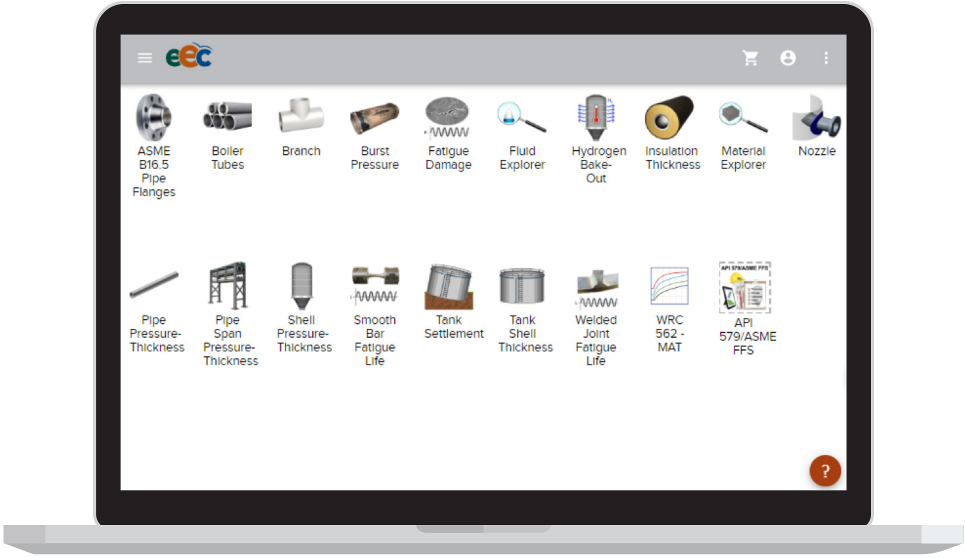
PlantEngineer Suite



The **eec** PlantEngineer Suite includes:

API 579/ASME FFS

This provides a complete set of WebTools for conducting a fitness-for-service assessment. Each Part (3 through 14) of API 579 is included as a separate WebTool. The WebTools incorporate the most recent updates to API 579 and offer numerous features, including an intuitive user interface, a clear organization of results, modern graphics, formatted printable PDF reports, the ability to save and load assessments, easy access to help, and much more.

ASME B16.5 PIPE FLANGES

The pressure-temperature rating for a standard flange manufactured in accordance with ASME B16.5 or B16.47 is determined using this software. The pressure-temperature rating is performed according to a specific edition of ASME B16.5 and B16.47. A materials database for these codes is provided. The three options are as follows:

- **Option 1** – Given a pressure, temperature, and material of construction, the required ASME flange class is determined.
- **Option 2** – Given a flange class, pressure, and material of construction, the maximum temperature is determined.
- **Option 3** – Given the flange class, temperature, and material of construction, a maximum pressure is determined.

BOILER TUBES

This function determines boiler tube thickness and MAWP calculations in accordance with ASME B&PV Code, Section I code calculations for boiler tubes. A materials database for these codes is provided. The two options are as follows:

- **Design Option** – Given the geometry, materials of construction, design pressure, and design temperature, the required thickness and recommended nominal thickness are determined.
- **In-Service Option** – Given the geometry, materials of construction, nominal thickness, design pressure, design temperature, metal loss, and corrosion allowance, the retirement thickness and MAWP are determined.

SMART TECHNOLOGY.

BRANCH

Branch reinforcement calculations for integrally and pad-reinforced fabricated connections (i.e., run pipes and headers) are performed in accordance with ASME B31.1, B31.3, B31.4, and B31.8 Piping Codes for power, process, liquid transportation, and gas distribution piping, respectively. A materials database for these codes is provided. The two options are as follows:

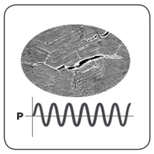
- **Design Option** – Given the geometry, materials of construction, design pressure, and design temperature of the run pipe (header) and the branch pipe, the branch design reinforcement requirements are determined.
- **In-Service Option** – Given the geometry, materials of construction, design temperature, metal loss, and corrosion allowance of the run pipe (header) and the branch pipe, the branch MAWP (MAOP) is determined.

BURST PRESSURE

This function calculates the burst pressure or a thickness that will result in a burst given a pressure for a cylinder and a sphere based on the analysis procedure developed by Svensson [1]. Svensson's method is applicable to the full range of radius to wall thickness ratios (i.e., both thick and thin cylindrical and spherical shells may be analyzed). Svensson's method makes use of a stress-strain model that includes the effects of strain hardening. The material model used is the Prager stress-strain curve model [2]. A materials database is provided. The two options are as follows:

- **Option 1** – Given the geometry, materials of construction, and temperature, the burst pressure is determined.
- **Option 2** – Given the geometry, materials of construction, and temperature, the thickness that will result in a burst for a specified pressure is determined.

[1] Svensson, N.L., The Bursting Pressure of Cylindrical and Spherical Shells, Pressure Vessel and Piping Design, Collected Papers 1927-1959, ASME, New York, NY, 1960, Pages 326-333.
[2] Osage, D.A. and Sowinski, J., "ASME Section VIII Division 2 Criteria and Commentary," ASME PTB-1, The American Society of Mechanical Engineers, New York, NY.



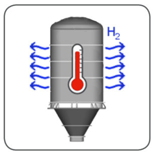
FATIGUE DAMAGE

This tool estimates cumulative fatigue damage for a user-specified stress-strain history. Fatigue damage is caused by repeated stress or strain cycling of a material and leads to damage such as incremental crack growth and plasticity. The methods employed here involve elastic and elastic-plastic analyses, plasticity correction methods, uniaxial and multiaxial cycle counting methods, and fatigue damage assessment procedures for both smooth bar and welded joint specimens. The available methods are those found in both API 579-1/ASME FFS-1 *Fitness-For-Service* and ASME Section VIII Div. 2 Design codes, as well as E^2G's own customized procedures based on the popular and widely accepted strain-life fatigue methods. The API 579-1/ASME FFS-1 *Fitness-For-Service* and ASME Section VIII Div 2. Design methods include Level 2 smooth bar assessments using alternating stress and a Level 2 welded joint method using structural stress. The API 579 approach also includes a Level 3 assessment method that uses a critical-plane, strain-life approach for either elastic or elastic-plastic stresses. The "Fatigue by E^2G" methods determine both uniaxial and multiaxial strain-life for both elastic and elastic-plastic stress solutions and also provide the option of using the structural stress method for welded joint specimens.

FLUID EXPLORER

The fluid explorer app predicts the thermodynamic and transport properties of a multi-component fluid mixture based upon the properties of its distinct molecular components using a cubic equation of state method. A database of over 1,800 pure components is available to choose from when building the mixture. This database contains many temperature-dependent correlations for the thermodynamic, transport, toxic, and flammable properties of each component. The user can select from the following thermodynamic calculations once the fluid mixture is defined (the combined properties of the mixture at the final state are provided):

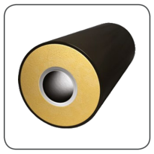
- Isothermal flash to a specified pressure
- Isenthalpic flash to a specified pressure
- Isentropic flash to a specified pressure
- Bubble point temperature for a given pressure
- Bubble point pressure for a given temperature
- Dew point temperature for a given pressure
- Dew point pressure for a given temperature



HYDROGEN BAKE-OUT

Determine the time required for a hydrogen bake-out operation at a user-specified temperature to ensure that the remaining hydrogen concentration in the vessel wall is no greater than a user-specified maximum value. Cylindrical and spherical vessels may be analyzed. The materials of construction may be specified as carbon steel or a low chrome alloy steel. The shell may include a Type 300 series stainless steel, an internal cladding or weld overlay, or a Type 410 cladding. A transient diffusion analysis is performed and the hydrogen concentration in the vessel wall is determined as a function of the shutdown time cycle.

When welding onto hydrogen-charged steel, hydrogen in the vessel wall increases the risk of cracking due to hydrogen embrittlement as the weld metal cools and higher levels of residual stress are induced in the weld region. To reduce this risk, atomic hydrogen present in the steel should be baked-out prior to welding. This is accomplished by heating the steel to a temperature for a sufficient period of time to allow the absorbed hydrogen to diffuse back out of the steel. Heating is required because both the diffusivity and solubility of hydrogen in steel are rapidly increasing functions of temperature.

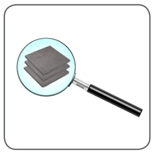


INSULATION THICKNESS

Determine the insulation thickness of a cylindrical or spherical component based on one of the following criteria:

- » Economic thickness
- » Personnel protection
- » Energy conservation
- » Condensation control

Insulation thickness tables are also generated that show insulation thickness requirements for different diameters. These calculations are based on the data provided by the Gas Processors Suppliers Association (GPSA) data book.



MATERIAL EXPLORER

Access to E²G's extensive material database for materials typically used in the construction of pressure vessels, piping, and tankage is provided. The database includes:

- » Material physical properties – Young's Modulus, thermal expansion coefficient, thermal conductivity, and thermal diffusivity as functions of temperature
- » Strength parameters – yield and tensile strength as functions of temperature
- » Allowable design stresses as a function of temperature – allowable stress may be determined based upon a specific year of the code shown below.
    - ASME Boiler and Pressure Vessel Code Section I, Section VIII, Divisions 1 and 2
    - ASME B31 Piping Codes B31.1, B31.3, B31.4, and B31.8
    - API 620, API 650, API 653

The above properties are determined for a specified input temperature. Supplemental output, including tables and graphs of material properties as functions of temperature, is also provided.

NOZZLE

The Nozzle WebTool can be used to evaluate nozzle reinforcement and nozzle weld strength requirements for nozzles located in ASME Section I and ASME Section VIII, Divisions 1 and 2 pressure vessels subject to internal or external pressure. A materials database for these codes is provided. The two options are as follows:

- » **Design Option** – Given the geometry, materials of construction, design pressure, and design temperature of the shell (head) and the nozzle, the nozzle design reinforcement requirements are determined.
- » **In-Service Option** – Given the geometry, materials of construction, design temperature, metal loss, and corrosion allowance of the shell (head) and the nozzle, the nozzle MAWP (MAOP) is determined.

The applicable shell (head) types include:

- » Cylindrical shells
- » Spherical shells
- » Ellipsoidal heads
- » Torispherical heads
- » Conical shells

PIPE PRESSURE-THICKNESS TOOL

Piping thickness, MAWP (MAOP), and MDMT calculations are determined for straight pipe, elbows, and miter bends in accordance with ASME B31.1, B31.3, B31.4, and B31.8 Piping Codes for power, process, liquid transportation, and gas distribution piping, respectively. A materials database for these codes is provided. Supplemental loads (i.e., forces and moments) may be specified. The two options are as follows:

- **Design Option** – Given the geometry, materials of construction, design pressure, design temperature, and supplemental loads, the required thickness, recommended nominal thickness, and MDMT are determined.
- **In-Service Option** – Given the geometry, materials of construction, nominal thickness, design temperature, supplemental loads, metal loss, and corrosion allowance, the retirement thickness, MAWP (MAOP), and MDMT are determined.

PIPE SPAN PRESSURE-THICKNESS

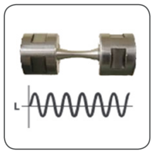
Calculations to determine the required thickness or MAWP (MAOP) of a pipe span are performed such that a user-specified maximum deflection and slope are not exceeded. Calculations are performed in accordance with the ASME B31.1, B31.3, B31.4, and B31.8 Piping Codes. A materials database for these codes is provided. Concentrated loads can be included and adjusted to model flange junctions, valves, and the weight of a person. Distributed loads automatically included in the calculations are the weight of the pipe, insulation, and fluid contents. Longitudinal, circumferential, and stress at the supports are computed, in addition to pipe properties including metal cross-sectional area, section modulus, moment of inertia, and weight. In the weight calculation, the additional weight due to insulation, refractory, and the fluid is accounted for. If refractory properties are input, a modified moment of inertia is computed to model the increase in stiffness due to the specified refractory thickness and its modulus of elasticity. The two options are as follows:

- **Design Option** – Given the geometry, materials of construction, design pressure, design temperature, and applied loadings, the required thickness and recommended nominal thickness are determined.
- **In-Service Option** – Given the geometry, materials of construction, design pressure, design temperature, and applied loadings, the retirement thickness is determined.

SHELL PRESSURE-THICKNESS

Pressure vessel thickness, MAWP, and MDMT calculations are determined for cylindrical shell, conical shell, sphere, elliptical head, torispherical head, and elbow in accordance with the ASME B&PV Code, Section VIII, Divisions 1 and 2. A materials database for these codes is provided. The two options are as follows:

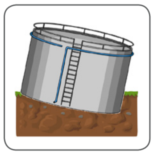
- **Design Option** – Given the shell geometry, materials of construction, design pressure, and design temperature, the required thickness, recommended nominal thickness, and MDMT are determined.
- **In-Service Option** – Given the shell geometry, materials of construction, nominal thickness, design pressure, design temperature, metal loss, and corrosion allowance, the retirement thickness, MAWP, and MDMT are determined.



SMOOTH BAR FATIGUE LIFE

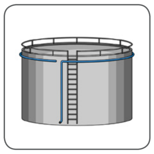
Predict the probability of fatigue failure for smooth bar specimens under known or relatively constant operating conditions. The calculations are based on the smooth bar methods that are included in both API 579-1/ASME FFS-1 *Fitness-for-Service* and ASME Section VIII Div. 2 codes. The smooth bar fatigue life is predicted using an alternating stress that is calculated from either linear elastic stresses (API 579-1 Method 2A and ASME Section VIII Div. 2 Equivalent Stress Method) or elastic-plastic strains (API 579-1 Method 2B and ASME Section VIII Div. 2 Equivalent Strain Method).

A Monte-Carlo sampling method is used to estimate the probabilistic fatigue life using a default of 20,000 random samples of the input random variables. All input parameters are assumed to be normally distributed random variables, while all calculated variables and the resulting fatigue life distribution make no assumptions about the distribution type (empirical PDFs and CDFs are determined). From the probability of fatigue failure distribution, more confident decisions can be made about extending the life cycle of smooth bar components with different levels of confidence.



TANK SETTLEMENT

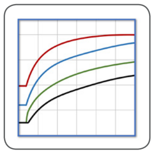
The Tank Settlement WebTool is used to evaluate the effects of bottom settlement in aboveground storage tanks per Annex B of API 653. Three types of settlement are available for analysis: shell settlement, edge settlement, and localized bottom settlement. Shell settlement is the sum of uniform and differential vertical displacement of the tank shell about a plane of rigid tilt, occurring around the circumference of the tank. Edge settlement is the vertical displacement of the tank bottom from the periphery of the tank shell. Localized bottom settlement is vertical displacement of a local region of the tank bottom away from the tank shell. By implementing procedures described in API 653 Annex B, the Tank Settlement WebTool can be used to determine the damage margin for each type of settlement.



TANK SHELL SETTLEMENT

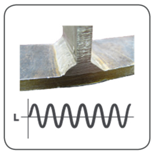
The Tank Shell Thickness WebTool can be used to evaluate aboveground storage tanks considering sustained loading. Only the tank shell courses are included in the evaluation. The references for the analysis procedures currently implemented in the Tank Shell Thickness WebTool are listed below:

- API 650 – API Standard 650, *Welded Tanks for Oil Storage*, Twelfth Edition, 2013.
- API 620 – API Standard 620, *Design and Construction of Large, Welded, Low-Pressure Storage Tanks*, Twelfth Edition, 2013.
- API 653 – API Standard 653, *Tank Inspection, Repair, Alteration, and Reconstruction*, Fifth Edition, 2014.



WRC 562-MAT

Determine the WRC 562 – Minimum Allowable Temperature (MAT) (i.e., the lowest [coldest] permissible metal temperature) for a given material and thickness based on its resistance to brittle fracture using the Wallin Fracture toughness Master Curve. The MAT is determined in accordance with WRC 562 and includes the effects of residual stress. In addition, the WRC 562-MAT curves may be determined based on a t/4 or t/8 reference flaw.



WELD JOINT FATIGUE LIFE

Predict the probability of fatigue failure for welded joint specimens under known or relatively constant operating conditions. The method is based upon the “Structural Stress Method” that is included in both API 579-1/ASME FFS-1 *Fitness-for-Service* and ASME Section VIII Div. 2 or 3 codes. A linear elastic stress solution is used to calculate the structural stress from the through-wall linearized membrane and bending stresses at the weld toe or root/throat failure locations, normal to the hypothetically assumed crack plane. The equivalent structural stress is then further calculated to reduce the statistical variance in the fatigue-life data by incorporating additional effects that are not accounted for in the elastic model. These include environmental and manufacturing improvement factors, weld improvement techniques, initial flaw size, notch effects, thickness effects, crack growth, and residual stress. The resulting welded joint fatigue curve is log-linear and correlates all steels or aluminum/titanium alloys into a single curve. The structural stress method is referred to by many as a “Hot Spot Method.”

A Monte-Carlo sampling method is used to estimate the probabilistic fatigue life using a default of 20,000 random samples of the input random variables. All input parameters are assumed to be normally distributed random variables, while all calculated variables and the resulting fatigue life distribution make no assumptions about the distribution type (empirical PDFs and CDFs are determined). From the probability of fatigue failure distribution, more confident decisions can be made about extending the life cycle of welded joint components with different levels of confidence.

SMART TECHNOLOGY. ANSWERS FOR TODAY. INSIGHTS FOR TOMORROW.

CORPORATE HEADQUARTERS
20600 Chagrin Boulevard, Suite 1200
Shaker Heights, OH 44122

SATELLITE OFFICES
Houston, TX

CONTACT
216.283.9519
Software@E2G.com
www.E2G.com

The Equity Engineering Group, Inc.