



# **Blade Technology Corporation**

## **Blade Energy Partners**

**StrinGnosis™ Presentation**  
**Prepared for AADE**  
**October 2016**





# Blade Energy Partners

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- Blade Technology Corporation is a fully owned subsidiary company of Blade Energy Partners, Limited.
- Blade Energy Partners is a global upstream engineering, R&D, project management, implementation and training company founded in January 2000 by former employees of the Mobil Technology Company.
- Blade Energy provides engineering consulting and technical implementation services to all major and independent oil and gas companies including major service companies and many National Oil Companies across the globe.
- Since its inception, Blade Energy has been committed to continuing R&D to stay on the leading edge of the technology and contribute new technologies to the industry. One outcome of this commitment has been ongoing development of novel software tools that are being used by its engineers in their everyday projects. Blade Technology Corporation was created as a vehicle to deliver these software solutions to the industry.
- Blade energy is the top leading company performing reliability based design as necessary in well design, pipeline integrity, reservoir engineering and any complicated system analysis. A good number of publications are done by the top engineers and partners.



# Blade Technology Corporation

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- Technical leadership position and dedicated R&D activities of Blade Energy Partners, LLC have led to development of several unique solutions and IP.
- Some of the IP delivered as class “A” software tools, used primarily for internal activities.
- In 2011, increasing demand from clients led to development of three commercial grade software tools -
  - **Crack Analyzer** for pipelines using Fracture Mechanics
  - **Dent Analyzer** for pipelines (high strain and large deformation loading)
  - **StrinGnosis**<sup>TM</sup> for wellbore tubular design
- Blade Tech was created as vehicle to deliver software solutions to industry
- Other software developed by Blade –
  - **StringNexus**<sup>TM</sup> - tubular connection selection tool for Oil and Gas Industry
  - **UBD Pie** - probabilistic Productivity Improvement Factor (PIF) estimator
  - **eRes UBD** - reservoir simulation as well being drilled
  - **eDams** - core calibrated dynamic damage modeling
  - **StringTracker**<sup>TM</sup> - tubular torque and drag application with comprehensive fatigue estimator as well as fatigue management tool for optimization for Oil and Gas Industry
  - **QRA & RBD** - aSTAT, TPT, Level 5 RBD and RBI



# StrinGnosis™

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- StrinGnosis™ is the first new well tubular design and wellbore thermal analysis software application in a generation.
- It is a wellbore tubular design and thermal analysis tool that reflects the logic and information flow of well design and streamlines the complex and iterative well design process.
- Its intuitive and advanced interface makes the well design experience less stressful.
- It includes advanced features and capabilities that no other commercially available software application provides.
- It provides a wide range of design options and streamlines the complex and iterative well design process.
- Current commercial version v2.7 released on October 2016





## Key features of StrinGnosis™ v2.7

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- Ability to create a complex casing program, with multiple sections in each string, multiple cement tops, custom performance properties, etc.
- Built-in database of API and non-API tubulars, API and proprietary connections (VAM and TenarisHydril), API and proprietary grades
- Ability to create custom pipes, grades and connections
- Custom grades for non-API materials with ability to demonstrate anisotropic design envelope along with conventional isotropic design envelope
- Standard casing and tubing loads with flexibility to modify as needed
- Custom loads that can be created from standard load templates
- Steady state production, injection and worst case discharge (WCD) thermal simulations



## Key features of StrinGnosis™ v2.7 (Cont.)

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- Level 2 (Working Stress Design), Level 3 (Limit State Design) and Level 4 (Reliability Based Design) design options
- ISO 10400 TR limit state performance properties
- Level 4 Reliability Based Design (RBD) showing the probability of failure for the load cases which failed to meet the Working Stress Design (WSD)
- Reliability Based Design using ISO TR 10400 defined distributions and distribution parameters
- Reliability Based Design using user defined distributions and distribution parameters
- Custom report generator can create a basis of design document with tables and graphs of design data, ability to save report template for a project basis as well as for an application basis



## Key features of StrinGnosis™ v2.7 (Cont.)

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- Summary load description table for each string with minimum safety factor
- Wellbore summary safety factor table showing design loads with corresponding minimum safety factors for each string
- Enhanced wellbore schematic and few modification in the user interface specially in the well definition and casing design, e.g. enhanced formation pressures chart with casing shoes and mud weights
- Both US and metric unit systems are implemented and ability to mix and match with any unit system
- Post- processing of data that creates an intuitive display of results which highlight the design drivers immediately in graphical and tabular forms
- Ability to check the results against hand calculations or other calculation engines



## Key features of StrinGnosis™ v2.7 (Cont.)

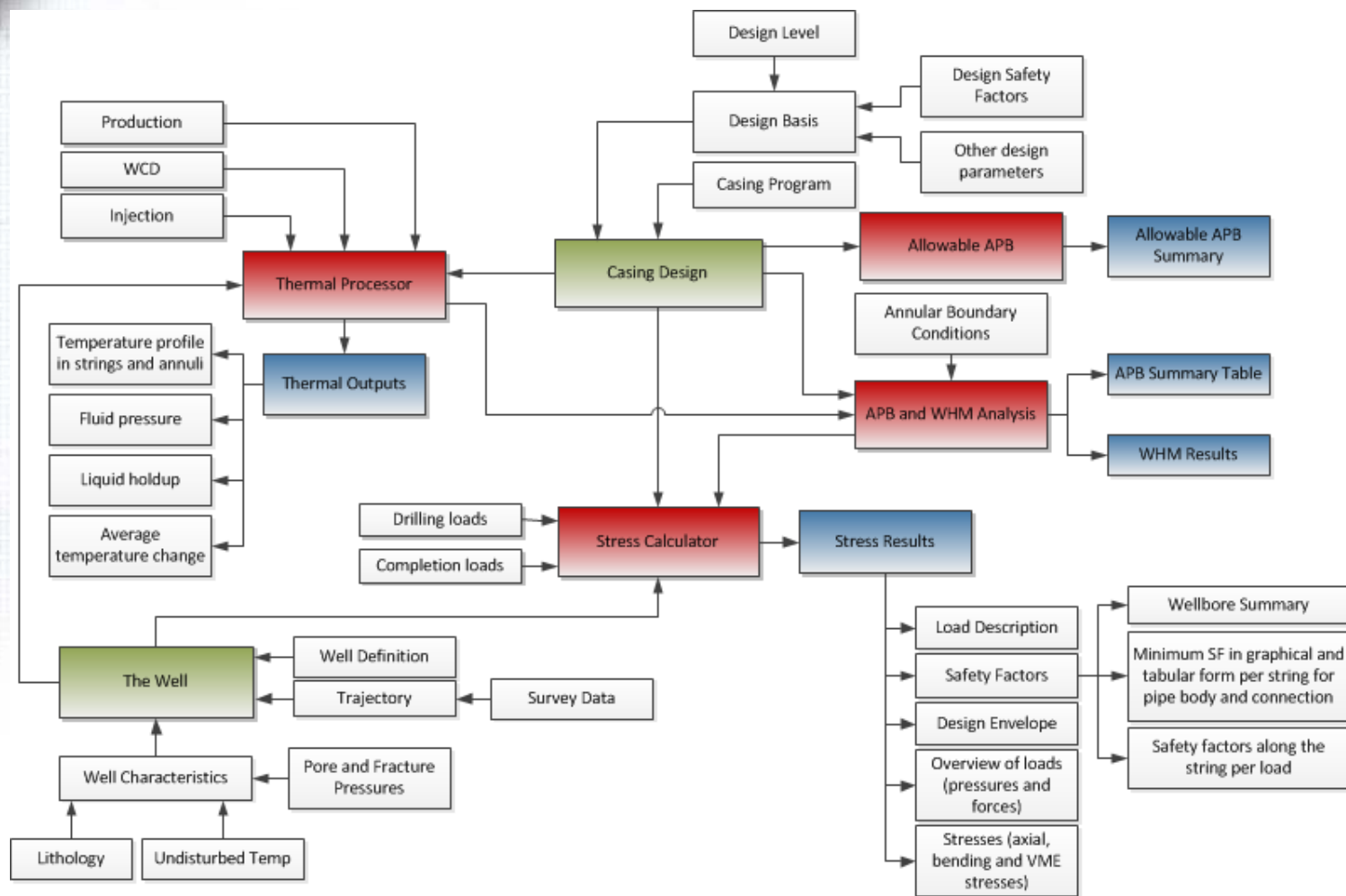
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- Multistring Annular Pressure Buildup (APB) analysis for various annulus boundary conditions
- Wellhead growth and wellhead forces calculation
- Thermal simulation for Worst Case Discharge (WCD) load
- Allowable APB calculation
- Worst Case Discharge (WCD) Level 1 and Level 2 Burst and Collapse standard loads according to BSEE
- Design Envelope for anisotropic materials
- Connection design check based on the connection performance properties
- Sidekick™ – included tool with customizable wellbore schematic and useful on-the-fly calculations needed for design checks and interpretation



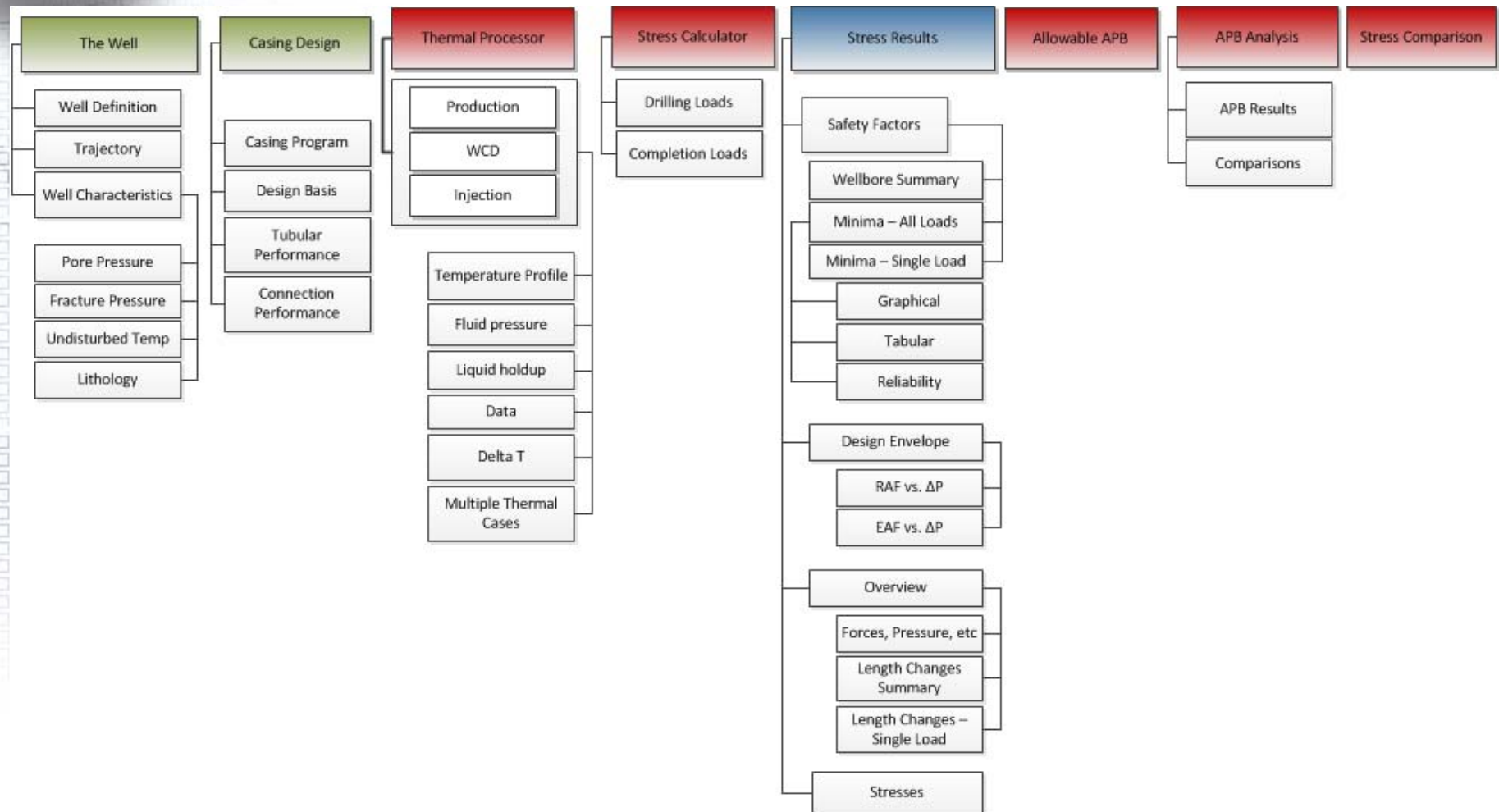


# StrinGnosis™ – Workflow Diagram





# StrinGnosis™ – Interface Diagram





# Setting up The Well

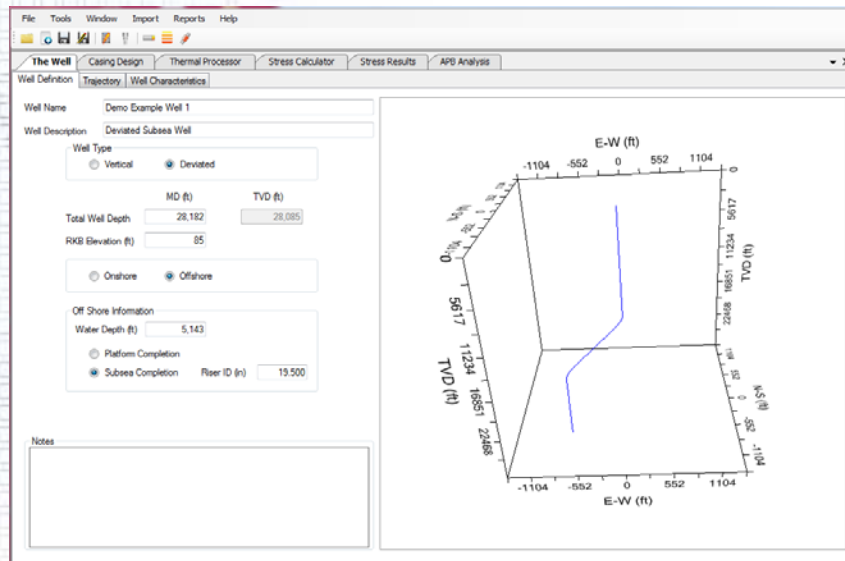
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- The well
  - Description of the well, well type
  - Wellbore Trajectory
  - Well Characteristics - Formation data
    - pore pressures
    - fracture pressures
    - undisturbed temperatures
    - lithology
- Casing Design
  - Construct the proposed casing program
  - Setting up the Design Basis
    - Design Level
    - Design Safety Factor

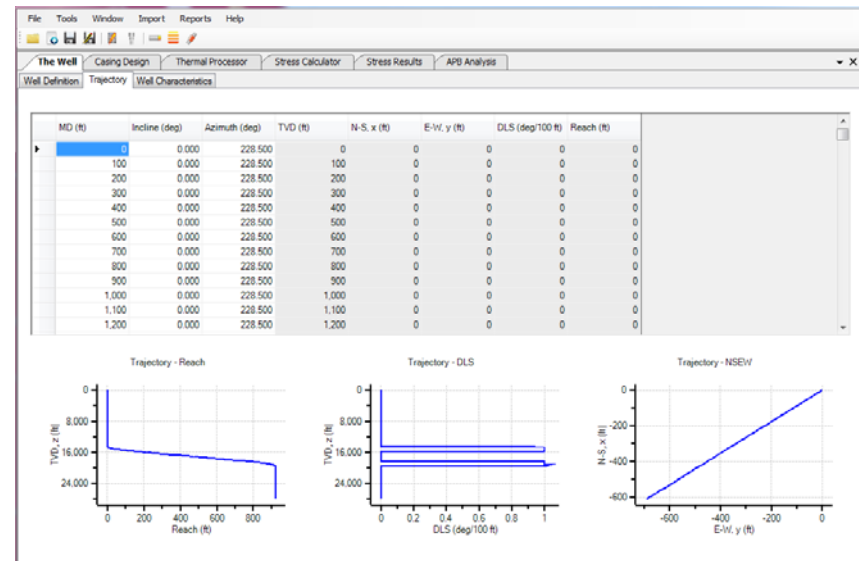


# The Well

## Well Definition



## Trajectory



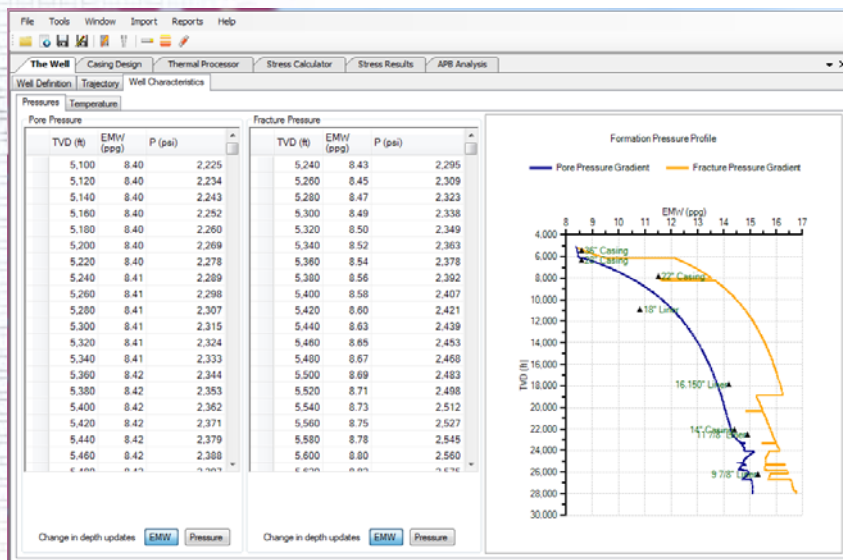
Trajectory data grid can be populated by –

1. Copying data from Excel or text file
2. Import functionality to import data from the Excel file
3. Edit/Add data manually in the grid

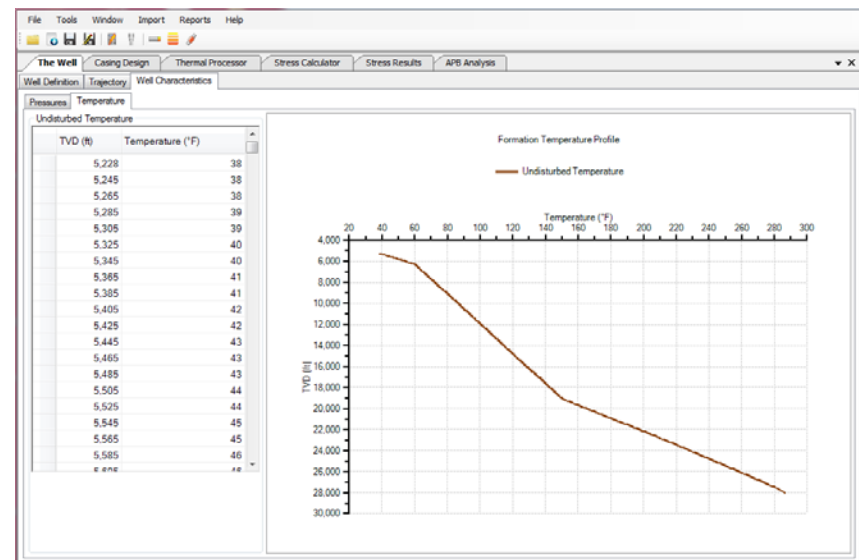


# The Well - Well Characteristics

## Pore and Fracture Pressures



## Undisturbed Temperature



Pore, fracture pressures and undisturbed temperature data grid can be populated by –

1. Copying data from Excel or text file
2. Import functionality to import data from the Excel file
3. Edit/Add data manually in the grid

Display data instantly as in the chart.

Formation chart can be displayed as either pressure or EMW.

Shoe depths can be plotted on the formation chart.





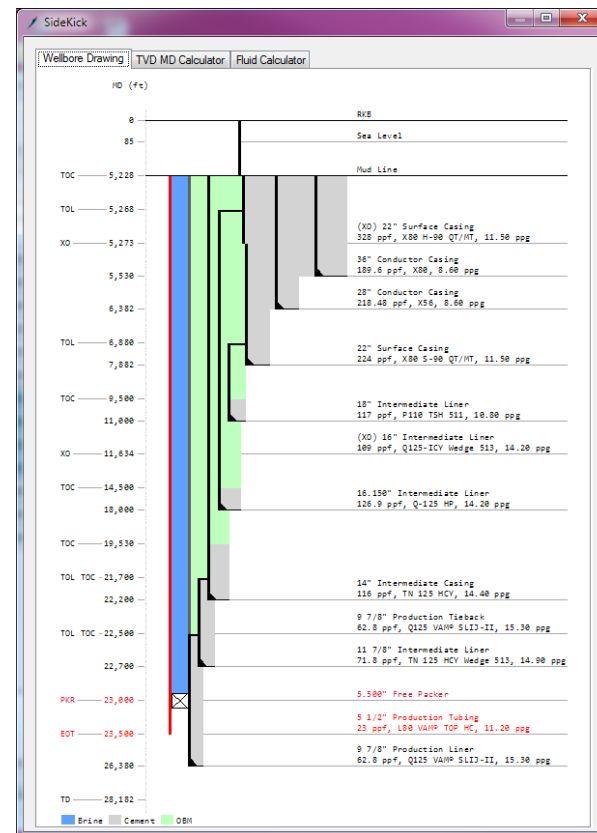
# Casing Design

## Casing Program

String - Section	Name	Type	OD (in)	Weight (ppf)	ID (in)	Wall Thk (in)	Grade	Connection Name	Top MD (ft)	Bottom MD (ft)	TOC MD (ft)	HoleSize (in)	Fluid Density (ppg)	Fluid Type
1-1	Conductor	Casing	36	189.600	35.000	0.500	X80	(none)	5.228	5.379	5.228	42.000	8.60	WBM
1-2	Conductor	Casing	36	189.600	35.000	0.500	X80	(none)	5.379	5.530	5.379	42.000	8.60	WBM
2-1	Conductor	Casing	28	218.480	26.500	0.750	X56	(none)	5.228	6.382	5.228	32.000	8.60	WBM
3-1	Surface	Casing	22	328.000	19.000	1.500	X80	H-90 QT/MT	5.228	5.273	5.228	26.000	11.50	WBM
3-2	Surface	Casing	22	328.000	20.000	1.000	X80	S-90 QT/MT	5.273	7.882	5.273	26.000	11.50	WBM
4-1	Intermediate	Liner	18	117.000	16.750	0.625	P110	TSH 511	6.880	11.000	9.500	21.000	10.80	OEM
5-1	Intermediate	Liner	16	309.000	14.688	0.656	Q125-KCY	Wedge 513	5.250	11.634	11.634	20.000	14.20	OEM
5-2	Intermediate	Liner	16.150	126.900	14.606	0.772	Q-125	(none)	11.634	18.000	14.500	20.000	14.20	OEM
6-1	Intermediate	Casing	14	115.000	12.369	0.820	TN 125	(none)	5.228	22.200	19.500	17.500	14.40	OEM
7-1	Intermediate	Liner	11 7/8	71.800	10.711	0.582	TN 125	Wedge 513	21.700	22.700	21.700	14.500	14.90	OEM
8-1	Production	Liner	9 7/8	62.800	8.625	0.625	Q125	VAMPI SLU-II	22.500	26.380	22.500	12.250	15.30	OEM
9-1	Production	Tieback	9 7/8	62.800	8.625	0.625	Q125	VAMPI SLU-II	5.228	22.500	22.500	NA	15.30	OEM
10-1	Production	Tubing	5 1/2	23.000	4.670	0.415	L80	VAMPI TOP	5.228	23.500	NA	NA	11.20	Brine

Easy to add string, create multiple sections.  
Instantly updating casing program in the SideKick™.

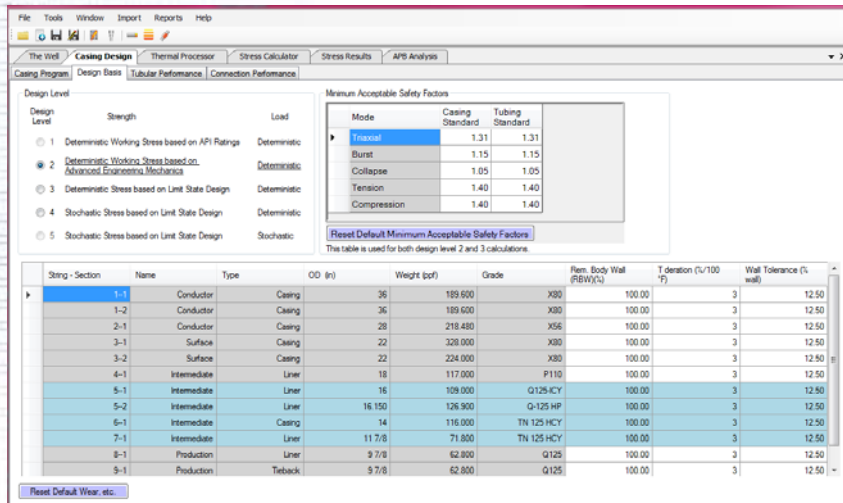
## SideKick™





# Casing Design (cont.)

## Design Basis



## Selections

- Design Levels
  - Level 2 – conventional working stress design (WSD)
  - Level 3 – limit stress design (LSD)
  - Level 4 – reliability based design (RBD)
- Minimum acceptable safety factors
  - For Triaxial, Burst, Collapse, Tension and Compression Loads
  - For Casing and Tubing
- Other parameters for various strengths calculation
  - Temperature deration factor for yield
  - Remaining Body Wall (RBW) for the worn pipe
  - Wall tolerance
  - Material toughness, imperfection depth, burst strength factor



# Casing Design (cont.)

## Tubular Performance

String Section	Name	Type	OD (in)	Weight (lb/ft)	Grade	Burst (psi)	Collapse (psi)	PBY5 (ksi)
1-1	Conductor	Casing	36	189.600	X80	1,944	129	4,461.06
1-2	Conductor	Casing	36	189.600	X80	1,944	129	4,461.06
2-1	Conductor	Casing	28	218.480	X56	2,825	953	3,596.55
3-1	Surface	Casing	22	328.000	X80	3,545	5,457	7,728.32
3-2	Surface	Casing	22	224.000	X80	6,354	3,874	5,277.88
4-1	Intermediate	Liner	18	117.000	P110	6,684	2,109	3,752.73
5-1	Intermediate	Liner	16	109.000	Q125 ICY	9,960	4,150	4,269.00
5-2	Intermediate	Liner	16.150	126.900	Q125 HP	11,620	6,650	5,036.00
6-1	Intermediate	Casing	14	116.000	TN 125 HCY	14,230	11,700	4,584.00
7-1	Intermediate	Liner	11.7/9	71.900	TN 125 HCY	11,910	7,800	2,787.00
8-1	Production	Liner	9.7/8	62.900	Q125	13,845	11,136	2,270.29
9-1	Production	Tieback	9.7/8	62.900	Q125	13,845	11,136	2,270.29
10-1	Production	Tubing	5 1/2	23.000	L80	10,564	11,162	530.37

## Connection Performance

String Section	Name	Type	OD (in)	Weight (lb/ft)	Grade	Connection Name	Tension Rating (kbf)	Compression Rating (kbf)	Burst Rating (psi)	Collapse Rating (psi)
1-1	Conductor	Casing	36	189.600	X80	NA	NA	NA	NA	NA
1-2	Conductor	Casing	36	189.600	X80	NA	NA	NA	NA	NA
2-1	Conductor	Casing	28	218.480	X56	NA	NA	NA	NA	NA
3-1	Surface	Casing	22	328.000	X80	H 60 QT-MT	3,660.00	5,240.00	12,900	2,190
3-2	Surface	Casing	22	224.000	X80	S 60 QT-MT	2,120.00	2,240.00	8,625	3,874
4-1	Intermediate	Liner	18	117.000	P110	TSH S11	2,330.45	2,763.01	6,677	2,109
5-1	Intermediate	Liner	16	109.000	Q125 ICY	Wedge S13	2,672.00	3,125.00	9,960	4,150
5-2	Intermediate	Liner	16.150	126.900	Q125 HP	NA	NA	NA	NA	NA
6-1	Intermediate	Casing	14	116.000	TN 125 HCY	NA	NA	NA	NA	NA
7-1	Intermediate	Liner	11.7/9	71.900	TN 125 HCY	Wedge S13	1,723.00	2,076.00	11,910	7,800
8-1	Production	Liner	9.7/8	62.900	Q125	VAM® SLU4	1,761.81	1,233.26	13,840	11,136
9-1	Production	Tieback	9.7/8	62.900	Q125	VAM® SLU4	1,761.81	1,233.26	13,840	11,136
10-1	Production	Tubing	5 1/2	23.000	L80	VAM® TOP ...	530.00	530.00	10,560	11,162

Tubular and connection performance properties are for display and review. Performance data are obtained from respective database table.

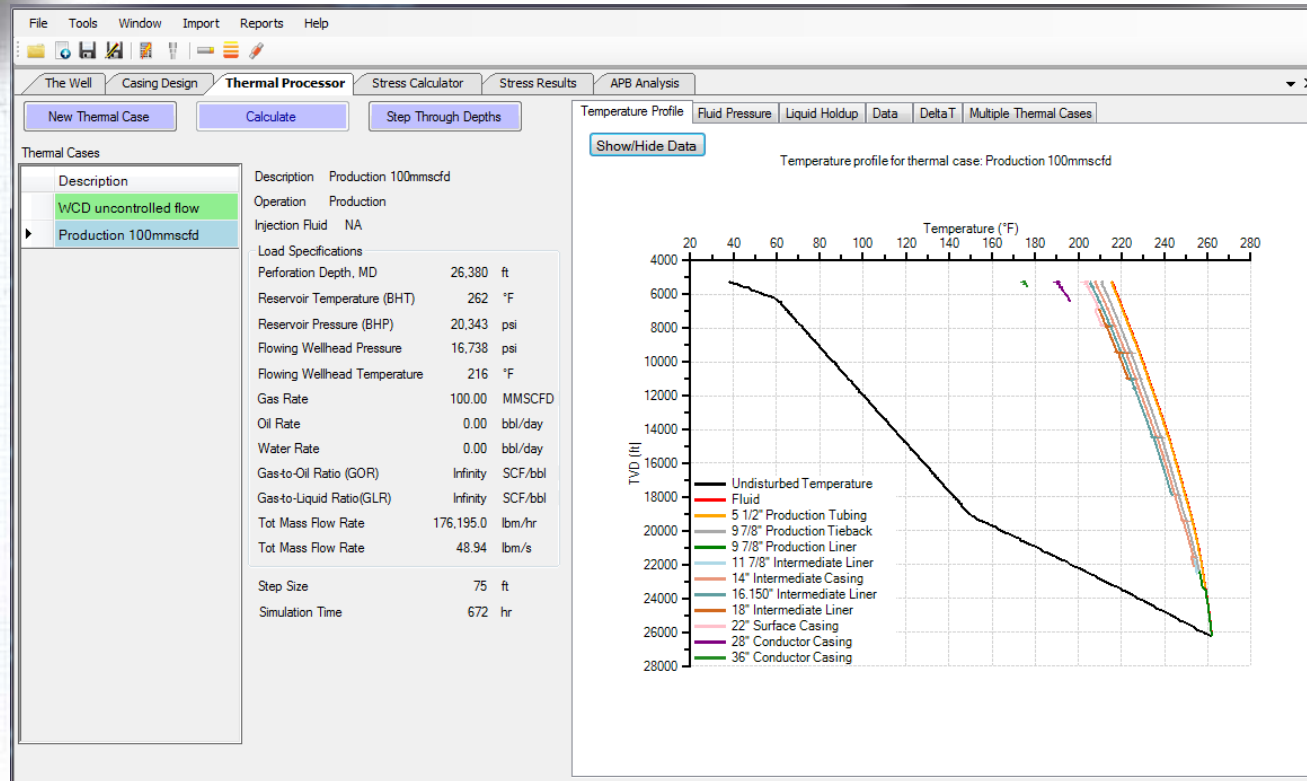


# Setting up the loads

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- Thermal Processor
  - Setting up production, injection and worst case discharge (WCD) thermal loads
- Stress Calculator
  - Setting up loads for each string
    - Standard drilling loads
    - Standard production loads
    - Custom loads for special loading scenarios
- APB Analysis with Wellhead movement
  - Setting up load with various annulus boundary conditions
    - Sealed annulus, vented annulus, limited pressure, leak off prior shoe
- Allowable APB
  - Estimating allowable APB in all annuli that will keep them safe independently

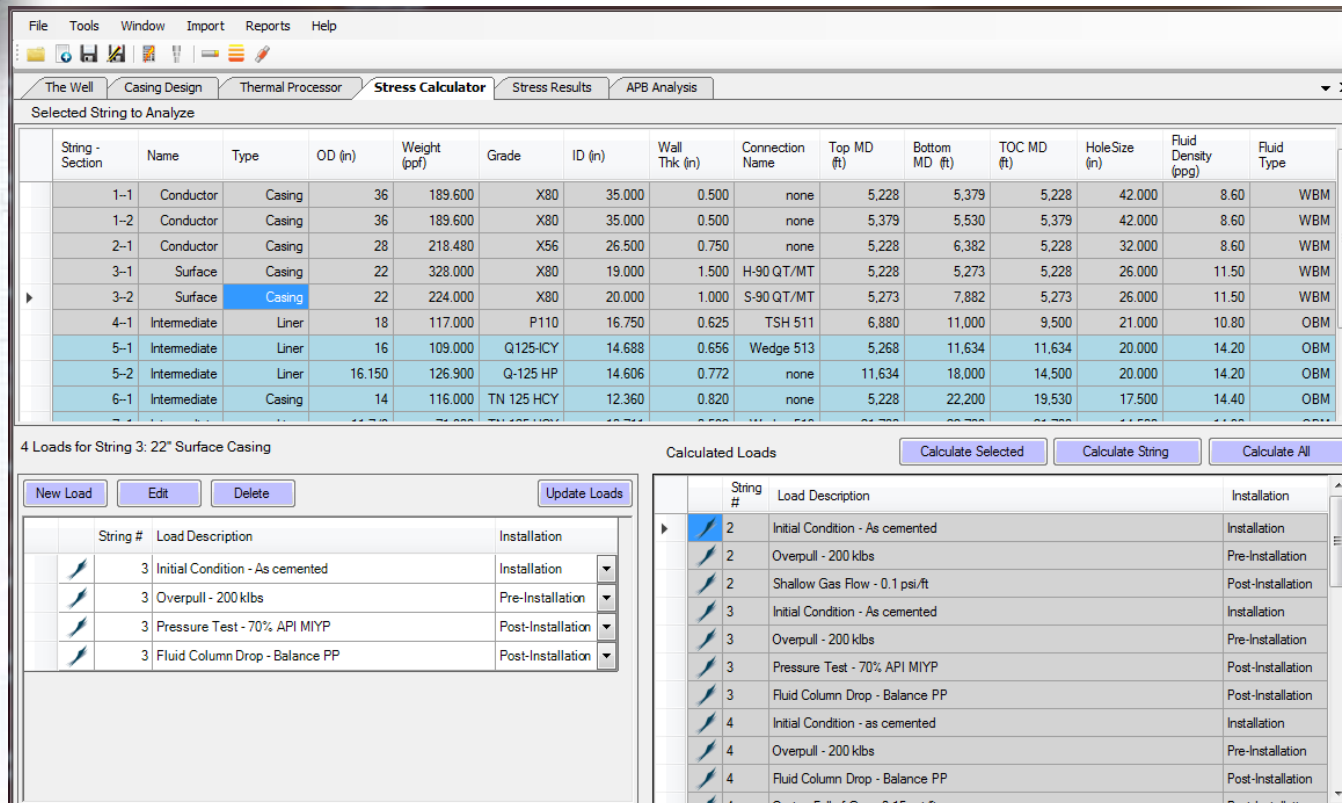
# Thermal Processor



- Create multiple thermal loads
  - production, injection and worst case discharge (WCD) thermal loads
- Calculate single load or multiple loads together
- View key inputs and outputs along side of temperature profile chart



# Stress Calculator



File Tools Window Import Reports Help

The Well Casing Design Thermal Processor **Stress Calculator** Stress Results APB Analysis

Selected String to Analyze

String - Section	Name	Type	OD (in)	Weight (ppf)	Grade	ID (in)	Wall Thk (in)	Connection Name	Top MD (ft)	Bottom MD (ft)	TOC MD (ft)	Hole Size (in)	Fluid Density (ppg)	Fluid Type
1-1	Conductor	Casing	36	189.600	X80	35.000	0.500	none	5,228	5,379	5,228	42.000	8.60	WBM
1-2	Conductor	Casing	36	189.600	X80	35.000	0.500	none	5,379	5,530	5,379	42.000	8.60	WBM
2-1	Conductor	Casing	28	218.480	X56	26.500	0.750	none	5,228	6,382	5,228	32.000	8.60	WBM
3-1	Surface	Casing	22	328.000	X80	19.000	1.500	H-90 QT/MT	5,228	5,273	5,228	26.000	11.50	WBM
3-2	Surface	Casing	22	224.000	X80	20.000	1.000	S-90 QT/MT	5,273	7,882	5,273	26.000	11.50	WBM
4-1	Intermediate	Liner	18	117.000	P110	16.750	0.625	TSH 511	6,880	11,000	9,500	21.000	10.80	OBM
5-1	Intermediate	Liner	16	109.000	Q125-ICY	14.688	0.656	Wedge 513	5,268	11,634	11,634	20.000	14.20	OBM
5-2	Intermediate	Liner	16.150	126.900	Q-125 HP	14.606	0.772	none	11,634	18,000	14,500	20.000	14.20	OBM
6-1	Intermediate	Casing	14	116.000	TN 125 HCY	12.360	0.820	none	5,228	22,200	19,530	17.500	14.40	OBM

4 Loads for String 3: 22" Surface Casing

New Load Edit Delete Update Loads

String #	Load Description	Installation
3	Initial Condition - As cemented	Installation
3	Overpull - 200 klbs	Pre-Installation
3	Pressure Test - 70% API MIYP	Post-Installation
3	Fluid Column Drop - Balance PP	Post-Installation

Calculated Loads

Calculate Selected Calculate String Calculate All

String #	Load Description	Installation
2	Initial Condition - As cemented	Installation
2	Overpull - 200 klbs	Pre-Installation
2	Shallow Gas Flow - 0.1 psi/ft	Post-Installation
3	Initial Condition - As cemented	Installation
3	Overpull - 200 klbs	Pre-Installation
3	Pressure Test - 70% API MIYP	Post-Installation
3	Fluid Column Drop - Balance PP	Post-Installation
4	Initial Condition - as cemented	Installation
4	Overpull - 200 klbs	Pre-Installation
4	Fluid Column Drop - Balance PP	Post-Installation

- Select string and create loads
  - Standard drilling/production loads
  - Custom load
- Post-installation load requires initial (installation) load
- Pre-installation (e.g. Over Pull, Running in Hole, Bump Plug Cementing) load is independent
- Single load or selected multiple loads or all loads for a string can be calculated



# APB Analysis

File Tools Window Import Reports Help

The Well Casing Design Thermal Processor Stress Calculator Stress Results **APB Analysis**

Add New Case Calculate Selected Case(s) Calculate All Cases

Case Name

APB Case 01

APB Results Comparisons

Annulus	Inner String of Annulus	APB: $\Delta P$ (psi)	Volumetric $\Delta T$ of Annular Fluid ( $^{\circ}F$ )	Annular $\Delta V$ (bbl)	$\Delta P/\Delta T$ (psi/ $^{\circ}F$ )
A	5 1/2" Production Tubing	14,896	119	6.2	125
B	9 7/8" Production Tieback	10,599	121	2.1	88
C	14" Intermediate Casing	8,035	118	2.3	68
D	16.150" Intermediate Liner	7,170	134	7.6	54
E	18" Intermediate Liner	7,174	139	4.1	52

Wellhead Movement Calculations

String Name	Buoyed Weight (lbf)	Net Hanger Force (lbf)	Unrestrained $\Delta L$ (ft)	Induced Forces (lbf)
String 1:	-193,363.73	0.00	0.09	793,553.70
String 2:	-194,273.87	0.00	0.10	705,432.80
String 3:	-59,862.02	0.00	0.07	2,165,301.81
String 6:	1,353,386.32	1,161,368.78	12.26	-863,011.83
String 9:	755,177.60	1,305,202.87	13.14	-409,979.10
String	327,748.71	-4,573,060.28	33.53	-373,638.29

\* "Induced forces" are forces created in a string due to the restraint on the length changes in the strings. The length changes are caused by pressure and temperature changes during production/injection.

Induced Upward Force (lbf) 1,074,909.76

As Installed Downward Force (lbf) 237,240.41

Resultant Upward Force (lbf) 837,669.35

Pullout Force (API-RP-2A) (lbf) 4,234,996.77

Total Movement (in) 1.697

- Multiple APB loads for various boundary conditions can be created.
- Results of a selected calculate load is displayed instantly on the same window.
- APB from multiple loads can be compared.



# Reviewing the results

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- Thermal Processor
  - Temperature and pressure profiles, liquid holdup
  - Outputs in graphical and tabular forms
  - Temperature change in the string and annulus between two depths of interest
  - Comparing multiple thermal loads
- Stress Calculator
  - Stress Results tab shows safety factors, design envelope, detail force and stress results
  - Minimum safety factors for each string for each loading category
  - Safety factors in graphical and tabular forms
  - Safety factor profile for each load for each string
  - Design envelope in both effective and real axial force
  - Design envelope provides sensitivities with respect to yield strength, wall tolerance and % remaining body wall
- APB Results
  - APB, change in temperature and volume in various annuli



# Commercial Packaging

StrinGnosis™ Version 2.5 (December 2015 Release) Included Features			
Feature	Std	Adv	Comments
Advanced, intuitive, multi-window GUI	✓	✓	Easy to use interface with intuitive controls and capabilities.
Working Stress Design (Level 2)	✓	✓	API ratings and triaxial VME checks
Connection design checks	✓	✓	Uses connection ratings and efficiency provided by manufacturers
Customizable Equipment Database	✓	✓	Allows proprietary tubulars and connections. Searchable and editable.
SideKick <sup>SM</sup>	✓	✓	Quick calculations, customizable, "always on" well schematic window
Minimum Safety Factor bar charts and summary tables	✓	✓	Unique summary charts and tables, in addition to detailed results
Standard Loads	✓	✓	Commonly used standard casing and tubing design load templates
Custom Loads	✓	✓	Allows custom definition of loads. Allows use of standard templates as starting point.
Worst Case Discharge / Well Containment		✓	Per US BSEE (Levels 1 & 2) Screening Requirements
Thermal Simulation	✓	✓	Production, injection and worst case discharge thermal analysis
Brittle Failure Limit		✓	Uses ISO TR 10400 (API TR 5C3) Level 2 Brittle Burst Failure Assessment Diagram
Limit State Design (LSD) (Level 3)		✓	Deterministic LSD for tension-burst and brittle burst. Collapse limit state in RBD.
Probabilistic Strength		✓	Includes ISO TR 10400 data. Allows user defined strength distributions.
Reliability Based Design (RBD) (Level 4)		✓	Both failure and exceedance (yielding) probabilities. Includes RBD graphs and summary tables.
Annulus Pressure Buildup (APB)		✓	Analysis of multiple APB cases
Wellhead Movement		✓	Multi-String wellhead movement and forces analysis, pile capacity, soil interaction
Allowable APB		✓	Determining allowable APB in annuli
Custom Report Generator	✓	✓	User-specified reports.
Standard Load Template customization		✓	Available for buyers of 10+ licenses
Reliability Based Design (RBD) (Level 5)		✓	Available add-on upon request
Triaxial connection checks		✓	StringNexus <sup>SM</sup> , Available add-on upon request
Design of anisotropic materials		✓	For analysis and design of CRA and other anisotropic tubulars
Training	✓	✓	Free online training. On-site training available for buyers of 10+ licenses.
User Support	✓	✓	Included 24-hour user support



# Unique Features

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- Features that are unique and not available in other software –
  - Intuitive, user friendly and very short learning curve
  - Split window option gives user to work in one area of the application while keeping the other relevant window open in multiple screens
  - Wellbore diagram is more informative and useful
  - Worst case discharge (WCD) thermal simulation is unique, no need to have production tubing in the casing program to simulate thermal cases
  - Allowable APB calculation in each annulus is unique
  - Reliability based design (RBD) is unique
  - Report generator is robust and useful for completing end of design report
  - Detailed results which include everything that is being computed inside the calculation engine and easily viewable to the user
  - Easily customizable to meet customers requirements for special need





# Licensing and Maintenance

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- License Types
  - Stand alone license
  - Network license
- Individual or corporate licenses
  - Perpetual license
  - Includes free online training for all users
  - Includes free 2-day on-site training for buyers of 10+ licenses
- Annual Maintenance and support
  - Recommends 5-7 years of maintenance plan
  - Entitles customer to timely 24/7 technical and user support
  - Customers get all the scheduled enhancements and developments
  - Preferential pricing for major releases
- Customization is extra and quoted separately
  - Standard load template customization is included for buyers of 10+ licenses
  - Quotes for other add-ons and customization available upon request



# Contact

To obtain an evaluation license or a price quote –

- please visit [www.stringnosis.com](http://www.stringnosis.com)
- Or call +1 855.255.7473
- Or email
  - Shaikh Rahman  
[srahman@blade-energy.com](mailto:srahman@blade-energy.com)
  - Pete Lumley  
[plumley@blade-energy.com](mailto:plumley@blade-energy.com)
  - Bob Pilko  
[bpilko@blade-energy.com](mailto:bpilko@blade-energy.com)

