

SAFETHERM

New generation aqueous-base or water-miscible insulating packer fluid for deepwater, low-temperature flow assurance

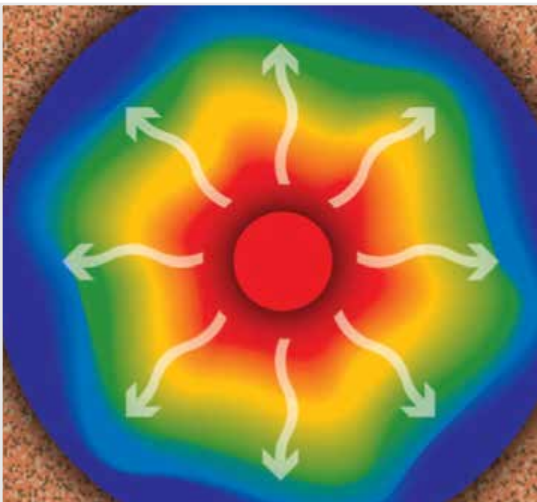


SAFETHERM: The aqueous-base solution for controlling APB, enhancing subsea production

In deepwater and ultra-deepwater environments, annular pressure-buildup (APB) can seriously jeopardize well integrity to the point of casing collapse, hindering the HSE and economic performance of your high-profile project. Moreover, during production start-up, well testing or shutting in for intervention, low subsea temperatures or cold formation can lead to distinctive flow assurance problems that can likewise seriously affect the value of your asset.

Engineered primarily for the deep and ultra-deepwater subsea environment, aqueous-base or water-miscible SAFETHERM[®] insulating packer fluid from M-I SWACO, a Schlumberger company, is equally effective in select onshore low-temperature formations, heavy oil developments and drill stem testing (DST) applications. SAFETHERM packer fluid has also emerged as a supporting riser insulating fluid for the joint industry Subsea Well Response Project (SWRP).

The aqueous-base solution for controlling APB, enhancing subsea production



Features

- Uniquely engineered to minimize convective and conductive heat loss
- Easily mixed and pumped on the rig
- Environmentally acceptable components
- Behavior modeling with proprietary heat-transfer computer model
- pH-buffered and corrosion-inhibitive
- Thermally stable for extended time periods

Benefits

- Helps maximize production
- Prevents production-line blockage, casing/cement bond failures, and casing-string collapse
- Eliminates the expense of mechanical and chemical heating and treatments
- Allows compatibility with a wide range of elastomers, fluids and surface processing equipment
- Enables modeling of fluid thermal behavior for production and shut-in scenarios
- Reduces costs
- Elevates HSE profile

To help ensure your well and your production are not left to the mercy of low subsea temperatures and cold formation, M-I SWACO developed the water-base SAFETHERM insulating packer fluid. Uniquely engineered to minimize convective and conductive heat loss, SAFETHERM packer fluid offers the utmost in environmentally sound, solids-free and thermally stable protection against production-stealing problems related to temperature cycling.

As an integral component of our comprehensive, application-specific approach to flow-assurance, SAFETHERM insulating packer fluid consistently demonstrates its capacity to prevent thermally-generated APB. What's more, SAFETHERM packer fluid helps optimize present and future project value by blocking heat transfer, effectively enhancing produced-fluid quality without the added expense of fluid heating and flow assurance treatment chemicals.

The deepwater has enough challenges. Heat transfer should not be one of them.

In tandem with proprietary behavior modeling software, such as our TPRO ST¹ package, SAFETHERM packer fluid routinely demonstrates its capacity to prevent profit-draining problems related to:

- The transfer of heat away from produced fluids, resulting in a product that is incompatible with the available surface processing equipment
- Multiple casing strings where heat is transferred into unvented annuli, which can increase temperature and pressure in the sealed space, posing a very serious risk of a casing collapse
- Well shut-ins for short-term suspensions and intervention operations during which thermal expansion and contraction of the tubular goods induces excessive stress in the metal that can disrupt casing/cement bonding
- Viscosity spikes that can adversely affect production quality
- Wax buildup, hydrate formation and salt precipitation in both deepwater and select onshore wells, resulting in production blockages and serious operational risks
- Loosening makeup torque of threaded connections, potentially compromising elastomer and cement seals, which can impact well stability

SAFETHERM packer fluid keeps the heat on your production and off your bottom line



A SAFETHERM insulating packer fluid system is customized to meet the unique temperature and pressure issues affecting well construction and development in a subsea or cold formation application. Specifically engineered for each deepwater or similarly cold temperature environment, SAFETHERM insulating packer fluid provides thermal protection for your produced oil by:

- Suppressing convective heat loss in the annulus
- Minimizing conduction of heat away from the production string
- Helping control the pressure buildup in sealed annuli
- Maintaining flowing surface temperature to ensure consistent produced fluid quality within the temperature criteria of processing equipment
- Matching a broad spectrum of fluids, elastomers and other components in a wide range of wells
- Combining thermal stabilizers, corrosion inhibitors and oxygen scavengers
- Remaining thermally stable and non-corrosive over a wide range of temperatures and pressures for extended periods of time
- Eliminating convection for minimal stress on tubing, casing, seals and cement bonds
- Reducing pressure cycling and thermal expansion for retention of optimum makeup torque and uncompromised threaded connections

- Heading off the need for mechanical insulation of tubing couplings when used with vacuum-insulated tubing

Specially engineered components proven to lower production-robbing convective heat loss

A key to enhancing production quality in the subsea and cold formation environments is suppressing convection, in which fluids become more dense and eventually sink as temperatures cool. If not arrested, the initiation of convection can suddenly increase total heat loss by a factor of 30 or more. As verified by our proprietary Thermal Conductivity and Heat Capacity Test Device, which measures both thermal conductivity and heat capacity as material properties, suppressing convection significantly minimizes heat loss and enhances produced fluid quality.

The SAFETHERM packer fluid is specially formulated to do just that. In fact, independent tests have shown SAFETHERM packer fluid to possess a convective heat-transfer coefficient 25 times lower than that of water with components that ensure your production remains thermally protected. Specifically, SAFETHERM packer fluid is:

- Resistant to thermal conduction and free of suspended solids
- Designed to be formulated for densities ranging from 8.33 to 12.5 lb/gal (1 to 1.5 kg/L) pH-buffered and inhibited to minimize corrosion

- Hydraulically optimized to yield low plastic viscosity with elevated low-shear-rate viscosities and yield stress
- Flat low-end rheological profile over a wide temperature range
- Thermally stable over extended time periods
- Engineered to be mixed and pumped on the rig
- Capable of being pumped at high rates through small tubing and orifice valves, with minimal frictional pressure loss

SAFETHERM packer fluid also helps protect the environment

As an aqueous-base fluid, SAFETHERM is relatively benign, making it the ideal insulating option for the most sensitive offshore and onshore ecosystems. The components of the system are specially selected to have minimal environmental impact, thereby mitigating the effects of spills or other unforeseen events. In the North Sea, for instance, the SAFETHERM insulating packer fluid has earned the stringent Class E designation, confirming its environmental acceptability.

Put our SAFETHERM aqueous-base or water-miscible insulating packer fluid to work for you

To find out more about our SAFETHERM packer fluid and how it is performing for our other customers, contact your local M-I SWACO representative.

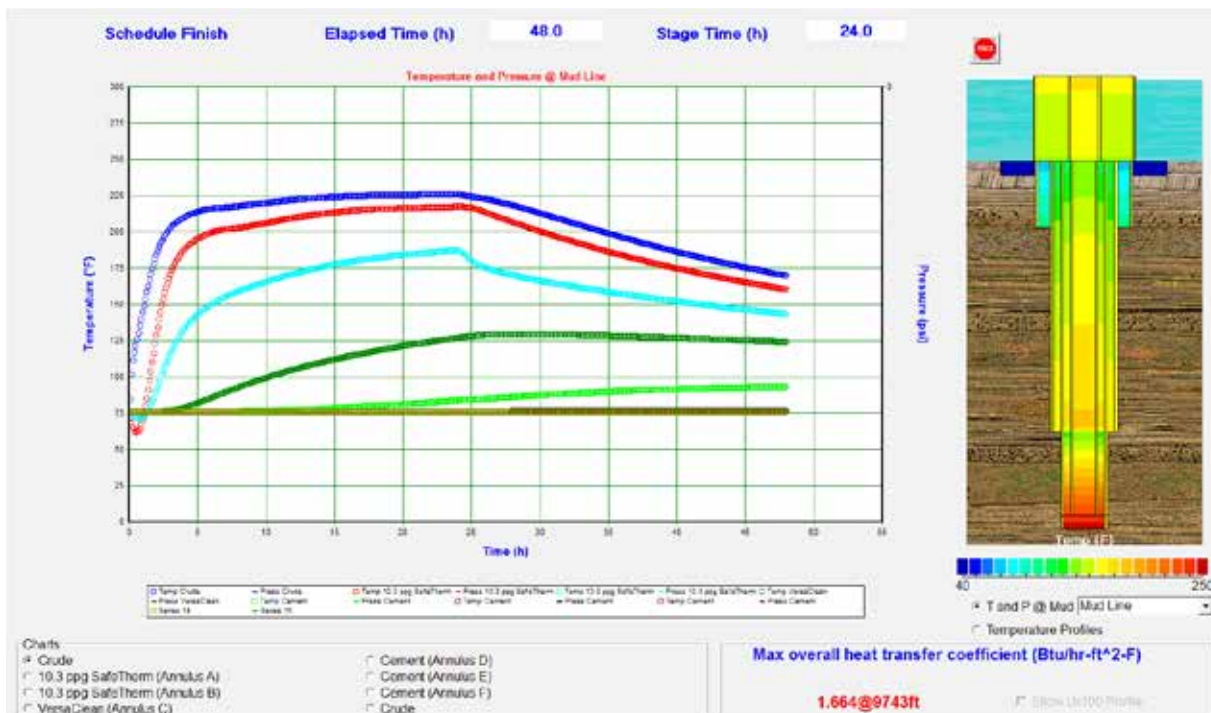
The figures below show the temperature development at the mud line in the different annuli for an offshore well during a 24 hour production period followed by a 24 hour shut-in period. The top and bottom figures show the well with sodium chloride brine and SAFETHERM packer fluid in the production annulus respectively. The two

graphs (blue line) representing the crude oil both level out at approximately 225 degF (107 degC), although a few degrees higher with the SAFETHERM packer fluid. When the well shuts in, the temperature starts dropping. As can be seen in the graphs, the crude with brine outside loose the heat significantly faster than the crude with

SAFETHERM packer fluid outside, ending up with crude temperatures of 150 degF (66 degC) and 170 degF (77 degC) respectively after 24 hours shut-in. This shows how the SAFETHERM packer fluid will significantly increase the no-touch times available.



Production and shut-in with brine in annulus. Final crude temp 150 degF (66 degC).



Production and shut-in with SAFETHERM packer fluid in annulus. Final crude temp 170 degF (77 degC).

SAFETHERM insulating packer fluid proves itself in the field

Gulf of Mexico: SAFETHERM packer fluid effectively insulates deepwater producers

The Situation

The operator required thermal protection for its deepwater Gulf of Mexico production wells to maintain produced fluid quality, prevent annular pressure build up and inhibit the formation of production-restricting gas hydrates. In addition, the solution would be required to protect threaded connections and elastomer seals while maintaining cement bond integrity. Failure in heading off any of these potential issues could threaten the entire project. To comply with the completion design, the insulating packer fluid selected would require a density of 11.5 lb/gal (1.38 SG).

The Solution

M-I SWACO recommended its SAFETHERM insulating packer fluid, which would be engineered specifically to meet the distinctive requirements of the project. The system was formulated with a thermal conductivity (k) value of 0.19 BTU/hr-ft-degF, specific heat capacity (Cp) value of 0.58 BTU/lb-degF, yield stress of 34 lb/100 ft² and the required density of 11.5 lb/gal. These properties were determined to give the SAFETHERM packer fluid the capacity to minimize convection and conduction and offer maximum protection against thermal cycling-related production problems in this particular application. The fluid was designed based on calculations derived from the proprietary TPRO ST behavior modeling software comprising an exclusive heat transfer computer model. Laboratory testing confirmed no pumping-related problems should be encountered.

The Results

The SAFETHERM packer fluid was installed trouble-free and with zero HSE incidents in the annulus above the TIP packer. Uniquely engineered for this application, the system minimized convective and conductive heat loss, while preventing production line blockages and casing string collapse. The mixing and pumping procedures determined through the lab tests proved effective for this operation.



West Africa: SAFETHERM packer fluid ensures four successful well tests in deepwater offshore

The Situation

An operator in deepwater Gulf of Guinea, West Africa, was looking for a way to provide thermal protection to their production wells for their produced fluid for a series of well tests. Early exploration work indicated that some of the crude oil in the area has high wax content and a relatively high wax appearance temperature. The operator was concerned that the crude oil would congeal in the drill stem test string during shut-in for pressure measurements. Thermally insulating the riser to slow the cooling of the stationary crude oil in the production string was required to ensure the success of the well tests.

The Solution

M-I SWACO provided the SAFETHERM insulating packer fluid, which was specifically engineered to well-specific requirements. A SAFETHERM packer fluid formulation was formulated to the density and thermal properties required in the laboratory. For the first well test, 9.3 lb/gal (1.12 SG) of SAFETHERM packer fluid with a thermal conductivity of 0.17 BTU/hr-ft-degF and a yield stress of 56 lb/100 ft² was used. These properties gave the SAFETHERM packer fluid the ability to minimize heat loss through conduction and convection, and offer maximum protection against production problems related to thermal cycling in connection with well shut-in. The well testing continued as part of the multi-year drilling campaign for a total of four well tests. The SAFETHERM packer fluid was treated prior to each well test to the required density and thermal properties.

The Results

The SAFETHERM packer fluid was successfully installed in the annulus of the riser above the 10.2 lb/gal (1.22 SG) packer fluid without any problems or QHSE incidents. Pumping procedures were executed effectively with continued improve to reduce fluid interfaces and minimize waste. Installation of the SAFETHERM packer fluid in the riser annulus of these four wells allowed the well tests to be successfully completed with no flow assurance issues related to thermal effects. The increased cool-down times associated with the SAFETHERM packer fluid provided sufficient shut-in times for the necessary measurement of reservoir pressures.



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