and flued) expansion joints on heat exchangers
- Influence of test position on hydrotest pressure
- Evaluation of large openings in flat heads

Individual Component Calculations**

With PV Elite, you can easily analyze individual components without having to create a complete vessel model. Quick checks of individual vessel components address the following:

** *These individual component calculations are also offered as a stand-alone package in COADE's CodeCalc program.*

Shells and Heads
MAWP or the required thickness for a specified internal or external working pressure, Appendix 9 for jackets and vessels, and the API 579 capability for calculating vessels that have an identified flaw.

Conical Sections
MAWP, the thickness required for specified internal or external working pressures and the discontinuity stresses at cone-to-cylinder junctures.

Nozzles
Area of replacement, minimum design metal temperature, minimum neck thickness, weld strength, minimum weld size, large nozzle and hillside calculations.

Flanges
Required thickness, MAWP and code-defined stresses using ASME Section VIII - Appendices 2 and Y for stress and rigidity calculations.

Nozzle Loads
Local stresses due to external loads according to WRC Bulletins 107, 297, and 368 as well as PD 5500 Annex G. Allowable stresses are also computed.

Base Rings
Required thickness of the gusset, skirt and annular baseplates due to wind or seismic moments and the local stress and required thickness of the top plate.

Saddles
Stresses at key points on the vessel and saddles for various conditions, including wind and seismic loads, using Zick Analysis.

Vessel Attachments
Stresses on legs, supporting lugs, trunnions and lifting lugs taking into account their allowable limits and stresses on cap type and continuous top support rings (girder rings).

Tubesheet and Flanged Extension
Required thickness using TEMA, ASME or the PD 5500 method and allowable tube stresses, tube-to-tubesheet joint loads and allowable loads.

Floating Heads
Required head thickness and resulting flange bending moments per ASME Section VIII, Division 1, Appendix 1 for floating heads under internal or external pressure.

Flanged and Flued Expansion Joints
Stress, cycle life and spring rate in accordance with ASME Section VIII, Division 1 and TEMA Standards.

Metal Bellows Expansion Joints
Stress and cycle life for both reinforced and non-reinforced bellows per ASME Section VIII, Division 1, Appendix 26.

Fabricated Piping Intersections
Required thickness due to internal pressure, required and available area of reinforcement and MAWP according to ANSI B31.3.

Rectangular and Non-circular Vessels
MAWP and stress, including stayed or reinforced geometry, per ASME Section VIII, Division 1, Appendix 14.

Large Openings in Integral Flat Heads
Stresses and allowable stresses based on ASME Section VIII, Division 1, Appendices 2 and 14.

Half-pipe Jackets on Cylindrical Shells
Required thickness and MAWP based on ASME Section VIII, Division 1, Appendix EE.

Results Presentation

Continuous Design Mode Control
PV Elite will interrupt the analysis output when a thickness change is indicated and request the user's confirmation of the design change. Upon continuation, previous analysis steps will be rerun with the new data (e.g. vessel weight). Reports will clearly indicate program-generated design modifications.

Complete Calculation Reports
PV Elite compiles output into a set of logical calculation groups. Major groups include an input echo and an accounting of all weight followed by thickness/stress results for the internal pressure, external pressure and structural load calculations. Reports are tabulated on an element-by-element basis and clearly identify the intermediate steps that produced the end results. Summaries gather overall results such as vessel MAWP (including attached flanges), nozzle schedule, total weight and a bill of materials. Color-coding highlights trouble spots. The level of report detail can be controlled by the user, and the output can be sent directly to Microsoft Word.

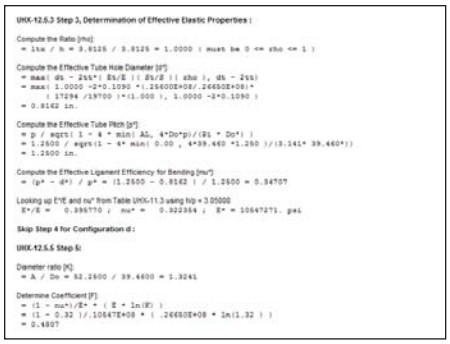
Equations with Substitutions
PV Elite will not only quote the source of safety code equations (e.g. wall thickness calculation) but also print out the equation used and replace parameters with actual data from the analysis. This is a great source of fabrication documentation for the inspector.

Design Drawings
Reports may be augmented with vessel plots including PCX and DXF file formats. Vessel and component drawings direct from PV Elite provide a quick starting place for the designer, saving both time and money.

Links to Design and Analysis Packages

PV Elite provides links that allow vessel designers and engineers to pass design and analysis data between these packages with no data loss:

- **Plant Design (CAD):** CADWorx Equipment
- **Finite Element Analysis:** Nozzle Pro
- **Thermal & Process Design:** Xist
- **Foundation Design:** Foundation3D
- **Fabrication:** ProFab
- **Inspection/Maintenance:** Visions Enterprise



Clear Reports
Output includes code formula references with numbers inserted into the equations.

Support

Comprehensive Online Support: Get quick and accurate answers to technical support questions at the touch of a button.

Dedicated Technical Support from COADE: Technical support at COADE is provided by trained and experienced product developers and programmers who are employees of COADE. This ensures the most complete and personalized software support, exactly when you need it and by a person who understands your specific needs.

Constant Development: Like all COADE products, PV Elite is continually updated as codes and standards change. Other enhancements are made with each release to ensure PV Elite continues to be the best solution for vessel design and evaluation.

System Requirements:

- Microsoft Windows (2000, XP Pro or later) Operating System
- Microsoft Internet Explorer (6.0 or later)

PV Elite Licenses:

All software licenses provide the following as standard:

- Complete program
- One complete set of program manuals
- Online technical newsletter
- Phone, fax, web site and e-mail access for technical support

Full License provides:

- Perpetual single license with no limit on the amount or duration of use
- One full year of automatic upgrades from date of purchase
- Eligibility for annual extensions of automatic upgrades
- Eligibility for discounts on additional Full License purchases

Monthly Lease provides:

- Full License copy on a monthly rental basis
- Option to apply first month lease when converting to a Full License purchase

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TECHSOFT3D

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