CTES
Intervention Hardware and Software

NOV Completion & Production Solutions

Leading edge intervention hardware and software

We understand knowledge is key when planning and performing productive well intervention and stimulation operations. Through innovation and dedicated specialists, we've developed the most trusted coiled tubing monitoring devices, data acquisition systems and modeling software. For more than 20 years, we've partnered with our customers to serve the needs of a challenging and growing industry. Our innovative solutions deliver the safety and reliability necessary for your success. With a global market presence, we provide the technical expertise, equipment and operational support to increase the efficiency and profitability of your business.

We specialize in the following products:

- Modeling software (Cerberus™) for intervention, drilling and completions
- Data acquisition systems (Orion™) and specialized monitoring sensors
- Engineered products for intervention operations

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Modeling Software and Data Acquisition Systems

CTES Rate Meter

The CTES rate meter provides advanced tracking of nitrogen's rate, temperature, pressure and volume during a pumping operation. The unit is capable of receiving input from multiple devices, and its single configurable output provides over-pressure shutdown.

Information obtained for the meter's onboard data acquisition system (DAS) is viewable on the included full-color graphical display. The meter's stored information can be downloaded via USB cable for reporting purposes.

The unit comes with step-by-step instructions for calibration on the first power-up for commissioning.

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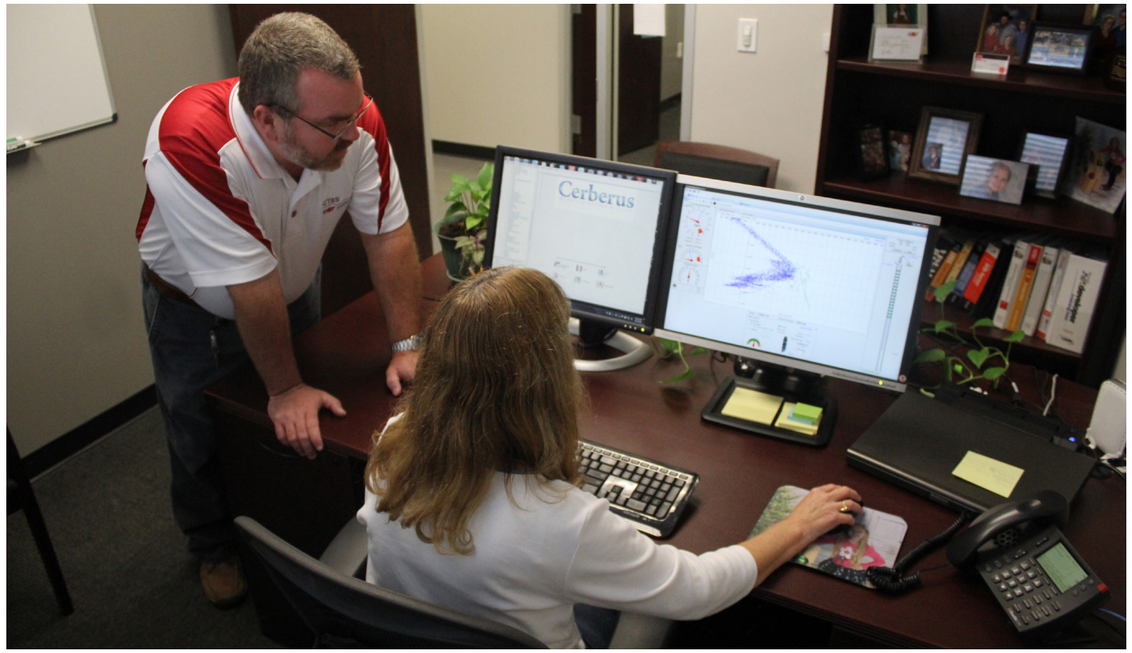


Cerberus modeling software can help accurately predict and analyze cumulative forces at each stage of a coiled tubing, wireline, slickline or jointed pipe job. Since 1995, Cerberus has been the leading commercial software for planning and performing efficient well intervention services with numerous service companies and operators worldwide relying on this software.

The Cerberus suite provides:

- Models - state-of-the-art calculations for
  - Fatigue life (Achilles™)
  - Hydraulics (Hydra™)
  - Tubing forces (Orpheus™)
- Editors - configuration tools to enter input data required by the models
- Monitors - real-time job modeling at the wellsite for enhanced safety and efficiency
- Reporting - professional print output and PDF reports
- Technical Support - provided by telephone and online, plus basic and advanced training courses, tutorials and extensive documentation

Wizards

Cerberus uses program wizards to guide the user through complex configuration and design tasks. These tools assist in stepping through key decisions in a logical sequence, presenting choices based on context and previous selections. Cerberus wizards make extensive use of graphics, calculation utilities and customization to present operation-specific selections.

Reporting

Cerberus generates professional-looking reports that are available as printed copies or PDF files.

These may be emailed and viewed at a PC with Adobe® Reader®.

Additional Information

Cerberus for coiled tubing is part of an integrated software suite used for planning and executing wellsite operations.

Other Cerberus versions include:

- Cerberus for well intervention for planning any well intervention or tool deployment, whether on wireline or slickline, conventional jointed pipe or coiled tubing

Cerberus Modeling Software

Fatigue Life (Achilles)

Coiled tubing fatigue is caused by plastic bending of the pipe as it is spooled off the reel and over the gooseneck into the well and then back again during a job. The cumulative fatigue is tracked along the length of the coiled tubing in small increments, taking into account the movement of the pipe and the internal pressure at the moment of bending.

Cerberus software helps operators determine used fatigue life. This results in cost savings in both terms of pipe utilization and reduced wellsite failures, compared with older coiled tubing retirement methods (such as running feet).

Achilles

Today's complex coiled tubing applications and more conventional workover operations require the pipe to be cycled more often and at higher pressures. This makes it critical to track the fatigue life and diametrical growth to avoid an expensive and potentially dangerous failure at the wellsite.

Achilles is the most advanced model of its kind, using sophisticated plasticity and damage algorithms calibrated and validated against hundreds of full-scale and laboratory tests, and proven in the field to be accurate and trustworthy.

String Editor

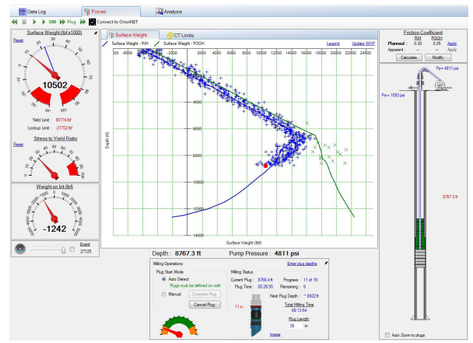
Cerberus' string editor provides string configuration and management tools to assist users in the optimal maintenance of a string's fatigue profile. String maintenance tasks, including cutting, splicing and reversing, may be performed in the string editor over the lifetime of the coiled tubing string.

Hydraulics (Hydra)

The Cerberus Hydra wellbore module provides a large number of tools to assist in the design of coiled tubing pumping operations. Options range from basic "snapshot" calculations to more complex simulations where conditions change with time. Extensive use of wizards step users through the often complex process of choosing fluids and specifying volumes and flow rates to design a successful workover or drilling program.

Features

- Power law, Bingham plastic and Newtonian fluid models
- Foam, gas and multiphase fluid models
- Well unloading and gas lift design wizards
- Fill Removal Wizard for sand cleanouts
- Velocity String Design Wizard
- Pump Wizard for circulation volumes and times
- Job Design Wizard, for rapid configuration of multistage jobs
- "Stage Table" data entry for time-based simulations
- Reservoir inflow/outflow calculations
- Nozzle and choke calculations



Forces (Orpheus)

Orpheus calculates the cumulative forces acting on the coiled tubing, taking into account effects such as drag, helical buckling and hydraulic effects in order to determine the feasibility of the job and to anticipate possible problems with lock-up or pipe yield.

Orpheus can analyze and model the friction reduction achievable by the use of a pulsation tool. More importantly, Orpheus' pre-job analysis provides an estimate of the additional coiled tubing penetration depth that can be achieved as a result of the friction reduction provided by the use of the pulsation tool.

Orpheus can be used to analyze the surface weights acquired during a job. This data can be used to identify the friction drag experienced during the job and help predict the appropriate friction factor to be used in future modeling projects. This analysis corrects for many issues that commonly cause problems when manually performing friction analysis, such as varying pressures, surface friction and weight calibration.

Orpheus Forces Monitor calculates real-time weight on bit during a milling operation.

Question and Answer Wizard

The Question and Answer Wizard in Orpheus provides a user-friendly interface that provides quick results for the most commonly asked questions:

- Can I reach the desired working depth with this configuration?
- How much can I pull or set-down once I reach the desired working depth?

Other features concentrate on contingency planning such as what course of action to take if the toolstring is stuck or if the well condition changes during the operation.

Run at Depth Feature

The Run at Depth calculation can be used to model intervention or drilling operations in the wellbore at a specific depth. Multiple conveyance methods are available, including jointed pipe, coiled tubing and wireline. In jointed pipe and coiled tubing mode, the depths where buckling is occurring can be observed; in wireline mode the depth of cable compression can be observed.

Orion Data Acquisition System

The Orion Data Acquisition System (DAS) is available in two modes: standard and hazardous area (ATEX) and is designed and built for coiled tubing units and pumpers. It captures and maintains an accurate record of all monitored parameters during a coiled tubing, pumping, acidizing or Hydraulic Workover Operation (HWO).

It incorporates a see-through pane so that operators can view critical diagnostic signals without having to open the electronics enclosure. These signals provide operators with a quick review of system functionality, giving them valuable troubleshooting information at a glance.

The Orion DAS is modular and configurable to meet your requirements. The standard coiled tubing package provides the following minimum channels:

- Tubing speed, depth and weight
- Pipe heavy/pipe light
- Circulating pressure
- Wellhead pressure
- Pump rate/volume
- Nitrogen rate/volume
- Roadside and curbside flow rates and volume

Features and Benefits

- Small footprint, electronics enclosure size: 16" W x 12" H x 7"D
- Retrofits to existing coiled tubing units
- Sensors and cabling*
- Controller box
- Electronic Memory Unit (EMU)
  - Typical-job-log storage capacity > 2,400 hrs.
  - Stores diagnostic data
  - Channel configuration changes, unit description, and serial number recorded in EMU files
  - EMU function internal to PLC
  - No user intervention required
- Laptop or desktop PC**

**quoted separately, may be provided by customer*

***minimum Pentium II - 1.2 GHz processor recommended*

Please contact an NOV representative to discuss specific hazardous area system requirements.

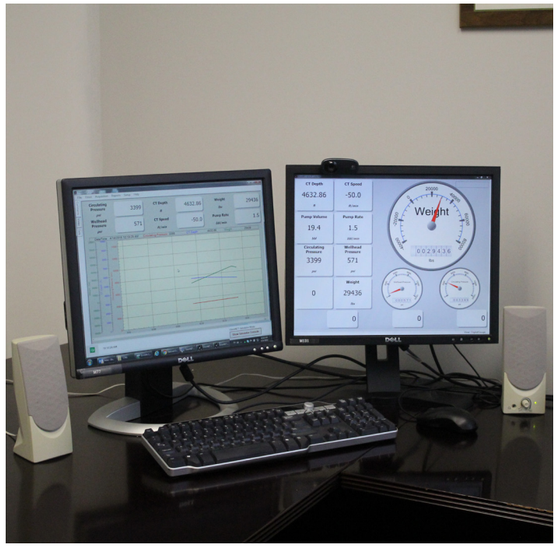
Orion for Coiled Tubing

Orion data acquisition system for coiled tubing provides a small footprint and a seamless interface with the industry's leading modeling software, Cerberus for coiled tubing.

Various electrical sensors send signals to the Orion V, where the signals are interpreted and scaled into engineering units. The Orion V makes the engineering-unit data available to memory devices, displays, third-party acquisition systems and/or computers as required.

Both the OrionNET™ data acquisition software and the Remote Orion Viewer (ROVer™) Human Machine Interface (HMI) acquire the scaled signals as channels. OrionNET software stores the channel values in a database on the PC's hard drive, while the ROVer allows data viewing only.

Orion Data Acquisition System



OrionNET

OrionNET enables the end user to:

- View secure, real-time data from a Windows® based PC connected to the Internet
- Monitor multiple jobs from a single location
- Obtain remote diagnostics and support
- Configure displays, including horizontal charts, using English, metric or combination units

The OrionNET acquisition server connects to local-network data sources, acquiring data and storing the acquired data in SQL Server CE databases. After data is acquired and stored, the OrionNET Viewer provides operation-customizable data viewing.

Features and Benefits

- Acquire data from multiple sources and view remotely
- Create customized screen layouts
- Acquire and store data automatically on system startup or on demand
- Use diagnostics displays to help identify and resolve any issues with Orion V, Orion IV, ASCII via Serial and Derived Channel data sources
- Password-protect the configuration utility and the view-designer layout
- Append data to an existing database or export data to a CSV file
- Use OrionNET's reporting functionality to modify copies of original databases to adjust sensor-data using factors, trim beginning or ending data and merge databases from the same job
- Filter data within the reporting functionality's data log
- Integrate with other hardware/software systems via ASCII or WITS0 output streams
- Incorporate alarms and warnings (high and low) on every channel

Orion^{SL} LifeSaver™

The Orion LifeSaver acquires, records and displays slickline operating data to estimate fatigue along the length of a slickline. The system's calculated remaining fatigue life information is useful to help avoid costly field failures and to optimize the slickline replacement schedule.

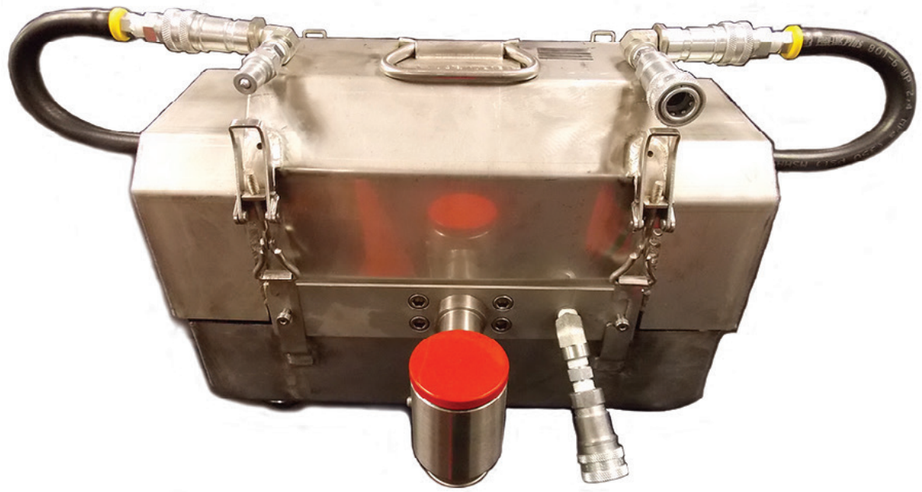
The Orion LifeSaver monitors slickline forces and bending events as tools are run in and out of the well. The standalone system records slickline depth information via an encoder mounted on a measuring device. An electronic load pin provides tension data.

Useful for post-job modeling, Orion LifeSaver's job data is written continuously (one time per second) onto a USB flash drive.

Features and Benefits

- OrionNET™ software arrives pre-installed in the unit
- Acquires, displays and records depth, tension, line speed and one additional analog data channel
- Allows users to see rapidly changing values in tension or depth via a high-speed data display (event-driven; up to 10 times per second)
- High-speed, sensitive tension display detects "tickle"" (small variations in tension) when moving past downhole restrictions
- Large graphical display screen includes analog gauge, strip chart and easy-to-read digital displays
- Easy operation: single switch provides "power on and go" data acquisition and USB media storage
- User-set alarms for all input channels drive digital output for horns, lights or relays
- Easy zero or calibration of input sensors
- English or metric units

Engineered Products



The Argus TubeSpec is a unique, patented, ultrasonic, coiled tubing monitoring device that provides highly accurate circumferential coiled tubing wall thickness measurements as the tubing passes through the device during field operations. These measurements allow you to evaluate the coiled tubing's wall thickness, OD and ovality along the length of the string.

In today's complex wellsite environments, coiled tubing failure can occur as a result of mechanical damage due to erosion, corrosion, tensile overload and abrasion. These failures are not only costly but time-consuming for both you and your customers.

While most ultrasonic transducer methods require clean water to couple the ultrasonic probe to the material measured, the Argus TubeSpec uses a polyurethane element as a medium between the sensor and the coiled tubing, eliminating the need for water coupling. The polyurethane element (a solid) exhibits excellent wear characteristics. When compressed, the element transforms to exhibit the attributes of a liquid, filling changes in the surface contour of the tubing. The polyurethane element is therefore not contaminated by the environment, and accurate circumferential wall thickness measurements can be made.

Features and Benefits

- Provides continuous, accurate, localized wall thickness, OD and ovality measurements using twelve ultrasonic probes
- Tracks weld-seam location to monitor rotation of the coiled tubing string
- No calibration needed to measure wall thickness
- Horizontally split for installation on coiled tubing; no need for dangerous stabbing-through of tubing
- Complete unit weight, excluding mounting bracket and electronics, is 66 ½ lbs
- Hazardous area certified – Zone II
- Digital signal processing internally processes 1,000 wall thickness calculations per second within ± 0.005" accuracy
- Outputs twelve minimum, maximum and average circumferential wall thickness measurements per second within ± 0.005" accuracy and one minimum, maximum and average diameter per second
- Indicates when the weld seam is in the vicinity of one of the twelve probes

Coiled tubing OD ranges

- 1 ¼" to 1 ½"
- 1 ½" to 1 ¾"
- 1 ¾" to 2"
- 2 ⅜" to 2 ⅝"
- 2 ⅝" to 2 ⅞"

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Cable Injector

Our cable injector pumps cable into and out of coiled tubing while it is still on the reel.

The cable injector system greatly reduces costs when compared to vertical or horizontal installations. The system also has the benefit of quickly installing cable without reducing the fatigue life of the coiled tubing string.

Our cable injection systems are skid mounted for ease of transportation offshore. Using the system, a coiled tubing string may be lifted onto a platform without the cable inside, therefore reducing the total weight of the lift. The cable can then be installed before a job and removed after a job.

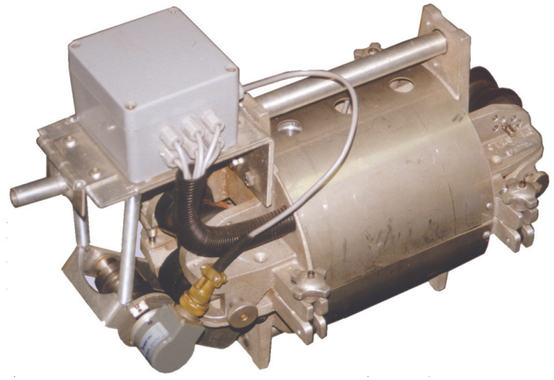
Our coiled tubing cable installation system uses the following equipment to pump (inject) cable into a reel of coiled tubing:

- Cable injector unit
- Reel mounted coiled tubing
- Cable/wireline spooling unit

Features and Benefits

- No impact on fatigue life of coiled tubing
- Fast (up to 200 ft/min)
- All coiled tubing sizes
- Small footprint (79" x 73")
- Rugged, field-proven design
- Third-party certification/registration available

CT-DOG™



The coiled tubing diameter and ovality gauge (CT-DOG) is an economical, real-time monitoring device for detecting tubing dimensional imperfections such as necked or ballooned sections and dents while the coiled tubing is running in or out of the hole. It is designed to notify and alarm the user of potential tubing problems by monitoring real-time diameter changes and ovality during coiled tubing operations.

CT-DOG can be used as a stand-alone monitoring device or it can be used with the Cerberus coiled tubing modeling software and Orion data acquisition system to create a fully integrated, real-time coiled tubing monitoring system.

Features

- Digitally displays maximum, minimum and average OD, ovality percentage, individual and paired sensor diameters and alarm flags
- User-defined alarms for diameters and ovality
- Audible alarms for out-of-limit conditions
- Display update once per second
- Keypad user interface
- Field calibration of probe spacing
- Installation on coiled tubing at any time during operations
- Bidirectional measurement
- Easily maintained

Feature	Specification
OD measurements	6 (30° radials)
Coiled tubing OD range	1 ¼" to 2 ⅞"
Axial resolution (100 ft/min)	0.120"
OD measurement accuracy	± 0.010"
Temperature sensitivity	0.0004" / °C
Bidirectional	Yes
Self-contained electronics/display	Yes
Orion compatibility	Yes
Digital data output capability	RS232
Tool head dimensions	20" OD x 19" L
Tool head weight	57 lbs
Power	110 VAC or 12 VDC
Integrated length measurements	Yes

Depth Measuring System (DMS)

Depth is the most important measurement made at the wellsite, yet conventional mechanical counters are often inaccurate due to pipe slippage past the single small-diameter friction wheel.

Our depth measuring system is a dual-wheeled measuring device for accurate depth measurements of coiled tubing operations at the wellsite or during reel-to-reel spooling. The DMS also employs proprietary software-controlled slippage compensation for a significantly more accurate measurement of the length of tubing spooled.

It is designed to be quickly and easily installed or removed from the coiled tubing prior to transport.

Data manipulation module

The display module is mounted in the control cabin of the coiled tubing unit. This module is used to display and reset depth and speed. This display module also houses the onboard processor that runs the Fastest Wheel Algorithm (FWA). Digital display meters show the measured depth from the top and bottom wheels as well as the composite depth from the FWA.

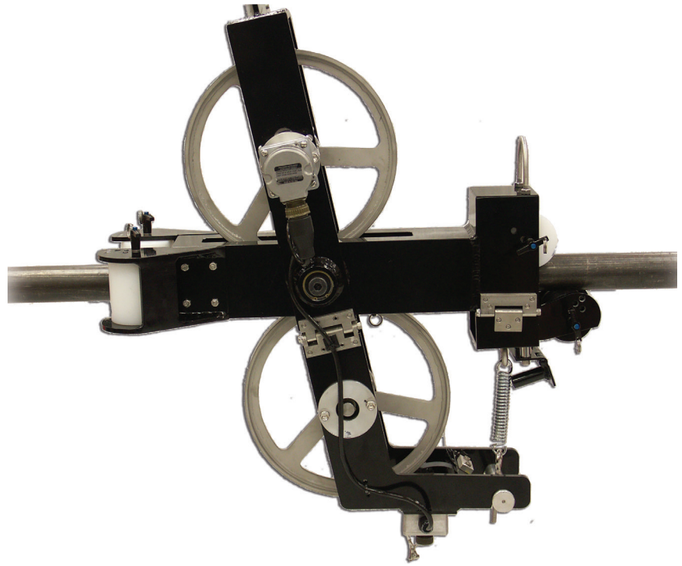
Quadrature signals from the DMS can be fed to any data acquisition system. An ordinary depth counter's accuracy is hindered by depth wheel slippage.

Alleviate slippage in three ways:

1. Lever-arm movement used to maintain a high frictional contact force between measuring wheels and the tubing
2. Two tungsten-coated stainless steel measuring wheels used for accuracy and dependability in harsh operating environments
3. Microprocessor incorporated to run the FWA while continually monitoring the speed of both wheels' electronic position encoders. The bottom wheel serves as master depth and the top wheel serves as backup depth. The top wheel takes over as master when the bottom wheel's speed is slower from slippage.

Features and Benefits

- Adjustable for 1 ¼" to 2 ⅞" coiled tubing
- Dual wheel design with dual depth encoders
- Slippage detection and compensation via microprocessor using FWA
- Internally mounted measuring wheel scrapers
- Integrates with Orion DAS and Cerberus to produce depth correction for temperature, stretch and buckling
- Stand-alone device compatible with any DAS
- Robust, field-proven design



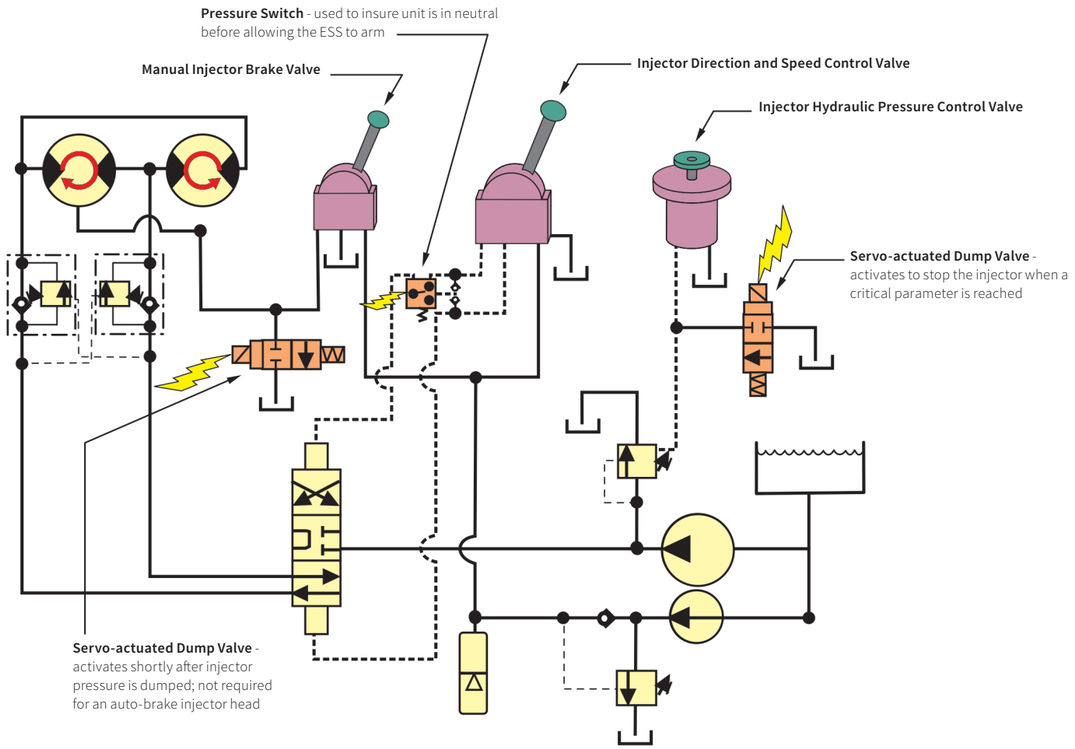
Specifications: DMS Measuring Head (Mechanical)

Feature	DMS	DMS for Hazardous ATEX Area Use
Weight	35 lbs	42 lbs
Length	30"	30"
Height	24"	24"
Width	13"	13"
Wheel circumference	36"	36"
Display	25.36W - 29.44W	25.36W - 29.44W
Enclosure	6" x 6" x 4"	6" x 6" x 4"
Type	NEMA 4X	NEMA 4X

Specifications: DMS Measuring Head (Electrical)

Feature	DMS	DMS for Hazardous ATEX Area Use
Supply voltage	5 VDC (head), 12 VDC (display)	5 VDC (head), 12 VDC (display)
Pulses/rev	600/150	600/150
Frequency	100kHz	100kHz
Output	2-channel Quadrature	2-axis Quadrature
Temperature range	-30° to 85°C	-40° to 40°C
Hazardous location rating		Suitable for Class 1 Zone 0, Group IIB locations, or ATEX II 1 G EEx ia IIB T4 -40° C < TAMB > 40° C

Emergency Stop System (ESS™)



Sample System Schematic
(Not representative of all designs)

The emergency stop system uses a combination of electro-hydraulic control valves and pressure switches, in conjunction with an Orion DAS, to stop the coiled tubing injector in the event of imminent failure.

System operation is accomplished by using the primary PC attached to the Orion DAS or the optional ROVer™ touch-screen interface. The ESS is adaptable to most coiled tubing units and can be installed during the manufacturing process or retrofitted in the field.

The operator responsible for the coiled tubing unit is a critical component of field operations, with key responsibility for controlling the coiled tubing injector. Serious events such as surface buckling or tensile yielding of the tubing string can occur when the operator is distracted, fatigued or working under a stressful environment. Even under optimum conditions, the average operator's reaction time to avoid such events can still be too long.

The ESS, an optional upgrade to the Orion DAS, provides a layer of defense to assist in preventing a simple distraction from becoming a very costly learning experience. Every action, from startup to shutdown, is recorded in the Orion DAS event log.

Features and Benefits

- Helps avoid costly operational failures
- Operator configurable
- System status displayed on-screen
- Records all events in Orion DAS Event Log
- Integrates into Orion DAS
- Retrofits to most coiled tubing units
- Continuous real-time monitoring of:
  - Minimum and maximum weight
  - Maximum rate of change of weight/second
  - Minimum coiled tubing speed

Zeta Safety System

The Zeta safety system consists of a real-time monitoring gauge and an advanced job design model for well intervention operations.

The system was designed to avoid catastrophic buckling and bending failures of longer and more complex well intervention stacks that we are now seeing in the industry. These tall stacks are more susceptible to bending excitation forces from crane, production riser and platform movements, and the failures are costly and could involve human injury and unplanned release of wellbore pressure to the atmosphere.

At present, a judgment call (based on little or no hard data) is made regarding how much lubricator sway or wellhead movement is acceptable, when to add supports or even when to halt operations due to safety concerns. Motion associated with TLPs and spars only compound this problem. The Zeta safety system eliminates guesswork and provides a tool for optimal rig-up configuration.

The Zeta system utilizes a proprietary 3D finite element analysis (FEA) model in combination with highly accurate measurements from fiber optic fiber gauges. This approach enables accurate modeling of changing stress levels across the entire riser/wellhead lubricator intervention stack.

The system can be used for pre-job modeling to optimize and verify the safety margin of your job design.

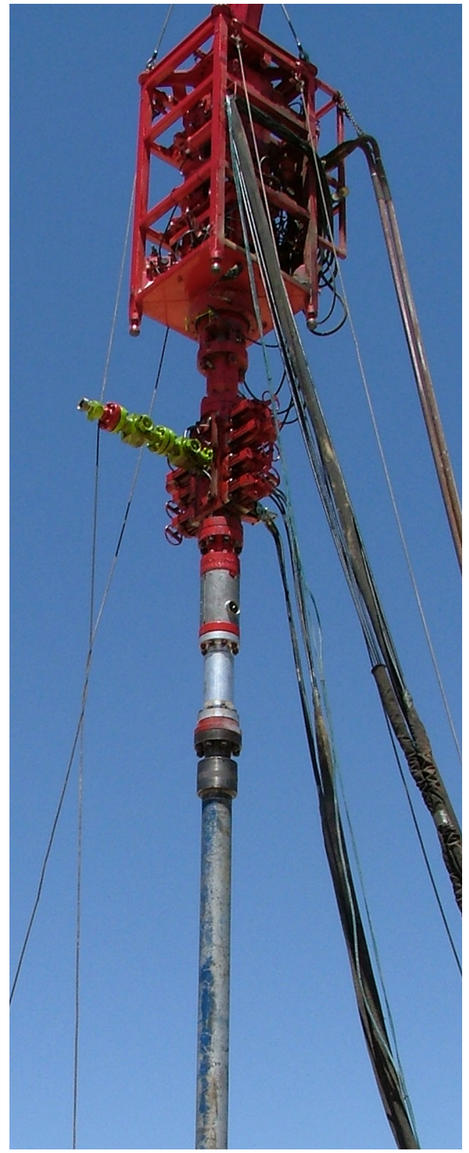
Zeta Model

The Zeta model software is one of the two primary components that comprise the Zeta safety system for well intervention operations.

The Zeta model is based on a nonlinear FEA approach, purpose-written for analyzing intervention structures. The FEA analysis is run repeatedly at very small time increments to perform a dynamic analysis. A finite difference, forward difference scheme is used to determine the acceleration of each component in the stack, and the associated dynamic forces. The model accurately calculates the buckling instability of the stack. It also calculates the Von Mises stress throughout the structure and compares the guy-wire loads to user-defined limits. Thus, it examines the structure for both modes of failure - failure due to buckling instability and failure due to yielding of a component in the structure.

Features and Benefits

- Cost-effective equipment selection (gimble tables, load frames, lubricator size/material)
- Adequate safety margin for the specific intervention operation
- Optimized rig-up configuration
- Avoid catastrophic buckling and bending failures of the intervention stack
- Eliminate guesswork and unproductive rig time



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