

CEMENTING

Integrated Controls for Precision Cementing

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Over the years, cementing equipment has been refined to maximize the performance of new materials and processes and to accommodate the requirements of increasingly complex cementing jobs. Now, technology is taking cement quality control to an even higher level with a new integrated control system.

For the first time in the industry, on-the-fly adjustments to a complex, multiunit cementing job will not require a four- to eight-man coordination effort. The new system consolidates the controls of all units into one computerized system, allowing an operator to monitor and simultaneously control all units on location when making an adjustment to the job. The new integrated control system is already being field tested with stimulation jobs and will soon be available for use with conventional and foamed-cement systems.

The importance of precision in controlling a job increases with the complexity of the job and the number of units involved. With the advent of foamed cementing, for example, a single job requires the installation of mixing, pumping, liquid-additive, and nitrogen equipment on location. More equipment demands more operators, and coordinating changes during an operation becomes logistically difficult.

Advanced computer technology provided a functional and economical solution, allowing a cost-effective step-change in the performance of cementing equipment. Because the new system fully integrates the controls of the cementing skid, the liquid-additive injection unit, and the nitrogen unit, an operator can query any or all of the operating systems for data to be displayed on a computer screen and send set point changes to any system as needed. Consequently, the operator can detect and act on potential problems with a few quick computer keystrokes, without leaving his post to investigate a problem or using hand signals to relay information. The system also features remote-control capabilities for off-site monitoring and control, which can greatly enhance the safety and efficiency of offshore cementing jobs.

The "brains" of the control system are housed within a PC-platform industrial computer

that is powered by a high-speed microprocessor and operated through the Windows NT operating system. A user-friendly interface was critical to the system's design for maximum efficiency. Developers accomplished this design with a color touch-screen, allowing the user to quickly maneuver the software menus and add or change data quickly by touching a selected color block on the screen ([Figure 1](#)). Other features include a small keypad and a built-in mouse that aids in setup and operation and provides backup to the touch screen. Because the system uses a controlled area network (CAN) bus for data input/output, the-use configuration, featuring the same easy-to-use touch-screen interface.

Automation of Equipment Components

Because of the increased use of foamed cementing, liquid-additive systems, and other sophisticated cementing techniques and materials, the number of jobs requiring highly technical control capabilities is growing steadily and placing greater demands on equipment. Over the years, refinements to cementing equipment have significantly improved reliability and expanded the operating envelope. The basic functions required have not changed, however, and the custom-designed equipment that has delivered reliable service for decades—the 400-hp triplex pump (in use since 1957), the industry's first recirculating mixer (introduced in 1975), liquid-additive pumps (used offshore since 1977), and nitrogen equipment (in use since 1974)—remains the foundation for the cementing system.

Cementing Unit

Introduced to the industry in 1975, the Recirculating Cement Mixer[®] (RCM) system has evolved to allow routine mixing of high-density and/or thixotropic slurries at high throughput rates ([Figure 2](#)). Reliability and service quality have remained at the forefront of RCM technology. In 1989, an Automatic Density Control (ADC) system was added to the RCM, improving control of the mixing process for even higher quality cement. Mixers equipped with the ADC system soon became the industry standard, with more than 400 systems installed to date.

Liquid-Additive System

In 1990, the batch process for adding liquid additives to the slurry through measuring (displacement) tanks was replaced by the Continuous Metering System (CMS), allowing additives to be injected at various points in the mixing and pumping process ([Figure 3](#)).

This system is more accurate than the batch process, and it accommodates foamed-cement jobs, which contain surfactants that are introduced downstream of the mixing process. Halliburton's injection unit continuously meters any number of additives required for a job, and it can inject additives into the mix-water stream or into the downhole-pump suction header for various customized job setups.

Integrating the liquid-additive system with the cementing unit not only makes it easier for the operator to monitor flow rates, it also allows the use of actual cement mixing rates as the main input for controlling additive proportioning. With this arrangement, an operator can alter the actual cement-mixing rate to suit the job's specific needs and be confident that the additives will be reportioned automatically to maintain the preset concentrations.

Technological advancements have also increased the metering accuracy for liquid-additive concentrations that are critical to the slurry's performance. A mass flowmeter option has been developed for the CMS, providing an alternative measure of flow rate. With this option, the user can:

1. Monitor the flow of additives by both the pump rate and the mass-flow indicator.
2. Use either signal for control-system feedback.

Because the mass flowmeter is not subject to calibration errors, it provides the accuracy required for some liquid additives, and provides a dependable system for quality control. In the first application, performed offshore Eastern Canada, metering accuracy was better than 1%, based on the total volume pumped.

Nitrogen System

A foamed cement's capacity to provide long-term zonal isolation is determined not only by the density of the base cement but also by the precision with which it is foamed through the injection of nitrogen. Traditionally, maintaining density integrity during stage changes has presented a challenge for operators. Today, with automated nitrogen injection, operators simply preprogram the stage changes into the operating system. Automated nitrogen injection has also allowed operators to ramp the foam concentration by programming the unit and achieve the desired foamed-cement density throughout the annulus.

Data Management

Mobile Control Center

The mobile control center, a van for land use and a skid for offshore use, provides a central focal point for monitoring and/or controlling the cementing job ([Figure 4](#)). Data-acquisition systems and real-time wellbore-simulation software allow data from all cementing components as well as discrete sensors to be fed into a mobile control center, where the operation can be monitored by operators and/or customers. Mobile control centers are currently being used in land and offshore cementing operations throughout North America.

Wellbore Simulation

Advanced wellbore simulation models are greatly improving the design of both conventional and foamed cementing jobs. The wellbore simulator has now been incorporated into the data-acquisition software so that, when conditions warrant, and especially when foamed slurries are run, the actual job parameters can be compared to the design values in real-time. These parameters include not only the traditional pressure, rate, and density values, but also wellhead pressure and fluid positions and pressures at any point in the wellbore. With this information, the risk of an unforeseen problem is minimized, and in the event that the operator must make a last-minute adjustment, the information generated by the simulation program can provide invaluable downhole information. [Figure 5](#) shows a postjob data graph from a conventional cementing job in California. The equivalent circulating density, which can now be displayed and monitored in real-time, can help an operator run the job while staying within the limits of low fracture gradient or high pore pressure.

The Authors

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Figure 1: Cementing unit PC controller

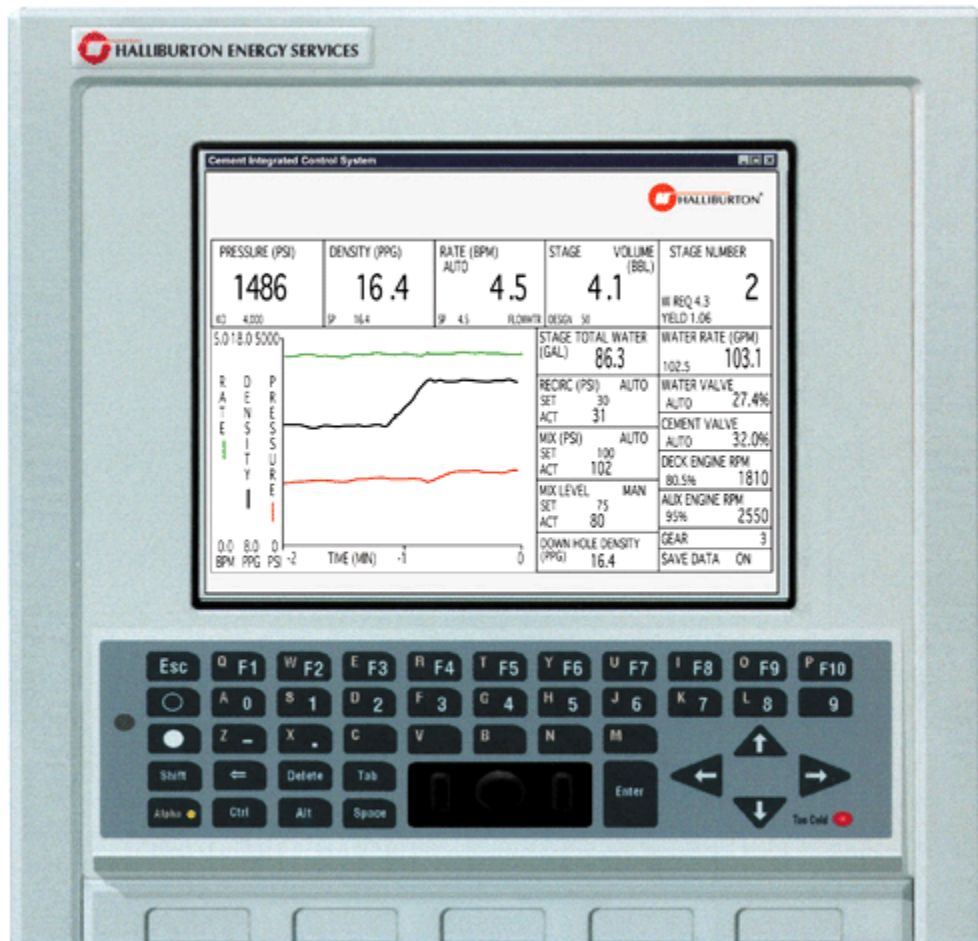


Figure 2: Cementing skid equipment with Recirculating Cement Mixer® (RCM) and Automatic Density Control (ADC) systems



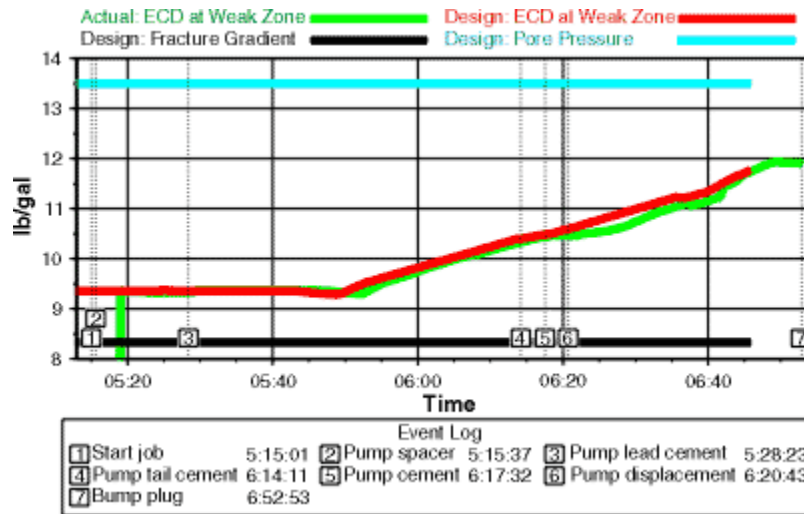
Figure 3: Continuous Metering System (CMS) liquid-additive injection unit



Figure 4: Mobile control center that allows customers to observe cementing parameters in real-time



Figure 5: Equivalent circulating density (ECD) graph comparing designed parameters with real-time parameters



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