



Completion Fluid Systems & Products, Reservoir Drill-In Fluids, Breakers, Filtration & Specialized Tools



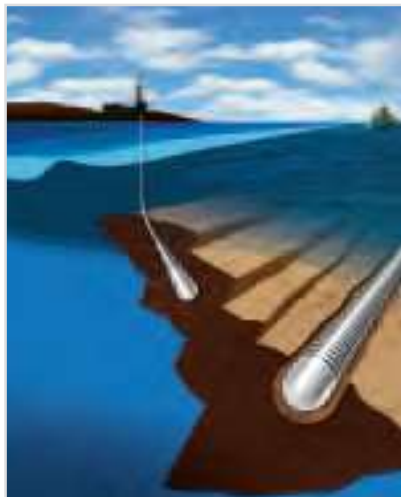
“Our Company is committed to continuous improvement of its global health, safety and environmental processes while supplying high-quality, environmentally responsible products and services to our customers.”

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Solutions for you and your well



Completion Fluid Systems & Products, Reservoir Drill-In Fluids, Breakers, Filtration & Specialized Tools

- Engineering/simulation software
- Reservoir drill-in fluids
- Intervention fluids
- Breakers
- Spacers and Displacement Chemicals
- Specialized Tools
- Completion Fluids
- Filtration
- Fluid-loss control systems
- Packer fluids



Drilling Fluid Systems & Products

- Wellsite and project engineering
- Simulation software
- Drilling-fluid systems and additives
- ALPINE SPECIALTY CHEMICALS*
- FEDERAL* Wholesale
- HDD Mining & Waterwell
- Technical support



Production Technologies

- Specialty production chemicals
- Chemical management
- Drag reduction
- H₂S treatment
- Descaling, decontamination and decommissioning
- Commodity and utility chemicals
- Produced water treatment
- Production Waste Management



Solids Controls, Pressure Control & Waste Management

- Rig-equipment engineering
 - Solids control
 - Solids-control systems
 - Mud mixing
 - Shakers
 - Mud cleaners
 - Centrifuges
 - FLUIDS PROCESSING SYSTEM (FPS)
- Cuttings handling and transportation
- Oilfield screens
- Waste injection
- Cuttings treatment
- Pressure control
 - D-GASSERS
 - Disc-type chokes
 - Shuttle chokes
 - Choke consoles
 - PRESSURE & FLUID MANAGEMENT SYSTEM (PFMS)
- Rig instrumentation
- Enhanced fluids treatment
- Vessel cleaning
- Produced water treatment
- Production waste management

OPTIBRIDGE

Engineering/Simulation Software

Versatile software that takes the guesswork out of designing non-damaging reservoir fluids

Any fluid entering your reservoir affects production. Whether it's a kill pill, a reservoir drill-in fluid or one designed for lost circulation or perforation sealing, it must be formulated precisely to block invasion and, ultimately, prevent formation damage. The first step in designing a non-damaging fluid is to determine the ideal particle-size distribution for the bridging material.

Our proprietary OPTIBRIDGE* software gives the M-I SWACO representative a tool for precisely and quickly selecting correctly sized bridging agents. With the OPTIBRIDGE program, the M-I SWACO representative inputs formation data as well as information about locally available products. The software then calculates the "best-fit" mixture of locally produced bridging particles for effectively sealing the formation face.

The OPTIBRIDGE software tool is another example of our commitment to ensure the integrity and long-time productivity of your reservoir.

OPTIBRIDGE software makes sure no void is left unsealed

The OPTIBRIDGE program improves on the popular Ideal Packing Theory, which takes a graphical approach to determine the optimum sizing of bridging material for specific formation characteristics. Basically, this theory examines all the voids in a given formation and considers



the full range of particle-size distribution that will be required to seal them effectively.

OPTIBRIDGE software takes that theory a major step further. It uses a mathematical model based on the largest pore size, also known as the D_{75} rule.

Using the software, the M-I SWACO representative examines data from the targeted formation, including maximum pore-size opening, permeability and/or screen sizes, and combines that input with the bridging-particle information. From that model, the program automatically generates a target line of the optimum blend of particles that will effectively minimize solids and filtrate invasion.

Features

- Accurately matches local bridging agents with formation characteristics
- Applicable for reservoir drill-in fluids, lost-circulation treatments, kill pills, fracture sealing and perforation sealing
- Prevents fluid invasion
- Uses actual formation and bridging-agent information that will provide an optimum filter cake

Advantages

- Reduces formation damage
- Takes the guesswork out of selecting bridging material
- Lowers material costs
- Optimizes production

Once the optimum blend is known, the ratio of bridging materials can be perfectly matched to the formation characteristics.

Because the OPTIBRIDGE program considers characteristics of your specific formation and matches them with bridging particles available in your area, there is no concern about having to wait or bear the burden of extraordinary delivery costs. What's more, this powerful software package ensures the desired solids are maintained in the fluid system, allowing you to maximize your solids-control program while still maintaining the precise particle-size distribution of the bridging agent.

OPTIBRIDGE software:

One more weapon in the battle against reservoir damage

The OPTIBRIDGE program clearly illustrates the ingenuity and lengths that M-I SWACO will undertake to develop systems and tools to minimize formation damage and maximize your production. To find out more about how the OPTIBRIDGE program is performing for our customers worldwide, contact your local M-I SWACO representative.



OPTIBRIDGE software generates a target line that defines the ideal blend of locally produced bridging materials that would best fit the targeted formation characteristics. Available anywhere in the world, the OPTIBRIDGE service is an ideal tool for formulating a non-damaging reservoir drill-in fluid. It also can be used to design fracture-sealing and lost-circulation treatments, and to formulate kill and perforation-sealing pills for workover and completion operations.

PRODUCTION SCREEN TESTER (PST)

Engineering/Simulation Software

The wellsite tool that helps avoid screen plugging and maximizes production

A wellsite scenario: Using one of the M-I SWACO new-generation reservoir drill-in fluids, you've reached the target zone much sooner than expected, saving both time and money in the process. Now you face a situation that could cost you those savings and then some, if not handled properly.

Your plan is to complete the well openhole, and that requires one of a variety of production screens for sand control. Of course, the drill-in fluid must remain in the hole while the completion assembly is being positioned. Afterward, at the initiation of production, the fluid must flow freely back through the screen. At that point, it is critical that the particle-size distribution of the bridging agent, the solids concentration of the fluid and the production screen be matched perfectly. If not, the screen will probably plug, not only impeding production, but raising the real risk of screen erosion, leading to unplanned-for remediation costs and possible reduction in the long-term productivity of the well.

Until now, you had to put everything on hold while you sent a fluid sample to a lab and waited for an analysis. The wait is over. M-I SWACO can now provide the wellsite PRODUCTION SCREEN TESTER* (PST*) that tells you in real time if the fluid remaining in the annulus will flowback

freely through the production screen. The proprietary unit is compatible with all types of screens and can test both invert-emulsion and water-base reservoir drill-in fluids.

Reduced downtime. Reduced costs. Maximized production.

The PRODUCTION SCREEN TESTER is just one more example of how M-I SWACO takes every opportunity to increase the productivity of your well.

M-I SWACO takes quality control from the lab to your rig

Over the years, laboratory-scale devices have been designed to study the phenomenon of how drilling-fluid solids affect the plugging of production screens. First, there was the development of full-scale flow loops containing a section of screen. This was followed by a laboratory apparatus that simulated the flow of drilling fluid through the screen at a constant production flow rate. While the flow loop and simulator provided valuable information, neither was practical for field use.

M-I SWACO has worked in conjunction with a major Norwegian operator to develop the PRODUCTION SCREEN TESTER, an easy-to-use unit that allows a quick quality-control check at the wellsite and fluid plant to ensure the drilling fluid is in optimum condition prior to completion. In wells worldwide, it has given operators confidence in preparing for the completion process without worrying about screen plugging.



PRODUCTION SCREEN TESTER (PST).

The correct design and maintenance of a reservoir drill-in fluid is critical where openhole completions are planned. The particle-size distribution of solids in the openhole must be carefully chosen, primarily to bridge across the exposed formation, but it may also permit flowback through the openings in the completion assembly. Initial fluid design and testing must be done in the laboratory, but once drilling has started in the reservoir, any flowback testing on field samples normally requires urgent shipping to shore, resulting in delays of days between sampling and test results. M-I SWACO has designed the PRODUCTION SCREEN TESTER to perform onsite testing of fluid flowback at the rigsite. The unit allows field fluid to be tested in real-time on samples of identical completion screen. This test also assists in determining the optimum cleanup chemistry such as the M-I SWACO BREAKFREE* or BREAKDOWN* treatments.

With this rigsite instrument, the operator can save the cost of additional completion fluid or freshly built fluid because the well can be completed with a properly conditioned reservoir drill-in fluid. Additional savings can be achieved in optimizing the performance of solids-control equipment and rig time. By testing the samples on the rig, you avoid the costs and downtime of waiting for laboratory results.

Regardless of screen type, the PST delivers data you can trust

Whether you're completing the reservoir in a standalone or openhole gravel-pack mode with a simple single-wire wrap screen or one of the more sophisticated, premium types, you can feel secure with the information you receive from the M-I SWACO PRODUCTION SCREEN TESTER. Early in the design phase, one of the primary criteria for the apparatus was its ability to test all of the different screens now on the market.

The PST accommodates a sample of any type of screen. Special holders have been constructed for prepacked screens, while wire-wrapped, expandable, multi-layered and sintered-metal screen samples can be manufactured from sections cut from the actual screen to be used rather than relying on ideal apertures.

Prior to running the screen in the reservoir, the M-I SWACO onsite drilling-fluid specialist loads the PRODUCTION SCREEN TESTER with a representative sample of the screen to be used. A fluid sample from the well is then run through the screen. In short order, the fluid specialist determines whether the fluid in the wellbore will flow freely through the screen or if additional conditioning or displacement is needed before the initiation of the completion process. There is nothing overly complicated about the PRODUCTION SCREEN TESTER.

It is very similar to the API Filtration Unit, so that every M-I SWACO drilling-fluid specialist is familiar with how it works. While it may be a relatively simple unit, the results it delivers have been proven accurate on wells around the world.

Used in the North Sea, the U.S., China, West Africa and elsewhere, the PRODUCTION SCREEN TESTER has exhibited a remarkable success rate approaching 100%. In none of the wells where it has been used to test the quality of the fluid, has a screen become blocked at the initiation of production. In fact, the PST helped one operator avoid a major problem when it was discovered that the fluid used to drill the first lateral could not be used for completion because it plugged the screen sample.

Features

- Accommodates all screen types
- Tests both invert-emulsion and water-base fluids
- Simple design
- Similar to API Filtration Unit
- Samples tested onsite

Advantages

- Reduces risks
- Real-time data on fluid condition
- Produces accurate results in minimum time
- Optimizes solids-control equipment and rig time
- Eliminates wait for lab results
- Saves training time

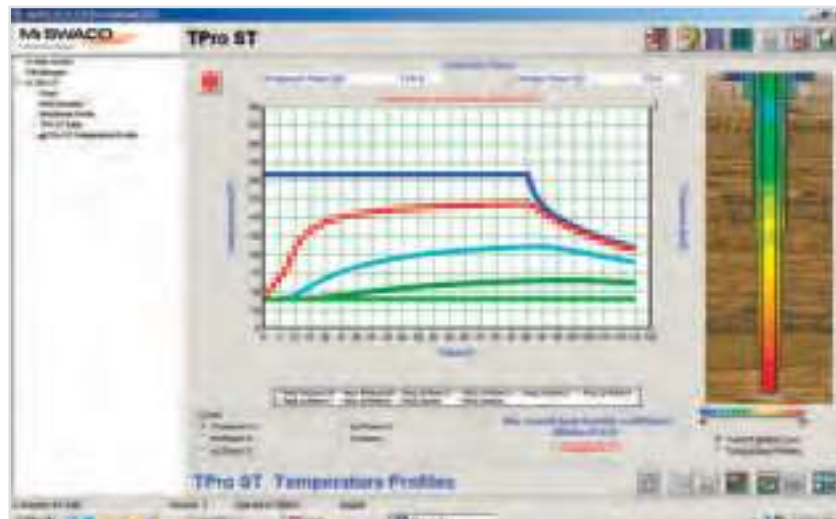
TPro ST

Engineering/Simulation Software

The TPro ST computer model provides added assurance

M-I SWACO has developed laboratory testing equipment and computer models to accurately test and predict the performance of insulating packer fluids like ISOTHERM* or SAFETHERM* fluid in any wellbore environment. The models are unique in the industry in that they address specific rheological properties of fluids and, most importantly, their capability to resist the onset of convective heat loss.

Complementing insulating packer fluid and our in-house thermal-conductivity-testing apparatus is a unique computer model capable of simulating Newtonian and non-Newtonian fluid behavior in an annulus to calculate temperature regression during production and shut-in. The proprietary TPro ST* computer model, which includes algorithms for rheologically engineered fluids, considers production temperature



and rate, thermal properties of the production and casing string(s), the external environment, and the insulating packer fluid itself. This sophisticated software calculates the temperature profile throughout the wellbore during start-up, steady-state production and during the duration of a shut-in.

With the TPro ST model, we can determine with a high degree of certainty just how long you can keep your well off-line before it must be returned to production or before other remedial action must be initiated.

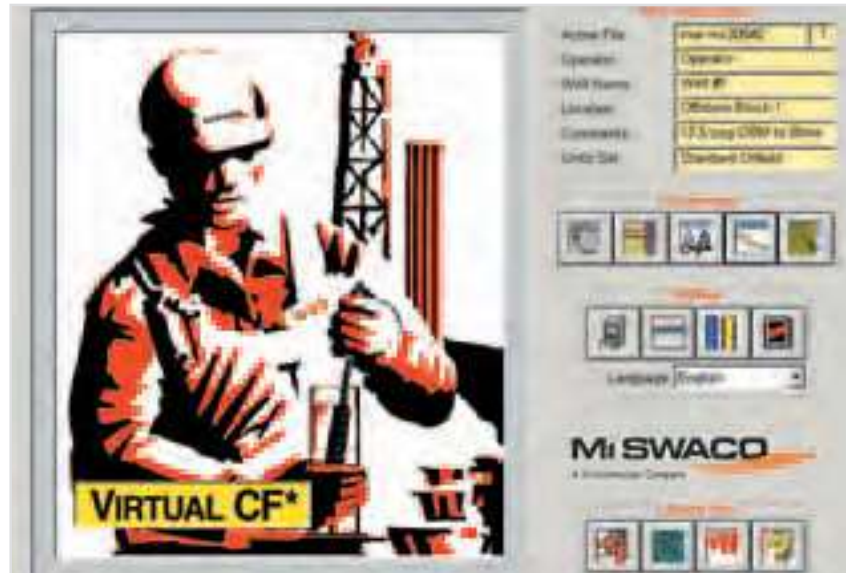
VIRTUAL CF (VCF)

Engineering/Simulation Software

Powerful software for designing and optimizing wellbore displacements

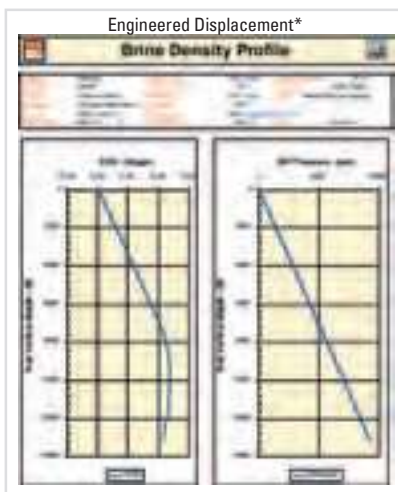
When displacing drilling fluid with a completion or reservoir drill-in fluid, neglecting critical variables can lead to a world of headaches down the road. Excessive rig time. Damaged reservoirs. Added cleanup and filtration costs. Lower production.

Our proprietary VIRTUAL CF* software package considers all the parameters, taking the uncertainty out of wellbore displacements. This sophisticated, integrated suite of computer programs targets the hydraulics modeling and displacement profiles of high-density brines and other completion fluids to enhance wellbore cleanup and ultimately the productivity of your well.



Armed with this powerful software package, the M-I SWACO representative can, with an unequalled degree of accuracy:

- Minimize rig time for displacements by calculating all critical variables in the wellbore, including rheologies, flow regime, velocity, contact time, pump strokes, pump pressure and differential pressures
- Design a displacement that meets equipment limitations by inputting exact wellbore geometry, including angle, and calculating such parameters as hydraulic horsepower, flow rate, choke pressures and back pressures – all based on actual wellbore geometry
- Ensure safety and well control by providing back-pressure schedules for those cases where differential or bottomhole pressures must be maintained
- Provide flexible operating parameters for critical wells by simulating displacement in either direction, tracking all fluids in the displacement as a function of volume or pump strokes, and displaying position, pressure, rate and other data at any point in the wellbore
- Optimize completion fluid economics by predicting equivalent static and local brine density at any point in the wellbore, accounting for varying temperatures from surface to bottom, which is especially beneficial in the cold, deepwater environments



VIRTUAL RDF (VRDF)

Engineering/Simulation Software

Specialized tools ensure formation integrity

VIRTUAL RDF

VIRTUAL RDF* (Reservoir Drill-In Fluids) software package is available to M-I SWACO operational personnel. VIRTUAL RDF consists of a suite of programs used in the selection, design, and optimization of reservoir drilling fluids. The suite includes OPTIBRIDGE, FINV*, RDFX*, BREAKER ADVISOR*, RDF FORMULATOR* and HD BRINE SOLIDS CALCULATOR*. In addition the standard M-I SWACO reference modules, CONV and Tables are included.

- **OPTIBRIDGE** optimizes bridging particle-size distribution based on reservoir characteristics such as pore size (preferred) or permeability
- **FINV** indicates potential filtrate invasion depth based on exposure time and filtration properties
- **HD BRINE SOLIDS CALCULATOR** allows a more accurate determination of solids in RDFs built with high-density brines like potassium/cesium formate or calcium/zinc bromide than conventional retort analysis
- **RDFX** is a reservoir drilling fluid selector program that assists the project manager in choosing an appropriate RDF for a specific project
- **RDF FORMULATOR** is a reservoir drilling-fluid formulation program. It is capable of formulating water and invert-emulsion based reservoir drilling fluids and can formulate all M-I SWACO RDF systems
- **BREAKER ADVISOR** is a program to assist the completion/project manager in selecting an appropriate breaker for a given project. The program uses reservoir, drilling, completion and production information to assist in the selection process



Well Assurance Solutions Provider (WASP)

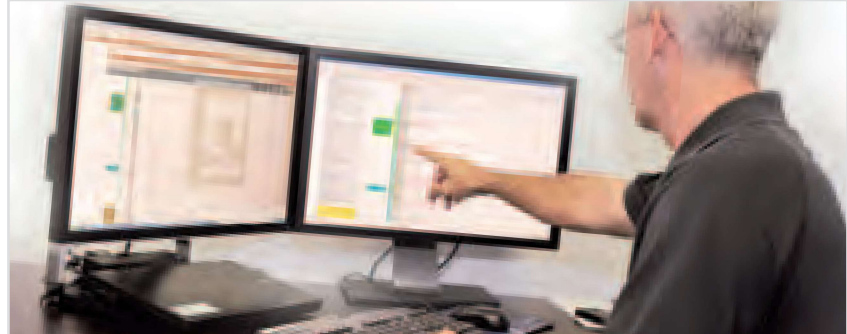
Engineering/Simulation Software

Software for planning, designing and reporting on debris management operations for wellbore preparation

Getting optimum results from your cleanout tool strings is the result of clear, concise and accurate preparation. The first step in this process is thorough pre-job planning and data capture of the wellbore geometry as well as the selection of specific cleanout tools. The proprietary M-I SWACO WASP* software package gives our specialists a powerful tool for designing the most effective BHAs. With WASP software they can select and place the desired wellbore cleanup tools for your application. Specialists can even access a worldwide database of previous runs with the same tools under similar conditions, to reinforce design recommendations. Your M-I SWACO Account Manager will discuss the resulting tool schematic with you to ensure that your objectives are met in delivering a debris-free well and an incident-free completion. However this is just the beginning of the benefits that the WASP & WASP-TMA* software can provide for your next project.

A valuable recording and reporting tool

During the wellbore preparation operation, your M-I SWACO specialist utilizes WASP software in the Onsite mode. With data gathered at the rigsite, the specialist can update the pre-planned schematic to reflect the actual tools run, their depths and other pertinent information associated with any tool in the string. In the Onsite mode, the WASP system can generate Microsoft® Excel-based BHA tally sheets and non-conformance reports. After the job is completed, the software is used to generate a rigsite and post-job report to provide you with timely information. The captured data can also



be used to generate tool-specific run histories which can be easily accessed to provide you with valuable information for future planning.

The WASP-TMA system stores and retrieves your valuable data seamlessly

The WASP-TMA (Tool Maintenance Application) software is integrated with, and stores all the files generated by, the WASP system. It facilitates data transfer to the ONE-TRAX* Central (OTC) database that houses the information collected for run, tool and job histories as well as drilling and completion fluid data. This provides a central location for all of the tools technical information, graphics and master lists. When combined with data gathered from other M-I SWACO software, it is possible to deliver a full case history on any project handled by M-I SWACO.

How it works

- The M-I SWACO specialist enters into the WASP software all of the pertinent operator and well information as well as the specific specialized tools to be utilized and their placement
- The WASP system generates a wellbore tool schematic which is then reviewed to ensure accuracy in string design and tool application
- As the project progresses, the M-I SWACO specialist uses the WASP software to generate BHA tally sheets, "as-run" schematics and a detailed job log

- This information is transferred into a template that creates the rigsite and post-job reports. The WASP post-job report includes all wellbore geometry, fluid types and volumes, job highlights, future recommendations, the as-run schematic, a detailed job log and charts that reflect the time spent on each part of the operation. The report can then be augmented with rig and shop photos of the tools as well as any hydraulics or torque-and-drag modeling that may have been required in the pre-planning stage
- All tools utilized will be added to the global M-I SWACO database, which will be available to assist you in planning your next project

Cleaner, faster completions begin with your call to M-I SWACO

WASP and WASP-TMA software are two more examples of the M-I SWACO commitment to provide current and future clients with fully engineered solutions that meet or exceed your expectations for wellbore preparation and debris management.

Discover for yourself how we are helping our customers succeed in completing their wells. Contact your M-I SWACO representative for case histories that demonstrate our performance.

Features

- Pre-job planning and data capture are integrated with the technical data of the Specialized Tools product line
- Concise, accurate and up-to-date wellbore schematics and technical data
- Onsite data capture
- Contributes to, and can draw from, a global database of run histories accessible from anywhere, anytime
- Rigsite and post job report generation
- Capable of breaking down time spent on specific phases of the operation
- QHSE quality-event recording and reporting into the M-I SWACO quality systems

Advantages

- Easy to read and review schematics that capture wellbore geometry, specific tool models, parameters and placement
- Quickly revise project schematics as job requirements or contingencies change
- Reduced data-entry time and improved data accuracy
- Tool-specific run histories shorten and add assurance to decision-making
- The global database provides the widest range of valuable information
- Report generation saves time
- Identify time-saving procedural changes



Tool Joint	Tool Joint ID	Tool Joint Description	Tool Joint Length (m)	Tool Joint Weight (kg)	Tool Joint Volume (m³)	Tool Joint Density (kg/m³)	Tool Joint Material
Wellhead	1	Wellhead	1.000	1.000	1.000	1.000	Wellhead
Casing	2	Casing	1.000	1.000	1.000	1.000	Casing
Packer	3	Packer	1.000	1.000	1.000	1.000	Packer
Wellhead	4	Wellhead	1.000	1.000	1.000	1.000	Wellhead
Casing	5	Casing	1.000	1.000	1.000	1.000	Casing
Packer	6	Packer	1.000	1.000	1.000	1.000	Packer
Wellhead	7	Wellhead	1.000	1.000	1.000	1.000	Wellhead
Casing	8	Casing	1.000	1.000	1.000	1.000	Casing
Packer	9	Packer	1.000	1.000	1.000	1.000	Packer
Wellhead	10	Wellhead	1.000	1.000	1.000	1.000	Wellhead
Casing	11	Casing	1.000	1.000	1.000	1.000	Casing
Packer	12	Packer	1.000	1.000	1.000	1.000	Packer
Wellhead	13	Wellhead	1.000	1.000	1.000	1.000	Wellhead
Casing	14	Casing	1.000	1.000	1.000	1.000	Casing
Packer	15	Packer	1.000	1.000	1.000	1.000	Packer
Wellhead	16	Wellhead	1.000	1.000	1.000	1.000	Wellhead
Casing	17	Casing	1.000	1.000	1.000	1.000	Casing
Packer	18	Packer	1.000	1.000	1.000	1.000	Packer
Wellhead	19	Wellhead	1.000	1.000	1.000	1.000	Wellhead
Casing	20	Casing	1.000	1.000	1.000	1.000	Casing
Packer	21	Packer	1.000	1.000	1.000	1.000	Packer
Wellhead	22	Wellhead	1.000	1.000	1.000	1.000	Wellhead
Casing	23	Casing	1.000	1.000	1.000	1.000	Casing
Packer	24	Packer	1.000	1.000	1.000	1.000	Packer
Wellhead	25	Wellhead	1.000	1.000	1.000	1.000	Wellhead
Casing	26	Casing	1.000	1.000	1.000	1.000	Casing
Packer	27	Packer	1.000	1.000	1.000	1.000	Packer
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Casing	29	Casing	1.000	1.000	1.000	1.000	Casing
Packer	30	Packer	1.000	1.000	1.000	1.000	Packer
Wellhead	31	Wellhead	1.000	1.000	1.000	1.000	Wellhead
Casing	32	Casing	1.000	1.000	1.000	1.000	Casing
Packer	33	Packer	1.000	1.000	1.000	1.000	Packer
Wellhead	34	Wellhead	1.000	1.000	1.000	1.000	Wellhead
Casing	35	Casing	1.000	1.000	1.000	1.000	Casing
Packer	36	Packer	1.000	1.000	1.000	1.000	Packer
Wellhead	37	Wellhead	1.000	1.000	1.000	1.000	Wellhead
Casing	38	Casing	1.000	1.000	1.000	1.000	Casing
Packer	39	Packer	1.000	1.000	1.000	1.000	Packer
Wellhead	40	Wellhead	1.000	1.000	1.000	1.000	Wellhead
Casing	41	Casing	1.000	1.000	1.000	1.000	Casing
Packer	42	Packer	1.000	1.000	1.000	1.000	Packer
Wellhead	43	Wellhead	1.000	1.000	1.000	1.000	Wellhead
Casing	44	Casing	1.000	1.000	1.000	1.000	Casing
Packer	45	Packer	1.000	1.000	1.000	1.000	Packer
Wellhead	46	Wellhead	1.000	1.000	1.000	1.000	Wellhead
Casing	47	Casing	1.000	1.000	1.000	1.000	Casing
Packer	48	Packer	1.000	1.000	1.000	1.000	Packer
Wellhead	49	Wellhead	1.000	1.000	1.000	1.000	Wellhead
Casing	50	Casing	1.000	1.000	1.000	1.000	Casing
Packer	51	Packer	1.000	1.000	1.000	1.000	Packer
Wellhead	52	Wellhead	1.000	1.000	1.000	1.000	Wellhead
Casing	53	Casing	1.000	1.000	1.000	1.000	Casing
Packer	54	Packer	1.000	1.000	1.000	1.000	Packer
Wellhead	55	Wellhead	1.000	1.000	1.000	1.000	Wellhead
Casing	56	Casing	1.000	1.000	1.000	1.000	Casing
Packer	57	Packer	1.000	1.000	1.000	1.000	Packer
Wellhead	58	Wellhead	1.000	1.000	1.000	1.000	Wellhead
Casing	59	Casing	1.000	1.000	1.000	1.000	Casing
Packer	60	Packer	1.000	1.000	1.000	1.000	Packer
Wellhead	61	Wellhead	1.000	1.000	1.000	1.000	Wellhead
Casing	62	Casing	1.000	1.000	1.000	1.000	Casing
Packer	63	Packer	1.000	1.000	1.000	1.000	Packer
Wellhead	64	Wellhead	1.000	1.000	1.000	1.000	Wellhead
Casing	65	Casing	1.000	1.000	1.000	1.000	Casing
Packer	66	Packer	1.000	1.000	1.000	1.000	Packer
Wellhead	67	Wellhead	1.000	1.000	1.000	1.000	Wellhead
Casing	68	Casing	1.000	1.000	1.000	1.000	Casing
Packer	69	Packer	1.000	1.000	1.000	1.000	Packer
Wellhead	70	Wellhead	1.000	1.000	1.000	1.000	Wellhead
Casing	71	Casing	1.000	1.000	1.000	1.000	Casing
Packer	72	Packer	1.000	1.000	1.000	1.000	Packer
Wellhead	73	Wellhead	1.000	1.000	1.000	1.000	Wellhead
Casing	74	Casing	1.000	1.000	1.000	1.000	Casing
Packer	75	Packer	1.000	1.000	1.000	1.000	Packer
Wellhead	76	Wellhead	1.000	1.000	1.000	1.000	Wellhead
Casing	77	Casing	1.000	1.000	1.000	1.000	Casing
Packer	78	Packer	1.000	1.000	1.000	1.000	Packer
Wellhead	79	Wellhead	1.000	1.000	1.000	1.000	Wellhead
Casing	80	Casing	1.000	1.000	1.000	1.000	Casing
Packer	81	Packer	1.000	1.000	1.000	1.000	Packer
Wellhead	82	Wellhead	1.000	1.000	1.000	1.000	Wellhead
Casing	83	Casing	1.000	1.000	1.000	1.000	Casing
Packer	84	Packer	1.000	1.000	1.000	1.000	Packer
Wellhead	85	Wellhead	1.000	1.000	1.000	1.000	Wellhead
Casing	86	Casing	1.000	1.000	1.000	1.000	Casing
Packer	87	Packer	1.000	1.000	1.000	1.000	Packer
Wellhead	88	Wellhead	1.000	1.000	1.000	1.000	Wellhead
Casing	89	Casing	1.000	1.000	1.000	1.000	Casing
Packer	90	Packer	1.000	1.000	1.000	1.000	Packer
Wellhead	91	Wellhead	1.000	1.000	1.000	1.000	Wellhead
Casing	92	Casing	1.000	1.000	1.000	1.000	Casing
Packer	93	Packer	1.000	1.000	1.000	1.000	Packer
Wellhead	94	Wellhead	1.000	1.000	1.000	1.000	Wellhead
Casing	95	Casing	1.000	1.000	1.000	1.000	Casing
Packer	96	Packer	1.000	1.000	1.000	1.000	Packer
Wellhead	97	Wellhead	1.000	1.000	1.000	1.000	Wellhead
Casing	98	Casing	1.000	1.000	1.000	1.000	Casing
Packer	99	Packer	1.000	1.000	1.000	1.000	Packer
Wellhead	100	Wellhead	1.000	1.000	1.000	1.000	Wellhead



DIPRO

Reservoir Drill-In Fluids

The system that transforms high-density divalent brines into premium, biopolymer-free reservoir drill-in fluids

The DIPRO system gives you high density, low solids, minimal formation damage and easy cleanup in divalent brines

For its base fluids, the DIPRO system uses the divalent-cation brines and brine blends – CaCl_2 , CaBr_2 , $\text{CaCl}_2/\text{CaBr}_2$, $\text{CaBr}_2/\text{ZnBr}_2$ and $\text{CaCl}_2/\text{CaBr}_2/\text{ZnBr}_2$ – in the 11.5 to 17.5 lb/gal (1.4 to 2.1 kg/L) density range. With any of these base brines, the system uses a unique viscosifier/filtration-control additive in conjunction with properly sized calcium carbonate bridging agents to build a fluid that generates low filtration rates and produces a thin filter cake to protect the reservoir.

The system's low ECDs help prevent excessive invasion of whole mud, especially in formations having low fracture gradients, such as those found in deepwater.

Because we can engineer the system so precisely, and because of its flexible chemistry, DIPRO can be formulated in densities ranging from 11.5 to 17.5 lb/gal (1.4 to 2.1 kg/L) for any of several completion methods:

- Openhole gravel packs
- Standalone screens
- Slotted/perforated liners
- Barefoot
- Expandable screen



M-I SWACO uses the petrographic microscope to analyze thin sections of reservoir rock materials. Through analysis of pore size and other mineralogical characteristics, we can tailor fluid formulations to specific reservoirs.

Features

- Biopolymer-free
- Divalent-brine base
- Precisely controlled particle-size distribution of bridging agent
- Customized formulations
- Low ECDs
- Excellent shale stability
- Compatible with complex completions, including openhole gravel packs

Advantages

- Maximizes production
- High production rates sooner
- Filter cake is easily removed
- Cost-effective, high-density fluids
- Minimal formation damage
- Minimal fluid loss with durable filter cake
- Reduces remediation and disposal costs
- High performance in deepwater applications

The DiPRO System has the characteristics you've come to expect from M-I SWACO

Completion

Formation damage. The system's unique viscosifier/filtration-control additive results in low filtration rates and protects the reservoir with a tough, thin filter cake.

Completion compatibility. The system forms a durable filter cake that remains intact during completion operations, such as high-rate water packing, but may also be flowed back through virtually any completion during production.

Displacement. Because of the base-brine composition, the DiPRO system is compatible with completion fluids and displaces easily.

Cleanup. The DiPRO system filter cake can be produced through a completion, or be easily destroyed with a variety of chemical breakers.

Long-term stability. The DiPRO system's divalent-brine base fluid allows the fluid to remain in the well for long periods of time without significant degradation.

Recoverability. The base brine from the DiPRO system can be easily reclaimed for use as a completion fluid or for formulating another DiPRO system.

Drilling

Density requirements. The DiPRO system functions optimally in the 11.5 to 17.5 lb/gal (1.4 to 2.1 kg/L) range and its density can be adjusted within this range without increasing the solids in the system.

Rheological properties. Typically, the DiPRO system has a shear-thinning rheological profile, low plastic viscosity, high yield point and relatively high LSRV.

Contaminant tolerance. The system tolerates the contaminants commonly found in drilling: cement, drilled solids, reactive shales and oil.

Torque and drag. While the DiPRO system produces torque and drag that is slightly higher than synthetic- or oil-base systems, its lubricity is good for water-base reservoir drill-in fluid systems. If needed, the system's lubricity can be enhanced with a compatible lubricant.

Wellbore stability. The base brines used to formulate the system produce an excellent level of shale inhibition.

Engineering ease. Because the DiPRO system consists of only a few components, it is easy to mix on the rig and maintain.



The M-I SWACO SAFE-CARB® bridging agent is high-purity ground marble which is selected using our OPTIBRIDGE software to obtain the optimal blend. In these photos, the disc to the left is coated with a typical filter cake as it would be deposited by the DiPRO system. The middle photo shows the even "pinholing" effect obtained by back-producing the well, when this is possible. The right hand photo represents instances where back-producing is not a viable option; the filter cake is almost completely dissolved after only a three-hour soak with 5% HCl acid.

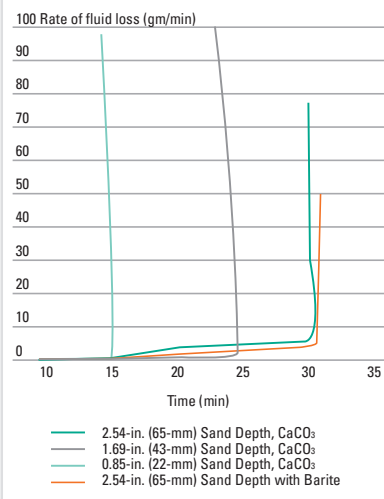
**Drill fast while oil-wet.
Complete clean while
water-wet. Do both with the
reversible, invert-emulsion
FAZEPRO* system.**

Dual objectives – ease of completion and efficient drilling – in challenging well designs and reservoirs demand a Reservoir Drill-In Fluid (RDF) that actually can satisfy two diverse requirements.

Operators today are faced with a two-sided problem in certain types of reservoirs:

- Drilling requirements demand an oil- or synthetic-base reservoir drill-in fluid. While this approach might meet technical, geological and economic objectives, completing a reservoir with a conventional invert-emulsion system has drawbacks in providing full reservoir connectivity during production or injection. Not only does it make sand-control completions more difficult, but thorough, even destruction of oil-wet filter cakes can be time-consuming and extremely costly
- Completion requirements call for a water-base system that makes it much easier to destroy the filter cake, but the system may be unable to inhibit water-reactive shale and its inherent clays, compromising drilling efficiency. In such cases, a troublesome, costly and often inadequate completion negates a fast and efficient drilling phase

Filter-cake cleanup with 40/60 gravel pack



Once the pH is modified, filtration rises dramatically, even when traces of barite are on the now water-wet filter cake.

Operators demand both drilling efficiency and unimpaired completions. The industry's only reversible, invert-emulsion reservoir drill-in fluid system delivers performance plus non-damaging, single-stage destruction of oil-base filter cake with an overall completion simplicity greater than that of water-base fluid.

Filter-cake removal is a matter of good chemistry

While drilling the reservoir, the FAZEPRO system generates the high performance you expect from an invert-emulsion system. With the oil- or synthetic-base fluid serving as the continuous phase, the FAZEPRO system delivers the excellent inhibition and lubricity inherent in these fluids, resulting in a high-quality wellbore and a cost-effective rate of penetration.

Features

- Oil-base drilling performance
- Water-base filter-cake removal
- Oil-wetting easily reversed with pH change
- Stable chemical package
- Water-wet surfaces after pH change
- Good shale inhibition

Advantages

- Faster drilling, stable wellbore
- Easier to destroy filter cake
- Better production/injection rates
- Reduced waste generation
- Simplified cleanup through openhole gravel packs and other complex completions
- No remedial treatments

The FAZEPRO system generates and maintains its strong invert emulsion during drilling operations.

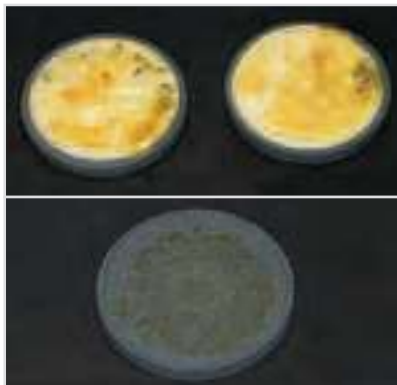
Once you reach the completion phase, the uniqueness of the FAZEPRO system really becomes apparent. By simply adjusting the pH of the breaker solution, the wettability of the filter cake is transformed from an oil-wet state to water-wet. Once the filter cake is water-wet, it can be removed easily and entirely with water-base breaker treatments. Even challenging gravel packs that are known to restrict lift-off/flowback performance and uniform accessibility of a breaker system to the filter cake (particularly with aggressive treatments) are not a problem for a FAZEPRO invert emulsion. The result is mitigation of formation damage and completion impairment.

As an added bonus, FAZEPRO chemistry has been shown to be exceptionally effective for water-injection wells, especially when immediate post-completion injectivity is desired without preproducing the well to “clean up” the reservoir.

Reversal from water-in-oil to oil-in-water

In the past, powerful surfactants and solvents were commonly used prior to well production/injection in an attempt to remove or break down conventional invert-emulsion filter cakes, but they met with only limited success. The FAZEPRO invert-emulsion system changed all that.

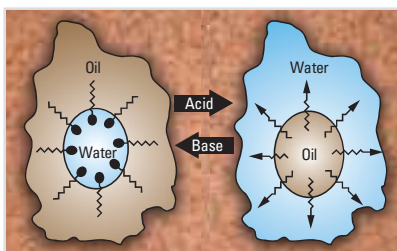
When the pH of the environment around the filter cake is lowered during completion, the FAZEPRO filter cake is converted from a water-in-oil emulsion to a direct oil-in-water emulsion, resulting in easy and complete filter-cake destruction. The uniquely engineered FAZEPRO system, consisting of FAZE-MUL* emulsifier and FAZE-WET* wetting agent, allows for an easy, single-stage efficient cleanup using “gentler” dissolution chemicals to achieve a better and more uniform result.



Filter cakes deposited by traditional invert-emulsion reservoir drill-in fluids (top) can be costly and time-consuming to clean up, unlike those from a FAZEPRO system (bottom).

The FAZE-MUL product is the industry's only emulsifier capable of being reversed from an invert emulsifier into a water-wet surfactant. M-I SWACO designed the emulsifier package so that alkalinity conditions slightly below neutral (pH 7) will change the oil-wet filter cake to a water-wet state. This reversible mechanism can permit total destruction of the filter cake, removing the barrier that was created between the formation face and the wellbore, thus regaining reservoir connectivity. This reversal process has contributed to increasing reservoir productivity/injectivity.

The emulsifier package is coupled with an application-specific, brine-base internal phase and uses organophilic clay for viscosity and lime as the alkalinity agent. The brine requires no special makeup, and it



Adjusting alkalinity to reverse emulsion. Changing the pH around in the FAZEPRO system chemistry converts a water-in-oil emulsion into a direct oil-in-water emulsion for easy and complete cleanup.

can be incorporated into a variety of invert-emulsion base fluids including synthetics, diesel, mineral oils, paraffins and olefins – any base fluid you would use in a conventional invert system. The organophilic clays are also used to create viscosity in reduced concentrations when compared to conventional invert-emulsion fluids.

Two approaches to remove filter cake

Easy, efficient destruction of the filter cake is crucial to smooth completion operations. There are two approaches to destroy the integrity of filter cake: dispersion or dissolution.

Dissolution is the act of destroying the filter-cake components to reduce the likelihood of solids impairing the formation or completion. Dissolution is the method of choice for injector wells using any type of openhole completion and production wells that are gravel-packed or that use fine-gauge premium and/or expandable-screen completions.

Dispersion involves destroying the integrity of the filter cake to allow the residual solid particles (bridging solids and drilled solids) to flow back through the completion or fall out of the way. Dispersion is generally applicable to gas or oil producers that are barefoot or predrilled-liner completions. It can also be useful in some gravel-pack completions.

The FAZEPRO system's chemistry simplifies both of these processes. In fact, it is easier to destroy the integrity of the FAZEPRO filter cake than that of many water-base reservoir drill-in fluid filter cakes that require finding and breaking down polymers of various molecular weights. The integrity of a FAZEPRO filter cake is generated by the invert emulsion. Separating the two phases (oil and water) compromises the filter cake.

FLOPRO NT

Reservoir Drill-In Fluids

The reservoir drill-in fluid that takes you to the new level of technology for minimizing formation damage and optimizing production

Start preparing your reservoir for higher production rates right from the start

In response to the industry's demands for greater drilling efficiencies and higher production rates, M-I SWACO developed this new-generation reservoir drill-in fluid – FLOPRO NT. The system begins with your production-rate target and completion design then works back to the drill-in operation, optimizing all the factors that will affect your success. You get a system which provides strong benefits as a high-performance, non-damaging drill-in fluid that optimizes production rates across a wide range of completion methods.

As the well is being drilled and completed, your M-I SWACO fluid specialist ensures that the system is capable of delivering what it promises – maximum reservoir productivity, lower total well costs and minimal environmental risk.

For production and reservoir engineers: wells that are productive sooner

Because the design of a FLOPRO NT system is based upon the way you'll complete your well, the completion process itself is greatly simplified. Every system component is soluble with some type of chemical treatment to make chemical breaking and cleanup relatively simple and straightforward. Because the filter cakes are designed to produce back with the minimum possible drawdown, FLOPRO NT wells can, in many cases, begin production without chemical cleanup treatments.

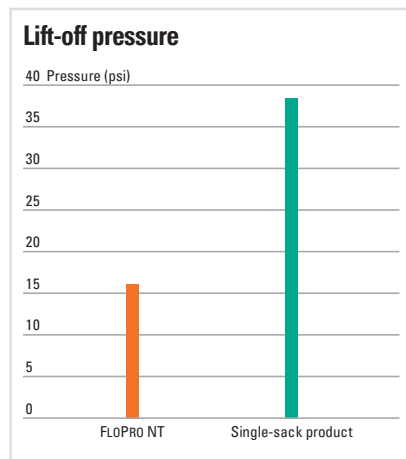
Because of the system's flexibility, your M-I SWACO fluid specialist can build a FLOPRO NT system from a number of base fluids, including freshwater, seawater, potassium chloride, sodium chloride, calcium chloride, sodium bromide and FORMIX* TECHNOLOGY, which includes sodium formate, potassium formate and cesium formate.

Features

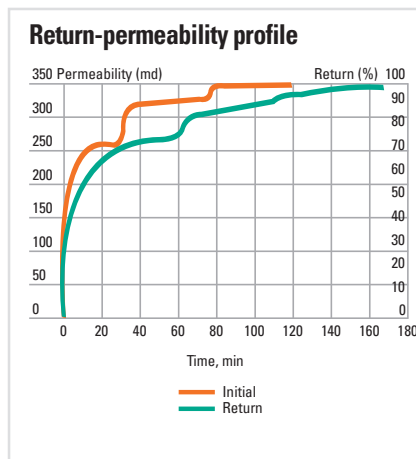
- Customized formulations
- Non-damaging
- Low lift-off
- Engineered for easy cleanup
- High return permeability
- Ultra-low-permeability filter cake
- Precisely controlled particle-size distribution of bridging agent
- Extremely low friction factor
- Promotes low skin values
- Environmentally acceptable
- Rheologically engineered for elevated LSRV

Advantages

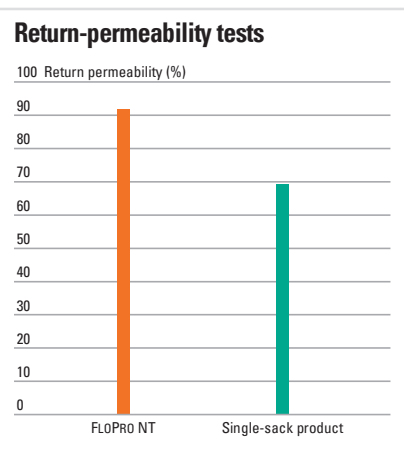
- Maximizes production
- Reduces remediation costs
- Higher production rates sooner
- Minimal lift-off required, faster cleanup
- Minimizes solids and fluid invasion to the formation
- Reduces pump pressures
- Maximizes ROP, saves drilling time
- Excellent hole-cleaning profile
- Reduces cleanup and disposal costs
- Compatible with any completion assembly



Because the FLOPRO NT system can be custom-tailored to the well conditions at hand, it consistently outperforms single-sack reservoir drill-in-fluid products in both return permeability and cleanup – two major factors in increasing production and reducing costs.



The High-Temperature, High-Pressure (HTHP) return permeameter measures the permeability of formations to oil, brine, and gas under high-temperature and high-pressure conditions. The apparatus can also be used to measure formation damage on core samples, test fluids containing lost-circulation materials and large bridging particles, and run acid cleanup tests in high temperatures and pressures.



FLOPRO NT with KLA-STOP

Reservoir Drill-in Fluids: Systems

FLOPRO* NT reservoir drill-in fluid (RDF) incorporating the KLA-STOP* shale inhibitor is ideal in applications where superb inhibition is required, such as when the production interval intersects numerous sand/shale stringers. The combination of the RDF and shale inhibitor has been shown to reduce swelling and dispersion of the shale significantly.

The KLA-STOP additive is a liquid polyamine shale inhibitor that can be used in reservoir drill-in fluids. Shale inhibition is achieved by preventing water uptake by clays and results in superior cuttings integrity. The KLA-STOP additive effectively inhibits shale or gumbo clays from hydrating and minimizes the potential for bit balling.

Advantages

- Minimizes incorporation of active drilled solids into reservoir drill-in fluids
- Controls acid insoluble portion of reservoir drill-in fluid filter cake
- Provides excellent shale inhibition and limits cuttings dispersion
- Reduces accretion potential and consequently bit and BHA balling
- Proper concentration of the KLA-STOP additive will provide a buffered pH in the 9.0 – 10.0 range, eliminating any need for additions of caustic soda or potassium hydroxide
- Tolerant to common contaminants such as: cement, hard water, CO₂, drill solids, and crude oil
- Environmentally acceptable for both offshore and onshore applications.
- Can be added to the active system without adverse effects on viscosity and filtration properties

FLOPRO SF

Reservoir Drill-In Fluids

The solids-free system for wells that require special handling

The FLOPRO SF (Solids-Free) system is a water-base Reservoir Drill-In Fluid (RDF) which has proven itself as a successful “rheologically engineered” system that relies on viscosity to control fluid invasion into the formation. It is formulated with a higher Low-Shear-Rate Viscosity (LSRV) than a conventional FLOPRO NT system.

The reservoir and your production come first when we design a FLOPRO SF system

M-I SWACO fluid specialists design FLOPRO SF systems with respect to the reservoir properties and the completion method to be used. Factors taken into consideration include:

- Formation permeability or pore size
- Formation temperature
- Presence of reservoir gases
- Formation sensitivity to particular ions
- Clay content
- Type of hydrocarbon(s) to be produced

Reducing fluid invasion without solids

FLOPRO SF systems can be used where bridging agents are not required or an oxidizer is the desired breaker. Heavy-oil formations, where formation viscosity confronts drilling-fluid viscosity to further reduce leak-off invasion depth, are also excellent candidates for the system. And FLOPRO SF fluids work well where overbalance pressure is kept to a minimum to reduce invasion depth into dolomite, limestone, and consolidated or unconsolidated sands.

The applications for FLOPRO SF can include:

- Coiled-tubing applications
- Ultra-low-permeability formations
- Formations that contain high-viscosity oil
- As pills for running completion assemblies after having drilled with FLOPRO NT
- Barefoot, slotted-liner, openhole-gravel-pack or non-gravel-pack completions
- Cased-hole completions where hole cleaning or minimizing fluid invasion is critical



Flexible formulation makes the system a practical solution virtually anywhere

FLOPRO SF systems can be designed with a number of base fluids, including:

- Freshwater
- Seawater
- Potassium, calcium or sodium chloride
- Sodium bromide
- Sodium, potassium or cesium formate

Features

- Does not rely on starch or sized bridging agents
- Circulates at low pump pressures
- Low friction factor
- Breaks easily with oxidizer
- Temperature-stable to 300°F (176°C)

Advantages

- Reduces and prevents formation damage
- Increases production
- Simplifies cleanup
- Ideal for coiled-tubing drilling
- Well-suited for high-temperature applications





FLOTHRU

Reservoir Drill-In Fluids

During an openhole completion where the filter cake is confined, as in openhole gravel packs or expandable-screen completions, the cake must remain intact to prevent losses and premature screenout. Once the completion operation has finished, however, the filter cake is usually removed with a chemical breaker to aid well productivity and avoid residual cake plugging the screen during production.

In many instances it is difficult to access the confined filter cake with a chemical breaker. Difficult access or incomplete contact could be caused by premature breakthrough, causing the breaker to bypass parts of the filter cake; failure of a circulating tool to open or dilution of the chemical breaker while attempting to place the breaker through the gravel pack. Incomplete contact with the entire filter cake can lead to a 'hot spot' limited flow area that can eventually lead to completion failure.

The FLOTHRU system offers a simple solution that eliminates the need for a chemical breaker.

How the FLOTHRU system works

The FLOTHRU system is a water-base reservoir drill-in fluid designed with enhanced flowback capabilities that eliminate the need for a chemical cleanup treatment, while providing higher return permeability and lower flow-initiation pressures. The primary application for a FLOTHRU system is in openhole completions where the filter cake is trapped between the formation and the completion assembly.

In openhole completions where the filter cake is not confined, the FLOTHRU system still provides a major benefit: lower flow initiation pressures at comparable return-permeability values.

In the FLOTHRU system, a proprietary hydrophobic-carbonate component combines with a hydrophobic starch to control fluid loss. These materials create organophilic (oil-preferential) channels through the FLOTHRU filter cake. Their filter-cake-building characteristics provide a low-permeability barrier to water and prevent high infiltration. These same organophilic channels avoid the cohesive nature of conventional water-base RDF filter cakes and provide increased transmissibility of hydrocarbons, eliminating the need for chemical breakers.

Features

- Higher return permeability through Openhole Gravel Packs (OHGP)
- Lower flow-initiation pressures for OHGP and other open hole completions
- Higher tolerance to drilled solids contamination
- Channels for steady hydrocarbon flow
- No chemical breakers needed

Advantages

- Uniform cleanup across the entire filter cake
- Increases production rates, from heel to toe
- Removes cleanup risk/cost
- Cuts completion time and costs
- Allows hydrocarbons to preferentially produce
- Eliminates remedial completion operations

The FLOTHRU system is one of the SMART RDF* Technologies from M-I SWACO and utilizes a combination of conventional and advanced RDF design concepts to minimize formation damage:

- Custom particle-size distribution to bridge formation pores
- Appropriate salts for density or inhibition
- Effective and appropriate shale inhibitors
- Effective solids engineering
- Minimal solids
- Low-Shear-Rate Viscosity (LSRV) for hole cleaning and suspension
- Hydrophobic components that enhance productivity
- An organophilic filter cake that promotes low flow-initiation pressures

Building a more productive filter cake

Like other SMART RDF systems, the FLOTHRU system contains the smallest possible amount and the correct size of bridging solids that will still protect the reservoir and minimize the impairment of openhole completions.

The system relies on a combination of conventional bridging agents and

THRUCARB* hydrophobic carbonate. The conventional bridging agents provide protection for a wide range of formation pore sizes. The THRUCARB product is a very fine, treated calcium carbonate that maximizes the number of organophilic channels while avoiding fine gravel-pack and completion-screen plugging.

The THRUCARB additive is supplemented with conventional calcium carbonate that has been selected with M-I SWACO OPTIBRIDGE* software. This program determines the optimum particle-size distribution of the bridging agent which helps to create an external filter cake and avoid deep invasion of potentially damaging solids.

Formation-damage testing, performed on FLOTHRU samples, has consistently shown higher return permeabilities and lower flow-initiation pressures in gravel-pack completions than conventional RDFs. The organophilic components aid the oil in flowing through the filter cake. For stand-alone completions, comparable return values have been seen with substantially lower flow-initiation pressures using the FLOTHRU system.

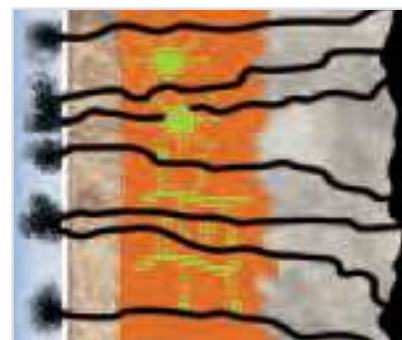
Maintaining the downhole environment

Freshwater and monovalent salts, such as NaCl, KCl, NaBr and sodium or potassium formate provide a wide density range as the base fluids for the FLOTHRU system.

In addition, calcium chloride brine up to 10.8 lb/gal (1.3 SG) can also be used as the base fluid for the system.

Description

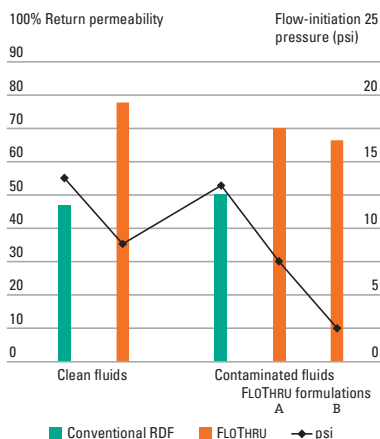
- Water-base monovalent salts
- Organophilic cake components
 - Carbonate: very fine
 - Starch
- Biopolymer viscosifier
- Properly sized bridging agents



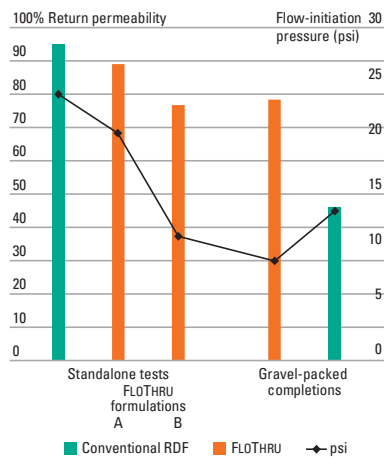
- Inside wellbore
- Hydrocarbons
- Hydrocarbons flowing through the filter cake
- FLOTHRU filter cake
- THRUCARB*
- Associations of THRUTROL* starch
- THRUTROL starch
- Formation sand where filtrate has displaced back the hydrocarbons
- Hydrocarbons

The FLOTHRU filter cake resists water invasion of the formation while allowing hydrocarbons to flow at low flow-initiation pressures.

Return Permeability and Flow-Initiation Pressure All 40/60 Gravel Packs with No Chemical Cleanup



Return Permeability and Flow-Initiation Pressure Clean Fluids, No Chemical Cleanup



FORMIX TECHNOLOGY

Reservoir Drill-In Fluids

The ideal foundation for building high-performing, low-solids drilling and reservoir drill-in fluid systems

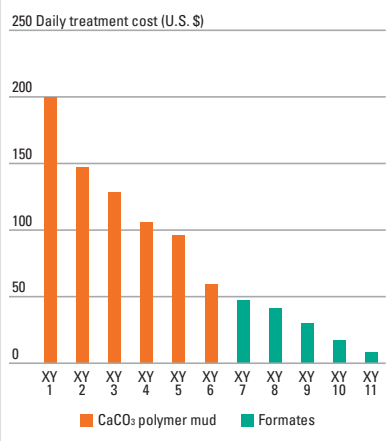
FORMIX TECHNOLOGY starts with a new look at some familiar compounds

Formates are relatively new to the petroleum industry. They are salts, not unlike the halide family of chlorides and bromides used in the oilfield for years. Monovalent formate salts are extremely soluble in water and form high-density, solids-free brines, reducing the need for weighting agents.

M-I SWACO has a long history of engineering formate-base brine systems for various global applications. Today, three monovalent organic formate salts – sodium formate, potassium formate and cesium formate – provide the basis for our latest breakthrough in fluids engineering.

FORMIX TECHNOLOGY has been successfully incorporated into the M-I SWACO FLOPRO NT reservoir drill-in fluid system to drill and complete wells in particularly challenging environments: high temperatures, damage-prone reservoirs, wells with narrow ECD windows and wells in environmentally sensitive areas. FORMIX TECHNOLOGY has also been utilized with our VERSAPRO* LS low-solids invert-emulsion system to produce fluids with densities higher than

Economics and Reclamation



those achievable with a conventional halide brine internal phase.

Formates bring versatility and environmental strengths to both invert and water-base fluids

Using FORMIX TECHNOLOGY in water-base RDFs results in increased productivity due to lower solids concentration; a thin, impermeable filter cake and compatible base-fluid chemistry. Being monovalent, they reduce scaling potential and are compatible with most reservoir minerals and fluids. Formates are also highly compatible with RDF polymers, viscosifiers and fluid-loss-control agents.

In conventional drilling applications, FORMIX TECHNOLOGY provides fluid stability for drilling through sensitive

Features

- High densities with minimal solids
- Minimal formation damage
- Excellent QHSE profiles
- Compatible with reservoir fluids and polymers
- Completion compatible
- High shale and gas hydrate inhibition
- Thermally stable to >350°F (177°C)
- Low corrosion rates

Advantages

- Increases production
- Reduces project costs
- Environmentally acceptable
- Enhances solids-control efficiency
- Fewer completion problems
- Increases ROP
- Ideal for HTHP drilling
- Reduces weight-material sag

shale sections, or when drilling in environmentally sensitive areas. For either RDF or conventional drilling, formates provide stability at high temperatures. Like other salts, formates can be blended together to create an assortment of densities and crystallization points.

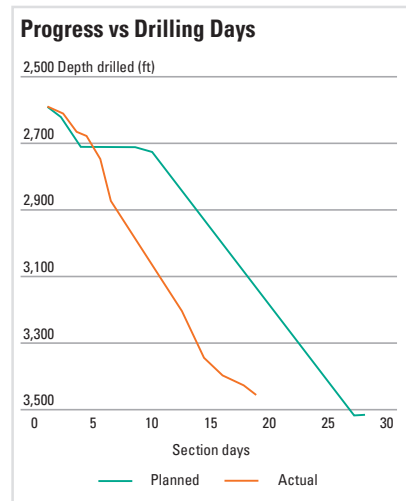
For high-density, invert-emulsion-fluid applications, FORMIX TECHNOLOGY provides density with minimal solids. The high-density, monovalent-brine internal phase is highly compatible with VERSAPRO LS emulsifiers, providing excellent emulsion stability at oil/brine ratios down to 50:50.

The systems that bring wide-ranging benefits to a wide range of applications

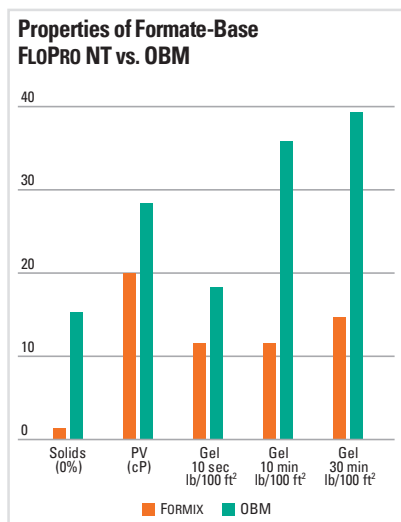
The more we utilize FORMIX TECHNOLOGY, the wider the range of applications grows for the systems based on it. Here are just some of the advantages being discovered and proven:

- The inhibitive water-base nature of these formate systems makes them ideal for drilling highly reactive shales

- Using natural polymers, they are inherently thermally stable, keeping the rheological and fluid-loss control properties stable in the face of downhole temperatures in excess of 350°F (177°C)
- They have the capacity to eliminate the problems associated with weight-material sag, as well as the compressibility and ensuing high ECDs of invert-emulsion fluids, making FORMIX TECHNOLOGY systems well suited for both HTHP and deepwater drilling
- All of the above tendencies also open the door for the systems' use as thermal stabilizers in conventional water-base fluid formulations
- Since these FORMIX TECHNOLOGY-base systems are engineered to deliver minimal circulating-pressure losses and maximize power transmission to both the bit and mud motor, they are viable choices for extended-reach and horizontal wells



Our FLOPRO NT reservoir drill-in fluid system, based on FORMIX TECHNOLOGY, is an excellent candidate for high-density, slim-hole drilling applications. The shear-thinning and drag-reducing properties are extremely compatible with the small-diameter tubulars and narrow annuli in both slim-hole and coiled-tubing wells.



Formate densities

Formate	Chemical Symbol	Maximum Density @ 68°F (20°C)	Maximum Salt Concentration
Sodium formate	NaCOOH	11.2 lb/gal (1.34 SG)	45%
Potassium formate	KCOOH	13.3 lb/gal (1.60 SG)	76%
Cesium formate	CsCOOH	19.7 lb/gal (2.37 SG)	83%

NOVAPRO/VERSAPRO/PARAPRO

Reservoir Drill-In Fluids

NOVAPRO (synthetic), VERSAPRO (diesel or mineral oil) and PARAPRO (paraffin) Reservoir Drill-In Fluid (RDF) systems are non-damaging, invert-emulsion fluids used for drilling developmental wells designed for both cased- and openhole completions. These systems are designed to minimize formation damage problems such as oil wetting, emulsion blocking, and solids plugging, yet retain the performance advantages of invert-emulsion fluids, including high ROP, lubricity and wellbore stability.

Owing to the higher priority of minimizing formation damage and compatibility with completion assemblies, these fluids differ from conventional invert-emulsion fluids in their design and application.

The emulsifier/wetting agent package, the type and size of bridging material and, indeed, all components required are reviewed for the best combination of drilling and completion characteristics.

The NOVAPRO/VERSAPRO systems are versatile, providing tremendous flexibility for numerous applications.

The key concepts to keep in mind when planning and using a NOVAPRO/VERSAPRO/PARAPRO system are:

- Minimizing formation damage
- Providing completion compatibility
- Maximizing productivity

Applications

NOVAPRO/VERSAPRO/PARAPRO invert-emulsion reservoir drill-in fluids are designed with flexibility in the formulation that makes them suitable for a variety of applications:

- Openhole gravel packs or standalone screens
- Cased-hole completions
- High-temperature applications
- Barefoot or slotted liner completions

System components

The NOVAPRO system is built using synthetic-base fluid; the VERSAPRO system uses either diesel or mineral-base fluid while the PARAPRO system uses paraffin-base oil. All systems exhibit all of the drilling advantages of conventional invert-emulsion fluids. In some cases, a conventional NOVAPLUS*, VERSACLEAN*, VERSADRIL* or PARADRIL* drilling-fluid system can be converted to a NOVAPRO, VERSAPRO or PARAPRO system. This may involve adjusting the size and/or concentration of the bridging/weighting agent and/or modifying the emulsion package.

Features

- Flexible formulation
- Non-damaging characteristics
- Invert-emulsion drilling-fluid properties
- Employs proprietary software and PRODUCTION SCREEN TESTER (PST)

Advantages

- Ideal for a variety of applications
- Maximizes production
- High ROP, lubricity and wellbore stability
- Assures proper bridging, flowback tendencies

VERSAPRO LS/SF

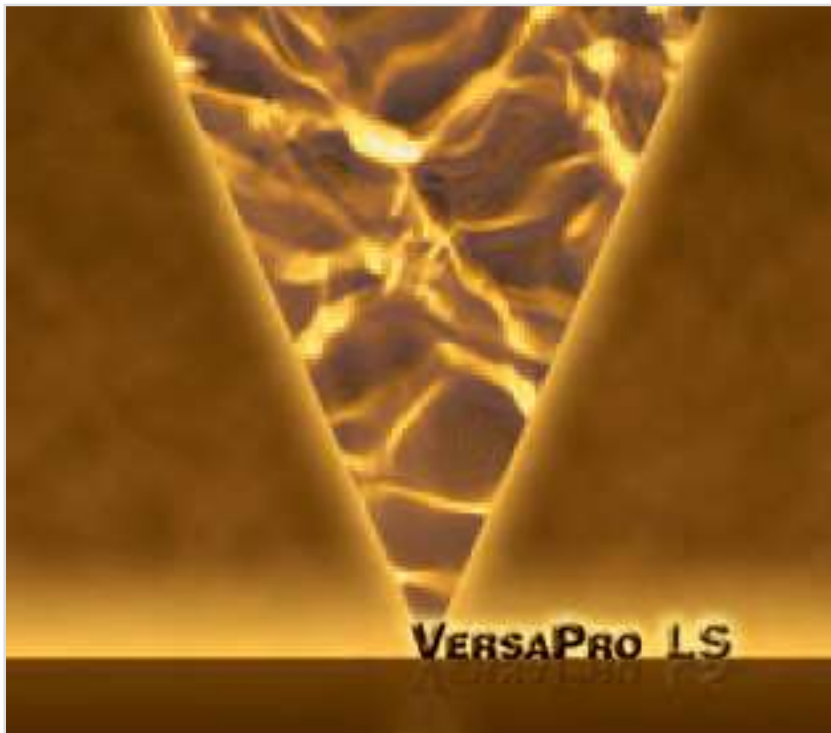
Reservoir Drill-In Fluids

Features

- Low to no solids loading
- High-density-brine internal phase
- Oil continuous phase
- Thermally stable
- Bridging agents optimized for specific formations

Advantages

- Maximized production
- Reduced screen plugging
- High return-flow efficiency
- Greatly reduced sag or settling
- Low fluid loss
- Reduced gelation
- Reduced production-facility upsets



The versatile, low-solids, oil-base-fluid system that helps maximize your field's productivity

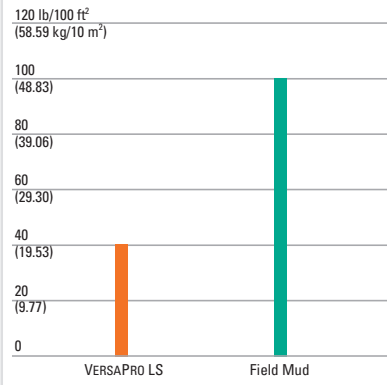
The system that lets you place formation protection where you need it

As a reservoir drill-in or completion fluid, or as a displacement or perforating pill, the VERSAPRO® LS system has proven to be one of the most versatile on the market:

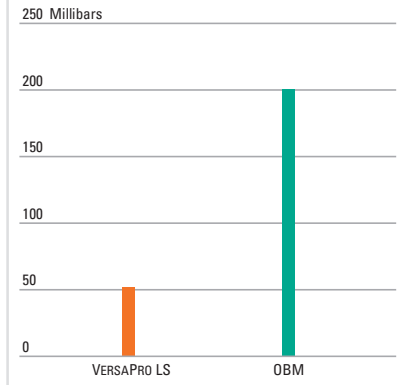
- In both cased-hole and openhole completions where oil-base fluid is required for drilling
- As a cased-hole perforation pill, it minimizes the threat of solids plugging the perforation tunnels, while preventing losses to the reservoir
- In openhole completions, it is ideal as a low-solids fluid-loss-control pill to be left in the productive section prior to running the completion assembly. Bridging agents can be eliminated in VERSAPRO SF pills used where there is a preexisting solids-laden filter cake. The pill can be used as a screen-running pill or preproduction pill
- As a temporary-abandonment fluid to minimize the risk of solids settling prior to the initiation of production



Gel Strength Comparison Over 12-day Period



Filter-Cake Lift-Off Pressure



The high-density internal phase of the system reduces the potential for solids plugging and settling. In addition, long-term gelation potential is significantly reduced due to the low-solids nature of VERSAPRO LS, resulting in better flowback with minimal flow-initiation pressure.

Here's an idea of what this low-solids, oil-base system can do for your bottom line

- A 400% increase in one well's productivity index as compared to previous perforated, horizontally completed wells in the same field
- A VERSAPRO LS pill remained very stable under downhole conditions and, unlike previous wells in the area, did not plug the completion assembly, so the operator could reach expected production levels
- As a workover fluid, the system enabled another operator to complete workover operations and return a group of wells to production rates at or above expectations while eliminating scale problems experienced with water-base workover fluids

VERSAPRO SF pills have displaced VERSAPRO drilling fluids in multilateral wells during completion and prior to production. This has allowed flowback through production facilities without facility upset.

These are only a few examples of why operators the world over are turning to the VERSAPRO LS system to get the most their reservoirs have to offer.

WARP FLUIDS Technology

Reservoir Drill-In Fluids

Features

- WARP particles are 10 times smaller than drilling-grade barite
- Lower friction factors: up to 10% in cased hole and 25% in open hole
- WARP micron-sized weighting agents pass more efficiently through shaker screens and open hole production screens
- When supplemented with properly sized bridging material it is nondamaging to producing formations and completion hardware
- Lower dynamic and static fluid loss with thinner filter cakes and lower breakthrough pressures

Advantages

- Reduces risk of static and dynamic sag
- Lower ECD values
- Lower swab and surge pressures
- Lower pump pressures
- Faster pipe-running and tripping speeds
- Lowers rotary torque and friction factors
- Increases solids-removal efficiency and lower dilution/maintenance
- Reduces risk of completion-screen plugging
- Lower downhole fluid losses

WARP* micronized barite fluid technology represents a milestone in water- and oil-base reservoir drill-in and completion fluids. The WARP fluid is the first system to employ micronized weighting material to address a number of downhole concerns, including barite sag. When evaluated against conventionally weighted fluids, both water-base and invert systems formulated with WARP fluids technology deliver more value-added benefits.

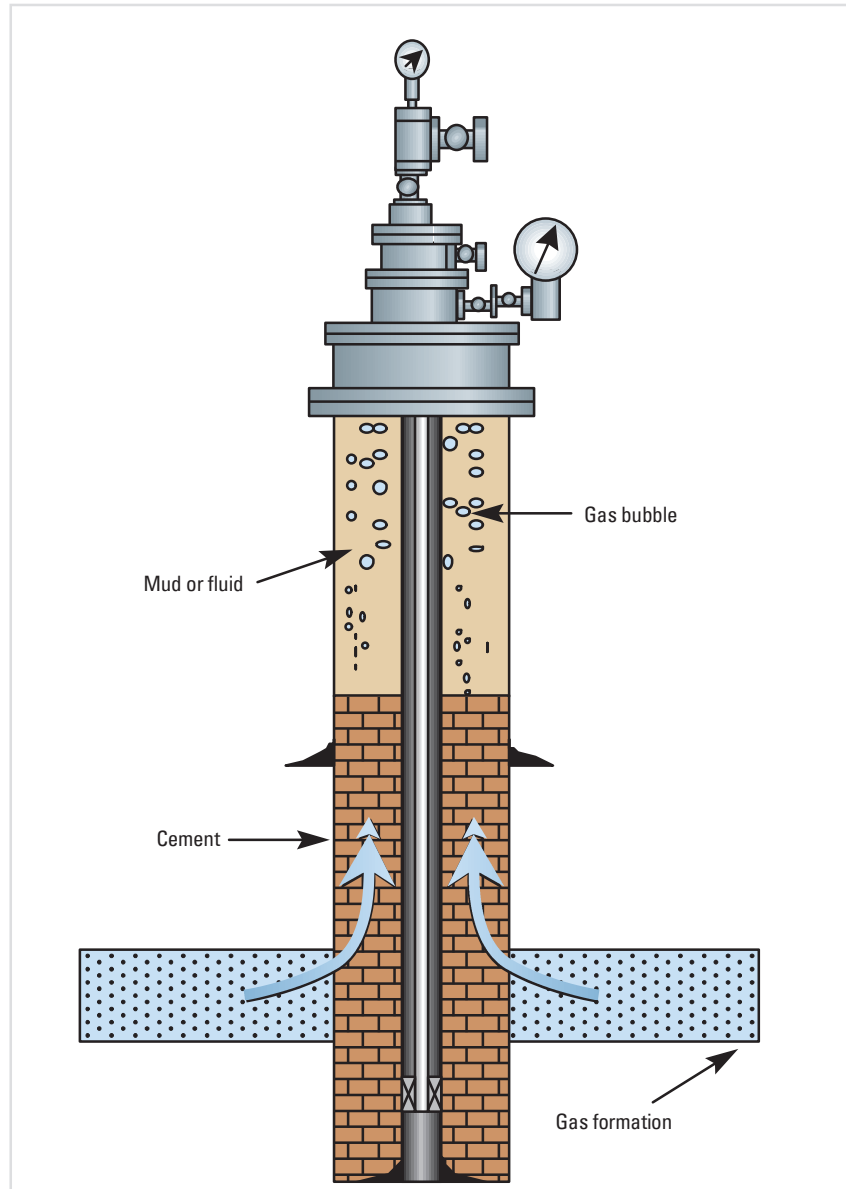
WARP technology is ideally suited for completion and workover fluids. Fluids can be formulated from moderate 10.0 lb/gal (1.2 SG) to above 18 lb/gal (2.16 SG). The technology promotes complete flowback through gravel-pack and sand-screen completions. Supplementing the system with properly sized bridging agents minimizes reservoir damage.

FLODENSE AP

Intervention Fluids

Top-down casing-pressure remediation: the methodical approach to managing sustained casing pressure

The uncontrolled release of pressure from a sealed casing string presents a serious safety and environmental hazard that reportedly affects nearly half of the wells in the Gulf of Mexico. The U.S. Minerals Management Service (MMS) estimates that the problem, known as Sustained Casing Pressure (SCP), affects some 11,000 casing strings in approximately 8,000 wells in the Gulf. According to the MMS, some 30% of the affected wells require special departure waivers to maintain production, while all of them require continuous investment in either remediation or monitoring. While half of these incidents are reported to occur in the production casing, SCP may arise in any of the annuli within a well. This problem is not unique to the Gulf and is prevalent in a number of fields worldwide.



Basically, SCP refers to any amount of recurring pressure in casing strings that will not bleed to zero psi after the well reaches a steady state of flow. Any number of failures, including leaks in tubing, casing, packers, wellhead packoffs and poor or failed cement jobs, can initiate sustained casing pressure.

Recognizing the critical safety, environmental and economic consequences of SCP, M-I SWACO has taken the lead in developing a systematic line of attack to reduce or control these annular pressures. While the nucleus of our approach is to increase hydrostatic pressure by pumping our specially formulated FLODENSE AP well-intervention fluid into the annulus, our all-inclusive Top-Down Casing-Pressure-Remediation Process entails so much more. We study the circumstances and parameters of each well to determine the best method for inserting a fluid-delivery system through an existing wellhead and into a constricted, pressurized annulus. Our specialists carefully examine corresponding data to establish how best to deliver the fluid downhole to achieve the necessary hydrostatic column for hydrostatic enhancement. The end result is the delivery of a fluid that will establish hydraulic control.

Designing a remediation project begins with giving your well the third degree

Before we ever attempt to design a pressure-remediation plan for your particular situation, we look at every facet of your well. We examine all the casing strings in the well geometry, the

well survey, production data and the types and densities of the fluids in all annuli. We evaluate the bottomhole, flowing and shut-in pressures; the flowing temperatures; and the sustained pressures on the various annuli. We then review drilling records to track the mud weights used and compare those densities to the trip and background gases. We identify the drilling breaks and track the cementing records.

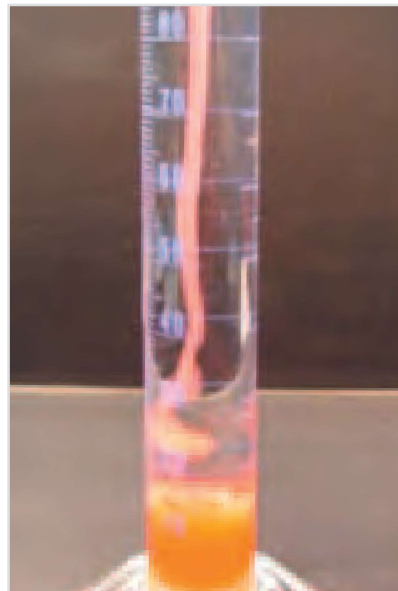
Armed with this mountain of data, we attempt to diagnose the cause of SCP on your well by first determining if the pressure is being released from the producing formation or another farther up the hole. Pulling all these pieces together is critical to designing the ideal solution for your individual situation.

FLODENSE* AP helps put the brakes on uncontrolled casing pressure

Complementing our Top-Down Casing-Pressure-Remediation Process is our high-density FLODENSE AP well-intervention fluid. The FLODENSE AP system contains a range of fluids that can be formulated for different applications with average densities ranging between 17.5 to 18 lb/gal (2.1 to 2.16 kg/L). If an application specifies, FLODENSE AP fluids can be formulated at densities up to 20.5 lb/gal (2.46 kg/L).

The FLODENSE AP system can be used as a viscous, lubricious and solids-free fluid that is engineered to fall through the annulus with minimal dispersion.

The FLODENSE AP well-intervention fluid also can be engineered with micron-sized particles that allow the fluid to pass in snakelike fashion through very



FLODENSE AP fluid falling through CaCl_2 .

narrow apertures. Densities as high as 20.5 lb/gal (2.46 kg/L) of the neat slurry permit it to fall through most existing annular fluids.

Owing to its micron-sized particles, the FLODENSE AP system exhibits reduced sag and settlement compared to competing systems. In fact, the settling rate of the fluid is 1,000 times less than that of API barite, while smaller FLODENSE AP particles have a settling rate 10,000 times less than barite.

Both of these systems are designed to provide hydrostatic control.

FLOPRO CT

Intervention Fluids



The rheologically engineered fluid that puts the squeeze on pressure losses while delivering a clean wellbore

The FLOPRO[®] CT system is a water-base, solids-free intervention fluid that meets the requirements of coiled-tubing drilling with specialized features:

- Promotes extended coil life
- Optimizes hydraulics
- Lower pump pressures and Equivalent Circulating Densities (ECD)
- Reduces mechanical drag, helixing and buckling
- Higher flow rates
- Applicable for all coil diameters and lengths

With the FLOPRO CT system at work, removing debris from the wellbore and clearing the way for the insertion of production tools has never been

easier or more efficient. As an added bonus, the hole typically can be cleaned thoroughly in one trip.

The system that gives operators a wider range of possibilities for difficult applications

The versatility of the FLOPRO CT system has dramatically extended the range of applications for coiled-tubing interventions:

- High-strength and tapered coil
- Well depths of more than 27,000 ft (8,230 m) reached with nearly 29,000 ft (8,839 m) spools
- Underbalanced environments of up to 4,500 psi (31,050 kPa)
- Wellbores with bottomhole temperatures of more than 300°F (149°C)
- Extended-reach wells exceeding 30,000 ft (9,144 m)

Features

- Low coefficient of friction
- Shear-thinning rheological profile with high LSRV
- Zero or minimal solids
- Inhibitive fluid
- Provides drag reduction
- Wide density range

Advantages

- Reduces mechanical friction and coil wear
- Promotes hole cleaning and solids suspension
- Minimizes pressure loss and coil wear
- Minimal reservoir damage
- Enables entering higher-angle deeper wells not previously attainable
- Simplifies cleanup



The FLOPRO CT system is ideal for a wide range of workover operations, including removing sand and debris from a well. The rheologically engineered system poses minimal risk of formation damage in perforated intervals, with a solids content that is routinely less than 1% by volume and elevated Low-Shear-Rate Viscosity (LSRV) that controls invasion.

Engineered to optimize your drilling efficiency and maximize your production

For flexibility, the FLOPRO CT system can be built with a wide variety of base fluids:

- Freshwater
- Seawater
- Potassium, calcium or sodium chloride
- Sodium bromide
- Cesium, potassium or sodium formate

Compared to conventional fluids in similar situations, the FLOPRO CT system has exhibited vastly improved sliding with reduced coil helixing and buckling. Its combination of rheology modifiers and interfacial tension and drag reducers has allowed for high flow rates at minimum pressure.

FLO-VIS L premium-grade, clarified xanthan gum gives the system its elevated LSRV. This high-yielding biopolymer is also dispersible and imparts the LSRV without adversely affecting the overall gross viscosity of the system.



The FLOPRO CT system delivers high LSRVs, which are measured using a Brookfield rheometer. Where extremely high LSRVs are required, a vane spindle is used.



BREAKDOWN

Breakers: Systems

The components of BREAKDOWN fluid are designed to attack specific components in the FLOPRO NT filter cake. The BREAKDOWN system uses an enzyme (WELLZYME*)/chelant (D-SOLVER* or D-SOLVER PLUS) combination to destroy the starch and calcium carbonate components, respectively. By destroying these major RDF components, formation or completion impairment is minimized.

Applications

- Oil or gas producer wells that are completed via openhole gravel pack or standalone screen/liner
- Water injector wells completed openhole

How it works

BREAKDOWN chemistry is slow acting so it permits complete placement in the horizontal section. Filter-cake breakthrough in the field usually requires 5 to 6 hrs and total filter-cake dissolution occurs within 72 hrs. This slow process allows the system to be spotted in the openhole interval without losses, permitting the breaker fluid to remain in contact with the filter cake instead of bypassing it and reacting with formation fluids and solids. It also allows removal of any wash-pipe assembly and

closure of the fluid-loss-control device before compromising the filter cake.

The WELLZYME component denatures at temperatures greater than 212°F (100°C), but the D-SOLVER component is effective to temperatures up to 350°F (175°C). The D-SOLVER component is used in potassium chloride and sodium bromide brines, while D-SOLVER PLUS chelant is compatible with sodium chloride and potassium chloride brines.

Features

- Slowly and uniformly destroys filter cake over a 72 hr period
- Provides a minimum of 5 to 6 hrs of delay in filter-cake breakthrough under most conditions
- Can be viscosified to increase filter-cake breakthrough time to more than 24 hrs
- Exhibits low corrosivity
- Demonstrates effectiveness over a wide range of temperature conditions from 40°F (4°C) to more than 200°F (93°C)
- Can be incorporated into a portion of the gravel-pack fluid for faster contact with filter cake
- Requires conventional drilling rig equipment for mixing and placement
- Is less aggressive to personnel and downhole completion equipment as a result of a moderate pH

BREAKFREE

Breakers: Systems



The BREAKFREE* system is an enzyme treatment used to disperse FLOPRO NT filter cakes. It is used in openhole completions, including barefoot, slotted liners, and some standalone screen applications. The only filter-cake component destroyed by the BREAKFREE system is the starch fluid-loss-control additive. By destroying the “filter-cake glue”, solids (bridging agents and drilled solids) are released and allowed to disperse in the annular space. From there, the solids may be produced back or fall out of the way.

Applications

- Openhole completions where total dissolution of the FLOPRO NT filter cake is not required
- Gas or oil producer wells
- Water injector wells that use sized salt as the bridging agent in a FLOPRO NT system

How it works

The BREAKFREE system works slowly and uniformly across the filter cake. A WELLZYME component destroys the starch component. WELLZYME enzymes break the starches into inert mono- and disaccharides. They continue this process until all starch is destroyed (usually within about 72 hrs) or the enzyme is denatured. Unlike conventional acid and oxidative breakers that can spend on tubulars and formation fluids/solids, BREAKFREE breaker only reacts with the filter cake.

Denaturing occurs when a change in the environment surrounding the enzyme occurs. Denaturing changes include pH, salinity or temperature. To avoid denaturing the WELLZYME component,

BREAKFREE fluid is mixed in monovalent brine solutions of near neutral pH. The WELLZYME component denatures at temperatures greater than 212°F (100°C). BREAKFREE fluid may be used at temperatures above 212°F (100°C) if only initiation of filter-cake destruction is desired.

The delay in filter-cake breakthrough can be increased by viscosifying the BREAKFREE system with SAFE-VIS* viscosifier.

The BREAKFREE system can be mixed in the rig pit system and placed with existing rig equipment. The near-neutral pH fluid is non-corrosive to completion equipment and not harmful to personnel.

Features

- Delays filter-cake breakthrough for a minimum of 6 to 8 hrs under most conditions
- Works slowly and uniformly across the filter cake
- Can be incorporated into a portion of gravel-pack fluid
- Is non-corrosive and non-emulsifying
- Specifically attacks the starch component of FLOPRO NT system filter cake
- Requires only existing rig equipment for mixing and placement

BREAKLOOSE

Breakers: Systems

BREAKLOOSE* oxidizer-base treatment is used as an external breaker for water-base polymer RDF filter cakes such as those produced by the FLOPRO NT and DIPRO systems. The oxidizer may be lithium hypochlorite, sodium hypochlorite or calcium hypochlorite.

Applications

- Barefoot or slotted-liner completions of wells drilled with the FLOPRO SF system
- Fluid-loss-control-pill destruction

Advantages

- Provides quick destruction of biopolymer and starch RDF components
- Provides instant gratification that there is communication with the formation
- Functions at temperatures from ~80° to 180°F (~27° to 82°C)

Limitations

- Reacts quickly with filter-cake components, promoting rapid breakthrough that can result in breaker-treatment bypass of the remaining filter cake
- Reacts with formation fluids and tubulars
- Can promote emulsions
- Is highly corrosive
- Is not compatible with acids

As it aggressively attacks filter cakes, hypochlorite may contribute to rapid losses and filter-cake bypass of the remaining breaker treatment. This will lead to incomplete filter-cake destruction. Washing the interval with a coiled-tubing-placed treatment may be more effective than trying to spot the placement across the openhole section. Lithium hypochlorite treatments are usually mixed at 2 to 4 lb/bbl in the appropriate completion fluid. Hypochlorites should not be combined with solvents such as SAFE-SOLV*.

How it works

The oxidizer is blended in brine and pumped into the openhole. The oxidizer destroys only the polymeric portion (starch and biopolymer) of the filter cake. The remaining components will disperse. The hypochlorite will also try to oxidize other organic materials such as lubricants or crude oil. It is non-specific and quite aggressive in its reactions and will attack metal tubulars and contribute to corrosion.

D-SOLVER

Breakers: Products

D-SOLVER brine-soluble chelating agent can complex many metal ions present in reservoir drill-in fluid filter cakes and completion fluids, specifically calcium, iron and magnesium. D-SOLVER chelating agent is used in FAZEBREAK and BREAKDOWN systems to assist in cleanup of FAZEPRO and FLOPRO NT filter cakes, respectively. D-SOLVER chelating agent is slower reacting and more effective at lower temperatures than conventional organic and mineral acid treatments.

Applications

D-SOLVER chelant is a potassium-base chelant/calcium carbonate dissolver of moderate pH. It is a component of the FAZEBREAK and BREAKDOWN cleanup systems. FAZEBREAK systems are used to disperse FAZEPRO filter cakes. The BREAKDOWN system is used to destroy FLOPRO NT filter cakes. The BREAKDOWN system also uses WELLZYME enzymes to remove the starch component of FLOPRO NT filter cakes. For applications greater than 250°F (121°C), WELLZYME enzymes are not required.

D-SOLVER chelating agent chelates divalent and trivalent ions. The carbonate-dissolving capacity of D-SOLVER chelating agent is compared to several acids in the table below. D-SOLVER chelating agent reacts specifically with calcium carbonate and is non-corrosive compared to acid or oxidizer treatments. In addition, D-SOLVER chelating agent has the ability to complex iron and magnesium, both

common metal ions present in the wellbore during completion operations. Breaker systems built with D-SOLVER chelating agent should be stored in plastic-lined containers to avoid “spending” before the product is used.

D-SOLVER chelating agent is used in breaker systems up to a concentration of 75% by volume. Concentration will depend on completion method, completion fluid and the amount of calcium carbonate present in the filter cake, as well as the desired effect.

D-SOLVER chelating agent is not compatible with seawater or calcium chloride or other divalent brines. D-SOLVER chelating agent has limited compatibility with sodium chloride. D-SOLVER product is not recommended for use with sodium chloride completion fluid. D-SOLVER chelating agent is fully compatible with potassium chloride brine to saturation and is also compatible with sodium bromide brine to 11 lb/gal (1.3 SG).

Advantages

- The relatively slow chelation process allows breaker placement without losses
- Reacts or “spends” only on the target chemistry, i.e., CaCO_3
- Near-neutral pH, approximately 4.5 to 5
- Preferentially chelates iron versus calcium, thus helping to mitigate emulsions
- Non-corrosive

Typical physical properties

Physical appearance	Liquid
Specific gravity	1.1 to 1.2
pH	4.5 to 5

- Can be used at temperatures to 350°F (177°C)
- Performance is effective in relatively low-temperature (~75°F [24°C]) reservoirs
- Will not emulsify in the presence of crudes as acids and oxidizers do, avoiding facility system upsets
- Compatible with sodium bromide and potassium chloride brines and most additives
- Shelf life is indefinite when product is stored in the proper plastic-lined tanks

Limitations

- Storage tanks should be lined and utilize a vinyl ester resin or equivalent. Aluminum, copper, copper alloys and/or galvanized iron must be avoided
- Strong oxidizing agents such as sodium hypochlorite, hydrogen peroxide, etc., will degrade a chelating agent
- Soluble calcium or iron will limit the calcium-carbonate-dissolving capacity
- Encapsulating polymers, lubricants and non-aqueous shale inhibitors can limit the ability of D-SOLVER chelating agent to attack calcium carbonate
- D-SOLVER chelating agent is incompatible with seawater, calcium chloride and divalent brines
- D-SOLVER chelating agent is not recommended for use with sodium chloride brine

Amount of calcium carbonate dissolved by 1 gal (3.785 L) of reagent

Reagent	lb (kg) CaCO_3
D-SOLVER*	0.84 (0.38)
15% hydrochloric acid	1.83 (0.83)
9% formic acid	0.726 (0.33)
10% acetic acid	0.422 (0.19)

D-SOLVER D

Breakers: Additives

D-SOLVER* D additive is a chelating agent that complexes calcium, iron, magnesium and other metals in filter cakes formed by reservoir drill-in fluids and workover fluids. The D-SOLVER D additive is a dry material, formulated with caustic potash, sodium hydroxide or citric acid to adjust the pH to a desired target. Ascorbic acid can also be used as a catalyst to enhance the effectiveness of the D-SOLVER D additive.

Applications

The primary function of the D-SOLVER D additive is to complex the calcium carbonate portion of a reservoir drill-in fluid filter cake in a uniform manner.

It is used in various open hole completions, such as barefoot, standalone screens, expandable screens, and open hole gravel packs where filter-cake degradation is desired. It can also dissolve and degrade fluid loss control systems used in perforating applications.

The D-SOLVER D additive is one of several chelants available in the BREAKDOWN* and BREAKOUT* breaker systems; the choice of chelant depends on the type of base brine available, the type of completion, type of well, density, metallurgy, delay desired, and cost.

Advantages

- Compatible with all types of monovalent halide brines
- Final pH of the BREAKDOWN and BREAKOUT breakers is flexible and no HCl is required
- Effective at lower temperatures.
- Can be placed during the completion operation
- Can be mixed at the rig site with rig equipment
- Reduces the risk of post intervention
- Helps in the overall clean-up process of aqueous filter cakes
- pH can be adjusted from 4.5 to 8.5

D-SOLVER HD

Breakers: Additives

D-SOLVER* HD chelant can be used as a main component in the BREAKDOWN* HD breaker system or as a supplementary component in the FAZE-OUT*, VERSA/NOVA-OUT* breaker systems.

When used with BREAKDOWN HD system, D-SOLVER HD dissolves the calcium carbonate components in a water-base filter cake. In the FAZE-OUT and VERSA/NOVA-OUT breaker systems, it not only aids in calcium carbonate dissolution, but also mitigates scaling and precipitation of divalent compounds.

As a primary component in the BREAKDOWN HD breaker system, the main function of D-SOLVER HD chelant is to dissolve the calcium carbonate portion of a water-base filter cake. The secondary role of D-SOLVER HD chelant is to complex divalent cations. The BREAKDOWN HD breaker system is recommended when higher density breaker systems are needed.

The D-SOLVER HD chelant can be used in all type of brines, including seawater, calcium chloride, calcium bromide and zinc bromide where other types of chelants are incompatible.

Applications

D-SOLVER HD additive can be mixed at the wellsite for use in open hole completions such as barefoot, standalone screens, expandable screens, and open hole gravel packs, where filter cake cleanup is desired. It also can be used to clean up perforating pill filter cakes.

Advantages

- Can be used in wells where higher densities are required with an upper limit of 14.8 lb/gal (1.77 SG)
- Used with the D-STRUCTOR* additive in "OUT" and "AWAY" breaker systems to mitigate precipitation
- Mitigates the precipitation of calcium and other divalent ion bearing scale
- Slow acting to allow the BREAKDOWN HD breaker system to be placed without contributing to immediate losses
- Can be used over a wide range of temperatures. Tested up to 300°F (146°C)
- Eliminates intervention trip as breaker systems using D-SOLVER HD can be placed during completion operations
- Helps in the overall clean-up process of non-aqueous filter cake in the various "OUT" breaker systems

D-SOLVER PLUS

Breakers: Products

D-SOLVER PLUS is a low-pH, brine-soluble chelating agent that can complex many metal ions present in reservoir drill-in fluid filter cakes and completion fluids: specifically calcium, iron and magnesium. D-SOLVER PLUS chelating agent is used in FAZEBREAK and BREAKDOWN systems to assist in the cleanup of FAZEPRO and FLOPRO NT filter cakes, respectively. D-SOLVER PLUS chelating agent reacts slowly and is more effective at lower temperatures than conventional organic and mineral acid treatments.

Applications

D-SOLVER PLUS calcium carbonate dissolver can be a component of FAZEBREAK and BREAKDOWN clean-up systems. FAZEBREAK systems are used to disperse FAZEPRO filter cakes. The BREAKDOWN system is used to destroy FLOPRO NT filter cakes.

D-SOLVER PLUS chelating agent chelates divalent and trivalent metal ions. The carbonate-dissolving capacity of D-SOLVER PLUS chelating agent is compared to several acids in the table below. D-SOLVER PLUS chelating agent reacts specifically with calcium carbonate and has a low order of corrosivity when compared to acid or oxidizer treatments. In addition, D-SOLVER PLUS agent can complex iron and magnesium, both common metal ions present in the wellbore during completion operations. Breaker systems built with D-SOLVER PLUS chelating agent should be stored in plastic-lined

containers to avoid “spending” the product before it is used. D-SOLVER PLUS agent has a limited shelf life and should be prepared as close as possible to the time it will be applied. Depending on environmental conditions, D-SOLVER PLUS chelating agent can be stored up to 30 days before being applied.

D-SOLVER PLUS chelating agent can be used in breaker systems up to a concentration of 85% by volume. However, the concentration will depend on the completion method, the completion fluid, the desired density, and the amount of calcium carbonate present in the filter cake, as well as the desired effect.

D-SOLVER PLUS chelating agent is not compatible with seawater, calcium chloride or other divalent brines. While D-SOLVER PLUS agent is compatible with sodium chloride and sodium bromide completion fluids, there is some limited compatibility with sodium chloride as it approaches saturation. D-SOLVER PLUS chelating agent is fully compatible with potassium chloride brine to saturation. Formulations should be evaluated in the lab.

Advantages

- The reaction rate of D-SOLVER PLUS chelating agent is significantly slower than conventional acid treatments, reducing the risk of losses
- Functional across a broad pH range
- Can be used at temperatures to 350°F (177°C)

Typical physical properties

Physical appearance	Liquid
Specific gravity	1.1 to 1.2
pH	3.5 to 4

- Effective in relatively low-temperature (~75°F [24°C]) reservoirs
- D-SOLVER PLUS chelating agent does not promote the development of emulsions with crude
- Compatible with sodium and potassium chloride brines and most additives

Limitations

- Storage tanks should be non-reactive. Do not utilize valves or hardware composed of aluminum, copper, copper alloys or galvanized steel
- D-SOLVER PLUS agent has a limited shelf life (< 30 days) and should be prepared as close as possible to the time it will be applied
- Do not mix with strong oxidizers
- Soluble calcium or iron will limit the calcium-carbonate-dissolving capacity
- Encapsulating polymers, lubricants and non-aqueous shale inhibitors can limit the ability of D-SOLVER PLUS chelating agent to attack calcium carbonate
- D-SOLVER PLUS chelating agent should not be blended with brines containing divalent ions

Amount of calcium carbonate dissolved by 1 gal (3.785 L) of reagent

Reagent	lb (kg) CaCO ₃
D-SOLVER* PLUS	1.36 (0.38)
15% hydrochloric acid	1.83 (0.83)
9% formic acid	0.726 (0.33)
10% acetic acid	0.422 (0.19)

D-SPERSE

Breakers: Products

D-SPERSE* surfactant is a mixed surfactant solution with excellent dispersion and surface-tension-reducing properties. D-SPERSE solution is used in the BREAKFREE and BREAKDOWN systems to aid in the cleanup of FLOPRO NT filter cakes. D-SPERSE surfactant disperses active clays in the filter cake and acts as a fluid recovery aid by lowering the resistance to flow through reduced surface tension.

Applications

D-SPERSE surfactant can be used at relatively low concentrations in BREAKFREE and BREAKDOWN breaker systems to act as a dispersant and reduce the surface tension of water and brine solutions. Surface tension is especially important in tight, low-permeability and low-pressure formations where high capillary forces impede fluid recovery. Unlike many conventional, hydrocarbon-base surfactants, D-SPERSE surfactant in brine has a relatively high interfacial tension with oil, resulting in reduced tendency toward oil emulsification. D-SPERSE additive leaves the surface of sandstone water-wet. By reducing interfacial tension, D-SPERSE surfactant promotes water-wetting and dispersion of residual solids, especially active solids. This promotes flowback of the residual filter cake as individual particles instead of as a large mass. The typical concentration

Typical physical properties

Physical appearance	Clear, nearly colorless
Specific gravity	0.94
pH (1% solution)	5
Solubility (water)	Soluble
Flash point	90°F (32°C) (PMCC)
Surfactant type	Non-ionic

for use of D-SPERSE surfactant as a dispersant or fluid-recovery aid is 0.25 to 1% volume, or 1 drum per 120 bbl.

D-SPERSE additive will generate foam in aqueous solutions, which may or may not be a desirable property, depending on its application. As a powerful surfactant, D-SPERSE additive will produce stable foams in aqueous media, including brines and mineral acids. To reduce the foaming tendency, minimal agitation and a defoamer are recommended.

Advantages

- Effective in lowering surface tension in relatively low concentrations
- Aids in fluid recovery
- Disperses active clays in FLOPRO NT filter cakes
- Will not alter wettability
- Effective in many different brines
- Does not typically induce oil emulsification

Limitations

- Produces stable foam at high concentrations
- Not recommended to use with non-emulsifiers as higher surface tensions may result



D-STROYER

Breakers: Products

D-STROYER* breaker is a polymer-coated oxidizer that is incorporated into a FLOPRO NT system. It is used at 0.5 to 2 lb/bbl (1.43 to 5.7 kg/m³) concentration in the RDF and becomes part of the filter cake. It is activated during the completion operation. This breaker assists in the destruction of xanthan and some lubricants that are not destroyed solely with a BREAKDOWN treatment. The D-STROYER breaker also assists in low-temperature (<180°F [82°C]) filter-cake destruction.

Applications

- All openhole-completed water-injector wells drilled with FLOPRO NT fluid
- Low-temperature wells where removing xanthan or ester-based lubricants is beneficial

Features

- Enhances performance of BREAKDOWN breaker by destroying xanthan gum and ester-based lubricants, especially at temperatures lower than 180°F (82°C)
- Is internal to the FLOPRO NT filter cake
- Is activated at moderate pH (<6) by acid, chelant or low-pH produced fluid
- Maintains peroxide activity for longer periods of time than SAFE-BREAK MP breaker
- Can also be used in DIPRO systems as well

How it works

D-STROYER breaker is activated by a pH of 6 or less, so chelants (D-SOLVER or D-SOLVER PLUS), weak acids or even acidic produced fluids will perform this function. It also helps to improve the performance of acid breakers in low-temperature (<130°F [54°C]) applications. The coating on the D-STROYER breaker protects the oxidizer from early initiation during the drilling phase, ensuring that there is material available for activation during the completion phase. At bottomhole temperatures above 180° to 200°F (82° to 93°C), significant depletion of the breaker will require two to three days. For temperatures below 180°F (82°C), it will take five to seven days before D-STROYER depletion occurs.

D-STRUCTOR

Breakers: Products

The D-STRUCTOR additive is an organic-acid precursor used in FAZE-AWAY or FAZE-OUT breaker systems. These systems are designed to remove FAZEPRO filter cakes. In addition, D-STRUCTOR additive can be used to formulate VERSA-WAY, VERSA-OUT, NOVA-WAY, or NOVA-OUT breakers to destroy conventional VERSAPRO/NOVAPRO filter cakes. D-STRUCTOR additive converts to organic acid downhole with time, temperature and free water.

Applications

D-STRUCTOR precursor is the active ingredient in FAZE-OUT, FAZE-AWAY, VERSA-OUT, VERSA-WAY, NOVA-OUT and NOVA-WAY breaker systems. These systems are designed to destroy residual filter cakes from FAZEPRO, VERSAPRO or NOVAPRO systems, respectively, in openhole completions such as standalone screens, expandable screens, or openhole gravel packs. D-STRUCTOR acid precursor converts to organic acid, destroys the emulsion and dissolves acid-soluble bridging agents under downhole conditions.

It is slow-acting, taking 6 to 8 hrs to initiate breakthrough under moderate temperature conditions <200°F (<93°C). Full filter-cake dissolution can occur within 16 hrs.

Due to its slow-acting nature, the breaker system can be spotted and the workstring extracted from the openhole section without fluid losses to the formation. If a fluid-loss-control device is present, the breaker system can soak for an extended period of time without significant bypass of the breaker, for thorough, uniform filter-cake destruction. The breaker system can be incorporated into the openhole gravel-pack treatment, eliminating the need for an intervention cleanup trip.

D-STRUCTOR precursor is compatible with a variety of brines, including KCl, NaCl, NaBr, CaCl₂, and CaBr₂. It is a part of the internal phase in the FAZE-AWAY, VERSA-WAY and NOVA-WAY breaker systems. It is used at a concentration of at least 30% by volume in all breaker systems. At temperatures above 200°F (93°C), an organic-acid corrosion inhibitor should be included in the breaker-system formulation.

Typical physical properties

Physical appearance	Liquid
Specific gravity	1.15
Flash point	200°F (93°C)

Advantages

- Slow-acting breaker that spends as it is generated
- Lower corrosivity than conventional acids
- Thorough, uniform destruction of FAZEPRO, VERSAPRO or NOVAPRO filter cakes
- Placed during the completion operation
- Eliminates an intervention trip

Limitations

- Temperature limit <330°F (165°C)
- Difficult to get high density (>12.5 lb/gal [1.5 SG]) breaker treatments



FAZE-AWAY

Breakers: Systems

FAZE-AWAY* fluid is an invert-emulsion breaker system specifically formulated to dissolve the filter cakes created by FAZEPRO reversible invert-emulsion drilling fluid. Once placed downhole, the invert emulsion disintegrates, releasing an internal phase. The internal phase contains the active component, D-STRUCTOR*, and a brine for density and formation compatibility. The brine can be sodium chloride, potassium chloride, calcium chloride, sodium bromide or calcium bromide.

How it works

The FAZE-AWAY breaker fluid can dissolve the filter cakes created by the FAZEPRO RDF system. FAZE-AWAY breaker is most applicable where significant delay in breakthrough is desired; FAZE-AWAY breaker can delay breakthrough for more than 20 hrs. The FAZE-AWAY breaker is also applicable for formations that are sensitive to water-base treatments. It is recommended for high-temperature (>210°F [99°C]) producer wells, for openhole completions that use standalone or expandable screens, and can be used after gravel-pack operations are performed in the openhole. The elevated viscosity of the systems precludes it

Applications

- Producer wells only
- Openhole completions that use standalone/expandable screens
- Post openhole gravel pack
- High-temperature wells with temperatures greater than 210° to 300°F (99° to 149°C)
- Where delay in filter-cake breakthrough of more than 8 to 10 hrs is desired
- Formations that are water sensitive

from being used during an openhole gravel-pack operation. These elevated rheological properties permit the FAZE-AWAY system to act as a spacer/pill during displacement in openhole, standalone applications.

Corrosion is not usually an issue with FAZE-AWAY fluid at temperatures below 200°F (93°C) because the acid is spending on the filter cake as it is being generated. At higher temperatures, an organic-acid corrosion inhibitor is recommended because the D-STRUCTOR precursor will be converting faster than it spends.

Features

- More than 20 hrs of delay in filter-cake breakthrough
- Effective destruction of FAZEPRO filter cakes through slow and uniform dissolution
- Invert-emulsion delay mechanism – diesel, mineral oil or olefin synthetic
- Sufficient rheological properties to act as a displacement pill
- Limited amount of aqueous fluid exposed to the formation
- Low corrosion rate and relatively controlled release of D-STRUCTOR acid precursor
- Maximum density limited to less than 11.5 lb/gal (1.38 SG)
- Capable of being mixed at the rigsite in rig pits and pumped as a part of the completion process
- No extra equipment or rig time required for placement

FAZEBREAK

Breakers: Systems



The FAZEBREAK* fluid is a water-base system that uses chelant technology to delay the reversal and dispersion of the FAZEPRO filter cake. It is designed to provide sufficient delay to complete the gravel pack and allow the operator to pull the workstring from the gravel-pack assembly while mitigating losses to the formation.

Applications

- Openhole gravel-packed producer wells
- Where only dispersion of the FAZEPRO* filter cake is desired
- For use only in monovalent halide carrier solutions

How it works

Chemical elements of the FAZEBREAK system promote: a delay of the reversal process, reversal of residual FAZEPRO solids from an oil-wet to a water-wet state, water-wetting of the residual solids and, finally, initiation of the chelation process. Taking advantage of the comprehensive M-I SWACO knowledge of surfactants and chelants, each formulation is designed for specific well conditions, using clear completion brine, FAZE-MUL surfactant and D-SOLVER carbonate remover.

Depending on bottomhole conditions, a breakthrough delay of 36 to 72 hrs is possible. Such a long delay allows the breaker to be placed in intimate contact with the filter cake while gravel packing, without the concern of prematurely compromising the filter cake, resulting in an incomplete gravel pack. It also permits the openhole section to remain

unisolated for a longer period of time during other completion operations.

The FAZEBREAK system is very efficient at low reservoir temperature of less than 155°F (68°C) at which corrosion is not a concern. At temperatures above 200°F (93°C) an organic-acid corrosion inhibitor may be desired. At these higher temperatures, D-SOLVER carbonate remover complexes the divalent ions more rapidly and a viscosifier, such as SAFE-VIS E, may be required to increase the delay in FAZEPRO system reversal and ultimately filter-cake breakthrough.

FAZEBREAK fluid should be allowed to soak on the filter cake in an isolated openhole section for at least 3 days for maximum destruction of the FAZEPRO filter cake.

Reservoirs requiring a density greater than 11.9 lb/gal (1.43 SG) are not candidates.

Features

- Provides more than 48 hrs of delay in filter-cake breakthrough
- Slow and uniform dispersion of FAZEPRO filter cake
- Slow chelation process for placement without losses
- Placement can be incorporated into the gravel pack and does not require coiled-tubing intervention
- Near-neutral pH, approximately 5 to 7
- Low corrosion rate
- Formulated for preblending and storage for later transport to a wellsite or for onsite blending



FAZE-OUT

Breakers: Systems

The FAZE-OUT* fluid is a water-base breaker system designed for use on FAZEPRO filter cakes. For use in either injector or producer wells, the FAZE-OUT fluid can totally dissolve invert-emulsion filter cakes, permitting ready injection or flowback through restrictive completions such as premium screens and openhole gravel packs.

Applications

- Injector and producer wells completed openhole using standalone/expandable screens or are openhole gravel-packed
- As a remediation treatment with proper engineering of the remediation operation

How it works

The FAZE-OUT system uses D-STRUCTOR precursor as its active component. The FAZE-OUT breaker system slowly penetrates the filter cake and with time, temperature, and free water, the D-STRUCTOR precursor converts to acid, which then destroys the invert emulsion, and water wets and dissolves the calcium carbonate bridging solids. The FAZEPRO emulsifiers enhance this process as they convert from emulsifiers to water-wetting surfactants. The filter cake is taken apart from the inside out. Total destruction of FAZEPRO filter cakes normally takes less than 16 hrs. The delay in breakthrough can be increased by viscosifying the

FAZE-OUT breaker with SAFE-VIS additive. Unviscosified systems will provide about 6 hrs of delay under mild conditions. Viscosifying the system can almost double the delay time under the same conditions. Viscosifying the system will also increase the time required for thorough filter-cake destruction.

Corrosion is not usually an issue with FAZE-OUT breaker at temperatures below 200°F (93°C) because the acid is spending on the filter cake as it is being generated. At higher temperatures an organic-acid corrosion inhibitor is recommended because the D-STRUCTOR component will be converting faster than it spends.

Features

- Provides more than 6 hrs of delay in filter-cake breakthrough
- Effective destruction of FAZEPRO filter cakes through slow and uniform dissolution
- Possesses a low corrosion rate as a result of the relatively controlled release of D-STRUCTOR acid precursor
- Can be placed during standard completion operations and does not require coiled-tubing intervention
- Onsite mixing in rig pits with rig equipment

SAFE-BREAK MP

Breakers: Products

SAFE-BREAK MP additive is an internal filter-cake breaker used in polymer-base reservoir drill-in and completion fluids and lost-circulation pills during a workover or completion operation. SAFE-BREAK MP breaker is initially deposited as an inert particle within the filter cake. When activated by lower pH, it greatly increases the degradation rate of the filter cake.

Applications

SAFE-BREAK MP breaker aids in filter-cake destruction when used in polymer-base reservoir drill-in and completion fluids and in lost-circulation pills during workover and completion operations. SAFE-BREAK MP breaker is deposited as an inert particle in the filter cake. During the completion/breaker phase, a mild acidic solution activates the SAFE-BREAK MP breaker, resulting in a more improved digestion of the filter cake. This process increases overall filter-cake destruction efficiency. Treatment levels are normally 0.5 to 1 lb/bbl (1.4 to 2.9 kg/m³) for reservoir drill-in fluid applications and 3 to 4 lb/bbl (8.6 to 11.4 kg/m³) for lost-circulation-pill applications.

Typical physical properties

Physical appearance	Yellow-to-white powder
Solubility (water)	Insoluble
Bulk density	37.5 to 50 lb/ft ³

Advantages

- When compared to a plain acid soak, SAFE-BREAK MP breaker reduces the time required for filter-cake removal by as much as 60%
- Can be used in any polymer-base drilling fluid with pH>9
- Most effective at temperatures <180°F (82°C)
- Weak acid, such as 1% HCl, can activate the decomposition process

Limitations

- Exposure of dry material to the atmosphere reduces the activity level of the product
- Do not apply in base brines with a pH below neutral

No claim of personal safety is intended nor implied by the use of the name SAFE in this product. Personnel handling this material should read and follow all safety and handling procedures set forth in the Material Safety Data Sheet.



VERSA-OUT/NOVA-OUT

Breakers: Systems

The VERSA-OUT* and NOVA-OUT* fluids are water-base breaker systems designed for use on VERSAPRO and NOVAPRO filter cakes. For use in either injector or producer wells, VERSA-OUT and NOVA-OUT fluids can totally dissolve invert-emulsion filter cakes, permitting ready injection or flowback through restrictive completions such as premium screens and openhole gravel packs.

Applications

- VERSA-OUT breaker is used to destroy VERSAPRO filter cake, and NOVA-OUT breaker is used to destroy NOVAPRO filter cake
- Injector and producer wells that are openhole-completed using standalone/expandable screens or that are openhole-gravel-packed
- As a remediation treatment, with proper engineering, for well operations

How they work

The VERSA-OUT and NOVA-OUT systems use D-STRUCTOR acid precursor as the active component. The VERSA-OUT and NOVA-OUT breaker systems slowly penetrate the filter cake and with time, temperature, and free water, the D-STRUCTOR precursor converts to acid, which then destroys the invert emulsion while it water wets and dissolves the calcium carbonate bridging solids. Total destruction of VERSAPRO or NOVAPRO filter cake normally takes less than 24 hrs.

The delay in breakthrough can be increased by viscosifying VERSA-OUT and NOVA-OUT breakers with SAFE-VIS additive. Unviscosified systems will

provide about 6 hrs of delay under mild conditions. Viscosifying the system can almost double the delay time under the same conditions and will also increase the time required for thorough filter-cake destruction.

Corrosion is not usually an issue with VERSA-OUT and NOVA-OUT breakers at temperatures below 200°F (93°C) because the acid is spending on the filter cake as it is being generated. At higher temperature conditions, an organic acid corrosion inhibitor is recommended because the D-STRUCTOR component will be converting to acid faster than it spends.

Features

- Provides more than 6 hrs of delay in filter-cake breakthrough
- Effective destruction of VERSAPRO or NOVAPRO filter cakes through slow and uniform dissolution
- Possesses a low corrosion rate as a result of the relatively controlled release of D-STRUCTOR acid precursor
- Can be placed during standard completion operations and does not require coiled-tubing intervention
- Onsite mixing in rig pits with rig equipment

VERSA-WAY/NOVA-WAY



Breakers: Systems

VERSA-WAY* and NOVA-WAY* fluids are invert-emulsion breaker systems specifically formulated to dissolve the filter cakes created by VERSAPRO and NOVAPRO conventional invert-emulsion drilling fluids.

Applications

- Producer wells only
- Openhole completions that use standalone/expandable screens
- Post-openhole gravel-pack
- High-temperature wells with temperatures greater than 230° to 300°F (110° to 150°C)
- Where delay in filter-cake breakthrough of more than 8 to 10 hrs is desired
- Formations that are water-sensitive

How they work

Once either of the breakers is placed downhole, the invert emulsion disintegrates, releasing an internal phase. The internal phase contains the active component, D-STRUCTOR acid precursor, and a brine for density and formation compatibility. The brine can be sodium chloride, potassium chloride, calcium chloride, sodium bromide or calcium bromide.

VERSA-WAY and NOVA-WAY breaker fluids are most applicable where significant delay in breakthrough is desired, possessing the ability to delay breakthrough for more than 20 hrs. They are also applicable for formations that are sensitive to water-base treatments. VERSA-WAY and NOVA-WAY breakers are recommended for high-temperature (>230°F [110°C]) producer wells, for openhole completions that use

standalone or expandable screens, and for use after openhole-gravel-pack operations are performed in the openhole. The elevated viscosity of the systems precludes these breakers from being used *during* an openhole-gravel-pack operation. These elevated rheological properties permit the VERSA-WAY and NOVA-WAY systems to act as a spacer/pill during displacement in openhole standalone applications.

Corrosion is not usually an issue with VERSA-WAY and NOVA-WAY fluid at temperatures below 200°F (93°C) because the acid is spending on the filter cake as it is being generated. At higher temperature conditions, an organic-acid corrosion inhibitor is recommended because the D-STRUCTOR fluid will be converting acid faster than it spends.

Features

- More than 20 hrs of delay in filter-cake breakthrough
- Effective destruction of diesel- or mineral oil-base VERSAPRO and synthetic NOVAPRO filter cakes through slow and uniform dissolution
- Invert-emulsion delay mechanism – diesel, mineral oil or olefin synthetic
- Sufficient rheological properties to act as a displacement pill
- Limited amount of aqueous fluid exposed to the formation
- Low corrosion rate and relatively controlled release of D-STRUCTOR acid precursor
- Maximum density limited to less than 11.5 lb/gal (1.38 SG)
- Capable of being mixed at the rigsite in rig pits and pumped as a part of the completion process
- No extra equipment or rig time required for placement

WELLZYME

Breakers: Products

There is little benefit in engineering a drilling or non-damaging reservoir drill-in fluid system for a reservoir if the chemicals used in the preproduction cleanup will damage the lifetime productivity of the well. All too often, conventional acids and oxidizers break down the filter cake unevenly, opening only a fraction of the reservoir and leaving behind a considerable amount of production – and profits. Add to that the risk of downhole corrosion and formation damage, and the long-term economics of your well can be seriously compromised.

To overcome these problems, M-I SWACO developed the WELLZYME* product specifically for breaking down the filter cake deposited by water-base reservoir drill-in fluids. A starch-specific enzyme designed specially for openhole-completed reservoirs, the WELLZYME breaker eliminates the corrosion, wormholing, and health and safety hazards associated with strong acids and oxidizing breakers. Depending on local standards, WELLZYME A, B, ME or NS, each with a different activity level and type of biocide, will be called for.

WELLZYME breakers enhance the M-I SWACO spud-to-production approach to fluids engineering and represent a significant milestone in our commitment to engineer and provide a total fluids-solution package.

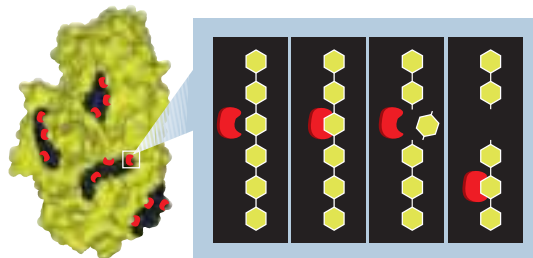
Breakers that open the door to unobstructed production

A typical reservoir drill-in fluid is composed of a base brine along with starch, biopolymer, and sized calcium carbonate or salt. These fluids deposit an impermeable filter cake on the borehole wall. While necessary to protect the formation during drilling, this barrier must be completely broken in order to maximize production rates.

In low-temperature reservoirs, acids and oxidizers often fail to remove the filter-cake barrier completely, leaving residue to dramatically restrict production.

Returning to the reservoir for remedial washes only increases operational costs and can further reduce productivity.

The WELLZYME breaker is an amylase, a starch-specific enzyme which, like all



The WELLZYME enzyme (red) works its way across the surface of the starch (yellow) until a fold in the enzyme, called the active site, fits itself onto a specific linkage in the starch chain, where cleavage takes place. Once the two sites are aligned, the enzyme breaks the link, then repairs the broken ends with water. Not consumed by this reaction, the WELLZYME breaker continues to randomly cleave links until the starch is destroyed.

enzymes, is a large, highly specialized protein produced by living cells. It degrades starch into simple sugars, breaking down the integrity of the filter cake evenly, allowing the bridging agent to disperse efficiently and cleanly.

Faster isn't always better

There will always be applications for conventional acid/oxidative breakers. They perform reasonably well in short- to medium-length, openhole completions, but there is a trade-off. These chemicals, by their very nature, can react quickly and indiscriminately with the tubulars, screens and other downhole components, often before reaching the reservoir. In such fast reactions, the chemicals also eat wormholes through the filter cake and escape into the formation before the openhole section is completely contacted with breaker.

The resulting leak-off puts active breakers into the reservoir, where they can adversely affect formation mineralogy and serve as a continuing "bleed" of corrosives back through the production hardware. A more significant problem is that the irregular removal of the filter cake leaves parts of the reservoir with slow or low communication with the wellbore.

Features

- Designed to react selectively, resulting in even distribution of breaker action
- Will not react with tubulars, hydrocarbons and most formation components
- The product of bacterial microorganisms, the WELLZYME breaker is biodegradable
- Integral component of a total fluids package

Advantages

- Even drainage of entire reservoir, for sustained production over the life of the well
- Does not promote corrosion of screens and other downhole components
- Does not react with tubulars, eliminating elevated iron concentrations which promote sludging and iron-precipitation problems
- Reduces system upsets because the completed well can be placed online in less time than conventional cleanup
- Lowers costs, increases return on investment

Acid breakers also require supplemental inhibitors, which can damage the formation.

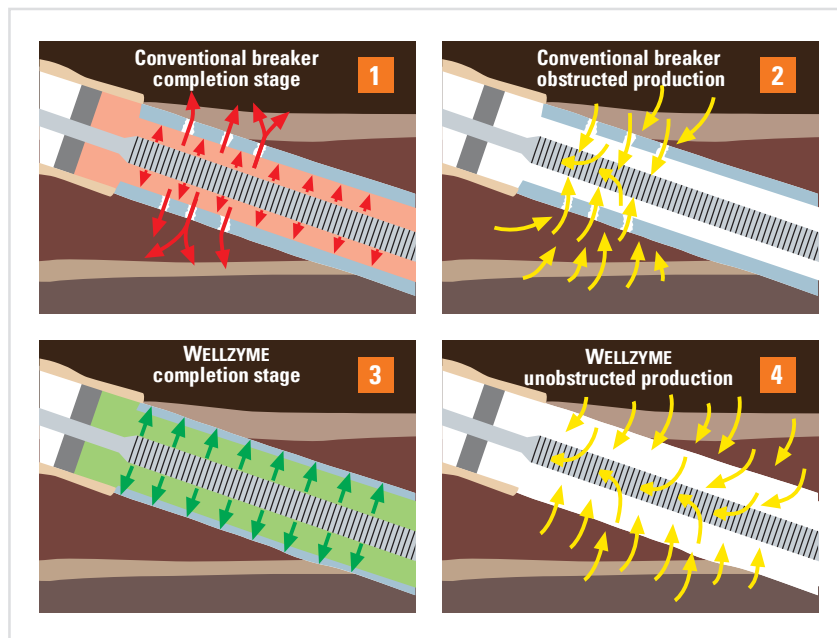
WELLZYME breakers work steadily to increase your production

In contrast to simple acids and oxidizers, a WELLZYME breaker is a complex, three-dimensional molecule that *works only on the starch component of the filter cake*. Specifically, it catalyzes the digestion of the starch via hydrolysis.

In your well, it works its way across the surface of the starch until a fold in the enzyme, called the active site, fits itself onto a specific linkage in the starch chain, where cleavage takes place. Once the two sites are aligned, the enzyme breaks the link, then repairs the broken ends with water.

Because the enzyme is not consumed during this reaction, a WELLZYME breaker continues to randomly cleave links until the starch is destroyed. This slow, specific reactivity gives you a breaker that can be pumped evenly down the length of the wellbore. There it attacks the outermost starch particles in the filter cake first and continues to break until the starch is gone. The result is a consistently distributed breaker that causes uniform filter-cake breakdown. This, in turn, promotes even, unrestricted drainage of the reservoir throughout its intended lifetime.

WELLZYME breakers can be applied in most brines, and break down most filter cakes within 16 hrs, and as quickly as one hour, depending on the temperature of the reservoir and the reservoir drill-in fluid. For thorough filter-cake destruction, a WELLZYME breaker can be combined with a chelant.



These illustrations demonstrate the difference between the way a conventional breaker and a WELLZYME breaker works during the completion operation, and their effects on production.

1. The conventional breaker causes wormholing in the filter cake, usually near the heel of the production assembly. 2. The uneven wormholing forces production to occur in a confined area, not only excluding much of the interval but also concentrating production flows that can erode the production screen prematurely. 3. In contrast to conventional breakers, a WELLZYME breaker works more consistently over the length of the interval, unlocking the bonds of the filter cake, without the use of aggressive chemicals. 4. The superior results include more even and complete production as well as less wear and tear on the production assembly.

Another key component in the M-I SWACO total-solutions approach to fluids engineering

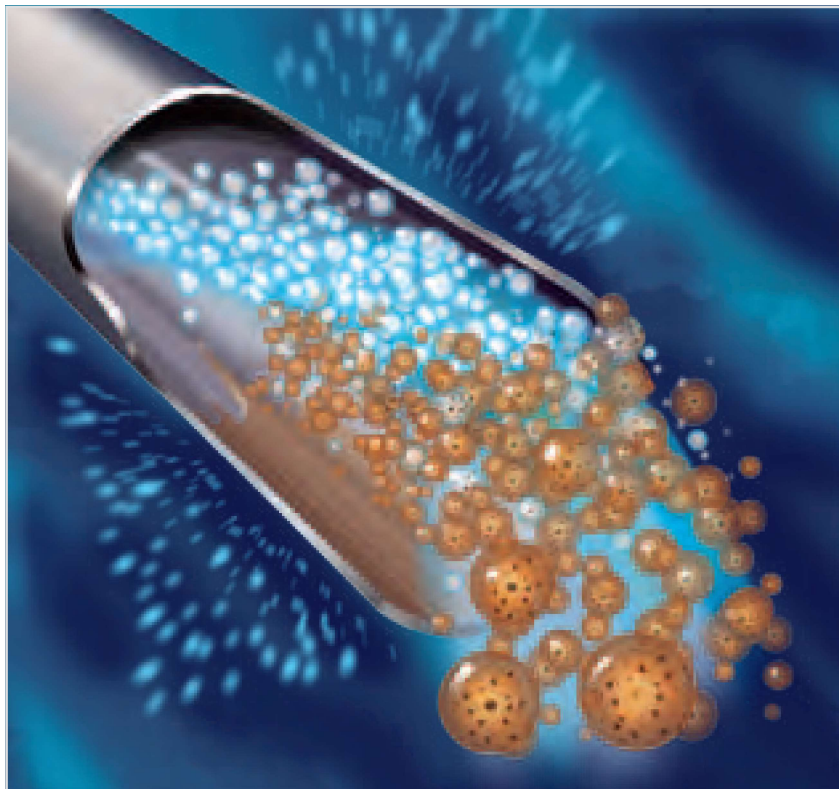
A WELLZYME breaker is not an off-the-shelf additive that can be incorporated into just any completion plan. It is one element in the M-I SWACO customized, systematic approach to fluids engineering.

If M-I SWACO is managing your completion, our specialists examine your well's formation characteristics and completion plan, and then design the fluid system and breaker formulation that will ideally match those features. We supply and engineer the fluid in

the field to ensure top performance. Reservoir drill-in fluids optimized for WELLZYME breakers are run in the field using the specifications needed for a clean break, as established by our laboratory testing. Similarly, the WELLZYME breaker application is engineered to break the M-I SWACO reservoir drill-in fluid system.

DEEPCLEAN

Spacers and Displacement Chemicals



A smaller, powerful spacer that cleans your well to water-wet in less time, even under extreme conditions

DEEPCLEAN* additive is a powerful, single-stage spacer pill that satisfies all the requirements of a multiple-stage displacement wash train with one product. This efficient combination of powerful solvents, surfactants and water-wetting agents not only provides highly effective surface cleaning, but does so with an excellent HSE profile.

The DEEPCLEAN additive resolves a major obstacle to displacing a synthetic- or oil-base drilling fluid with completion brine. Conventional chemistry dictated the use of several clean-up pills, comprising a wash train that cleans the wellbore of the invert fluids and produces a water-wet state. In addition, the temperature stability of these pills usually was ill-suited to high pressure/high temperature (HPHT) wells. Before the DEEPCLEAN additive was introduced, no single product worked in water, seawater and high density brines.

Applications

The DEEPCLEAN additive can be used in water, seawater and high-density brines as a one-stage displacement chemical. It is temperature stable up to 300°F (149°C). Its effectiveness over a wide temperature range makes the DEEPCLEAN additive ideal for deepwater applications.

The double emulsion of the DEEPCLEAN additive thins, dissolves and disperses oil - or synthetic-base fluid residue. It also leaves downhole tubular and metal surfaces in a water-wet state.

Advantages

- Leaves casing and pipe surfaces in a water-wet state, ready for completion operations
- Enhanced wellbore cleanliness by removing and dispersing the oil based film on the first circulation
- Reduced costs
- Minimal environmental footprint
- Acts quickly, saving time
- Fewer chemicals are required
- Fewer pills are required and less waste is produced
- Better waste separation at the surface
- Potential reduction in spacer sizes required
- Simplifies storage and logistics



POWERVIS

Spacers and Displacement Chemicals

The POWERVIS* linear biopolymer rheology modifier is used in coiled tubing fluids and solids free reservoir drill-in fluid systems. A viable alternative to xanthan gum biopolymer, it produces similar elevated low shear-rate viscosities (LSRV) but at lower concentration levels. In coil tubing operations, the POWERVIS biopolymer provides rheological properties that lower ECDs, pressure loss, and free spin pressures.

Applications

The multi-functional POWERVIS biopolymer is used to provide viscosity and solids suspension in solids free systems. Compared to xanthan gum, the POWERVIS biopolymer is capable of lowering system pressure by more than 20%. It can be used as a viscosifier in freshwater or low-salinity FLOPRO* NT systems where enhanced hole cleaning is desired. The unique rheology profile of the POWERVIS biopolymer delivers lower pump pressures and ECD, making it an ideal alternative for coil tubing and extended reach drilling or any applications where a solids-free system is used. As a spacer, the flat velocity profile of the POWERVIS biopolymer improves displacement efficiency.

Advantages

- Higher thermal stability - > 300°F (149°C) in freshwater
- Tolerant of cement
- Provides the LSRV equivalent to xanthan gum, but at a lower polymer concentration
- Lower PV and YP than xanthan gum
- Lower ECD
- Lower pump pressure
- Lower free spin pressures in coil tubing operations
- Extends the life of coil tubing fluids due to higher solids tolerance

SAFE-SOLV 148

Spacers and Displacement Chemicals

SAFE-SOLV* 148 additive is a nonflammable, environmentally acceptable blend of solvents used to displace or remove oil- or synthetic-base drilling fluid and solids. It is designed to soften, dissolve, and suspend any pipe dope, paraffin wax, asphaltenes, and heavy crude oil deposits on tubular surfaces or on the wellbore surface that could restrict production. The SAFE-SOLV 148 additive contributes to reduced filtration costs and formation damage, as well as increased well productivity and lower overall well costs. The SAFE-SOLV 148 additive is biodegradable.

Applications

SAFE-SOLV 148 additive is designed specifically for cleanup during the displacement of oil- or synthetic-base drilling fluids prior to the start of production.

It is intended to be used as a solution in freshwater or seawater, and applied as a spacer. Solutions may be made between 3 and 10% by volume through the rig hopper. Higher concentrations should be used where increased levels of hydrocarbons exist in the fluid to be displaced, or when displacing unconditioned or high-density drilling fluids.

Advantages

- Designed to soften, dissolve, and suspend hydrocarbon deposits that could interfere with production
- Contains no aromatic or chlorinated hydrocarbons
- Contains no alkylphenol ethoxylates
- Useful in dealing with the same type of hydrocarbon deposits in tanks, pipes, and related equipment

SAFE-SOLV E

Spacers and Displacement Chemicals

SAFE-SOLV* E additive is a blend of non-aromatic hydrocarbon and natural terpene solvents designed to give optimum grease solvency properties without using hazardous chemicals. SAFE-SOLV E additive is particularly effective at removing pipe dope and oil- or synthetic-base mud residues from downhole surfaces, either as part of a full wash train or separately as part of a pipe pickling procedure prior to gravel packing. SAFE-SOLV E additive is also effective in dissolving waxes and asphaltenes and contains no aromatic compounds, such as benzene, ethylbenzene, toluene or xylene. Unlike many commercial solvents, SAFE-SOLV E additive has a pleasant, citrus-like odor.

Applications

SAFE-SOLV E additive is designed specifically for downhole use during well cleanup or pipe-pickling operations. It may also be used to remove waxes and asphaltenes from production tubulars.

SAFE-SOLV E additive is commonly used as a concentrated pill or slug, but may also be used as a dispersion in water or brine as part of a wash train.

For mud-displacement applications, SAFE-SOLV E additive should be used in conjunction with a wash containing a surfactant, such as SAFE-SURF* E, in order to ensure water-wet tubulars.

SAFE-SOLV E additive may also be used with a surfactant in a transition pill for SBM displacements. Contact the Technical Services Group for more information.

Typical physical properties

Physical appearance	Clear liquid
Odor	Pleasant, citrus-like
Specific gravity	0.81 @ 68°F (20°C)
Flash point	144°F (62°C)

Advantages

- SAFE-SOLV E additive is designed to soften, dissolve and suspend hydrocarbon deposits that could interfere with production
- Contains no aromatic or chlorinated hydrocarbons
- Does not contain alkyl-phenol ethoxylates
- Immiscible with brine; distinct interface
- Readily biodegradable in the marine environment
- Can be used to remove waxes and asphaltenes from production tubulars
- Has pleasant, citrus-like odor
- Small volumes normally required; can be pumped from cement unit or slug pit

Limitations

- Although combustible, SAFE-SOLV E additive is not considered hazardous for U.S. ground transport when shipped in non-bulk (<119 gal [450 L]) containers. When shipped in bulk containers in the U.S., the appropriate warning labels are required (see Section 14 of the MSDS)
- May interact with elastomer materials on prolonged exposure. Avoid storing or shipping in rubber-lined tanks

No claim of personal safety is intended nor implied by the use of the name SAFE in this product. Personnel handling this material should read and follow all safety and handling procedures set forth in the Material Safety Data Sheet.

SAFE-SOLV OM

Spacers and Displacement Chemicals

SAFE-SOLV OM solvent is a combination of powerful, non-aromatic hydrocarbon and natural terpene solvents and surfactants with exceptional oil- and grease-solvent properties. It is fast-acting and requires less contact time than “solvent only” pickling agents. SAFE-SOLV OM solvent is especially effective in removing pipe dope and oil- or synthetic-base mud residue from casing and pipe prior to gravel packing and other operations that may carry greasy residue into the producing formation. It contains no aromatic compounds, including benzene, ethylbenzene, toluene, or xylene (BETX). It does not contain alkyl-phenols such as nonyl-phenol or other such surfactants.

Applications

SAFE-SOLV OM solvent can be used without dilution or as a dispersion in freshwater or seawater. A dispersed solution should be continuously mixed while pumping. Sufficient volume should be used to give a minimum of 5 min contact time. Pump rates should be designed to give turbulent flow.

To ensure water-wet pipe, the SAFE-SOLV OM spacer should be followed by SAFE-SURF W detergent, SAFE-SURF O cleaner, or another water-wetting surfactant package formulated to remove oily films.

Typical physical properties

Physical appearance	Clear, light yellow liquid
Odor	Pleasant, citric
Specific gravity	0.82 (68°F) (20°C)
Solubility (water)	Very slight
Flash point	124°F (51°C) (PMCC)

Advantages

- Excellent solvent spacer for pipe-dope removal or oil-mud displacements
- Pleasant odor
- Immiscible with brine to give distinct interface
- Does not contain BETX components
- Spent product can usually be processed with produced crude
- Can be used without mixing or dilution
- Can be handled with the same ease as diesel fuel

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SAFE-SURF E

Spacers and Displacement Chemicals

SAFE-SURF* E well wash is a blend of non-ionic surfactants and powerful water-wetting agents designed to clean up and displace oil- and synthetic-base mud and solids. It disperses filter cakes efficiently, while leaving downhole tubular and casing in a water-wet condition. This contributes to reduced filtration costs, reduced formation damage, increased well productivity and lower overall well costs.

Applications

SAFE-SURF E well wash is designed specifically for downhole use in oil and gas wells for cleanup prior to the start of production.

It is intended to be used as a solution in freshwater or seawater, and applied as a “spacer”. Solutions may be made between 5 and 10% by volume through the rig hopper. Use higher concentrations where higher levels of hydrocarbons exist in the mud to be displaced.

Typical physical properties

Physical appearance	Light, pale tan liquid
Specific gravity	1 @ 68°F (20°C)
pH (conc.)	8.0
Boiling point	212°F (100°C)

Advantages

- SAFE-SURF E is a near-neutral non-ionic blend of surfactants and water-wetting agents that will effectively emulsify and suspend the residues of drilling mud and other deposits which could otherwise damage the formation
- Solutions generally have a pH in the region of 7.5 to 9.5, which not only prevents any attack of cement or acid-sensitive formations, but also assists in controlling possible corrosion of steel
- The non-ionic solution is not affected by normal levels of calcium, magnesium or barium ions found in most solution makeup waters
- It does not contain alkyl-phenol ethoxylates

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SAFE-SURF NS

Spacers and Displacement Chemicals

SAFE-SURF NS additive is a highly effective, environmentally friendly, single-stage well displacement chemical, designed to perform all the requirements of a multiple wash displacement train with one additive. SAFE-SURF NS additive is a blend of non-ionic surfactants, incorporated into a solvent system. When used in wellbore cleaning operations, it performs the task of thinning, dissolving, and dispersing oil-base mud residues as well as ultimately leaving all downhole tubulars and metal surfaces in a water-wet state. SAFE-SURF NS additive is a non-aromatic blend of solvents and surfactants with a high flash point and contains no recognized carcinogens. It is effective over a wide temperature range and is ideal for deepwater applications.

Applications

SAFE-SURF NS additive is designed primarily for downhole use in oil and gas wells for cleanup during the displacement of oil- or synthetic-base drilling fluids prior to the start of completion operations. SAFE-SURF NS additive is recommended at concentrations of 5 to 20% (v/v), in the main cleanup pill. The combined action of the solvents and surfactants

Typical physical properties

Physical appearance	Clear yellow liquid
Odor	Pleasant, citric
Specific gravity	0.85 to 0.95
Solubility (water)	Very slight
Flash point	158°F (70°C) (Sh CC)

in SAFE-SURF NS additive provides efficient cleanup of solids and drilling-fluid residue during displacement operations and leaves all downhole tubulars in a water-wet state without the need for a subsequent surfactant wash.

SAFE-SURF NS additive can be mixed in freshwater or seawater. It can also be incorporated into a high viscosity pill to aid in removing heavy solids prior to pumping the main cleanup pill or as a subsequent high-viscosity displacement aid following the main cleanup pill. The exact product concentration and spacer/wash volumes vary depending on mud type and wellbore conditions. Recommendations for a specific application should be made after consulting an M-I SWACO representative.

Advantages

- Environmentally friendly product with no recognized carcinogens
- Effective surfactant/solvent blend for removing oil- or synthetic-base drilling-fluid residue from wellbore surfaces
- Surfactant content leaves metal surfaces in a water-wet state without the need for a subsequent surfactant wash
- Suitable for wellbore cleanup operations following water-base drilling-fluid operations
- High flash point
- Requires minimal contact time
- Although combustible, SAFE-SURF NS additive is not considered hazardous for shipping because of its high flash point

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SAFE-SURF O

Spacers and Displacement Chemicals

SAFE-SURF O well cleaner is a concentrated blend of surfactants, solvents, and powerful water-wetting agents designed to clean up and displace oil- and synthetic-base mud and solids. It disperses filter cakes efficiently with low environmental impact, while leaving downhole tubulars and casing in a water-wet condition.

Applications

SAFE-SURF O cleaner is designed specifically for downhole use in oil and gas wells for cleanup prior to the start of production. It is intended to be used as a solution in freshwater or seawater, and applied as a “spacer.” SAFE-SURF O well cleaner emulsifies oil- and synthetic-mud components into the water phase and prevents redeposition of oil-wet solids onto pipe surfaces. SAFE-SURF O cleaner contains neither aromatic hydrocarbons nor alkyl-phenol surfactants.

Solutions may be made between 3 and 10% by volume in the rig pits. Use higher concentrations where higher levels of hydrocarbons exist in the mud to be displaced, or when displacing unconditioned or high-density muds.

Typical physical properties

Physical appearance	Clear amber liquid
Specific gravity	0.95
pH (1% in water)	3
Solubility (water)	Soluble
Solubility (oil)	Soluble
Flash point	153°F (67.2°C) (PMCC)

Advantages

- Facilitates suspension of drilling mud residue and other deposits which could damage the formation
- Can be dispersed in heavy brines to provide the means for a weighted spacer
- Is unaffected by normal levels of calcium, magnesium, or barium ions found in many solution makeup waters
- Does not contain alkyl phenol ethoxylates

Limitations

- Do not heat product

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SAFE-SURF W

Spacers and Displacement Chemicals

SAFE-SURF W fluid is a surfactant-based detergent, formulated to remove water-base drilling mud and residue from casing, pipe and surface equipment. This high-pH, strong, water-wetting cleaner helps displace mud and solids from tubulars to ensure a clean wellbore is obtained for placement of the completion fluid.

Applications

The SAFE-SURF W displacement chemical is used as a cleaning spacer between water-base mud and completion fluid. It disperses mud solids into the water spacer and helps prevent subsequent “hard settling” of the solids as the spacer remains stagnant in a holding vessel. SAFE-SURF W fluid is also used to clean surface equipment and as a rig wash.

Added directly to freshwater or seawater, SAFE-SURF W fluid is typically applied at 1 to 10% by volume, depending on the amount of turbulence and degree of communication. Typical application during a wellbore displacement is 2 to 5% by volume. Surface cleaning is typically accomplished with a concentration of 2 to 3% by volume.

As with any surfactant-base cleaner, efficient cleaning is best achieved at high flow rates.

Typical physical properties

Physical appearance	Colorless liquid
Specific gravity	0.99 to 1.06
pH (10% solution)	10 to 12
Freezing point	32°F (0°C)

Advantages

- Effective at low concentrations
- Can be used in combination with caustic spacers
- Contains no alkyl phenol ethoxylates and is environmentally friendly
- Prevents mud solids from settling “hard” on the bottom of containers or the wellbore
- Has no odor
- Functions in seawater or freshwater

Limitations

- Freezes at temperatures below 32°F (0°C)
- May cause detergent builders to precipitate during extended periods of storage temperatures significantly greater than normal. These solids are easily dispersed and are resolubilized at cooler temperatures

No claim of personal safety is intended nor implied by the use of the name SAFE in this product. Personnel handling this material should read and follow all safety and handling procedures set forth in the Material Safety Data Sheet.

SAFE-SURF WN

Spacers and Displacement Chemicals

SAFE-SURF WN fluid is a displacement wash chemical used as a cleaning spacer between water-base mud and completion fluid. A blend of anionic and non-ionic glucose-base surfactants classified for discharge in the UK, SAFE-SURF WN cleaner helps displace mud and solids from tubulars to ensure a clean wellbore.

Applications

SAFE-SURF WN fluid is formulated to remove water-base drilling mud residue and oil-mud film from casing, pipe and surface equipment. It is used as a cleaning spacer between water-base mud and completion fluid, as a cleaner for surface equipment and as a rig wash. SAFE-SURF WN fluid is typically applied at 1 to 10% by volume, depending on the flow rate and degree of contamination. Typical application during a wellbore displacement is 5 to 10% by volume. Surface cleaning is typically accomplished with a concentration of 2 to 3% by volume.

SAFE-SURF WN fluid is added directly to freshwater or seawater and can be added to high-viscosity spacers as a water-wetting agent. As with any surfactant-base cleaner, efficient cleaning is best achieved at high flow rate.

Typical physical properties

Physical appearance	Viscous, yellow liquid
Specific gravity	1.03 kg/L
pH	about 5
Cloud point	32°F (0°C)
Flash point	Not flammable

Advantages

- Biodegradable, nonflammable, and classified for discharge (OCNS Category E) in the UK
- Effectively removes water, mud and oil film from equipment
- Exhibits reduced aquatic toxicity
- Efficient at low concentrations
- Requires no special handling under conditions of normal use

Limitations

- Pour point is about 32°F (0°C)

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SAFE-SURF Y

Spacers and Displacement Chemicals

SAFE-SURF* Y surfactant is a blend of non-ionic surfactants and powerful water-wetting agents designed to clean up and displace water-, oil- and synthetic-base drilling fluids and solids. SAFE-SURF Y additive will remove drilling fluid residue from casing, pipe and surface equipment. It will emulsify oil- and synthetic-base drilling fluid components into the water phase and prevent redeposition of oil-wet solids onto pipe surfaces. SAFE-SURF Y surfactant disperses filter cake efficiently with low environmental impact. This strong water-wetting cleaner helps displace drilling fluid and solids from downhole tubulars and casing to help ensure that a clean wellbore is obtained for the completion-fluid displacement. This contributes to reduced filtration costs, reduced formation damage, increased well productivity and lowered overall well costs.

Applications

SAFE-SURF Y surfactant is designed specifically for downhole use in oil and gas wells for cleanup prior to completion operations or the start of production.

SAFE-SURF Y surfactant is used as a cleaning spacer between the drilling fluid and completion fluid and can be mixed using freshwater, seawater or brines. Solutions may be made between 6 and 12% by volume, depending on the flow rate, contact time and degree of contamination.

Typical physical properties

Physical appearance	Clear liquid
Odor	Alcohol
Specific gravity	0.95 to 1.05
pH (concentrate)	7
Melting point	<32°F (0°C)
Flash point	>212°F (100°C)
Solubility	Miscible with water

Advantages

- SAFE-SURF Y surfactant is a near-neutral, non-ionic blend of surfactants and water-wetting agents that will effectively emulsify and suspend the residues of drilling mud and other deposits which could otherwise damage the formation
- Solutions generally have a pH in the region of 7 to 9, which assists in controlling potential steel corrosion
- The non-ionic solution is not affected by normal levels of calcium, magnesium or barium ions found in most solution makeup waters
- It does not contain alkyl phenol ethoxylates
- SAFE-SURF Y surfactant has a category "yellow" environmental rating in Norway

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SAFE-T-PICKLE

Spacers and Displacement Chemicals

SAFE-T-PICKLE* additive is a highly effective, non-aromatic, high flash point pipe dope solvent that contains no recognized carcinogens. It is effective in cleaning commonly used copper- and zinc-base compounds. A fast-acting solvent that requires minimum contact time, SAFE-T-PICKLE additive is effective over a wide temperature range and is ideal for deepwater applications.

Applications

SAFE-T-PICKLE solvent removes excess pipe dope that is used to lubricate pipe threads during tripping operations. Removal efficiency is a function of flow rate and contact time. A minimum of five minutes' contact at a flow rate of 120 ft/min (36.6 m/min) is recommended. Pumping should proceed down the drillstring until the solvent is several barrels from the end of the string. The solvent should then be reversed out at the maximum allowable rate to aid the removal of debris cleaned from the pipe. If the pipe dope solvent circulation is followed by a pickling acid to remove pipe scale, solvent and spent acid, returns should not be co-mingled until the acid is fully neutralized with soda ash (2 lb [0.9 kg] Na_2CO_3 per gal of

Typical physical properties

Physical appearance	Clear liquid
Odor	Pleasant, citric
Specific gravity	0.82
Solubility (water)	Very slight
Flash point	144°F (62°C) (CCCFP)

15% HCl). At least two drillstring volumes should be reverse circulated following the pickle to ensure the drillstring is free of debris.

Example: Volume/Pump Rate required for five minutes' contact time in 5.5 in. (139.7 mm) 24.7# drillstring:

Pump rate (BPM)	Volume (gal)
2.0	420
2.5	525
3.0	630
3.5	735
4.0	840
4.5	945
5.0	1,050

Advantages

- Excellent solvent for pipe dope removal
- Effective solvent for difficult copper-base pipe dopes
- High flash point
- No recognized carcinogens
- No hazardous components (BETX)
- Requires minimal (~ 5 min) contact time

Limitations

- Not recommended to mix directly with acid. Acid returns should be neutralized with soda ash at a rate of 2 lb (0.9 kg) Na_2CO_3 /gal of 15% HCl

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WELL COMMISSIONER (WC)

Specialized Tools: Liner Top Test Tools

The WELL COMMISSIONER* Wellbore Productivity* tool from M-I SWACO is unique in that it is designed to allow inflow and negative tests to be carried out on a liner overlap and the liner shoe track on the same trip as the wellbore cleanup. It can also be used to perform an inflow or negative test on the liner top and liner shoe track at any time during the life of the well. Regardless of when the tool is run, it results in significant savings in rig time compared to other methods of performing an inflow test. Significant reduction in oil-contaminated seawater or brine volumes generated is also possible where OBM is in use.

Advantages

The WELL COMMISSIONER tool eliminates the need for a controlled displacement of the entire well to lower density fluid through the choke with the blowout preventers closed. It also eliminates a dedicated run with a retrievable packer to perform the test, saving significant rig time. Positive tests on the casing or liner can also be carried out. Significant reduction in waste volumes of contaminated fluids is also made.

How it works

The WELL COMMISSIONER tool is run on the drillstring, spaced out to land on the liner-top Polished-Bore Receptacle (PBR) when the cleanout string is at final depth. The integral RAZOR BACK lantern cleans ahead of the packoff element and prepares the area in which the tool itself is to be set. The bypass under the element is open while running in hole and allows high-rate circulation without the need for fluids to go around the outside of the element (Figure 1).

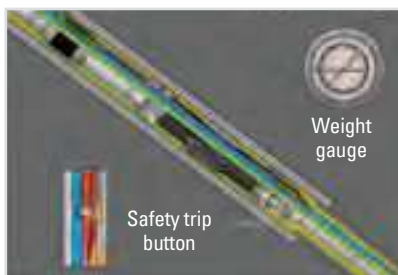


Figure 1. Pick up off the liner and begin circulating and conditioning the mud.

Features

- One-piece mandrel
- Integral RAZOR BACK* (scraper) lantern
- Integral liner-top dress mill
- Internal bypass under packoff element
- Standard tool rated to 5,000 psi (345 bar) differential up to 302°F (150°C)
- High-pressure tool rated to 7,000 psi (483 bar) differential up to 302°F (150°C)

Advantages

- Saves rig time and improves effectiveness of cleanup
- Simple to operate
- Allows inflow/negative test on same trip as cleanup
- Allows drilling and milling with tool in string
- Reduces waste volumes



Operation

When the integral liner-top dress mill lands on the PBR, it can be used to dress off the PBR top if required. A tieback mill can be run below the tool to clean inside the PBR.

A low-density water- or oil-base fluid is then pumped into the upper portion of the drill pipe to reduce the hydrostatic pressure on the liner overlap and liner shoe track. While back pressure on the drill pipe is held, the tool is set down on the liner top, the packoff element is set and the bypass closed. Back pressure bleed-off is the inflow test performed by monitoring for an increased pressure in the drill pipe, indicating inflow (Figure 2).

When the test is complete, repressurize to the previous back pressure, pick up to release the packoff element and open the bypass. The normal cleanup and displacement to completion fluid can now be conducted.

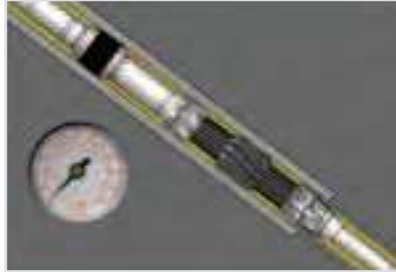


Figure 2. Slowly bleed down the work-string pressure to begin the inflow test.

The MFCT* (Multi-Function Circulating Tool) can be run above the liner top to boost circulation rates.

Operating Parameters

If an MFCT unit is proposed in the same string as the WELL COMMISSIONER tool, M-I SWACO will perform a torque and drag analysis to verify the effective tension in the string at the liner top while tripping in hole at 150 ft/min (46 m/min) without rotation.

When a WELL COMMISSIONER tool is run in conjunction with an MFCT unit, at least 10,000 lb (4,536 kg) effective string weight (tension) should be available below the tool when it is at operating depth. If this is not the case, consideration should be given to increasing the shear rating on the MFCT unit or running a Clutch-Type, Heavy-Duty MFCT unit or adding drill-collar weight to the string below.

It is recommended that a tieback mill is run below the WELL COMMISSIONER tool to polish the inside of the tieback receptacle of the PBR. This reduces the risk of a cement sheath, or other debris buildup, preventing the tool from seating on top of the tieback receptacle or PBR. Maximum running-in-hole/pulling-out-of-hole speed is 150 ft/min (46 m/min). The required inflow test pressure can only be achieved, if the resulting loading on the liner hanger system is within operating guidelines.

Operating parameters

Tool (casing) size, in.	Maximum rotating speed in tension, rpm	Maximum rotating speed in compression, rpm	Maximum compression at tool when rotating, lb (kg)
7 – 8%	100	60	5,000 (2,268)
9% – 10%	120	90	10,000 (4,536)

These are general guidelines only and are subject to review, if required, for individual circumstances.

BRISTLEBACK REDRESSABLE

Specialized Tools: Casing Cleaning Tools

The BRISTLEBACK REDRESSABLE* brush tool utilizes a unique lantern design that provides greater bristle life. This lantern design also allows easy, remote location redressing when required, saving time and delivering a higher level of service. The tool's effective, robust, and flexible design allows for complex, precompletion/Drill-Stem Test (DST) and workover cleanup operations.

Applications

The BRISTLEBACK REDRESSABLE brush is run as an integral part of the drillstring to brush the casing ID clean as the pipe is run in hole. It can be run as part of most drilling/milling/ polishing assemblies and can be rotated and reciprocated without damage to either the casing or the tool.

Features

- Brush cleaning life prolonged during rotation
- Self-centralizing, flexible-brush lantern
- Available in all common casing/liner sizes
- Supplied with drill-pipe box-up/pin-down connections
- Brush pads can easily be replaced on location

Advantages

- Scouring action ensures a clean pipe wall
- Non-rotating stabilizer sleeves and lantern avoid wear or damage to the casing and the tool bristles during pipe rotation
- Self-centralizing lantern distributes cleaning force equally for all hole inclinations
- Removes mud solids, cement sheath and pipe scale
- Saves time and inventory requirements



Heavy-Duty RAZOR BACK CCT (HDRB)

Specialized Tools: Casing Cleaning Tools

The Heavy-Duty RAZOR BACK CCT (Casing Cleanup Tool) from M-I SWACO Wellbore Productivity consists of a high-strength, one-piece mandrel and is designed to meet the demands of complex wellbore cleanups. By allowing a higher RPM and weight-on-bit rating than the standard RAZOR BACK CCT device, the Heavy-Duty RAZOR BACK CCT unit is well suited for drilling up cement accessories commonly found inside the liner or casing.

Advantages

The Heavy-Duty RAZOR BACK CCT device is more effective, robust and safer to use in all wellbore-cleanup or casing-scraping operations than other designs. It has a higher RPM and weight-on-bit rating than the standard RAZOR BACK CCT unit.

The lantern is self-centralizing inside the pipe to ensure equal cleaning force at all

angles of well inclination. The mandrel rotates through the stabilizer sleeves and lantern to avoid wear or damage to the casing during pipe rotation. The tool is HTHP-compatible and is not vulnerable to chemical or acid attack.

Operation

The Heavy-Duty RAZOR BACK CCT device is run with a maximum running-in-hole/pulling-out-of-hole speed of 150 ft/min (46 m/min) and should be positioned at least 30 ft (9 m) above the drill bit/mill. The string should be picked up off-bottom and circulated regularly to clear any accumulation of debris.

Where possible, the bit or mill OD should be greater than the stabilizer sleeve OD of the tool. If this is not possible, it is recommended that a full-gauge mill be run below the first Heavy-Duty RAZOR BACK CCT unit in the bottomhole assembly.

Features

- Self-centralizing flexible-bladed lantern
- Increased strength, one-piece main mandrel
- Carbide-compound-covered, fixed-mill rings
- Available in all common casing and liner sizes
- Supplied with drill-pipe box-up/pin-down connections

Advantages

- Fixed-mill rings enhance efficiency when drilling cement accessories
- Lower mill ring ensures larger cuttings are ground down to a size that is manageable for other cleanup tools in the string
- Mandrel rotates through stabilizer sleeves and lantern to avoid damage to casing during pipe rotation
- Lantern is self-centralizing inside casing and ensures an equal cleaning force for all hole inclinations



How it works

This tool has all the unique features of the standard RAZOR BACK CCT device, plus a carbide-compound coated fixed upper and lower mill ring and an increased-strength, one-piece mandrel. This ensures the tool can cope with the demands of drilling up cement accessories commonly found inside the liner or casing. When a drill bit or mill is used, cuttings generated are not always small enough to easily pass inside or around wellbore-cleanup tools. The lower mill ring of the Heavy-Duty RAZOR BACK CCT unit ensures that larger cuttings and debris are ground down

to a size that makes it easier for them to circulate past any other tools in the string.

The one-piece, main mandrel is complete with non-rotating, right-hand spiral stabilizer sleeves and a metal-bladed lantern covering 360°. The main tool body rotates through the stabilizer sleeves and lantern, avoiding wear or damage to the casing during pipe rotation. The metal-bladed lantern is strong, flexible and self-centralizing, providing the force to contact and scrape the pipe ID equally and effectively.

Operating parameters

Tool (casing) size, in.	Maximum rotating speed in tension, rpm	Maximum rotating speed in compression, rpm	Maximum compression at tool when rotating, lb (kg)
4½ – 5½	90	60	30,000 (13,608)
7 – 7½	100	60	35,000 (15,876)
9½ – 11¼	120	90	50,000 (22,680)
13¾	120	100	55,000 (24,948)

These are general guidelines only and are subject to review, if required, for individual circumstances.

MULTIBACK (MBACK)

Specialized Tools: Casing Cleaning Tools

The MULTIBACK* combination casing cleaning tool merges the latest proven magnet, scraper, and brush technologies into a simplified and rugged tool that can be used on wellbore preparation trips. The flexibility of the component arrangement provides numerous options to customize the tool for a specific application.

Applications

The modular design of the MULTIBACK tool allows it to be configured for specific applications or requirements. The MULTIBACK tool has an integral magnet section to capture ferrous debris, scrapers to dislodge difficult-to-remove debris, and brushes to disturb the sheath and any other fluid build-up on the inner wall of the casing or liner. The tool can be run in the inner production riser, casing, and liner to remove a combination of scale, rust, mud film, drilling debris, ferrous debris, and pipe dope.

How it works

The MULTIBACK tool is run in the well as a conventional wellbore preparation tool on the workstring. The lanterns for the scraper and brush unit are flexible, non-rotating, and provide the force to contact and clean 360° of the casing's internal diameter. Its self-centralizing design ensures equal cleaning force at all angles of inclination. The magnet section comprises a mandrel with fins that allow for large flow channels between them. The magnets are installed on the inside faces of the fins using a method for retaining the individual magnets so that the debris is collected in the high volume channels. The magnet section is integral in the tool while the scraper and brush sections are interchangeable.

Features

- One tool carries scrapers, brushes, or magnets on the same mandrel
- Large flow area between magnets to capture large debris
- BRISTLEBACK REDRESSABLE brush component can be readily redressed at remote locations

Advantages

- MULTIBACK combination tool provides brushing, scraping and magnetic debris recovery
- Scouring action of brush and scraping action of scraper removes cement sheath, burrs, and pipe scale to ensure a clean pipe wall
- Self-centralizing lanterns distribute cleaning force equally for all hole inclinations
- No risk of casing wear or damage from rotating stabilizers or lanterns
- Large capacity for up to 67 lb (41 kg) of ferrous material retrieval
- Recovered debris from magnets removed easily on location



RAZOR BACK CCT (RB)

Specialized Tools: Casing Cleaning Tools

This new-generation improvement in metal-bladed scraper design brings even the most complex wellbore cleanups under control. The RAZOR BACK CCT (Casing Cleanup Tool) has critically important features not found on any other metal-bladed casing scraper that render it more effective, more robust and safer to use in wellbore cleanup and casing scraping operations.

Advantages

The lantern is self-centralizing inside the tubular to ensure equal cleaning force at all angles of well inclination. The mandrel rotates through the stabilizer sleeves and lantern to avoid wear or damage to the casing during pipe rotation. The tool is HTHP-compatible and is not vulnerable to chemical or acid attack.

Operation

The RAZOR BACK CCT unit is run with maximum running-in-hole/pulling-out-of-hole speed of 150 ft/min (46 m/min), and should be positioned at least 30 ft (9 m) above the drill bit/mill and placed so that

it does not pass through any drilled-out accessories such as landing or float collars. The string should regularly be picked up off-bottom and circulated to clear any accumulated debris.

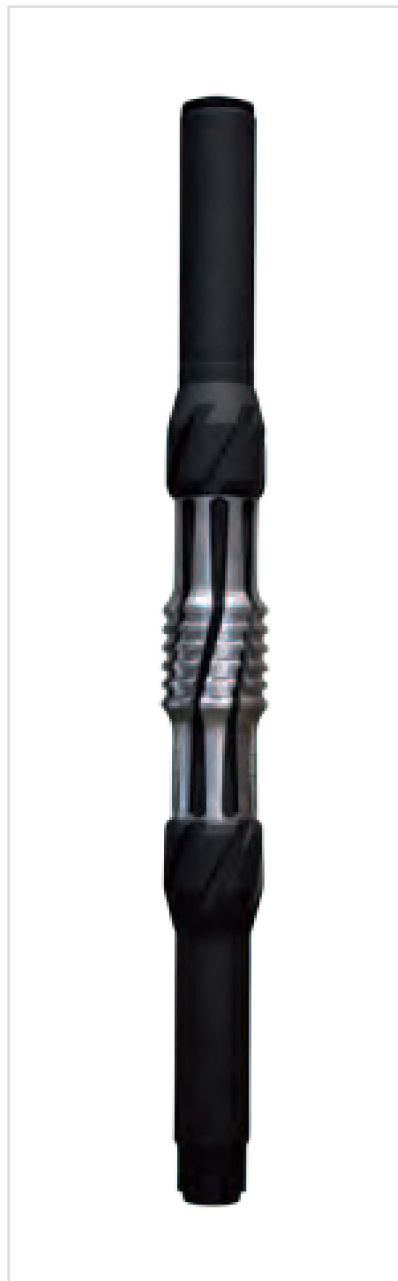
Where possible, the bit or mill OD should be greater than the stabilizer sleeve OD of the RAZOR BACK CCT device. If this is not possible, it is recommended that a full-gauge mill be run below the first RAZOR BACK CCT unit in the bottomhole assembly. It is not recommended to drill cement with a small RAZOR BACK CCT (3½ to 5½ in.) device. Alternatively, it is suggested that a dedicated slick-drilling run be made first to drill out the excess cement and establish Plug Back Total Depth (PBSD) prior to the cleanup run. Should a slick run not be possible, a Heavy-Duty RAZOR BACK CCT unit is recommended.

Features

- Non-rotating, 360° coverage, self-centralizing metal-bladed lantern
- Right-hand spiral stabilizer sleeves with flutes for fluid and debris bypass
- Available in all common casing and liner sizes
- Supplied with drill-pipe box-up/pin-down connections

Advantages

- Removes cement sheath, burrs, pipe scale
- Eliminates risk of casing wear/damage from stabilizers or blades during rotation
- Enhances chemical cleaning action



How it works

The RAZOR BACK CCT Wellbore Productivity tool from M-I SWACO is run as an integral part of the drillstring to scrape the casing as the pipe is run in hole. It can be run as part of most drilling/milling/polishing assemblies, as a standalone device or, more often, with circulating tools and the WELL PATROLLER* tool as part of the

cleanup system. It can be rotated and reciprocated without fear of damage to casing or the tool itself.

The RAZOR BACK CCT device consists of a one-piece main mandrel complete with non-rotating, right-hand spiral stabilizer sleeves and a metal-bladed lantern covering 360°. The metal-bladed lantern is both strong and flexible,

and provides the force to contact and scrape the pipe ID effectively. While running in hole, it is good practice to break circulation and reciprocate the pipe regularly (every 5,000 ft [1,524 m]) to disperse and enhance the cleanup of any debris buildup.

Operating parameters			
Tool size	Maximum rotating speed in tension, rpm	Maximum rotating speed in compression, rpm	Maximum compression at tool when rotating, lb (kg)
3½	60	60	3,000 (1,361)
3½ – 5½	90	60	5,000 (2,268)
6½ – 8½	100	60	10,000 (4,536)
9½ – 13½	120	90	15,000 (6,804)
16	120	90	50,000 (22,680)

These are general guidelines only and are subject to review, if required, for individual circumstances.

RAZOR BACK CCT with Integral Top Dress Mill (RBTDMD)

Specialized Tools: Casing Cleaning Tools

The RAZOR BACK CCT (Casing Cleanup Tool) with Integral Top Dress Mill from M-I SWACO Wellbore Productivity ensures that the casing is scraped to a point very close to the top of the liner so that subsequently installed liner-top tieback packers will be set and sealed in a clean, properly prepared section of casing.

Applications

This tool is designed as a mechanical aid for cleaning wellbore casings and dressing liner-top Polished-Bore Receptacles (PBRs). The tool is HTHP-compatible and not vulnerable to chemical or acid attack. It can be run as a standalone device or in conjunction with circulating tools, BRISTLE BACK CCT units and chemical cleaning agents. The RAZOR BACK CCT unit is very robust and effective in removing mud solids, heavy cement sheath, heavy pipe scale and perforation burrs from the casing ID, in addition to dressing off the liner-top PBR.

How it works

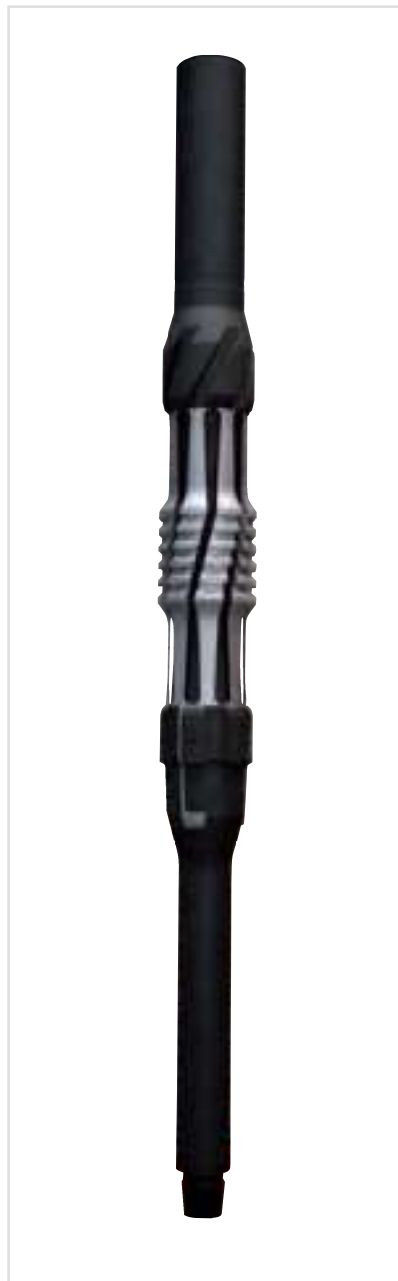
The RAZOR BACK CCT device consists of a one-piece body, a non-rotating stabilizer sleeve, a non-rotating scraping bladed lantern, and an integral liner-top dress mill. The body rotates through the upper stabilizer sleeve to avoid wear/damage to the casing during pipe rotation. The bladed lantern is strong and flexible and provides the force to contact and clean 360° of the pipe ID. The lantern is self-centralizing inside the pipe to ensure equal cleaning force at all angles of inclination. No clamps, bolts, threaded rings, springs or multiple scraper blocks that may be lost downhole are used in tool construction.

Features

- Secure components
- Self-centralizing, flexible-blade lantern
- Available in all common casing-liner sizes; complete with top dress mill for all common PBR sizes
- Supplied with drill-pipe box-up/pin-down connections

Advantages

- Removes cement and mud solids, burrs, pipe scale
- Enhances chemical cleaning action
- Scrapes casing very close to the liner top



RIDGE BACK Burr Mill (RBBM)

Specialized Tools: Casing Cleaning Tools

The RIDGE BACK® Burr Mill is an M-I SWACO Wellbore Productivity casing cleanup tool developed for use in perforated casing or liner to remove perforation burrs and to ensure the safe passage of completion equipment.

Advantages

A unique feature of the RIDGE BACK Burr Mill is the ability to turn it off once the milling/cleaning operation is complete if other extensive rotation is anticipated before pulling out of the hole. This is achieved by circulating a ball down, and shifting an internal support sleeve, to remove the expanding force on the milling ribs. These ribs are then held recessed into the tool and away from the pipe ID.

Full circulation through the ID of the tool is possible before and after the support sleeve is moved. The tool can also be used to clear off equally stubborn

ID-restricting materials (e.g., heavy pipe scale) from the inside of casing/liner to regain full pipe ID.

Operation

At least one MAGNO BACK® tool should be run above the RIDGE BACK Burr Mill to collect the milled material. In addition, consideration should be given to running a RAZOR BACK tool and a WELL PATROLLER unit above the top MAGNO BACK tool. It should be run at a maximum run-in-hole/pull-out-of-hole speed of 150 ft/min (46 m/min). If the string is to be rotated at the same depth for more than 30 min, it is recommended that the RIDGE BACK Burr Mill be deactivated. This is achieved by dropping and circulating a ball to the tool and applying pressure to shift the internal support sleeve. It should be noted that when the tool is deactivated, it cannot be reactivated.

Features

- One-piece mandrel
- Cleans by rotation and up/down pipe movement
- Supplied with drill-pipe box-up/pin-down connections
- Available in all common casing/liner sizes
- Milling ribs can be deactivated by ball drop to minimize casing wear during periods of prolonged rotation

Advantages

- Provides advanced wellbore cleanup in the post-perforating well phase, where a high degree of casing or liner ID smoothness through the perforated interval is required
- Completely removes perforation burrs, preventing damage to completion equipment, including expandable screens/expandable pipe used in complex/smart completions
- Capability to turn off tool once the milling/cleaning operation is complete to avoid casing wear



How it works

The RIDGE BACK Burr Mill is built on a one-piece drill-pipe mandrel and is equipped with three expandable milling ribs that make contact with the full ID of the casing/liner. The right-hand face of the milling rib is dressed with a carbide compound so that the expanding force, coupled with right-hand rotation, ensures perforation burrs are removed from the ID of the pipe.

The lower end of the tool has a fixed-mill sleeve (Figure 1), also dressed with a carbide compound to remove a proportion of the perforation burrs before the expandable mill ribs remove the remainder of the burrs to reinstate the full pipe ID. The upper end of the tool

has a fixed stabilizer sleeve to provide balanced support to the mill ribs. Removal of perforation burrs is achieved by running in hole and pulling out of hole through the perforated interval at a predetermined speed

(10 ft/min [3 m/min]), while rotating at the recommended 60 rpm. This ensures sufficient contact time between the mill ribs and each perforation to effectively remove all burrs and leave the pipe ID smooth and free of restrictions.



Figure 1. Lower fixed mill sleeve.



Figure 2. Burrs on tubular ID prior to cleaning with RIDGE BACK® Burr Mill.

Operating parameters

Tool size, in.	Maximum rotating speed in compression, rpm	Maximum rotating speed in tension (activated), rpm	Maximum rotating speed in tension (deactivated), rpm	Deactivation pressure, psi (bar)
7 – 8 ¹ / ₁₆	60	60	100	1,800 (124)
9 ⁵ / ₁₆ – 10 ³ / ₄	60	60	120	830 (57)

These are general guidelines only and are subject to review, if required, for individual circumstances.

SWITCHBACK (SWB)

Specialized Tools: Casing Cleaning Tools

The SWITCHBACK® casing cleaning tool is versatile and can be configured as a scraper, brush or mill. It can be run as an integral part of the BHA while drilling the final hole section multiple tools can be run in a single string that allows scraping, brushing, milling, or a combination of all three operations. While RIH and during drilling operations the component pads are recessed. Once drilling operations have reached TD the SWITCHBACK tool can be functioned by dropping a ball and applying pressure. As the ball shears through the tool the pads extend to begin the clean up operation.

Features

- Modular design allows flexibility among scraping, brushing and milling modes
- High torque, rugged design for use in demanding applications
- Recessed blades that are RIH in dormant position
- Activated by ball-drop using patented ball seat technology
- Cleaning action in rotation, force exerted on casing ID by magnetic repulsion of pads
- Integral stabilizer to provide standoff – fluted design for maximized bypass
- Innovative pad retention mechanism
- Pads locked in dormant or engaged positions

Applications

The SWITCHBACK can be utilized in situations where sand screens are being used, a packer setting area needs to be cleaned or while milling a perforation interval. By having the tool properly located in the drilling BHA, the targeted casing section can then be cleaned and prepared for the subsequent operation without making a dedicated cleanup trip.

Advantages

- Saves a trip by allowing scraping, milling or brushing of lower completion packer setting areas during final hole section drilling
- The dormancy feature (pads recessed until activated) greatly reduces risk of pack-off around tool blades during drilling
- Patented ball seat technology enables multiple tools, all activated by the same ball, to be run in the same string saving rig time
- Disperses accumulated cuttings beds through a combination of hydraulic and mechanical actions, particularly when used with the WELL COMMANDER® drilling valve
- Generous bypass flow area minimizes ECD increases



Clutch-Type, Heavy-Duty MFCT (MFCT-HD)

Specialized Tools: Circulating Tools

The Clutch-Type, Heavy-Duty Multi-Function Circulating Tool (MFCT-HD)* unit from M-I SWACO Wellbore Productivity is a valuable option when well cleanout is required in deeper, deviated wells and/or when it is necessary to start and stop the cleanout operation at several places in the wellbore.

Applications

This tool is an enhanced version of the original MFCT device and is suited for use in deeper, deviated wells where there is a requirement for higher tensile and torsional ratings. It is also applicable when it is desirable to lock this type of circulating tool in the open/closed position, such as performing an inflow test on a liner lap.

The Clutch-Type, Heavy-Duty MFCT unit has the same basic functionality as the original version. It allows higher circulation rates to be achieved at various times during a wellbore cleanup

to displace debris or fluid out of the hole. It also allows flow rates to be boosted at a liner top to increase the annular velocity of the wellbore fluid, thereby increasing the cleaning action. The tool is particularly suited to wells with small liner diameters in which well-cleanup operations are performed prior to running completions or test strings. The tool can be run when drilling cement and milling/polishing liner-top PBRs.

The use of this tool also allows the spotting of chemical pills and the efficient displacement of wellbore fluids. In addition, it offers the benefit of pipe rotation and circulation above a liner, with the jetting ports open, while protecting the lower string from potentially damaging torque. When the tool is open, only the drillstring above the tool can be rotated. When the tool is closed, the complete string can be rotated with circulation directed through the bit or mill.

Features

- Does not require darts or balls to be pumped down the drill pipe
- Can be cycled open and closed in the hole as many times as required by simply slacking off/picking up the drill pipe
- Allows drilling/milling to take place with the tool in the string
- Internal clutch for drillstring rotation above the tool with the circulating ports open
- Can be locked closed in compression to avoid premature opening while RIH; can be locked open in tension to allow the tool to be picked up off the liner top while continuing to circulate at high rates

Advantages

- Allows flow rates to be boosted at a liner top to increase the annular velocity of the wellbore fluid, thereby increasing cleaning action
- Allows spotting of chemical pills and efficient displacement of wellbore fluids
- Gives the benefit of pipe rotation and circulation above a liner with the ports open, while protecting the lower string from potentially damaging torque



How it works

The Clutch-Type, Heavy-Duty MFCT device is run with a suitable no-go device (liner-top dressing mill, bearing sub or stabilizer) below it, allowing it to be operated without putting the lower string in compression. No darts or balls need to be pumped down the drill pipe, and the tool can be operated in the hole as many times as required by simply slacking off/picking up the string. When Running In Hole (RIH), the tool is fully stroked out, with all circulation passing through the end of the drillstring. In this initial position, rotating torque is transmitted to the whole drillstring. The tool has shear screws installed to ensure that it will not open prematurely while RIH. If the shear screws are inadvertently sheared by high drag forces, the tool will remain closed and RIH can continue without any further action being taken.

To operate the Clutch-Type, Heavy-Duty MFCT device, the driller sets the tool down and applies the required weight to shear the screws. When the screws are sheared, the outer body of the tool moves down a short distance, putting the tool into the “locked-closed” position. The string is then picked up and slacked off again to move the outer body down the full stroke length, putting the tool in the open position. High circulating rates can now be achieved through the circulating ports. If required, the tool can be picked up off the liner top into the “locked-open” position. Rotation is still not transmitted below the tool in this position. To close the tool, the string is slacked off and picked up once again, returning it to the original closed position. The tool can be opened and closed as many times as required by manipulating the string.

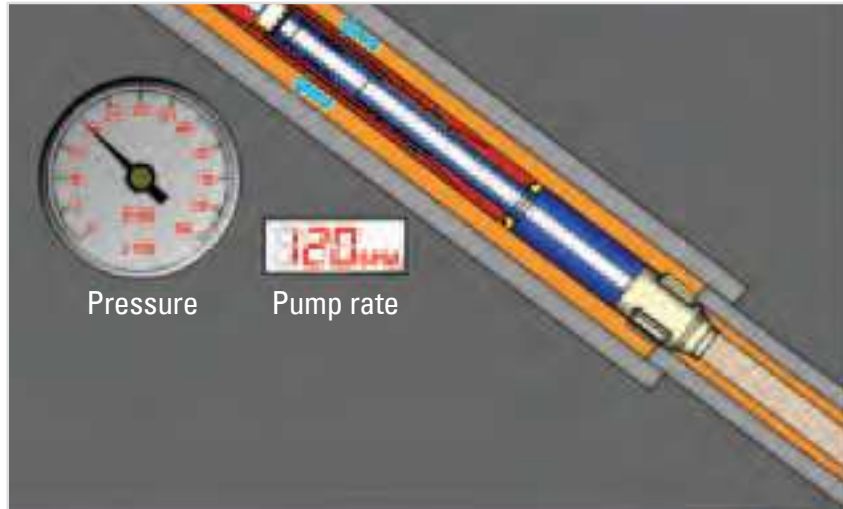


Figure 1. Slack off onto the liner top without circulation with sufficient weight to shear the shear ring and open the circulation ports. Check circulation rates to establish that the tool is open.

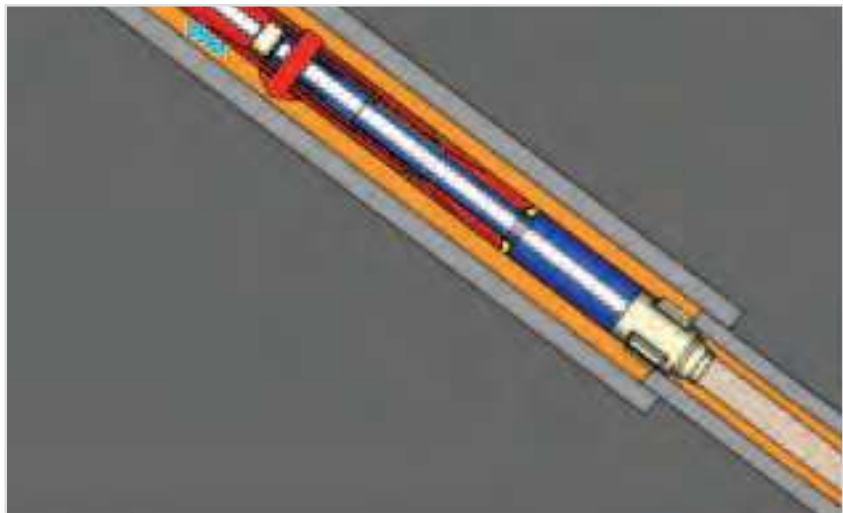


Figure 2. Slack off onto the liner top without circulation to open the tool. Displace the drill-pipe/casing annulus and rotate the string. Note that the clutch is now disengaged and only the upper string is rotated in this position.

Dual-Action Bypass Sub (DABS)

Specialized Tools: Circulating Tools

The DABS* (Dual-Action Bypass Sub) Completions Wellbore Productivity tool from M-I SWACO is designed to run in the cleanup string when it is desirable to jet the riser and Blowout Preventer (BOP) while Running In Hole (RIH) and/or when Pulling Out Of Hole (POOH). It can also be used nearer the bottom of the string as a bypass valve above a drilling motor or small-diameter tail pipe.

Advantages

The DABS tool permits jetting operations while running in hole and/or when pulling out of hole.

Operating Parameters

Note that the balls do not need to be circulated down at this reduced rate. It is only when the ball nears the ball seat that these rates should be applied (see table below).

Operating parameters			
Tool size, in.	Rotating speed	Maximum circulating rate when landing balls, gpm (bbl/min)	Maximum circulating rate in the open position, bbl/min
3½ IF	No limit	63 (1.5)	15
4½ IF	No limit	105 (2.5)	30
XTM50	No limit	105 (2.5)	30

These are general guidelines only and are subject to review, if required, for individual circumstances.



Features

- One-piece, full-strength mandrel
- Two sets of ports and two internal ball seats that can be moved to open/close ports
- Available in 4¾ and 6½ in. OD
- Also available as 11 and 16 in. (279 and 406 mm) jetting tools

Advantages

- Used to jet BOPs and risers
- Can be used to bypass drilling motors
- Can be run above small, non-draining pipe

Operation

The DABS unit is RIH with the cleanup string, self-filling through the open ports and circulating/jetting as required. A ball is dropped to close the ports, then drilling or circulating occurs as required (Figure 1). Dropping another ball opens the ports to trip out which allows self-draining and circulation/jetting to take place as required (Figure 2).

How it works

The tool is run in the open position to jet and clean as it moves through the riser and BOPs. The external jetting ports on the sub are then closed to circulate once again, and reopened when POOH, allowing jetting to occur.

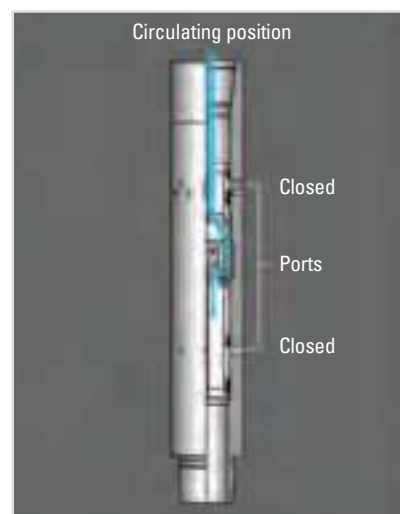


Figure 1. The lower ports are closed by dropping a ball and applying pressure.



Figure 2. The upper ports can be opened by dropping a second ball and applying pressure.

Multi-Function Circulating Tool, Clutch-Type (MFCT)

Specialized Tools: Circulating Tools

Efficient drilling is dependent on keeping the hole free of debris. The clutch-type MFCT (Multi-Function Circulating Tool) unit, developed for use when well cleanout is required prior to running completions or test strings, is a valuable option.

Applications

The MFCT Completions Wellbore Productivity tool from M-I SWACO

is particularly suited to wells with small liner diameters where well cleanups are performed prior to running completions or test strings. This tool can be run when drilling cement and milling/polishing liner-top Polished-Bore Receptacles (PBRs), providing pipe rotation above the liner with the ports open while protecting the string below from potentially damaging torque.

Features

- Does not require darts or balls to be pumped down the drill pipe
- Can be operated in the hole as many times as required by slacking off or picking up the drill pipe
- Allows drilling or milling to take place with the tool in the string
- Internal clutch allows drillstring rotation above the tool with the circulating ports open
- Available to run in all common casing and liner sizes

Advantages

- Offers the option of performing the open/closed cycle as many times as required without having to pull out of hole, allowing immediate control of the circulation route
- More accurate fluid placement than can be obtained with a conventional ball drop circulation sub
- Only transmits rotating torque above the circulating ports, protecting the lower string from potentially damaging torque
- Increases flow rate in the annular sections

How it works

The MFCT unit is operated in a similar fashion to a bumper sub used during drilling. The tool, made up with a shear ring in place (7,000 to 60,000 lb [3,175 to 27,216 kg] shear), is fully stroked out when running in hole, and circulation passes through the end of the drillstring. Rotating torque is transmitted to the whole string (clutch engaged). Upon first activation, the required weight is slacked off onto a device, such as a stabilizer or top-dress mill, at the point of interest (usually above a small-diameter liner) and the outer sleeve moves down, allowing the fluid bypass to be activated.

The tool is now open and high circulation rates can be attained through the tool ports. Rotating torque is only transmitted above the circulating ports (clutch disengaged). Circulation is restored through the end of the drillstring by simply picking up the drill pipe, moving the outer sleeve up and re-engaging the clutch. The open-closed cycle can be performed as many times as required without the need for expensive trips out of the hole, giving the driller immediate, positive control of the circulation route.



Ported Bypass Sub (PBS)

Specialized Tools: Circulating Tools

The Ported Bypass Sub helps to establish communication between the fluids in the drill-pipe pressure and fluid flow around a tool in the drillstring.

Applications

The Ported Bypass Sub from M-I SWACO Wellbore Productivity is normally run above the WELL PATROLLER tool to provide an additional means of equalizing pressure and fluid flow around the tool, should it fill with debris while pulling out of hole. The WELL PATROLLER unit is run as a contingency device, and is only opened if required.

The Ported Bypass Sub can also function as a drill-pipe drain sub.

How it works

The tool is run in the closed position, and when required, a ball is dropped to open the ports. Fluid can then be pumped both through the ports and down through the tool.

The Ported Bypass Sub is open communication between the drill pipe and the annulus.

Features

- One-piece, full-strength drill-pipe mandrel
- Ball retained on seat in tool

Advantages

- To open up communication between the internal diameter of the drill pipe and the annulus

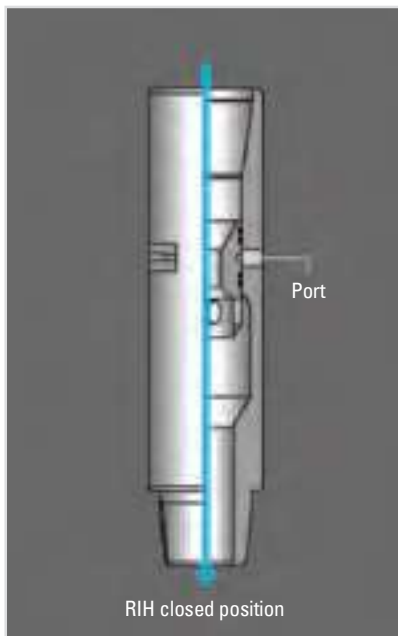


Figure 1. The Ported Bypass Sub is run in the hole in the closed position.

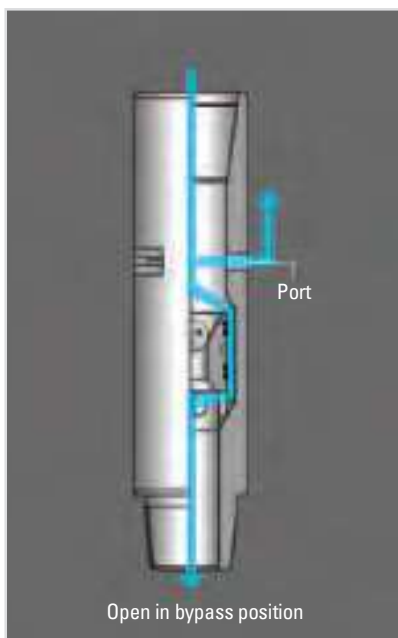


Figure 2. When pulled out of the hole, the tool is in the open position.



Single-Action Bypass Sub (SABS)

Specialized Tools: Circulating Tools

This tool makes it possible to boost the flow velocity in a casing string above a liner or casing crossover where a smaller liner exists.

Applications

The SABS unit from M-I SWACO Wellbore Productivity is used: to boost the flow velocity in a casing string above a liner or casing crossover where a smaller liner exists; to spot lost-circulation material or other pills, bypassing the motor or measurement-while-drilling tool; to boost flow in the annulus to remove cuttings beds; or to jet wellhead, blowout preventers or risers.

How it works

Initially, the tool is run in hole with its ports in the closed position. To open the ports, a ball is dropped, and the pump rate is increased to circulate at higher annular velocity through the ports in the tool. To close the ports, a second ball is dropped, and pumping can be resumed through the string below the sub. Once dropped, both balls remain on seat at all times.

To have the option of reopening and then re-closing ports after the initial cycle, two SABS units can be run in tandem.

The SABS tool is used to boost flow velocity in a casing string above a liner or casing crossover.

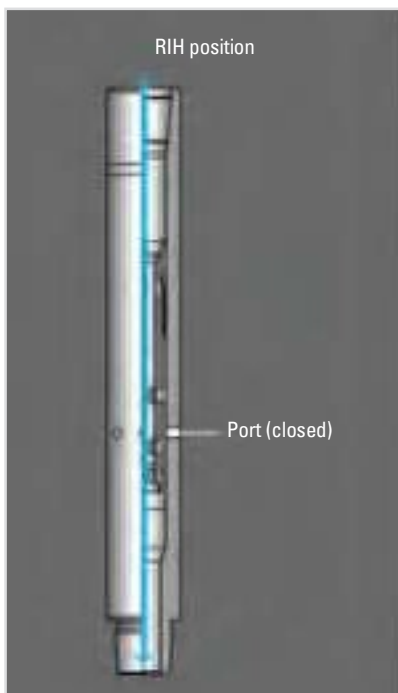


Figure 1. When desirable during the wellbore cleanup, a ball is dropped to a ball seat and pressure applied to open up the ports.

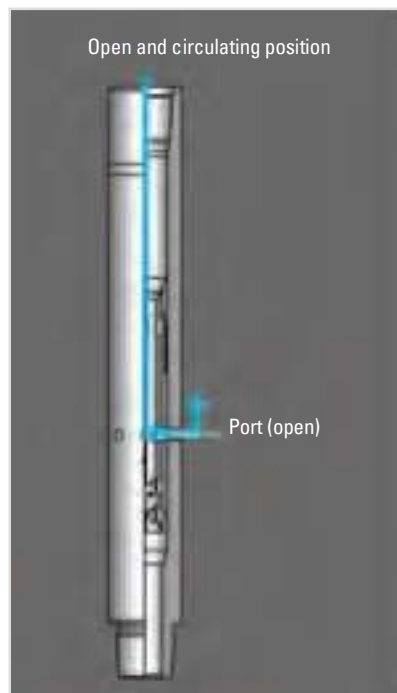


Figure 2. The pump rate can then be increased to circulate at increased annular velocity through the ports in the tool.



Features

- One-piece, full-strength mandrel
- Balls retained on seats in tool

Advantages

- When using the SABS (Single-Action Bypass Sub) tool to jet the riser, wellhead and/or BOP stack, the large, 11 to 16 in. (279 to 406 mm) OD sleeves allow the jets to clean closer to the profile
- To reopen and close ports after the initial cycle, two SABS units can be run in tandem

WELL COMMANDER

Specialized Tools: Circulating Tools



The WELL COMMANDER tool is a ball activated circulating valve that can be placed above sensitive bottomhole equipment such as MWD and LWD tools, core barrels and mud motors. It provides an alternate circulation path for performing numerous critical functions and mitigating drilling hazards. The WELL COMMANDER tool mitigates the problems encountered with a restrictive BHA that limits the flow rate and annular velocity. These BHA restrictions also limit the size and concentration of the lost circulation or wellbore strengthening material needed for lost-circulation zones. The WELL COMMANDER tool provides a large, flow-area bypass on demand through as many as nine open-and-close cycles in one trip.

Applications

The innovative WELL COMMANDER tool is used in the I-BOSS* wellbore strengthening technology to provide an alternate path for placing the WSM in troublesome zones. The tool allows placement without having to pass the material through size- and concentration-restricted BHAs.

Placing the WELL COMMANDER tool above an under-reamer or similar ball-drop tool can be highly advantageous. The WELL COMMANDER tool permits increasing annular velocities during drilling operations by bypassing BHA components. In addition it can be used to enhance annular velocities during displacements. Typically, this capability prevents or removes cuttings-bed buildup, enhances fluid displacement and simplifies reverse circulation.

The tool can be used as a fill or drain valve while tripping the drill string to control surge and swab pressures.

The WELL COMMANDER valve can also be used to place kill weight fluid in underbalanced or managed pressure drilling operations.



Features

- The tool has a generous flow through area via multiple ports
- The BYPASS BALL CATCHER has an 18 ball capacity which allows up to 9 complete open/close cycles
- The same size ball opens and closes the ports
- The tool is available in 5 in., 7 in., 8¼ in. and 9½ in. OD, for all drillstring configurations
- There are no internal tool connections
- The tool activation mechanism locks into the open or closed position and is isolated from the circulating fluids
- The WELL COMMANDER and BYPASS BALL CATCHER permits smaller ball and/or limited wireline access below the WELL COMMANDER even after it has been activated
- The WELL COMMANDER saves valuable rig time by reducing trips/circulating time

Advantages

- Due to the large flow area, pump rates can be boosted significantly increasing annular velocities to aid in cuttings-beds removal
- Coarse lost-circulation or wellbore-strengthening materials can bypass sensitive downhole drilling tools and be easily placed in the loss zone
- Kill-weight fluid can be pumped in underbalanced or managed-pressure drilling applications before initiating a trip
- The tool is excellent for hole cleaning enhancement during underreaming, hole-opening, or coring operations
- The tool can condition fluid at high flow rates in any drilling or displacement workstring
- The WELL COMMANDER helps fill or drain the drillstring during trips to control surge and swab pressures and to enhance tripping operations by minimizing fluid discharge
- When the tool is in the locked open position a small percentage of fluid will still flow through the bit, keeping it lubricated. If the optional shut-off ball is utilized, 100% of the flow is through the ports



The WELL COMMANDER tool uses the same size operating ball to open and close the ports



Open circulating ports provide generous flow area

How it works

The WELL COMMANDER tool is run in or pulled out of the hole with the ports locked open or closed. The WELL COMMANDER valve remains in the same position until activated by dropping a ball and pressuring up to shift the tool open or closed. The activation ball is then captured in the side pocket of the ball catcher. The tool uses the same size activation ball to open and close the ports, with the capacity of the ball catcher (18 balls/9 cycles) the only limit. With the tool in the open position a smaller optional

BHA shut-off ball can be dropped which will seat on the lower ball seat and direct 100% flow out of the ports. This ball is then expelled with the subsequent activation ball, which also cycles the tool to the closed position. Both balls are then captured by the ball catcher.

The bypass ball catcher captures the balls to one side of the inside diameter to facilitate positioning other ball-drop tools below it, as smaller activation balls can pass through the WELL COMMANDER tool and ball catcher.





1. Ball landing
Drop ball on connection and pump down to tool. Ball lands on seat. Pressure is applied



2. Valve activation
When pressure exceeds activation pressure, ports open and ball proceeds to ball catcher below tool



3. Open circulation
Majority of flow passes through the ports with lower pressure to allow increased pump rates, while some flow is maintained through the bit for lubrication



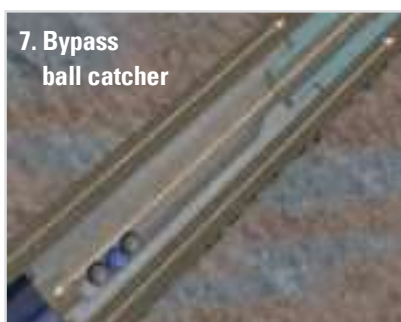
4. BHA shut off
Optional shut-off ball can be landed on lower ball seat to prevent LCM or WSM from entering the BHA while treating the formation



5. Valve closing
The BHA shut-off ball is removed when subsequent activation ball closes the ports



6. BHA shut off removal
After pressuring up on the activation ball, the BHA shut-off and activation balls move to the ball catcher



7. Bypass ball catcher
Bypass ball catcher captures activation and BHA shut-off balls to the side permitting high flow rate with minimal pressure loss and allowing smaller balls to pass through it



8. Other activation balls
Other ball activation tools that use smaller diameter balls can be positioned below the WELL COMMANDER tool as the ball will not activate it



9. Ball bypassing
The activation balls for these other tools will pass through the bypass ball catcher

WELL ISOLATION TOOL (WIT)

Specialized Tools: Circulating Tools

The WELL ISOLATION TOOL* is a circulating tool with annular-isolation capabilities, allowing the operator to isolate the wellbore from hydrostatic and induced pressures and still circulate at increased rates. This is often necessary to control fluid loss to open perforations or an open hole interval below the tool.

Applications

The WELL ISOLATION TOOL can accommodate high circulation rates to displace the upper part of a well without applying pressure to the lower part. It is most effective where there is no set-down point, such as a liner top for conventional weight-activated circulating tools. It is ideal where fluid loss to perforations or open hole sections would be expected below the tool, and it can be run above pressure-sensitive equipment, such as fluid-isolation valves.

How it works

The tool is run in the hole in the open position, with full flow to the bit. In this configuration the internal bypass is open so the annular fluid can bypass the annular diverter cup. In operation, the activation ball is dropped to a ball seat, and applied pressure shears the shear screws, moving the activation sleeve. This closes the diverter-cup bypass. In this position, all flow through the string is directed out through the WIT ports above the diverter cup to the upper annulus. The tool isolates the open perforations or open-hole section below the full gauge diverter cup from the circulating fluid. To reverse the procedure, the deactivation ball is dropped and pressure is applied to shear another set of screws and move the activation sleeve to reopen the bypass and reestablish circulation to the bit. The WIT then can be tripped out of the hole without swabbing the well.

Features

- Ball-drop activation and deactivation
- Two internal ball seats move to activate and deactivate the tool
- Balls retained on seats in tool
- Stabilizer and stabilizer-mill profiles ensure there are no casing restrictions and protect the diverter cup from possible damage
- Available in 7 in., 9 5/8 in. or 10 3/4 in. sizes
- No limit on rotation speed while circulating

Advantages

- Boosts annular velocity while protecting the formation or open perforations from excessive surge/ECD pressures
- Built-in bypass channel around the annular-isolation diverter cup prevents surging or swabbing the well during trips
- Prevents losses under static as well as dynamic conditions



Junk Muncher (JM)

Specialized Tools: Debris Recovery Tools

The Junk Muncher Wellbore Productivity tool from M-I SWACO is used to validate wellbore cleanup operations. It collects larger pieces of milling debris generated during casing milling or window-cutting operations. It can also clean up perforation debris that restricts the ID of perforated pipe.

Advantages

The Junk Muncher tool is suitable to run after casing-milling or window-cutting operations to collect larger pieces of milling debris sometimes produced during these operations and which cannot otherwise be removed. It is also suitable for use in already perforated pipe to clean up or remove perforation debris that restricts the ID while retrieving junk that cannot be circulated out.

The milling profile can be supplied suitable to dress off liner-top Polished-Bore Receptacle (PBR) profiles. The bypass and swallowing capacity have been maximized by using a smaller, high-torque, rotary-shouldered connection on the bottom of the tool.

Features

- One-piece mandrel with box-up/pin-down connections
- Integral liner-top dress-mill profile or junk-mill profile available
- Pilot mill available

Advantages

- Designed to remove large pieces of debris from the wellbore through large entry throats
- Run as part of the cleanup operation or as part of a dedicated junk cleanout run
- When run below the WELL PATROLLER device, the tool allows smaller debris to pass through to be collected by the WELL PATROLLER tool

Operation

The Junk Muncher can be run in a combination drillstring to collect junk in larger casing above a liner, or directly above a mill or bit to collect large pieces of junk off the bottom. The bit or mill acts to jet and circulate the junk up into the catcher.

When the integral liner-top dress mill lands out on the PBR it can be used to dress off the PBR top. If required, a tieback mill can be run below the tool to clean the PBR ID. The Junk Muncher is run with a maximum running-in-hole/pulling-out-of-hole speed of 150 ft/min (46 m/min), which means that there are no restrictions compared to others in the string.

How it works

The collection vessel is a large-OD tube ported to allow debris, cuttings, cement particles and smaller pieces of junk to pass through and be circulated out of the hole. The large pieces of junk that enter the collector are retained and prevented from falling out the bottom by flapper valves that are flow-assisted to open and spring-assisted to close.

A significant volume of large junk pieces can be collected in the tool. In the case of extremely large pieces of junk, drilling/milling services can be provided to assist in reducing the size of the junk.



The Junk Muncher can be run on the same trip as a precompletion mechanical wellbore cleanup run or during a dedicated junk cleanout run.



Operating parameters

Box connection size, in.	Maximum rotating speed in tension, rpm	Maximum rotating speed in compression, rpm	Maximum compression at tool when rotating, lb (kg)
3½ IF	100	60	5,000 (2,268)
4½ IF	120	90	10,000 (4,536)
5½ NK DSTJ	120	90	10,000 (4,536)

These are general guidelines only and are subject to review, if required, for individual circumstances.

MAGNOSHOE (MSHOE)

Specialized Tools: Debris Recovery Tools

The MAGNOSHOE* magnet is designed to retrieve irregular shaped debris that has fallen to the bottom of the wellbore and cannot be circulated back into the annular path of a traditional drillstring magnet. Designed with the best technology available in magnets, the tool simplifies and enhances any wellbore preparation operation.

Applications

The MAGNOSHOE tool can be used in any situation where large metallic debris is sitting on the bottom of the wellbore or on top of another element in the wellbore. Since large debris can be difficult to mill and circulate back into the fluid stream, the debris must be retrieved mechanically. The tool is used in any wellbore preparation activity such as displacement or dedicated fishing or cleanout trip. It is deployed quickly on the end of the workstring.

How it works

The MAGNOSHOE tool is run in the well on the end of the workstring. The tool employs a protective coating of gel to prevent the accumulation of debris on the way into the hole. The target debris will yield the gel on contact so that the target comes into direct contact with the magnetic forces. The target debris is then held connected to the magnet until it is physically removed on surface. When the tool and the debris are brought out of the hole, the MAGNOSHOE tool can be quickly removed from the string and set aside to prepare for the next operation.

Features

- Fully encased rare earth magnet
- Magnet components rated to 480°F (250°C)
- Forward facing circulation ports
- Simple three piece construction
- Modular protective shroud

Advantages

- High strength magnet array can carry and retain oddly shaped debris
- Magnet components rated to 480°F (250°C)
- Captured debris is not disturbed by fluid draining from drill string
- Protective shroud can be changed out on the rig to increase capture space for the varying amount, size and shape of debris
- Easily cleaned on rig for subsequent runs



MAGNOSTAR (MSTAR)

Specialized Tools: Debris Recovery Tools

The MAGNOSTAR* magnet was designed specifically for large-volume cleanup applications in high torque strings. The MAGNOSTAR magnet provides superior magnetic surface area for high volume ferrous debris extraction when circulation alone is insufficient.

Applications

The MAGNOSTAR tool is well-suited for a variety of applications, including displacements, post-perforating, pre-fracturing, multi-zone completions, milling, burning, fishing and smart completions. The tool should be run whenever the potential exists for significant ferrous debris in the wellbore.

How it works

The MAGNOSTAR magnet is run in the well on the workstring in combination with other wellbore clean-up tools. The magnet can be rotated and reciprocated without fear of damage to the casing or the tool itself. The blades on the housing provide generous flow area for fluid bypass around the tool. The fixed stabilizer sleeve on the box end provides stand-off and a secure area away from the casing wall to collect debris while pulling out of the hole. It is available in common casing/liner sizes and weights.

Features

- Single Piece Mandrel, no internal connections
- Optional Dedicated Flow Path to prevent flow path restrictions when packed full of debris
- Fixed Stabilizer Sleeve on box end to provide standoff when POOH
- Casing compatible facing material to minimize casing wear
- Unique, patent pending mechanical method of retaining magnets
- Available in common casing/liner sizes and weights (13 $\frac{3}{8}$ in. to 7 in.)

Advantages

- Potential capacity for up to 200 lb (91 kgs) of ferrous material retrieval
- High strength, rare earth magnets rated to 350°F (177°C)
- Removable magnets for body inspection
- Designed with premium high torque connections
- No flow restriction below the tool permitting large debris-free access to magnets
- Recovered debris easily removed on location



MAGNOSTAR HEAVYDUTY (MSTAR HD)

Specialized Tools: Debris Recovery Tools

The MAGNOSTAR HD* magnet was designed specifically for large-volume cleanup applications in high torque strings. The MAGNOSTAR magnet provides superior magnetic surface area for high volume ferrous debris extraction when circulation alone is insufficient. The MAGNOSTAR HD version is fitted with mill rings on the box and pin connections for more aggressive applications.

Applications

The MAGNOSTAR HD tool is well-suited for a variety of applications, including displacements, post-perforating, pre-fracturing, multi-zone completions, milling, burning, fishing and smart completions. The tool should be run whenever the potential exists for significant ferrous debris in the wellbore.

How it works

The Magnostar HD magnet is run in the well on the workstring in combination with other wellbore clean-up tools. The magnet can be rotated and reciprocated without fear of damage to the casing or the tool itself. The blades on the housing provide generous flow area for fluid bypass around the tool. The fixed stabilizer sleeve on the box end provides stand-off and a secure area away from the casing wall to collect debris while pulling out of the hole. The mill rings allow the tool to grind down larger pieces of debris either below or above the magnet. It is available in common casing/liner sizes and weights.

Features

- Single Piece Mandrel, no internal connections
- Optional Dedicated Flow Path to prevent flow path restrictions when packed full of debris
- Fixed Stabilizer Sleeve on box end to provide standoff when POOH
- Casing compatible facing material to minimize casing wear
- Unique mechanical method of retaining magnets
- Upper and lower mill rings
- Available in common casing/liner sizes and weights (13 $\frac{3}{8}$ in. to 7 in.)

Advantages

- Potential capacity for up to 200 lb (91 kg) of ferrous material retrieval
- High strength, rare earth magnets rated to 350°F (177°C)
- Removable magnets for body inspection
- Designed with premium high torque connections
- No flow restriction below the tool permitting large debris-free access to magnets
- Recovered debris easily removed on location
- Larger pieces of debris can be ground down with the mill rings



MAGNOSWEEP II (MSWEEP II)

Specialized Tools: Debris Recovery Tools

The MAGNOSWEEP® II magnet is designed to recover large volumes of ferrous debris to ensure the integrity of the wellbore cleanup. The magnet features a large magnetic surface area along with discrete flow channels to combine higher magnet strength with greater volume to optimize recovery. The tool can be run as a component of most drilling/milling/polishing assemblies or as an integral part of the drillstring during wellbore preparation operations.

Applications

The MAGNOSWEEP II magnet is run as an integral part of the work string during cleanup to collect and remove ferrous debris. It also can be run as a part of a cased hole drilling assembly, including milling or polishing assemblies. The MAGNOSWEEP II magnet should

be run in any operation with the potential of generating or encountering ferrous debris. This could include displacements, perforating, pre-fracturing, milling, burning, fishing, and multizone or smart completions. The tool can be rotated and reciprocated without fear of damaging the casing or other tools.

How it works

The MAGNOSWEEP II magnet is made up in the workstring as a conventional tool. It has no limiting trip-speed factor and can be rotated at common drilling speeds. The blades on the housing provide generous flow area for fluid bypass around the tool while at the same time the stabilizers provide stand-off for a secure area away from the casing wall to collect debris.

Features

- Compact design
- Single piece mandrel
- High strength rare earth magnets
- Fixed stabilizer sleeve to provide stand off when POOH
- Optional dedicated flow channel to prevent flow path restrictions when packed full of debris

Advantages

- Removable magnets for body inspection
- Recovered material is easily removed on location
- High temperature rating on magnets up to 350°F (177°C)
- Debris channels allow for larger volume of ferrous material to accumulate



SWITCHBACK MAGNET (SWBM)

Specialized Tools: Debris Recovery Tools

The SWITCHBACK* MAGNET tool can be run in the hole in the dormant position as an integral part of a drilling or milling BHA. The tool's magnets are activated when desired via a ball drop mechanism, at which time they will collect ferrous debris from the wellbore. As such, the magnet only collects metallic debris at the zone of interest, such as in a milled window and above. Material is not collected while tripping in or during the milling or drilling operation as a conventional magnet would.

Applications

The SWITCHBACK MAGNET tool can be used during any operation where ferrous debris is expected in the wellbore. This can include milling casing exits, downhole equipment such as packers, tubing, or other debris left in a well, sidetracks or conventional drilling operations.

How it works

The SWITCHBACK MAGNET is included in the drilling or milling workstring. The tool is run in the well in dormant mode,

with the magnets inactive (turned off). When drilling/milling operations cease at interval total depth, a ball is dropped to the tool. If more than one SWITCHBACK MAGNET tool is run in the workstring, this ball will activate all the tools simultaneously. Once the ball lands on seat, pressure is applied to the recommended amount to function the tool and allow the magnet to activate. If more than one SWITCHBACK MAGNET tool is run on the same workstring, the process of pressuring up is repeated until all of the tools are activated. At that point, the ball is caught in a BYPASS BALL CATCHER tool below the lowest SWITCHBACK MAGNET tool. Once functioned, the SWITCHBACK MAGNET tool is tripped out of the well collecting ferrous debris along the way. On surface, the tool is moved away from the rotary table to remove the debris and clean the tool. The reset button is pressed to deactivate the magnet and release captured debris. The SWITCHBACK MAGNET is then ready to rerun into the well when desired.

Features

- Tool is activated downhole by dropping a ball, through patented ball seat technology
- One-piece body; no internal connections
- Free rotating stabilizer sleeves independent of drill string rotation
- Reset button functionality to switch tool off once on surface
- BYPASS BALL CATCHER run below the tool to capture expelled ball(s)
- BYPASS BALL CATCHER retains operating balls yet allows smaller balls to pass enabling numerous ball activated tools to be utilised in the same string

Advantages

- Ferrous debris collected from the bottom to top of the well and not while running in the hole
- Stabilizer sleeves will not rotate when drill string is rotating, minimizing casing wear
- Several SWITCHBACK MAGNET tools can be run in series or with a SWITCHBACK Scraper or SWITCHBACK Mill, with the same ball activating all tools
- Mill rings break up large pieces of debris to circulate past the tool
- SWITCHBACK MAGNET tools generate a very low magnetic field and will not interfere with the MWD system signal



WELL PATROLLER (WP)

Specialized Tools: Debris Recovery Tools

The WELL PATROLLER* downhole filter is an advanced M-I SWACO Wellbore Productivity wellbore preparation tool developed for use in precompletion / displacement operations, where a high degree of cleanliness and validation thereof is required.

Applications

The WELL PATROLLER tool is designed to be run in the displacement workstring. It completes the displacement operation by filtering the completion fluid in the wellbore while pulling out of the hole and as a result validates well cleanliness. It should be run in the well with other wellbore preparation tools like the BRISTLEBACK brush, RAZORBACK scraper and MAGNOSTAR, as well as circulating tools like the WELL COMMANDER or MULTI-FUNCTION CIRCULATING TOOL (MFCT). The WELL PATROLLER can also be used in the blow out preventer jetting string. When used in the wellhead cleaning string, the WELL PATROLLER is placed in the casing below the wellhead to capture debris jetted from the blow out preventer cavities.

Operating parameters

Tool (casing) size, in.	Maximum rotating speed in tension, rpm	Maximum rotating speed in compression, rpm	Maximum compression at tool when rotating, lb (kg)
4½ – 5½	90	60	5,000 (2,268)
6% – 8%	100	60	10,000 (4,536)
9% – 13%	120	90	15,000 (6,804)

These are general guidelines only and are subject to review, if required, for individual circumstances.



How it works

As the workstring is run in the well, the diverter/wiper cup cleans the inside diameter of the casing and forces all the wellbore fluid to pass through the WELL PATROLLER from the bottom.

(Fig. 1) After running in the hole, the displacement is carried out in the usual manner with the fluid in the annulus passing between the mandrel and filter screen. When circulation is complete and the workstring is pulled out of the well, the diverter/wiper cup cleans the inside diameter of the casing and directs all fluid into the filter screen section. As the kidney valves are now closed, all the fluid is filtered through the screen and any debris remaining in the wellbore is now captured inside the filter screen.

(Fig. 2) If the well was displaced properly, there should be very little material captured in the WELL PATROLLER tool, thereby validating the casing is thoroughly cleaned and ready for the next completion operation.

The WELL PATROLLER should not be placed where it passes through drilled out casing accessories like landing or float collars. It should be placed at least 30 ft (9 m) above the bit or mill. It can be run in or pulled out at speeds up to 150 ft/m (46m/min). It is possible to reverse circulate through the WELL PATROLLER, but it is recommended to circulate at least one hole volume conventionally before reverse circulating.

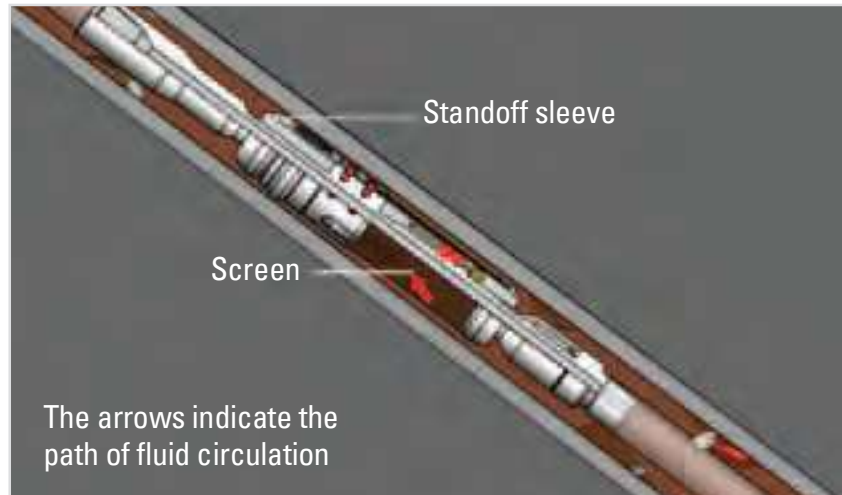


Figure 1. Running in hole, wiping the ID of the casing.

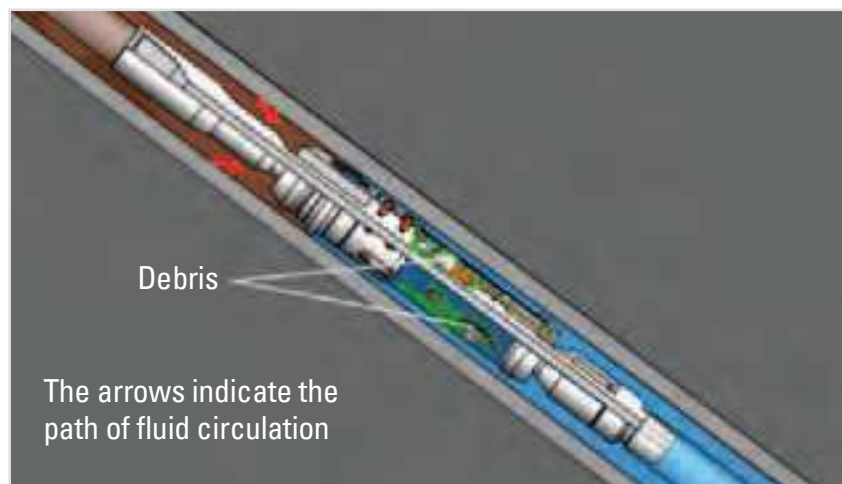


Figure 2. Pulling out of the hole, collecting residual debris.

Features

- Available in all common casing and liner sizes
- No balls or darts required for activation
- 600 micron screen to effectively filter debris
- Kidney shaped valves allow large debris pieces to be captured in the tool
- Large flow area through tool
- Field redressable
- Rupture disc relieves pressure if filter is plugged or filled

Advantages

- No balls or darts pumped down the workstring
- Tool operated during basic tripping operations in and out of the well
- Can drill or mill with WELL PATROLLER in the workstring
- Tool cleans wellbore and then validates cleanliness of the wellbore
- Multiple tools can be used in a single string

WELL PATROLLER 500 SERIES

Specialized Tools: Debris Recovery Tools

The WELL PATROLLER* downhole filter tool is an advanced M-I SWACO Wellbore Productivity wellbore cleanup tool developed for use in the precompletion/ drill-stem test phase of a well, where a high degree of cleanliness and validation of such is required. The 500 SERIES tool uses a secure flapper valve assembly and a more robust filter assembly than previous models of the WELL PATROLLER validation tools.

Applications

The tool is designed to be run in the cleanup string and completes the cleanup by filtering the remaining debris from the annulus through a wire screen filter. It is usually run in conjunction with the MFCT* (Multi-Function Circulating Tool), RAZORBACK* and BRISTLEBACK* tools, or other wellbore preparation tools. In this application the WELL PATROLLER 500 SERIES tool validates that the well is clean post displacement. One other application is that the tool is often positioned in the casing below the wellhead during riser cleaning and

blowout preventer wellhead jetting to collect any dislodged debris that falls into the well.

How it works

As the string is run in the hole, the diverter cup/wiper cleans the ID of the casing, removing the film of gunk (oil-base mud, barite, cement and magnetized steel particles) clinging to it.

The displacement operation is carried out in the normal way, pumping down through the WELL PATROLLER 500 SERIES drill-pipe mandrel and back up between the mandrel and the filter jacket. When circulation is complete, the string is pulled and the diverter cup/wiper cleans the ID of the casing and diverts the annular fluid through the tool. The fluid passes through the wire screen filter with debris being retained inside the tool screen body. Performing a dual function, the WELL PATROLLER 500 SERIES tool first performs a cleaning action and then validates the effectiveness of the cleanup operation.

Features

- Available in all common casing and liner sizes
- No balls/darts for activation
- Increased mandrel strength
- 0.025 in. (0.6 mm) screen to filter out small particles
- Flapper valves allow larger pieces of debris to pass into tool
- All fasteners are internal
- 12.72 gallon debris capacity
- Large flow areas through the tool even though diverter cup is in contact with casing ID
- Field redressable
- Rupture discs relieve pressure in the unlikely event that the tool becomes completely full of impermeable material

Advantages

- The tool is operated simply by running in hole and pulling out of hole
- Allows milling or drilling to take place with tool in the string
- Avoids surge and swab pressures
- Dual functionality tool, first performs a cleaning action, then validates the effectiveness of the cleanup operation
- Tandem and triple runs possible



WELL PROTECTOR (WPR)

Specialized Tools: Debris Recovery Tools

Thorough cleaning of the wellhead and Blowout Preventer (BOP) areas of any surface well must include catching the harmful debris loosened by the operation.

Applications

The WELL PROTECTOR* tool from M-I SWACO Wellbore Productivity captures material loosened during cleaning of the BOP and wellhead and/or operational testing of the BOP rams. It acts as a backup to catch debris that is not circulated out or that falls downward into the well.

How it works

The tool is run below the wellhead inside the casing during BOP and wellhead jetting or functioning of the BOP rams. It can be positioned in the casing during riser cleaning operations or when retrieving wear bushings/bore protectors.

The tool features a large-capacity, 6 ft (2 m) wire-wrap screen to filter out small and large debris that falls into it. A rounded bullnose on the bottom acts as a guide and is equipped with a large valve for easy removal of collected material. Above the filter screen is a diverter cup and ported standoff guide to ensure that all the debris is collected rather than falling around the outside of the tool.

The WELL PROTECTOR tool is equipped with an integral drill-pipe-handling sub for slips and elevators and a 4½ in. (114 mm) IF (NC 50) box connection.

Features

- Large debris/junk collection capacity
- 0.025 in. (0.635 mm) screen filters out small particles
- Diverter cup prevents bypass of debris
- Integral drill-pipe handling sub
- Can be redressed in the field

Advantages

- Available for all common casing sizes located directly below the wellhead
- Simple to run and redress and can be used multiple times without the need for onshore service and inspection



WELL SCAVENGER (WS)

Specialized Tools: Debris Recovery Tools

The WELL SCAVENGER* vacuum debris removal tool is designed specifically to capture and remove debris from the wellbore. The tool can be combined with magnets or junk baskets to enhance removal of ferrous or larger debris, respectively. The tool engine module generates a high velocity reverse circulation path at the end of the workstring to pick up heavier debris and capture it in-situ. The modular designed WELL SCAVENGER tool comprises a single nozzle jet pump; a screen filter with an internal magnet assembly; debris chambers with a suction tube and flow deflector.

Applications

The WELL SCAVENGER tool is used during intervention applications requiring in-place debris removal. It can be run to remove debris from top of isolation valves, blanking plug removal, and cleaning out after perforating.

The tool also can be run during milling operations to capture debris as it is generated, or during fishing operations to remove unknown debris. The tool can be used effectively in clear brine completion fluids with no carrying capacity or suspension characteristics. The WELL SCAVENGER tool can also be used where low circulation rates are desired, such as near sensitive downhole hardware or where perforations are open.

How it works

The WELL SCAVENGER tool pumps the “driving” fluid through the fluid jet pump, thus generating a reverse circulation flow from the bottom of the tool through the suction tube. Once the debris is picked up, it settles in the debris basket as the fluid velocity decreases after passing through the flow diverter. The fluid then passes through the filter screen to capture suspended material.

Features

- Circulation rate of the driving fluid is 200-350 gpm (750-1,325 L/min)
- Suction fluid is usually 25-30% of the driving fluid flow
- The WELL SCAVENGER tool incorporates an internal magnet assembly
- Debris chamber capacity is 0.5 bbls
- Designed for small amounts of debris recovery on or near sensitive equipment such as plugs and Formation Isolation Valves (FIVs)

Advantages

- Generates a reversing flow path that promotes in-situ debris collection
- Operates with 125 ft (38 m) of tail pipe to allow removing debris on top of packers and formation isolation assemblies
- Creates various “reverse” flow rates
- Removes heavy/difficult debris from wellbore with minimal circulation
- Efficiently collects magnetic debris
- Safe and well-organized debris collection that is 100% contained and allows all fluid to be drained in a safe controlled manner
- Minimize risk of debris plugging filter screen with internal magnet assembly



PUP Riser Brush (PRB)

Specialized Tools: Riser Cleaning Tools

Applications

The PUP Riser Brush utilizes three aggressive stainless steel brush rings to remove debris from the marine riser or outer production riser ID. The design of the tool provides a flow path through the brush-ring carrier, with the majority of the flow passing through 65 in.² (41,935 mm²) of flow area in the brush carrier, minimizing pressure drops above and below the tool.

Tool Use

The PUP Riser Brush mechanically cleans marine risers and outer production risers.

Features and Advantages

- Safety feature: The tool design incorporates an integral pup joint to facilitate tool pickup with standard drill-pipe elevators and slips
- Aggressive, non-rotating stainless steel brushes (synthetic brushes available)
- Workstring can be rotated and reciprocated with the PUP Riser Brush in the workstring
- Debris can be effectively circulated through and around the tool
- The large mandrel ID enhances circulation
 - Available in 13¾ through 24 in. OD
 - Large flow-through area reduces the probability of swabbing/surging in the hole or pulling out of the hole
 - Eliminates the need for a junk basket tool above the Riser Brush
 - Can be run as a standalone tool, and it is typically run in conjunction with the PUP Quick-Trip Boot Basket or PUP Finger Basket to protect the well from debris re-entering the wellbore while jetting the BOP



RISER CLEANING TOOL (RCT)

Specialized Tools: Riser Cleaning Tools

The RISER CLEANING TOOL* is designed to simultaneously brush, wipe and collect any debris that may be present in the riser, with the added capability of passing through a constrictive wellhead ID. The tool is also equipped with an integral junk bucket to enable any loosened debris to be captured.

Applications

The RISER CLEANING TOOL is used prior to any completion operation requiring a clean riser or when displacing drilling fluid from the riser. The tool ensures removal of the sheath of debris-laden fluids from the riser wall and prevents the remaining fluid sheath from depositing solids on sensitive completion string components, thus helping eliminate expensive and time consuming non-productive time (NPT).

Features

- Mandrel designed to support full casing string
- Long, stiff brush bristles to pass through smaller BOP restrictions, yet permit aggressive riser contact
- Integral junk bucket to capture debris

How it works

The RISER CLEANING TOOL is designed to pass through ID restrictions, yet still provide aggressive mechanical scratching and wiping to remove even the most stubborn fluid sheaths. The debris is extracted from the riser with the associated integral Junk Bucket.

Advantages

- Stops accumulated debris from interfering with completion operations
- Full 360° cleaning coverage
- Can be short-tripped during a pre- or post-clean up job
- Fits into any string where the riser is to be cleaned
- Designed for safe handling on the rig floor
- Permits running liner/casing during cleanup trip



RISER DISPLACEMENT CLEANING TOOL (RDCT)

Specialized Tools: Riser Cleaning Tools

The RISER DISPLACEMENT CLEANING TOOL* (RDCT) is a cost-effective solution for displacing invert emulsion drilling fluids with seawater before quickly disconnecting the riser. The RDCT is set in the riser at the top of the BOP and pumped back to surface. It wipes the riser while pushing all debris to surface. It helps eliminate the environmental risks associated with disconnecting the riser while improving safety and simplifying the cleaning process by avoiding laying down an unclean riser.

Applications

The RDCT is used prior to any completion operation requiring a clean riser or when displacing fluid from the riser prior to a disconnect operation. The tool protects expensive fluids from contamination or dilution with seawater. It provides assurance that not only is debris removed from the riser, but also the residual film of solids-laden invert fluid is cleaned from the riser wall.

This tool is especially beneficial during emergency disconnects when time is critical. The RDCT eliminates extra

pumping time to over-displace the riser to insure that the fluid interface is completely out of the riser before disconnecting. It also simplifies pit management concerns as fluids and interfaces will not need to be separated on surface. In addition, it is used when the riser is left open-ended during disconnect operations. It allows for easy displacement without risking the contamination of expensive drilling or completion fluids and any subsequent reconditioning of the fluids.

How it works

The RDCT is deployed on a running tool and staged at the top of the BOP. It is released from the BOP and pumped to surface through choke and kill lines. It acts as a wiper to clean the riser wall. With different sized wipers to account for varying diameters in the riser system, the tool forms a positive seal that assures all surfaces are cleaned. It also acts as a mechanical barrier between fluids during displacement. It can be run by itself or in conjunction with a storm packer.

Features

- Provides a mechanical barrier between two different fluids
- Uses specialized, simple running and retrieving tools
- The buoyant material provides a lightweight tool that quickly and efficiently arrives at surface
- Multiple size wipers clean varying ID of riser wall

Advantages

- Less fluid loss to interface
- Cleaner riser and displacement
- No special pumping restrictions
- Does not increase disconnect time
- Eliminates mud residue on deck
- Eliminates riser cleaning on deck
- Minimizes fluid contamination



Dual-Action Bypass Sub Jetting Tool (DABS-JT)

Specialized Tools: BOP Cleaning Tools

During drilling operations, debris such as drill cuttings and mud cake attach to riser, Blowout Preventer (BOP) and wellhead walls. Removing these contaminants is crucial to ensuring clean cementing and completion operations.

Applications

The DABS Jetting Tool from M-I SWACO Wellbore Productivity is designed to run in a cleanup string for jetting the riser, BOPs and wellhead areas.

How it works

The DABS Jetting Tool is run in the open position for jetting and cleaning while traveling through the BOPs, wellhead and riser. The external jetting nozzles on the sub are then closed, by dropping an actuator ball, to allow flow through the sub and to circulate the string. By dropping another ball, they are reopened when pulling out, allowing jetting of the riser and BOPs. The balls remain on seat at all times.

Features

- One-piece, full strength mandrel
- Balls retained on seats in tool
- Available with 11 or 16 in. (279 or 406 mm) OD sleeve
- Sixteen 0.437 in. jet nozzles at 22° phasing

Advantages

- When using the DABS (Dual-Action Bypass Sub) unit to jet the riser, wellhead or BOP stack, the large 11 or 16 in. (279 or 406 mm) OD sleeves allow the jets to clean closer to the profile



Single-Action Bypass Sub Jetting Tool (SABS-JT)

Specialized Tools: BOP Cleaning Tools

During drilling operations, debris such as drill cuttings and mud cake attach to riser, Blowout Preventer (BOP) and wellhead walls. Removing these contaminants is crucial to ensuring clean cementing and completion operations.

Applications

The SABS (Single-Action Bypass Sub) Jetting Tool from M-I SWACO Completions group Wellbore Productivity is designed to run in a cleanup string for jetting the riser, BOPs and wellhead areas.

How it works

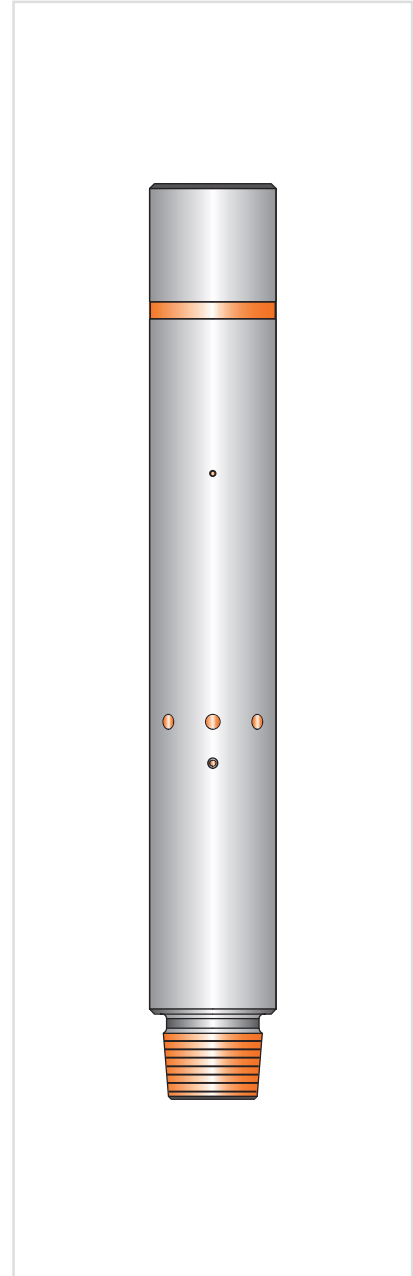
The sub is run with the nozzles in the closed position. Dropping an actuator ball opens them so the pump rate can be increased to jet through the nozzles for cleaning. Dropping a second ball closes the nozzles to allow flow through the sub and to circulate the string. The balls remain on seat at all times but, when the nozzles are closed, pumping can be resumed through the string below.

Features

- One-piece, full-strength mandrel
- Balls retained on seats in tool
- Designed to boost annular velocity
- Available with 11 or 16 in. (279 or 406 mm) OD sleeve
- Sixteen 0.437 in. jet nozzles at 22° phasing

Advantages

- When using the SABS Jetting Tool to clean the riser, wellhead or BOP stack, the large 11 or 16 in. (279 or 406 mm) OD sleeves allow the jets to clean closer to the profile
- Where it is necessary to reopen and close ports after the initial cycle, two SABS units can be run in tandem



Short Trip Jetting Sub (STJS)

Specialized Tools: BOP Cleaning Tools

The Short Trip Jetting Sub (STJS) from M-I SWACO Completions group Wellbore Productivity is designed for mechanical wellbore cleanup in risers, Blowout Preventers (BOPs) and wellheads, and is well suited for operation from platforms, jackups and land locations.

Advantages

The STJS is suitable for operation from platforms, jackups and land rigs

Operation

When the STJS is in the BOP stack, a maximum of 10 bbl/min should be pumped through the tool. When in the riser, an optimum rate of 25 to 30 bbl/min should be pumped (dependent upon riser ID and drill-pipe OD) to achieve a minimum annular velocity of 80 ft/min (24 m/min) to efficiently carry debris from the well. As much as 25 to 30 bbl/min can be

achieved by pumping through the tool alone or by a combination of pumping through the tool and through the choke/kill/booster lines.

The STJS is normally run in conjunction with, and above, the WELL PATROLLER or WELL PROTECTOR tools. Any pieces of debris that are dislodged, but not circulated out during the cleaning operation, are collected in the WELL PATROLLER or WELL PROTECTOR tools as they fall or are pulled out of hole.

How it works

The Short Trip Jetting Sub (STJS) is equipped with standard drill-pipe box-up/pin-down connections for insertion in a cleanup or drillstring when it is necessary to jet. The tool is generally short-tripped and run in hole and pulled out of hole with the jets open at all times.

Features

- One-piece mandrel, full drill-pipe strength
- Simple, robust design
- Six replaceable jet nozzles
- Standard drill-pipe box-up/pin-down connections
- Can be used to jet BOP and risers with 11 and 16 in. (279 and 406 mm) sleeves available

Advantages

- Ball drop is not required to open the tool



Wellhead Brushing/Jetting Tool

Specialized Tools: Wellhead Cleaning Tools

The Wellhead Brushing/Jetting Tool is designed to ensure the multiple profiles of wellheads are clean and free of debris prior to the completion or re-entry. The wellhead area has been widely identified as requiring special attention during wellbore clean up operations. The tool can be used to ensure all profiles are clean, which can reduce the incidence of non-productive time.

Applications

The Wellhead Brushing/Jetting Tool simultaneously performs brushing and jetting functions on wellheads.

How it works

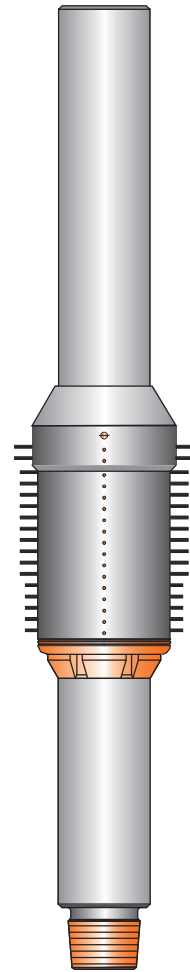
The Wellhead Brushing / Jetting Tool is constructed on a one-piece, full-strength mandrel with box-up/pin-down drill-pipe connections. A brass bristle-impregnated sleeve with jetting slots is mounted on the mandrel and sized for the various ID changes within the hanger area. The sleeve is rotationally locked to the mandrel and provides an annular space for circulation between the ID of the sleeve and the OD of the mandrel. A bearing/diverter ring is mounted at the bottom of the bristle sleeve to act as a “no-go” ring when running in hole.

Features

- One piece, full strength mandrel
- Brass bristle impregnated sleeve
- Integral jetting slots on tool
- Jetting activated by bearing/diverter ring
- Simple and easy to operate

Advantages

- Ensures surfaces are cleaned and free of debris before running the completion
- Reduces NPT



BYPASS BALL CATCHER (BBC)

Specialized Tools: Ancillary Tools

The BYPASS BALL CATCHER * tool is a key reason for the operational flexibility of the WELL COMMANDER* tool and SWITCHBACK* line of tools. It has the capacity to hold multiple balls for numerous cycles as well as allow smaller balls to pass through to other tools located below.

Applications

The BYPASS BALL CATCHER tool is run below a WELL COMMANDER valve or SWITCHBACK tool to hold the activation and/or shut-off balls after they have activated or deactivated the tool(s) above it. Additional ball-drop tools can be run below the BYPASS BALL CATCHER as long as the OD of the corresponding balls is small enough to pass through the BYPASS BALL CATCHER tool.

How it works

As the basis for the flexibility of the WELL COMMANDER and SWITCHBACK tools, the BYPASS BALL CATCHER is designed with a unique rail system that guides all balls through and captures only those too large to pass through the rail. All other balls pass freely through and exit the bottom of the BYPASS BALL CATCHER tool. When returned to surface, the captured balls can be easily emptied from the BYPASS BALL CATCHER, which can be retorqued onto the tool or workstring and used for another run.

Features

- Fits directly on to pin end of WELL COMMANDER or SWITCHBACK tool
- Captures all balls for retrieval on surface
- Stores captured balls off to one side to allow smaller balls to pass through
- 14 or 18 ball capacities available
- Easily emptied on surface for multiple runs
- Available in 5 in., 7 in., 8¼ in., and 9½ in. OD for all drillstring configurations
- No internal connections

Advantages

- Bypass feature allows flexibility in string design
- Wireline access (depending on size and configuration of the tool string) is possible through the BYPASS BALL CATCHER
- Large capacity allows multiple cycles on a single tool run
- Any other ball-drop tools with smaller activation balls can be run below the BYPASS BALL CATCHER
- Large flow area does not contribute to increased internal pressure loss.



Landing Sub (LS)

Specialized Tools: Ancillary Tools

Compatible with other tools from M-I SWACO Wellbore Productivity, the Landing Sub acts as a “no-go” for landing and activating other tools.

Applications

The Landing Sub can be used to activate an MFCT device or act as a “no-go” for other tools. This is usually done on a liner-top polished-bore receptacle or other similar internal-diameter restriction.

Features

- Lands on liner top, polished-bore receptacle or other suitable shoulder
- One-piece, rugged construction
- No restriction in internal diameter

How it works

The unit is manufactured from one piece with box-up/pin-down drill-pipe connections and has a central set of large, tapered, fluted outer lugs.

Advantages

- Designed to be run below an MFCT (Multi-Function Circulating Tool) unit and act as a “no-go” device for activating the tool
- Fluted body for generous fluid bypass



Posi-Drift Sub (PDS)

Specialized Tools: Ancillary Tools

It is important to check the drift ID of casing while running drill pipe in the well. The Posi-Drift Sub has been designed as the ideal tool to meet this need while not interfering with normal drilling operations or harming the casing.

Applications

The Posi-Drift Sub from M-I SWACO Wellbore Productivity is specifically designed to drift the casing not only during drilling but wellbore cleanup operations as well, prior to running the completion equipment. Customized outside diameters can be supplied.

How it works

The machined OD of the gauge sleeve matches the API or a custom drift size of the casing. The tool is built on a one-piece main mandrel with box-up/pin-down drill-pipe connections. The gauge sleeve is free to rotate on the mandrel and remain static when the drill pipe is rotated, preventing wear and/or damage to the casing ID. There are no bolts, threaded-on rings, clamps or welding used in the construction of the tool, so there are no components to loosen and fall off downhole. The tool should be run above other casing-cleaning tools to ensure the casing has been cleaned prior to drifting with the sub.

Features

- One-piece main mandrel
- Free-rotating gauge sleeve
- Standard drill-pipe connections
- Generous fluid/debris bypass
- No square shoulders to hang up in well
- Simple, robust design
- Available for most casing sizes/IDs

Advantages

- The tool has been designed to check the drift of the casing while running drill pipe in the well and during wellbore cleanup operations, prior to running the completion equipment
- Two or more units can be run consecutively to “mimic” a packer or other long completion assembly



Bearing Sub (BS)

Specialized Tools: Customized Tools

The Bearing Sub allows the entire drillstring to be rotated while circulating with the Standard-Type MFCT (Multi-Function Circulating Tool) device in either the open or closed position.

Applications

In addition to allowing the drillstring to be rotated while circulating with the Standard-Type MFCT device, the Bearing Sub from M-I SWACO Wellbore Productivity prevents debris from entering the liner when the Bearing Sub is located on the liner top.

How it works

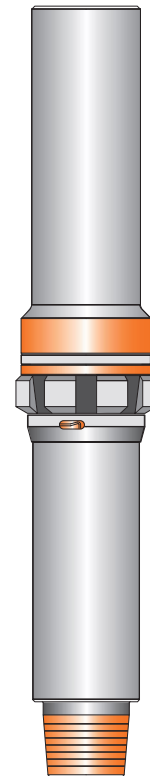
The sub lands on the liner-top polished-bore receptacle or other suitable shoulder and allows the MFCT tool to be sheared open and remain open while circulating. When resting on the sub's shoulder, the whole string can be rotated as fluid circulated through the MFCT ports. When the string is lifted, the MFCT ports close and the Bearing Sub leaves the shoulder and opens the flow path, allowing circulation down the string and up the liner and casing annulus over the liner top. The whole string can still be rotated with the Bearing Sub off the liner top.

Features

- Lands on liner-top polished-bore receptacle or other suitable shoulder
- No internal connections
- No restriction on internal diameter
- Simple, rugged construction
- Fluted mandrel with bronze bearings
- Utilizes AISI steel for body and parts; SAE 660 bronze bearings

Advantages

- Allows the whole drillstring to be rotated while circulating with the Standard-Type MFCT device
- When the Bearing Sub is located on the liner top, prevents debris from entering the liner



Disengageable Mill Assembly (DMA)

Specialized Tools: Customized Tools

The Disengageable Mill Assembly has been designed to allow liner-hanger-top Polished-Bore Receptacles (PBRs)/ Tieback-Bore Receptacles (TBRs) to be cleaned and dressed off with no need for complicated space-out considerations, especially when drilling inside the liner below.

Applications

The Disengageable Mill Assembly from M-I SWACO Wellbore Productivity allows conventional liner-top PBRs/ TBRs to be dressed off or cleaned in the normal manner. This unique tool allows two different PBR/TBR combinations to be dressed off on the same run, eliminating a separate trip for each receptacle.

How it works

After dressing off and cleaning the PBRs/TBRs, additional weight is applied and the inner mandrel of the mill set shears through the mills, allowing the drill pipe above to be tripped in the hole further. The mill set remains in the PBR/TBR to protect the already cleaned receptacles while other drill pipe is tripped in the hole and/or rotated. The ability to disengage through the upper PBR/TBR means that a conventional set of mills can land on another PBR/TBR below the first, and allow it to be dressed in the conventional manner. The disengageability allows drilling-milling to take place in the liner below without “no-going” or landing on the existing liner top and preventing further progress in the hole.

Features

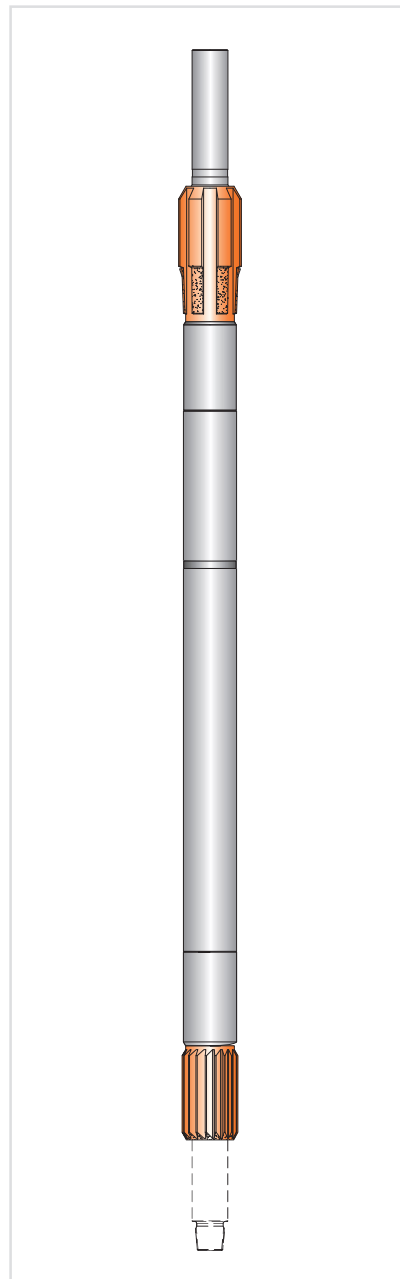
- Allows two different PBR/TBR combinations to be dressed in one run
- Has a set of “trip buttons” which prevents premature release of the mills from the mandrel
- Enables liner-hanger PBRs/TBRs to be cleaned and dressed without the need for complicated space-out considerations
- Permits drilling in the liner below without “no-going” on PBR/TBR as a restriction

Advantages

- Saves valuable rig time by eliminating trips
- Drilling is enabled in the liner below without “no-going” on PBR/TBR as a restriction

The Disengageable Mill Assembly left behind in the PBR/TBR is then collected by the inner mandrel as the drill pipe is retrieved from the well. A unique feature of the unit is a set of “trip buttons” that prevents the separation of the mills from the mandrel until the mill set is correctly positioned inside the relevant PBR, thus preventing unwanted, unplanned premature release.

When the unit has been located and left inside the PBR, additional “no-go”/ landing subs can be spaced out to land and stop. This allows activation of other weight-set tools such as the MFCT (Multi-Function Circulating Tool).



Disposable BRISTLE BACK CCT (DBB)

Specialized Tools: Customized Tools

The area in which a plug/packer is to be set often requires thorough cleaning by reciprocation prior to the setting sequence. Having the option to run a drillable cleanup tool in conjunction with drillable and permanent bridge plugs and cement retainers can greatly improve the reliability of the setting operation.

Applications

In addition to running in conjunction with drillable or permanent bridge plugs or cement retainers, the Disposable BRISTLE BACK CCT (Casing Cleanup Tool) unit from M-I SWACO Wellbore Productivity can be attached to cementing plugs to brush-clean the pipe wall as the plugs are pumped down the casing/tubing during cement-displacement operations.

How it works

In the case of bridge plugs or cement retainers, the tool is attached to the bottom of the packer. As the device is run in hole to setting depth, it brushes and cleans the casing or tubing. The setting area for the packer or plug can be thoroughly cleaned by reciprocating the device prior to the setting sequence.

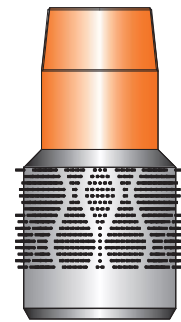
The Disposable BRISTLE BACK CCT unit is run in conjunction with drillable or permanent bridge plugs or cement retainers.

Features

- Removes mud solids, cement sheath and pipe scale
- Available in all common casing/liner sizes
- Supplied with customer-requested connection
- Drillable with polycrystalline or rock bits

Advantages

- Area for setting plug or packer can be thoroughly cleaned by reciprocation immediately prior to setting



Pressure Shear Sub (PSS)

Specialized Tools: Customized Tools

Sometimes, a reliable source of additional pressure inside the drillstring is required to activate other tools. The Pressure Shear Sub is designed to meet this need.

Applications

The Pressure Shear Sub (PSS) from M-I SWACO Wellbore Productivity is specifically designed to be run in a drillstring to apply temporary pressure for actuating another tool above the PSS, such as a near-bit reamer.

How it works

The tool consists of a one-piece body with an internal inner- and outer-sleeve arrangement. The tool is run in the initial position, which allows flow through the string. When additional pressure is needed inside the drillstring, the ball is dropped and landed on the inner sleeve. Pressure is then built up behind the ball to activate the other tool above the PSS. Once the other tool has been actuated, the driller increases fluid pressure until the predetermined shear pressure is reached. The inner sleeve shears and moves downward, re-establishing flow to the bit.

The PSS is used to apply additional pressure required to activate other tools in the string.

Features

- One-piece, full-strength body
- Full pressure integrity – no holes or ports in body
- Ball retained on seat in tool

Advantages

- Enables pressure to be applied to other tools in the string when required



SAFE-BREAK 611

Completion Fluids: Additives

SAFE-BREAK® 611 additive is a concentrated blend of surfactants and solvents designed to prevent emulsions caused by, or improve the compatibility between, highly asphaltic crude oils and seawater, low-density completion brines or acidizing treatments. SAFE-BREAK 611 additive prevents or eliminates the sludge caused by the flocculation of asphaltenes and produces a clean, sharp interface between the water/oil phases. It is also effective in controlling reverse wettability or oil-wetting effects caused by strongly cationic surfactants. SAFE-BREAK 611 additive is soluble in seawater and low-density brines such as 2 to 3% KCl and 3% NH₄Cl.

Applications

The typical application of SAFE-BREAK 611 emulsion preventer ranges from 0.1 to 2% by volume in a filtered, low-density completion fluid or seawater. When used as an acid additive, concentrations up to 5% by volume may be required. If possible, compatibility between the specific crude oil and completion fluid should be established through laboratory pilot testing prior to applying the product in the field.

The optimum treatment concentration for SAFE-BREAK 611 is determined by considering several factors, including: its solubility in the brine, the rate at which the oil and brine phases separate, the condition of the oil-water interface and observing the crude oil/brine mixture for the presence or formation of a sludge and wettability of the brine phase.¹

¹SPE 39444 for details on laboratory procedures.

Typical physical properties

Physical appearance	Straw-colored liquid
Odor	Alcohol
pH (5% vol in IPA/water)	5 to 6
Density	7.6 to 7.7 lb/gal (0.91 to 0.92 SG)
Flash point (TCC)	146°F (63°C)
Freeze point	<32°F (0°C)

If the opportunity to pilot test SAFE-BREAK 611 emulsion preventer does not exist, it should be applied at 0.5% by volume. In all applications, fluid returns should be monitored and the dosage adjusted accordingly.

Advantages

- Prevents emulsions and improves compatibility between heavy crude and low-density completion fluids

Limitations

- Limited to low-density, monovalent completion fluids such as 2 to 3% KCl and 3% NH₄Cl due to solubility
- Only prevents emulsions
- This product will not act as a demulsifier and break an emulsion. It only works as a preventive additive

No claim of personal safety is intended nor implied by the use of the name SAFE in this product. Personnel handling this material should read and follow all safety and handling procedures set forth in the Material Safety Data Sheet.

SAFE-BREAK CBF

Completion Fluids: Additives

SAFE-BREAK CBF emulsion preventer is a specialty solvent/surfactant blend that acts to prevent the formation of a stable emulsion between clear-brine completion fluids and reservoir crude oil. SAFE-BREAK CBF is formulated to penetrate the formation with minimal adsorption and to provide the intended benefit to the leading edge of invading fluid. SAFE-BREAK CBF is soluble in all standard non-zinc-bromide- or non-formate-base completion fluids. It will not “gunk out” of solution at typical bottomhole temperatures. This combination of properties makes SAFE-BREAK CBF effective at the lowest possible concentration and maximizes the possibility for full reclamation of the completion fluid.

Applications

The typical application of SAFE-BREAK CBF ranges from 0.1 to 1% by volume in a filtered completion fluid (4 to 40 gal/100 bbl [15 to 151 L/15.9 m³]). If possible, compatibility between the specific crude oil and completion fluid should be established through laboratory pilot testing prior to applying the product in the field. During a pilot test, the optimum concentration of SAFE-BREAK CBF is determined by considering the rate at which the oil and brine phases separate, the condition of the oil-water interface, observing the crude-oil/brine mixture for the presence or formation of a sludge, and wettability of the brine phase.¹

Typical physical properties

Physical appearance	Clear, pale yellow-to-amber liquid
Odor	Alcohol
Specific gravity	0.89
pH (10 vol % in water)	4
Flash point	70°F (21°C) (PMCC)

The benefits of SAFE-BREAK CBF can sometimes be enhanced by the addition of a small amount of mutual solvent such as Ethylene Glycol MonoButyl Ether (EGMBE), however, the effect of mutual solvent should be considered with respect to reclamation of the completion fluid. In most circumstances, addition of EGMBE over about 0.5% by volume will reduce the ability to reclaim the completion fluid and will usually increase the cost of reclamation. If the opportunity to pilot test SAFE-BREAK CBF does not exist, it should be applied at 0.5% by volume. In all applications, fluid returns should be monitored and the dosage adjusted accordingly.

Advantages

- Soluble in most completion fluids and water-base systems
- Effective at low concentrations
- Prevents formation damage due to crude-oil emulsions

Limitations

- Flammable liquid
- Not soluble in zinc-bromide- or formate-containing completion fluids

¹See SPE 39444 for details on laboratory procedures.

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SAFE-BREAK ZINC

Completion Fluids: Additives

SAFE-BREAK ZINC emulsion preventer is a blend of surfactants and solvents designed to prevent the formation of a stable emulsion between clear-brine completion fluids containing zinc bromide or a formate salt and reservoir crude oil. It is formulated to penetrate the formation with minimal adsorption and to provide the intended benefit to the leading edge of invading fluid.

SAFE-BREAK ZINC additive is soluble in all zinc- and formate-base completion fluids. It will not precipitate out of solution at typical bottomhole temperatures. SAFE-BREAK ZINC additive does not affect the ability to reclaim these high-density brines.

Applications

SAFE-BREAK ZINC product is designed specifically for downhole use in oil and gas wells for cleanup prior to the start of production. It is intended to be used as a solution in filtered zinc-base completion fluids. Solutions can be made between 0.1 to 1% by volume through the rig hopper.

If possible, compatibility between the specific crude oil and completion fluid should be established through laboratory pilot testing prior to applying the product in the field. The optimum concentration of SAFE-BREAK ZINC preventer is determined by considering the rate at which the oil and brine

Typical physical properties

Physical appearance	Clear-to-amber liquid
Odor	Alcohol
Specific gravity	0.88 to 0.92 @ 68°F (20°C)
Solubility (water)	100%
Flash point	70°F (21°C) (PMCC)

phases separate, the condition of the oil-water interface, by observing the crude oil-brine mixture for the presence or formation of a sludge, and the wettability of the brine phase¹

The benefits of SAFE-BREAK ZINC emulsion preventer can sometimes be enhanced through the addition of a small amount of mutual solvent such as Ethylene Glycol MonoButyl Ether (EGMBE). However, the effect of mutual solvents should be considered with respect to reclamation of the completion fluid. In most instances the addition of EGMBE over about 0.5% by volume will reduce the ability to reclaim completion fluid and will usually increase the cost of reclamation.

If the opportunity to pilot test SAFE-BREAK ZINC additive does not exist, it should be applied at 0.5% by volume. In all applications, fluid returns should be monitored and the dosage adjusted accordingly.

Advantages

- Soluble in zinc bromide- and formate-base completion fluids
- Effective at low concentrations
- Prevents formation damage due to crude oil emulsions

Limitations

- Flammable liquid

¹See SPE 39444 for details on laboratory procedures.

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SAFE-DFOAM

Completion Fluids: Additives

SAFE-DFOAM* additive is a blended, alcohol-base additive designed to reduce foaming and prevent entrained air in all fluids; it is made with higher alcohols. SAFE-DFOAM additive is very effective in all completion fluids as well as water-base drilling fluids – freshwater, brackish, seawater, saltwater and saturated saltwater.

Applications

SAFE-DFOAM additive can be used in any water-base drilling fluid or completion fluid. It is used in small concentrations and is effective in pretreatments to prevent foam formation and as a foam-removal treatment. Usually a treatment of 1 to 2 gal/100 bbl (0.24 to 0.48 L/m³) of fluid is sufficient to overcome foaming.

Advantages

- Eliminates foaming tendency of completion fluids and water-base drilling fluids
- Compatible with any fluid
- Restores pump pressure lost due to foaming and air incorporated in the fluid
- Conveniently added to the system by simply allowing a container to drip into the suction pit
- Can also be broadcast over the surface of the pit as a shock treatment

Typical physical properties

Physical appearance	Opaque liquid
Odor	Alcohol
Specific gravity	0.95
Flash point	240°F (120 °C) (COC)
Pour point	<–70°F (–57°C)
Boiling point	491°F (255°C)

Limitations

- SAFE-DFOAM additive works best when gel strengths are not exceedingly high
- Drilling or completion fluids with high gel strengths are very difficult to defoam
- Vapors from the mud pits can cause coughing and nose/throat irritation

No claim of personal safety is intended nor implied by the use of the name SAFE in this product. Personnel handling this material should read and follow all safety and handling procedures set forth in the Material Safety Data Sheet.

SAFE-LUBE

Completion Fluids: Additives

SAFE-LUBE* additive is a patented¹ water-soluble brine lubricant. The chemistry demonstrates exceptional reduction in metal-to-metal friction when added to brine-base completion fluids at extremely low concentrations.

Applications

SAFE-LUBE lubricant is designed to reduce the coefficient of friction in seawater, sodium-chloride, sodium-bromide, calcium-chloride and calcium-bromide completion fluids.

Torque and drag in completion fluids in high-angle, extended-reach wells have become major problems in completion operations. SAFE-LUBE lubricant has reduced torque and drag up to 50% at extremely low concentrations in field applications.

The optimum concentration of SAFE-LUBE lubricant is one drum per 218 barrels (0.6% by volume). The product can be added before the fluid passes through a DE filter press or cartridge unit. SAFE-LUBE lubricant will not be removed by the filtration process.

Coefficient of Friction (CoF) data derived from tests using the OFI Digital Lubricity Tester at 60 RPM and 150 in./lb torque gave the following results:

Brine	CoF	CoF with 0.6% SAFE-LUBE*
Seawater	0.36	0.08
Seawater with 3% KCl	0.37	0.09
9 lb/gal KCl	0.38	0.08
10 lb/gal NaCl	0.37	0.08
10.7 lb/gal CaCl ₂	0.26	0.13
11.6 lb/gal CaCl ₂	0.09	0.08
11.2 lb/gal CaCl ₂ /CaBr ₂	0.11	0.09
12.2 lb/gal CaBr ₂ (20 TCT)	0.15	0.04

¹U.S. Patent number 7,094,738 B2.

Typical physical properties

Physical appearance	Clear liquid
Specific gravity	1.01 @ 60°F (16°C)
pH	6.5
Solubility	100%

Advantages

- Return permeability testing has shown that SAFE-LUBE lubricant does not damage the formation
- Stable lubricant does not increase fluid oil and grease valves when used at concentrations to 6% volume
- SAFE-LUBE lubricant does not contribute a sheen in a Static Sheen Test
- Soluble in most completion brines
- Effective at low concentration (0.6% by volume)
- Filtration operations are not adversely impacted by addition to brine

Limitations

- Not to be used with zinc-base fluids
- Add product directly to mud pit; do not add through a hopper because excessive foaming may occur

No claim of personal safety is intended nor implied by the use of the name SAFE in this product. Personnel handling this material should read and follow all safety and handling procedures set forth in the Material Safety Data Sheet.

SAFE-LUBE CW

Completion Fluids: Additives



SAFE-LUBE* CW additive is a water-soluble brine lubricant. The novel chemistry demonstrates an exceptional reduction in metal-to-metal friction when added to brine-base completion fluids at extremely low concentrations. SAFE-LUBE CW additive can withstand storage temperatures as low as 0°F (-18°C).

Applications

SAFE-LUBE CW lubricant is designed specifically for cold weather climates to reduce the coefficient of friction in completion fluids. It is applicable in seawater, sodium chloride, sodium bromide, calcium chloride, and calcium bromide systems. SAFE-LUBE CW lubricant provides all the benefits of SAFE-LUBE additive, but at a lower operating temperature.

Advantages

- Return permeability testing shows that the SAFE-LUBE lubricant is minimally damaging to the formation
- Completion fluid oil and grease values are not elevated with as much as 10 times the recommended concentration of SAFE-LUBE lubricant
- SAFE-LUBE lubricant does not contribute a sheen in a Static Sheen Test
- Soluble in most completion brines.
- Effective at low concentration (0.6% by volume)
- Filtration process will not remove lubricant from system

No claim of personal safety is intended nor implied by the use of the name SAFE in this product. Personnel handling this material should read and follow all safety and handling procedures set forth in the Material Safety Data Sheet.

SAFE-SCAV HS/SAFE-SCAV HSW

Completion Fluids: Additives

SAFE-SCAV HS and its winterized version, SAFE-SCAV HSW, hydrogen sulfide scavengers are brine-soluble and remain soluble after reacting with H_2S . Based on an organic chemical rather than the typical zinc- or iron-base compound, each provides a solids-free solution to H_2S intrusion.

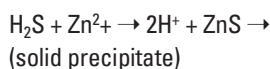
Applications

SAFE-SCAV HS and HSW scavengers are designed specifically to remove H_2S from brine-base fluid systems.

Recommended treatment levels are 0.1 lb/bbl (1 gal/100 bbl) (0.29 kg/m³). Use higher concentrations where higher levels of H_2S exist in the fluid to be treated. Under optimal conditions, each 1 lb/bbl (2.85 kg/m³) of either scavenger can consume about 0.1 lb (0.045 kg) of H_2S .

SAFE-SCAV HS and HSW scavengers have been used successfully to treat water-base fluids where zinc cannot be used for environmental reasons.

Many hydrogen-sulfide scavengers use inorganic chemicals to tie up H_2S . For example, zinc oxide is a partially soluble product which liberates zinc ions for scavenging. Similarly, SV-120*, which is essentially completely soluble, yields an active zinc component for sulfide removal.

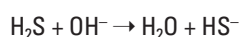


In many completion-fluid applications, however, the resulting solid zinc sulfide is undesirable.

Typical physical properties: HS / HSW

Physical appearance	Liquid / Liquid
Specific gravity	1.08 @ 60°F (16°C) / 1.08 @ 60°F (16°C)
pH (5% solution in 75/25 isopropanol/water)	9.4 to 11.4 / 10 to 11.5
Solubility (water)	Soluble / Soluble
Flash point	>212°F (>100°C) (PMCC) / 125°F (51°C) (PMCC)
Pour point	<-4°F (<-20°C) / -35°F (-37°C)

Another popular treatment for H_2S is to rely on high pH to neutralize the acidic hydrogen sulfide (also known as hydrosulfuric acid) and render it non-volatile:



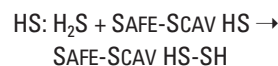
This can be done in a completely solids-free way, and any base can do it, but treatment with base raises the pH of the fluid. Getting enough sodium hydroxide in solution to provide a large capacity for scrubbing requires a very high pH, approximately 12 to 13. Lime is somewhat better in this regard because it has limited solubility at high pH. This allows additional H_2S -scrubbing capacity to build up in the system in the form of undissolved lime.

Organic amines, such as ethanolamine, can also provide a high-pH sink for H_2S , while buffering the pH around 10.

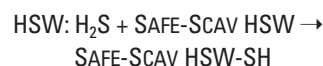
All these pH methods have a significant drawback: the H_2S that is "scrubbed" will be released immediately if the pH is lowered. Carbon dioxide influx can lower the pH enough to release H_2S .

Furthermore, while hydrogen sulfide is no longer being released, the corrosive effects are unabated and in fact can even be enhanced at higher pH.

SAFE-SCAV HS and HSW scavengers offer a solution to many of these scavenging problems in non-zinc brines. While nitrogen-base, the unique chemistry of both scavengers results in an irreversible reaction with H_2S :



or



Unlike the zinc or iron scrubbers, the final product is still brine- and water-soluble, delivering solids-free sulfide scrubbing.

Advantages

- Chemically "ties up" the H_2S in an irreversible reaction, preventing release if pH drops
- Not zinc-base
- Does not form a precipitate

No claim of personal safety is intended nor implied by the use of the name SAFE in this product. Personnel handling this material should read and follow all safety and handling procedures set forth in the Material Safety Data Sheet.

SAFE-SCAVITE II

Completion Fluids: Additives

SAFE-SCAVITE* II scale inhibitor is a concentrated, phosphonate-base system that inhibits scaling caused by calcium carbonate, calcium sulfate and barium sulfate. It is soluble in most water-base fluids, including calcium-chloride and calcium-bromide completion brines. SAFE-SCAVITE II inhibitor exhibits good thermal stability.

Applications

SAFE-SCAVITE II inhibitor is a phosphonic acid that inhibits scaling caused by calcium sulfate, barium sulfate and calcium carbonate.

It is intended to be used as a solution in the entire completion-fluid system. Solutions can be mixed to contain between 25 to 1,000 ppm, depending on solids concentration, the density of the brine and the severity of scaling problems.

Typical concentration of SAFE-SCAVITE II additive in a calcium-base completion fluid is 0.05 to 0.1% by volume.

Typical physical properties

Physical appearance @ 77°F (25°C)	Clear, yellow liquid
Specific gravity	1.34 to 1.37 @ 77°F (25°C)
pH (1% in water)	<1
Solubility (water)	Soluble
Flash point	200°F (93°C) (PMCC)

Advantages

- Effective in calcium-chloride- and calcium-bromide-base completion fluids
- Inhibits formation damage caused by precipitation of carbonate scale from calcium-containing fluids
- Compatible with monovalent brines

No claim of personal safety is intended nor implied by the use of the name SAFE in this product. Personnel handling this material should read and follow all safety and handling procedures set forth in the Material Safety Data Sheet.

CLEANPERF

Completion Fluids: Fluid-Loss-Control Systems and Products

Both CLEANPERF[®] OB and CLEANPERF WB fluid-loss- and damage-control systems are designed for use during Schlumberger[^] pure dynamic underbalance perforating operations. They provide a low-permeability barrier to limit deep invasion of solids and fluids along the perforation tunnel and assist in limiting debris in the tunnel. The CLEANPERF system is also designed to readily flowback without a remedial treatment when production commences. CLEANPERF OB is an oil-base system and CLEANPERF WB is a water-base system.

There are certain variables that must be addressed in designing the fluid system in which either CLEANPERF system will run:

- Adequate density to provide desired overbalance/dynamic underbalance
- Proper bridging of the formation face
- A thin/low-permeability filter cake
- Minimal adhesive and cohesive forces within the filter cake to promote its dispersion during flowback
- Thermal stability to maintain filtration and suspension properties
- Fluid filtrate chemically compatible with formation fluids and mineralogy
- Chemical compatibility with perforation charges
- Validated fluid characteristics in laboratory
- The exact product blend will vary depending on fluid requirements. CLEANPERF fluid requirements will generally be quite small, in the tens of barrels range. These fluids should be mixed at a fluid plant and shipped to location as a finished volume. Large bridging agents may be omitted in the initial mix and added at the rigsite, just prior to spotting the fluid.

[^]Schlumberger is a mark of Schlumberger Limited Corp.

FORM-A-PLUG II

Completion Fluids: Fluid-Loss-Control Systems and Products

FORM-A-PLUG* II pumpable lost-circulation plug is a blend of borate mineral and polymers designed for suspension, fluid-loss control and cross-linking technology. When activated with time and temperature, FORM-A-PLUG II plug develops a rigid cross-linked gel structure that effectively prevents loss of fluid to the formation. The FORM-A-PLUG II components are acid-soluble, more than 95% being dissolved on contact with a solution of 15% HCl. Destroying the plug can be more difficult as access to it may be limited.

Applications

FORM-A-PLUG II fluid-loss-control plug is the main additive used to form a lost-circulation plug, which can be used in any application where a squeeze plug would be beneficial. It is particularly advantageous in areas where loss of whole mud is prevalent. FORM-A-PLUG II product can be used to stop losses occurring with any water-base or non-aqueous-base fluid system. It is used for suspension, fluid-loss control and cross-linking in the lost-circulation plug.

FORM-A-PLUG II material can be used in combination with FORM-A-PLUG ACC accelerator and FORM-A-PLUG RET retarder. Together they will make a chemical reaction to form a rigid cross-linked gel structure. It is therefore important to carefully control the

Typical physical properties

Physical appearance	White to beige powder
Specific gravity	2
pH (1% solution)	7 to 8
Solubility (water)	Slightly

product concentrations and mixing conditions in order to ensure that the reaction proceeds as expected.

The formulation can be adjusted for density by adding barite or other appropriate weighting materials up to 18 lb/bbl (2.16 SG). Pilot testing is recommended before use to estimate the time to create a well-set plug. Recommended FORM-A-PLUG II material concentrations are 60 to 100 lb/bbl (170 to 285 kg/m³) depending on the final slurry density.

The plug should be pumped to the annulus at the depth of loss. The drillstring is then pulled above the FORM-A-PLUG II plug. The plug can be squeezed into the loss zone. Be careful not to leave the plug in the pipe even if the losses have stopped or slowed. Do not shut down pumping while the plug is in the drillstring.

Advantages

- Provides suspension, fluid-loss control and cross-linking
- Forms a rigid gel structure

FORM-A-PLUG II RET

- FORM-A-PLUG RET retarder is a grade of soluble magnesium chloride which delays the cross-linking reaction in the FORM-A-PLUG II lost-circulation plug to avoid premature setting during the mixing stage
- FORM-A-PLUG RET retarder should be added to the drill water before adding FORM-A-PLUG II material and/or FORM-A-PLUG ACC accelerator
- Pilot testing is recommended before use to estimate the time to create a well-set plug

FORM-A-PLUG II ACC

- FORM-A-PLUG ACC accelerator is a blend of inorganic compounds designed for pH and salinity adjustment necessary to control the cross-linking reaction in the lost-circulation plug
- FORM-A-PLUG ACC accelerator should be added to the lost-circulation slurry immediately before pumping the mixture down the well. The accelerator will create a chemical reaction with the FORM-A-PLUG II material to form a rigid cross-linked gel structure
- Pilot testing is recommended before use to estimate the time to create a well-set plug

PERF-N-PEEL

Completion Fluids: Fluid-Loss-Control Systems and Products

The PERF-N-PEEL* fluid-loss-control system is designed for use during a perforating operation. It provides a low-permeability barrier to limit deep invasion of solids and fluids along the perforation tunnel and assist in limiting debris in the tunnel. The PERF-N-PEEL system is also designed to readily flow back without a remedial treatment when production commences.

There are certain variables that must be addressed in designing the fluid system in which either PERF-N-PEEL system will run:

- Adequate density to provide desired overbalance
- Proper bridging of the formation face
- A thin/low-permeability filter cake
- Minimal adhesive and cohesive forces within the filter cake to promote its dispersion during flowback

- Thermal stability to maintain filtration and suspension properties
- Fluid filtrate chemically compatible with formation fluids and mineralogy
- Chemical compatibility with perforation charges
- Validated fluid characteristics in laboratory

The exact product blend will vary depending on fluid requirements.

SAFE-LINK 110/SAFE-LINK 140

Completion Fluids: Fluid-Loss-Control Systems and Products

SAFE-LINK® fluid-loss-control product comprises a chemically modified, cross-linked cellulose polymer used primarily to control loss of clear brine fluid to the formation during completion or workover operations. SAFE-LINK additive controls fluid loss by applying a very viscous material across the formation face, virtually stopping the flow of brine into the formation. SAFE-LINK fluid-loss-control additive functions through a cross-linked polymer network that is held in place on the formation face. The effectiveness of this product is not dependent on bridging solids or on viscous drag within the formation matrix.

Applications

SAFE-LINK fluid-loss-control additive is designed to work in non-zinc, halide brines such as CaCl_2 , CaBr_2 , NaCl , seawater, NaBr , and KCl , ranging from 8.6 to 15.1 lb/gal (1,030 to 1,809 kg/m³) to control wholesale loss of brine to the formation. Generally, SAFE-LINK fluid-loss-control additive is stable to 250°F (121°C) for at least 48 hrs exposure time. Due to the SAFE-LINK additive's cross-linking mechanism, differential pressure greater than 2,000 psi (137.9 bar) is not advisable.

Based on recommended treatment levels and recommended use, the fluid loss to moderately permeable formations (100 to 1,000 mD) can be reduced to <2 bbl/day per 30 ft (9.1 m) interval.

Typical physical properties

Physical appearance	Viscous, tan liquid
Odor	Faint solvent
Specific gravity	1.32
pH	~10
Pour point	10°F (–12.2°C)
Viscosity	>10,000 cP

Advantages

- Premixed liquid
- No special mixing equipment requirements
- Good to 250°F (121°C)
- Can be used at differential pressures up to 2,000 psi (137.9 bar)
- Clean up with dilute acid

Limitations

- Not designed for temperatures higher than 250°F (121°C)
- For less severe fluid-loss applications, a SAFE-VIS (i.e., un-cross-linked) pill may suffice
- For more severe fluid-loss applications, even a SAFE-LINK pill may not be sufficient, and the user may have to resort to a solids-laden (sized-carbonate or sized salt) pill

SAFE-LINK 140

SAFE-LINK® 140 fluid-loss control product is designed to work in calcium and moderate zinc halide brines up to 16.0 lb/gal (1.9 SG) to control wholesale loss of brine to the formation. The 1.4 sg density of SAFE-LINK 140 minimizes divalent base brine dilution. It is stable to 250°F (121°C) for at least 48 hours of exposure time. A 10 bbl pill is the minimum recommended treatment, even for shorter intervals. Use a treatment of 0.5 pail per perforated foot (0.3 m) is recommended. Using the SAFE-LINK 140 fluid-loss control product, operators can expect to reduce their fluid loss to moderately permeable formations (up to 1,000 mD) to < 2 bbl/day per 30 ft (9.1 m) interval.

No claim of personal safety is intended nor implied by the use of the name SAFE in this product. Personnel handling this material should read and follow all safety and handling procedures set forth in the Material Safety Data Sheet.

SAFE-VIS

Completion Fluids: Fluid-Loss-Control Systems and Products

SAFE-VIS* is a high-grade, clarified HEC polymer. It is a glyoxylated form of HEC with an average molecular weight of approximately 1,000,000 daltons. This glyoxyl coating retards hydration until either time, temperature or solution pH (above about 7) strips the coating from

the surface. This retardation allows a more controlled and full hydration. SAFE-VIS is used to viscosify freshwater, seawater or brine fluids used in workover and completion operations. SAFE-VIS is normally added at concentrations of 2 to 4 lb/bbl (0.9 to

1.8 kg/bbl) for viscous pills and 0.1 to 0.5 lb/bbl (0.05 to 0.23 kg/bbl) for drag reduction.

SAFE-VIS is packaged in 50 lb (22.7 kg) multi-wall, waterproof sacks.

SAFE-VIS E

SAFE-VIS E liquid viscosifier is a suspension of high-quality HEC polymer in a highly purified mineral oil carrier. SAFE-VIS E is designed to viscosify single-salt CaCl_2 brines and

all monovalent-salt halide brines. Treatments usually range between 0.5 to 1.5 gal/bbl (1.9 to 5.7 L/bbl) of completion fluids.

SAFE-VIS E is packaged in 5 gal (18.9 L) plastic cans. SAFE-VIS E contains 16.5 to 17 lb (1.9 to 5.7 L/bbl) HEC per 5 gal (18.9 L) can.

SAFE-VIS HDE

SAFE-VIS HDE liquid viscosifier is a suspension of high-quality HEC polymer in water-soluble carrier. It is specially formulated for high density CaCl_2 , $\text{CaCl}_2/\text{CaBr}_2$, CaBr_2 , CaBr_2 , $\text{CaCl}_2/\text{CaBr}_2/\text{ZnBr}_2$ and most other

divalent brines. Treatments usually range between 2 to 5 gal/bbl (7.6 to 18.9 L/bbl) of completion fluid. Special mixing procedures are required for ZnBr_2 fluids in the 15 to 16.5 lb/gal (1.8 to 1.98 SG) density range.

SAFE-VIS HDE is packaged in 5 gal (18.9 L) plastic cans. SAFE-VIS HDE contains 4.5 lb (2.04 kg) HEC per 5 gal (18.9 L) can.

SAFE-VIS OGS

SAFE-VIS OGS liquid viscosifier is a suspension of high-quality HEC polymer in a water dispersible, synthetic carrier. SAFE-VIS OGS liquid viscosifier is specially formulated to pass Oil and Grease, LC_{50} and Static Sheen Test

requirements for offshore GoM use. The product viscosifies single salt CaCl_2 and CaBr_2 brines and all monovalent-salt brines. Treatments usually range between 0.5 to 1.5 gal/bbl (1.9 to 5.7 L/bbl) of completion fluid.

SAFE-VIS OGS is packaged in 5 gal (18.9 L) plastic cans. SAFE-VIS OGS contains 16.5 to 17 lb (7.5 to 7.7 kg) HEC per 5 gal (18.9 L) can.

No claim of personal safety is intended nor implied by the use of the name SAFE in this product. Personnel handling this material should read and follow all safety and handling procedures set forth in the Material Safety Data Sheet.

SEAL-N-PEEL

Completion Fluids: Fluid-Loss-Control Systems and Products

Maximum fluid-loss protection with easy cleanup in sand-control completions

Fluid losses during and after sand-control completions can severely jeopardize a well's productivity. Once fluid invades the formation, remedial treatments cannot only inflate costs dramatically, but lead to a host of additional problems, not the least of which is the risk of formation damage. Even with the additional costs and risks, it is extremely difficult, if not impossible, to completely rid a formation of the ill effects of invading fluid.

The SEAL-N-PEEL pill is a uniquely engineered fluid-loss control system, designed specifically as a contingency for frac-pack, gravel-pack or standalone completions. It provides superb supplemental fluid-loss control when mechanical fluid-loss-control devices either fail or are unavailable. The SEAL-N-PEEL pill deposits an impenetrable, thin, filter cake against the inside surface of the screen assembly. When the well is ready to go on production, the cake simply peels away, using production pressure and flow as the lift-off mechanism.

There's no invasion into the formation or gravel pack. No damage from remedial cleanup measures. No impediment to downhole completion hardware. And no resistance to production initiation.

A safety net for your gravel-pack completions

Until now, there weren't many options for controlling fluid loss in sand-control completions, and quite often, they had negative consequences. Popular mechanical controls, such as spring-loaded flapper valves, have been known to fail and are sometimes unavailable or incompatible with the completion scheme.

The only other option was to pump minimal-solids or solids-free fluid-loss-control pills. Sized-salt pills and those containing some solids are usually of the "all-in-one-sack" variety, which eliminates the ability to customize particle-size distribution. Such a non-specific approach to bridging raises the risks of particles invading the gravel-pack medium or the formation.

On the other hand, solids-free pills cannot be fully effective without some invasion into the gravel-pack and formation matrix. They also have to be pumped in large volumes to control losses effectively.

Regardless of the pill type used, once its job is done, it must be removed with acid, oxidizers or enzymes. All too often, pumping an external breaker is corrosive to screens and other downhole components. There is also the threat of leak-off and serious formation damage.



With a SEAL-N-PEEL pill, the calcium carbonate particles are specially sized for each application. This promotes the immediate deposition of a thin, tough filter cake on the inside surface of the gravel-pack screen. Once in place, the cake becomes an impenetrable shield that effectively reduces fluid invasion into the formation.

When it's time to produce the well, the releasing agent within SEAL-N-PEEL fluid will have reduced the cohesive and adhesive forces that bind the filter cake together and to the screen surface, respectively, allowing it to be completely removed with very little differential pressure. In fact, production from the well removes the filter cake entirely.

The evolution of the new standard in fluid-loss control

To understand why SEAL-N-PEEL technology works so well, it's helpful to see how it evolved in the laboratory and how it has succeeded in the field. Each component is the result of a painstaking development and testing program that has resulted in a superior product.

M-I SWACO has developed bridging agent guidelines for all types of completion screens from premium to expandables to wire wrapped.



These guidelines have been incorporated into the M-I SWACO OPTIBRIDGE software program. The sealing capability is evaluated under downhole conditions on the expected filter media. Additional laboratory testing is undertaken to confirm the laboratory formulation effectiveness.

We look at the rheological stability of the pill to make certain it will remain intact during sometimes lengthy stays in the wellbore environment. We look at its damage potential and how it should be placed inside the screen to optimize sealing capacity and facilitate easy removal.

Features

- Supplements or replaces mechanical fluid-loss-control devices
- Particles sized specifically for each screen
- Specially engineered additive reduces adhesive and cohesive tendencies
- Contains minimal solids

Advantages

- Minimally invasive pill
- Easily peels from the screen
- Requires no remedial washes
- Non-damaging to the formation

ISO THERM

Completion Fluids: Packer Fluid Systems and Products

Features

- Uniquely engineered to minimize both conductive and convective heat loss
- Thermal stability
- Suitability for zero-discharge systems
- Low corrosion profile typical of most oil-base fluids
- Compatibility with various base oils, including diesel, mineral oil, synthetic oils, etc.
- Easy placement and displacement
- Pumpable after long-term aging

Advantages

- Prevents production-line blockage and casing-string collapse
- Formulated for compatibility with a wide range of elastomers, fluids, and surface processing equipment
- TPRO ST enables modeling of fluid thermal behavior for production and shut-in scenarios
- Reduces operating costs
- Helps maximize production
- Prevents annular pressure buildup
- Increases flowing surface temperature
- Lowers thermal conductivity for concentrated effectiveness below the mudline
- Easily removed during intervention

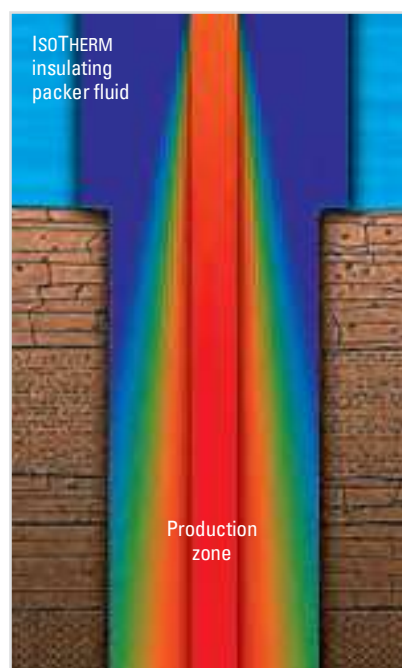
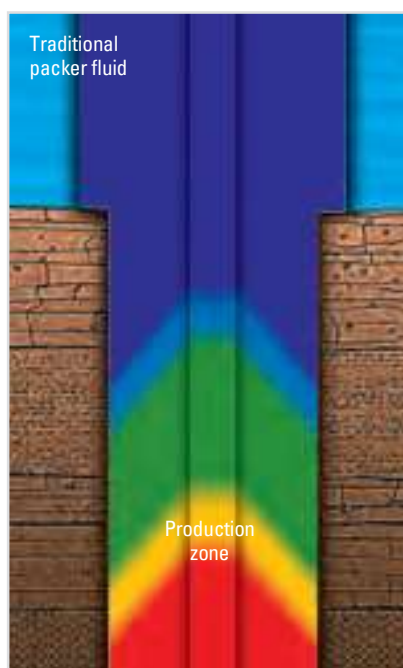
ISO THERM* is a non aqueous-based insulating packer fluid that delivers thermal protection for produced fluids in deepwater and permafrost environments.

In deepwater, ISO THERM protects against cold subsea temperatures that can alter the properties of produced fluids and the temperature cycling can loosen threaded connections and compromise the integrity of cement and elastomer seals. In the Arctic environment, the packer fluid controls heat transfer on producer and injector wells that can thaw the permafrost, leading to loss of well seal integrity or well stability.

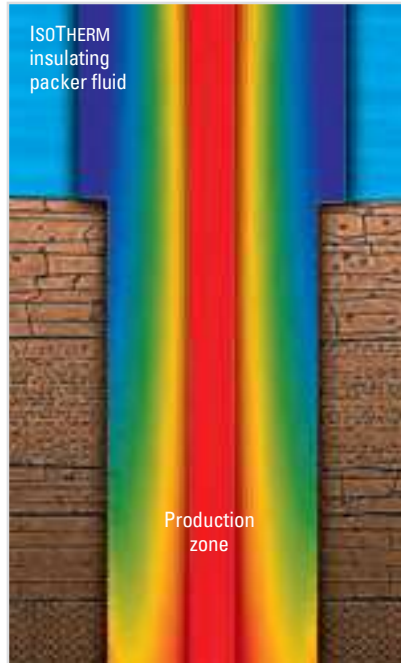
ISO THERM packer fluid, used in conjunction with our proprietary TPRO- ST computer modeling software, offers maximum protection against low-temperature-related production problems, such as hydrates, paraffins and wax. The ISO THERM system lowers



thermal conductivity and arrests thermal convection to avoid annular pressure buildup. In addition, it can be used to enhance vacuum-insulated tubing performance. ISO THERM is available with a density of 7.0 lb/gal (0.84 SG) and is formulated to provide a thermal conductivity value up to one fourth that of a conventional brine packer fluid.



ISO THERM fluid creates an insulating barrier that eliminates temperature loss in the production fluids during shut-in conditions



ISO THERM fluid creates an insulating barrier that eliminates temperature loss in the production fluids during steady-state production



Conduction is the transmission of heat across matter and is always directed from a higher to a lower temperature. Thermal conductivity is defined as the heat transferred through a medium as a result of temperature difference

Convection is the internal movement of currents within fluids. It can be described as the density- and heat-driven cycling, transfer or circulation of energy through which material initially warms up and becomes relatively less dense, rising, then cooling and becoming relatively more dense, and finally sinking

SAFE-COR C

Completion Fluids: Packer Fluid Systems and Products

SAFE-COR C corrosion inhibitor is a modified, amine-type additive designed to protect all oilfield tubular goods. It helps prevent general corrosion attack on casing, tubing and downhole tools in contact with clear completion brines. SAFE-COR C inhibitor is a highly concentrated product designed and packaged for use in clear workover and completion brine.

Applications

SAFE-COR C additive controls corrosion of tubing and casing strings when used in workover or packer brines. It has application in all brine systems. SAFE-COR C corrosion inhibitor is designed for use in clear brines but may be used in viscosified completion or drilling fluids. Pilot testing for compatibility is recommended for this application.

For treatment of clear brine fluids, SAFE-COR C inhibitor should be used at 0.22 gal/bbl (4.8 L/m³) of completion brine. This is equal to 2 lb/bbl (5.7 kg/m³) or roughly four 5 gal (18.9 L) cans per 100 barrels of completion brine. SAFE-COR C corrosion inhibitor can be added directly to the brine without special mixing equipment or agitation.

Typical physical properties

Physical appearance	Dark brown liquid
Specific gravity	1.09

Advantages

- Protects metal surfaces in both the shallow part of the well and in the deeper, hotter areas. At the recommended concentration, SAFE-COR C corrosion inhibitor provides protection at bottomhole temperatures up to 350°F (177°C)
- Highly concentrated product in easy-to-handle 5 gal (18.9 L) cans
- Protects both tubular goods and completion tools exposed to workover or clear completion brines
- Compatible with sodium chloride, potassium chloride, calcium chloride, sodium bromide, calcium bromide and moderate-density zinc bromide brine fluids

Limitations

- When applied to zinc bromide fluids, recommendations should be obtained from the Completion Fluids Technology Group
- Designed for application in clear brine fluids. If used in a viscosified completion or drilling fluid, pilot testing for compatibility is recommended

No claim of personal safety is intended nor implied by the use of the name SAFE in this product. Personnel handling this material should read and follow all safety and handling procedures set forth in the Material Safety Data Sheet.

SAFE-COR EN

Completion Fluids: Packer Fluid Systems and Products

SAFE-COR* EN corrosion inhibitor is a modified, amine-type product formulated for use in clear brine packer fluids. The additive is designed to protect all oilfield tubular goods, is soluble in clear brine completion fluids and minimizes environmental impact. It helps prevent general corrosion attacks on casing, tubing, and downhole tools in contact with completion brines.

Applications

SAFE-COR EN inhibitor is a highly concentrated product designed and packaged for use in solids-free workover and completion brines. SAFE-COR EN inhibitor controls the corrosion of tubing and casing strings when used in workover and packer brines. It has applications in all brine systems except zinc bromide. SAFE-COR EN inhibitor can be added directly to brine without special mixing equipment or agitation.

Advantages

- Protects both tubular goods and completion tools exposed to workover or clear completion brines
- Protects metal surfaces in both the shallow, upper part of the well and in deeper, hotter intervals
- Compatible with most brines

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SAFE-COR HT

Completion Fluids: Packer Fluid Systems and Products

SAFE-COR HT high-temperature corrosion inhibitor is an inorganic thiocyanate-base additive designed to protect carbon steel tubular goods. It helps prevent general corrosion attack on casing, tubing and downhole tools in contact with zinc-bromide-base workover or completion brines. SAFE-COR HT inhibitor was developed for use in zinc bromide fluids within a temperature range of ambient to 400°F (204°C).

Applications

SAFE-COR HT inhibitor controls corrosion of carbon steel tubing and casing strings when used in zinc-bromide-base workover, packer or completion fluids. It is recommended whenever operations require zinc bromide brine to be in contact with tubulars at high temperature for more than 24 hrs. SAFE-COR HT inhibitor should not be used with chrome steel tubulars.

For treatment of clear brine fluids, SAFE-COR HT inhibitor is recommended for use at a concentration of 1.5 lb/bbl (4.27 kg/m³) or approximately 15 gal/100 bbl (3.57 L/m³). It can be added directly to the brine without special mixing equipment or agitation.

Typical physical properties

Physical appearance	Clear liquid
Specific gravity	1.28
pH	6.5 to 7
Flash point	>212°F (100°C) (PMCC)
Boiling point	>252°F (122°C)
Crystallization point	<15°F (–9°C)

Advantages

- Effective in high-density, zinc bromide brines
- Effective alternative to amine-base products
- Effective from ambient temperature to 400°F (204°C)
- Easy and safe to handle on location

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SAFE-SCAV CA

Completion Fluids: Packer Fluid Systems and Products

SAFE-SCAV* CA oxygen scavenger is an organic, sulfur-free additive used in calcium-base brines and seawater. It is a fast-acting material that is effective even at low temperatures.

Applications

SAFE-SCAV CA additive inhibits corrosion caused by the presence of dissolved oxygen in completion and workover brines. It is primarily intended to be used in calcium- and zinc-containing brines such as calcium chloride, calcium bromide, zinc bromide and seawater.

The recommended initial treatment of SAFE-SCAV CA additive is 15 lb/100 bbl (0.43 kg/m³) of brine. If the concentration of oxygen is high, then this level should be increased to roughly 10 times the concentration of dissolved oxygen. SAFE-SCAV CA scavenger should be added at the suction and not through the mixing hopper.

To reduce the amount of air entrained in the brine and the amount of oxygen that may be incorporated into the system, minimize the use of the mixing hopper and agitation of the completion fluid by surface equipment.

Typical physical properties

Physical appearance	White crystalline powder
Specific gravity	1.65
pH (10% solution)	5.5 to 8
Solubility (water)	Soluble

Advantages

- Effective sulfur-free oxygen scavenger for calcium-containing brines
- Fast-acting reaction with O₂, even at low temperature
- Will not precipitate calcium
- A natural product with good health, safety and environmental characteristics
- Easy to handle and store powder; effective at low concentrations

No claim of personal safety is intended nor implied by the use of the name SAFE in this product. Personnel handling this material should read and follow all safety and handling procedures set forth in the Material Safety Data Sheet.

SAFE-SCAV NA

Completion Fluids: Packer Fluid Systems and Products

SAFE-SCAV NA oxygen scavenger is a liquid bisulfite-base additive designed to be used in sodium- and potassium-base brines. It reacts with, and eliminates, dissolved oxygen as a possible source of corrosion in workover and completion fluids and in packer and drilling fluids. In addition to reducing oxygen corrosion, SAFE-SCAV NA additive is essential to extending the temperature limit of polymers, such as FLO-VIS PLUS (xanthan gum) and FLO-TROL (modified starch), used in the FLOPRO NT reservoir drill-in fluid system.

Applications

SAFE-SCAV NA additive inhibits corrosion caused by the presence of dissolved oxygen in completion and workover brines. It can be used in all monovalent-base brines that do not contain significant amounts of calcium or magnesium.

The recommended initial treatment is 1 gal/100 bbl of brine (0.24 kg/m³) (0.025% by volume). If the concentration of oxygen is known to be high, then this level should be increased. SAFE-SCAV NA additive should be added directly to the pump suction and not through the mixing hopper.

To reduce the amount of air entrained in the brine and the amount of oxygen that may be incorporated into the system,

Typical physical properties

Physical appearance	Straw-to-yellow colored liquid
Specific gravity	1.3
pH (1% solution)	4.9 to 5.5
Solubility (water)	Soluble

minimize the use of the mixing hopper and agitation of the completion fluid by surface equipment.

To assure the complete removal of dissolved oxygen, maintain an excess sulfite (SO_3^{2-}) content in the fluid of 100 to 300 ppm. For systems that contain some hardness, or for polymer-viscosified brines, increase the concentration of excess sulfite to the 300 ppm level. Use a sulfite test kit to determine excess SO_3^{2-} . Instructions are included in the test kit.

Inject SAFE-SCAV NA additive directly into the pump suction if at all possible and avoid exposure of the product to the air. The best method of application is to inject the product using a chemical proportioning pump. Injection rate is dependent upon the oxygen content and fluid circulation rate. Typical injection rates can be 1 to 2.5 gal/hr (3.8 to 9.5 L/hr). The injection rate should be adjusted based on the measured excess sulfite concentration at the flowline.

Advantages

- Removes dissolved oxygen, thereby reducing corrosion
- Concentrated, fast-acting oxygen scavenger, effective at low levels
- Liquid, easy-to-mix product
- Reduces rig equipment maintenance cost
- Extends the life of casing strings and production tubing

Limitations

- Not compatible with calcium-containing fluids with total hardness >300 mg/L
- Not compatible with aldehyde-type biocides

No claim of personal safety is intended nor implied by the use of the name SAFE in this product. Personnel handling this material should read and follow all safety and handling procedures set forth in the Material Safety Data Sheet.

SAFETHERM

Completion Fluids: Packer Fluid Systems and Products

Features

- Uniquely engineered to minimize heat conduction and convective heat loss
- Easily mixed and pumped on the rig
- Environmentally acceptable components
- pH-buffered and corrosion-inhibitive
- Thermally stable

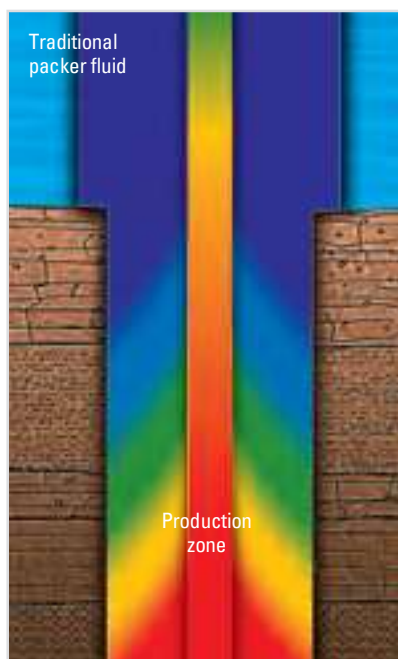
Advantages

- Prevents production-line blocking and casing-string collapse
- Formulated for compatibility with wide range of elastomers and fluids and with surface-processing equipment
- TPRO ST enables modeling of fluid thermal behavior for production and shut-in scenarios
- Reduces costs
- Helps maximize production
- Poses minimal environmental impact

SAFETHERM* fluid is an aqueous-based or water-miscible insulating packer fluid engineered specifically to thermally protect produced fluids in deepwater and ultra-deepwater environments. The packer fluid is equally effective in permafrost applications.

SAFETHERM fluid is custom-designed and blended for specific deepwater and permafrost applications. It is formulated from an inherently low-thermal-conductivity-base fluid and viscosified to suppress convective heat loss. SAFETHERM is available in

densities up to 12.0 lb/gal (1.44 SG) and can be formulated with thermal conductivity values up to one half that of conventional brine packer fluids. SAFETHERM packer fluid, used in conjunction with our proprietary TPRO* ST computer modeling software, offers maximum protection against low-temperature-related production problems like hydrate, paraffin and wax formation. The insulating annular fluid is compatible with a wide range of fluids, elastomers, and other components. SAFETHERM packer fluid has a Class E environmental designation for the North Sea and for Gulf of Mexico applications contains no free oil and produces no sheen.



SAFETHERM creates an insulating barrier that eliminates temperature loss in the production fluids during shut-in or steady-state production

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Completion Fluids Filtration

Filtration: Filtration Equipment

A complete service for optimizing your production with solids-free completion fluids

There is hardly any element of drilling a well today that isn't considered "critical" at some point in the well-construction process. This is definitely true of the

completion process and all the elements that comprise it, especially the purity of the completion brines.

Operators have come to rely on the filtration equipment and services from M-I SWACO to deliver solids-free brines in a safe, reliable and cost-efficient manner.

QHSE features

In addition to being newer than most of our competitors' equipment, our filtration units and other components have been outfitted for worker health and safety as well as environmental protection.

- Pollution pans and curtains
- Certified slings and shackles
- Drilled pad eyes that are certified annually
- Anti-fall devices
- Spill-containment berms
- Can handle zero-discharge fluids such as ZnBr_2
- Stainless steel connections with safety pins
- Hoses tested to maximum working pressure



Bulk DE delivery system

Since 1998, M-I SWACO has provided the industry's first bulk DE delivery system for extra convenience, safety and health protection. The totally enclosed unit features precise controls and provides a considerable list of advantages.

- Significantly reduces dust inhalation
- No lifting required, eliminates back injuries
- No sack or pallet waste
- Waterproof DE filtering media
- Simple operation and hookup; equipped with air-operated vibrators
- First in the industry
- Fine, medium, coarse DE grades available



Bulk tank



The high-efficiency filtration solutions from M-I SWACO minimize downtime and formation damage while reducing waste and environmental costs

DE filtration system equipment

The DE units from M-I SWACO utilize a proven design that is recognized not only for its effective filtration but also for reliability, low maintenance and significant environmental safeguards.

- O-ring-gasketed plates
- Blow-down valves maximize fluid recovery
- Curtains minimize spill potential
- Hose construction
 - Open/close ball valves
 - Stainless steel fittings
 - Designed to eliminate spillage of trapped fluids
 - Pressure tested and certified
- Backup hydraulic systems



Backup hydraulic power-pack unit

Oil and grease remediation services

M-I SWACO can use existing technology to effectively remove organic components that cause failure of static sheen test. This will reduce completion fluid oil and grease values to levels acceptable for discharge.

- Various grades of DE filter media
- Media additives tailored for oil and grease removal
- Specially designed, oil-adsorbing cartridges; one replaces ten 2.5 in. (64 mm) standard cartridges of similar length
- Plant-reclaimed fluids pass oil and grease specification
 - This process has been used successfully on offshore and land locations. M-I SWACO utilizes it to reclaim oil-contaminated fluid returned to its completion fluid plants

Onshore reclamation services

After onshore reclamation, M-I SWACO certifies that the levels of oil and grease will meet NPDES permit (or similar) requirements and that reclaimed fluids will meet new-fluids specifications. For fluids with densities greater than 11.6 lb/gal (1.4 kg/L), M-I SWACO

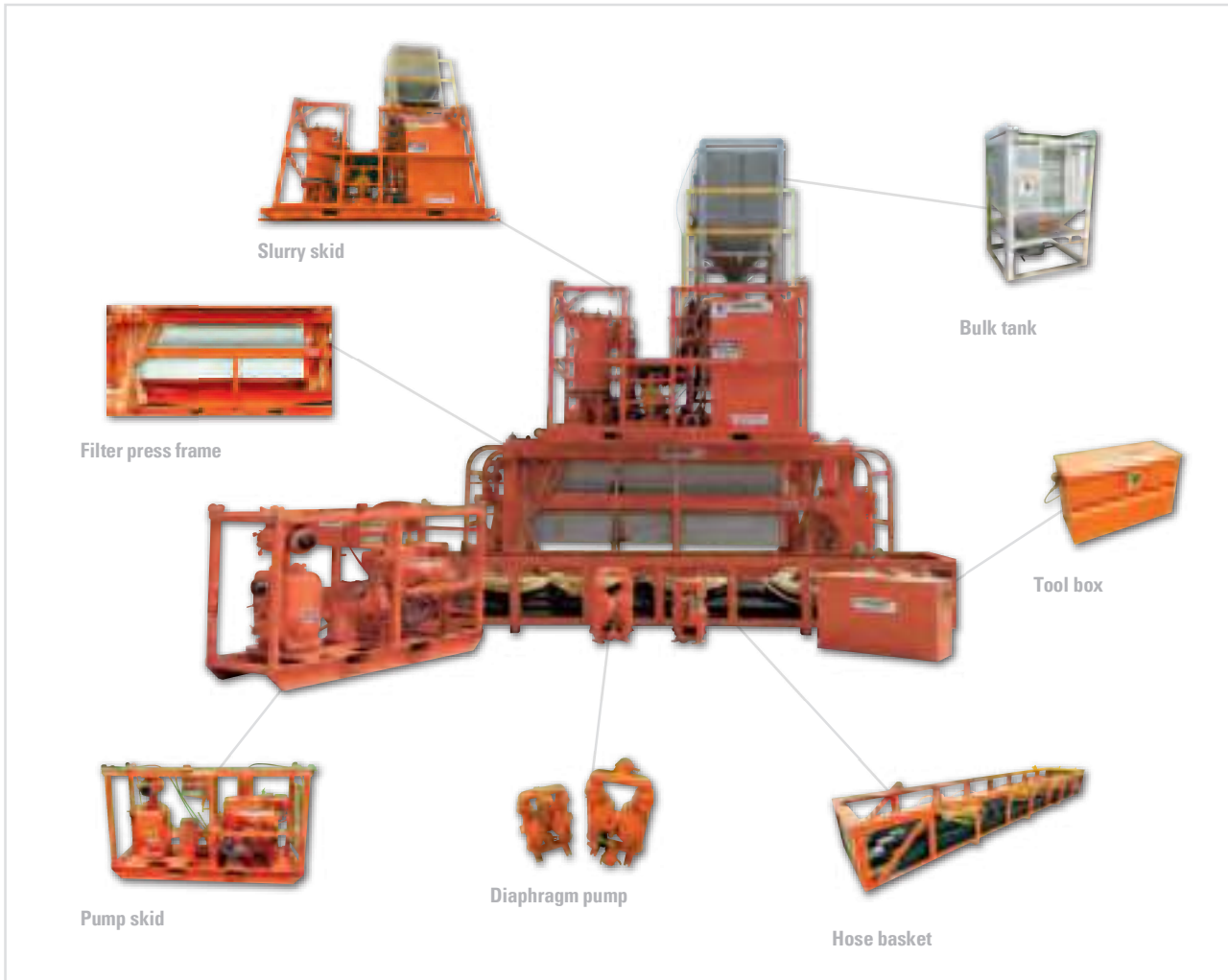
guarantees immediate credit after completion of the wellbore, based upon agreed-to volume and density losses. All charges associated with the disposal of oil, sludge, spent DE and other waste materials resulting from the reclamation are absorbed by the operator.

Typical service parameters

Type of Fluid	Expected Solids Loading	Filtration Package
Fresh seawater	Low	2 or 10 micron filters
Light brine: NaCl/KCl	Low	2 or 10 micron filters
Medium-weight brine: CaCl ₂ , NaHCO ₂	Low	2 or 10 micron filters
Medium-weight brine: CaCl ₂ , CaBr ₂	High	DE and 2 or 10 micron filters
Heavy-weight brine: NaBr, CaBr ₂ , KHCO ₂	Low/high	DE and 2 or 10 micron filters
Very heavy-weight brine: ZnBr ₂ , CsF, NaHCO ₂	High	DE and 2 or 10 micron filters



Dual pod unit



Features and advantages

- New, well-maintained equipment
- Customizable DE filtration
- Specially designed cartridge filtration
- Flexible equipment configurations
- Well-trained technicians
- Oil and grease remediation
- Filtration solutions for all brines
- Bulk DE delivery system
- Greater filtration efficiency
- Less waste
- Environmental compliance
- Healthier working environment
- Two chemical-injection diaphragm pumps
- Platinum-grade cartridges – 33% more efficient than standard stick-type
- Thiocyanate removal
- DE filtration press and slurry skids are stackable for tight spaces
- Backup hydraulic pump

DE Filtration Units plate and frame skid

Filtration: Filtration Equipment



Safety and operational considerations

- M-I SWACO provides ladders with each unit
- Retractable lanyard fall-protection devices
- Slurry skids equipped with handrails
- Diatomaceous Earth (DE) bulk tanks reduce back injuries associated with handling sacks
- Safe working and operating conditions require 3 ft (0.9 m) clearance around equipment
- All DE filtration presses and slurry skids stackable
- Maximum filtration rates 12 to 14 bbl/min (1.9 to 2.2 m³/min) (clean fluid with little or no solids). Accounting for solids and density, the average filtration rate is 10 bbl/min (1.6 m³/min). Factors that affect filtration rates are density, viscosity and solids loading. Mechanically, filtration rates are decreased as the length of the pump suction increases
- Average DE filtration capacity (lb/bbl) depends upon viscosity, density and solids loading
- Average number of filtration cycles depends upon viscosity, density and solids loading

Operating specifications

- Cake thickness, in. (mm): 1¼ (32)
- Plate size, in. (mm): 47 x 47 (1,200 x 1,200)
- Filter cloths/polypropylene with sewn-in, high-density cord for caulked-in-place installation
- Recessed, center-feed, alternating four-corner discharge
- Material of construction: polypropylene
- Gasket sealing area with EPDM elastomer O-ring-type gaskets
- Fully ported
- Maximum operating pressure 100 psi (7 bar) @ 120°F (49°C) operating temperature

Filter press frame

- Oil-rig-style
- Design pressure: 100 psi (7 bar)
- Full-width, 304 stainless steel sidebar caps
- 304 stainless steel sluice pan, welded in place: 36 in. (914 mm) deep with 12 in. (305 mm) slope end to end
- Lifting eyes certified tested
- Mounting pad for sluice pump
- Forklift slots in base



Hydraulic closing system

- Double-acting hydraulic cylinder
- Stainless steel cylinder rod
- Dual Haskel[^] hydraulic pumps

Paint system

- White sandblast to SSPC-SP10 material preparation
- Special, three-coat Carboline[^] paint system

Feed and discharge manifold

- Material of construction: schedule 20, 304 stainless steel
- PVC butterfly valves
- 4 in. (102 mm) inlet and outlet connections
- Manual valve actuation



Slurry skid

- Size, L x W x H, ft (m): 14 x 8 x 7.5 (4 x 2 x 2.29)
- Weight, lb (kg): 8,000 (3,629)
- Equipped with a dual-pod cartridge unit containing a total of 10 uniquely designed, 6½ in. (165 mm) OD, platinum-grade cartridges or 30 standard, 2½ in. (64 mm) OD cartridges. (Platinum-grade cartridges are 33% more efficient than standard stick-type)
- Each cartridge is 40 in. (1,016 mm) long
- It takes approximately 10 min to change a set of 10 cartridges; easy disposal
- The slurry skid may be stacked on top of the filter press
- Ladder and retractable lanyard device for fall protection included



Pump skid

- Size, L x W x H, ft (m): 10.42 x 3 x 6.42 (3.18 x 0.9 x 1.96)
- Weight, lb (kg): 3,500 (1,587)
- Engine manufacturer: Deutz[^]
 - Displacement, in.³ (cc): 353/371 (5,785/6,080)
 - Output, hp: 85
- Pump manufacturer: Gorman-Rupp[^] UBB60-B
 - Size, in. (mm): 4 x 4 (102 x 102)
 - Self-Priming Centrifugal
 - Output: 14½ bbl/min @ 75 psi (5 bar)
- The 1600, 1500, 1200 and 800 DE filtration presses and slurry skids are stackable
- Maximum filtration rates are 12 to 14 bbl/min (1.9 to 2.2 m³/min) for clean fluid with little or no solids-loading; lower with increased solids-loading

[^]Haskel is a mark of Haskel International, Inc.

[^]Carboline is a mark of Carboline Company.

[^]Deutz is a mark of Deutz AG Corporation.

[^]Gorman-Rupp is a mark of Gorman-Rupp Company.



Miscellaneous and safety equipment

DE Bulk Tanks

- Size, L x W x H, ft (m): 4 x 5 x 7.42 (1 x 2 x 2.26)
- DE bulk tanks hold 1,800 lb (816 kg) of DE
- DE bulk tanks weigh 850 lb (386 kg) empty

DE Sack Material

- DE available in 25 and 50 lb (11 and 23 kg) sacks



Chemical Injection Diaphragm Pump

- Type: Air
- Size, in. (mm): 2 (51) and 3 (76)
- Manufacturer: Versa-Matic[^]



Hose Basket

- Size, L x W x H, ft (m): 22 x 4 x 3 (7 x 1 x 0.9)
- Weight, lb (kg): 4,500 (2,041)
- Hose lengths and sizes:
 - Most hoses are available in 20 ft (6.1 m) sections rented by the foot
 - 4 in. (102 mm) suction and discharge hose with stainless steel safety lock camlock connections
 - 3 in. (76 mm) suction and discharge hose with stainless steel safety lock camlock connections
 - 2 in. (51 mm) suction and discharge hose with stainless steel safety lock camlock connections
- All hoses are pressure-tested, certified and have stainless steel connections
- 1 in. (25 mm) air hose with brass safety crow connection is available in 25 and 50 ft (8 and 15 m) sections

[^]Versa-Matic is a mark of Versa-Matic Tool, Inc.

Specifications				
Filtration unit	1,600 ft ² DE Filtration Unit (149 m ²) plate and frame skid	1,500 ft ² DE Filtration Unit (139 m ²) plate and frame skid	1,200 ft ² DE Filtration Unit (111 m ²) plate and frame skid	800 ft ² DE Filtration Unit (74 m ²) plate and frame skid
Unit size, ft ² (m ²)	1,600 (149)	1,500 (139)	1,200 (111)	800 (74)
Plates	64	60	45	33
Manufacturer	JWI [^] (Siemens [^])	JWI (Siemens)	JWI (Siemens)	JWI (Siemens)
Size, L x W x H, ft (m)	23.25 x 9 x 7.75 (709 x 3 x 2.36)	23.25 x 9 x 7.75 (709 x 3 x 2.36)	22 x 4 x 7.17 (7 x 1 x 2.19)	16.75 x 4.76 x 7.17 (5.11 x 1.5 x 2.19)
Weight, lb (kg)	24,000 (10,886)	24,000 (10,886)	22,000 (9,979)	20,000 (9,072)
Filtration surface area, ft ² (m ²)	1,600 (149)	1,500 (139)	1,200 (111)	800 (74)
Design operating pressure, psi (bar)	100 (7)	100 (7)	100 (7)	100 (7)

[^]JWI is a mark of Siemens Water Technologies Holding Corp.[^]Siemens is a mark of Siemens Aktiengesellschaft Corporation.

Equipment

Filtration: Filtration Equipment



Centrifugal pump

- 4 x 4 ft (1 x 1 m) NPT female connections
- Open-type, 6-vane impeller 40-50-18 ductile iron
- No. 20 gray-iron casing (max. operating 130 psi [9 bar])
- Handles 1½ in. (29 mm) spherical solids
- Oil sight glass
- Brass pressure-relief valve
- Oil-lubricated silicon carbide vs. tungsten carbide mechanical seal
- Maximum temperature of liquid pumped: 160°F (71°C)
- Buna N O-ring
- Double discharge fitting of stainless steel material
- Dodge[^] Para-Flex[^] coupling



Cargo boxes

- Unit size L x W x H, ft (m): 6 x 6 x 9.33 (2 x 2 x 2.84)
- Weight, lb (kg) empty: 8,000 (3,629)



Dual pod unit

- Skid size L x W x H, ft (m): 7 x 3 x 6.5 (2 x 1 x 1.98)
- Weight, lb (kg): 2,000 (907)
- Number of cartridges: 10
- Hoses (25 ft [7.6 m] sections): 25 ft (7.6 m) of suction and 25 ft (7.6 m) of discharge



M-I SWACO blending tank

- Size, L x W x H, ft (m): 9.42 x 8 x 9.5 (2.87 x 2 x 2.9)
- Weight, lb (kg): 6,000 (2,722)
- Capacity, bbl (m³): 65 (10.3)
- Jetted chemical hopper

Hydraulic power pack

- Size, L x W x H, ft (m): 7.5 x 3.42 x 5 (2.29 x 1.04 x 1.52)
- Weight, lb (kg): 4,000 (1,814)
- Engine manufacturer: Deutz
 - Displacement, in.³ (cc): 353/371 (5,785/6,080)
 - Output, hp: 72
 - Panel with oil-pressure and temperature gauges equipped with safety shutdown
 - Cast-iron manifold
 - Spark-arrestor muffler
 - Manual Chalmatic air intake shutdown
 - Oil-bath air cleaner
 - V-belt shutdown
 - Hand throttle, rigid mounts
 - PTO clutch
- Hoses (hydraulic hoses), ft (m): 80 (24)

[^]Dodge and Para-Flex are marks of Baldor Electric Company.

Filter Press Package (Unit)

Filtration: Filtration Equipment

The Filter Press Unit is used as part of a filter package and is typically the first point of filtration for completion brines.

Applications

Inexpensive Diatomaceous Earth (DE) filter media is used in the Filter Press Unit from M-I SWACO WELLBORE PRODUCTIVITY to remove heavy solids contamination from high volumes of brines.

How it works

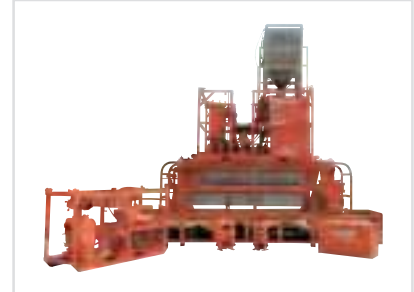
The Filter Press Unit is always used with a guard filter placed downstream to catch any possible DE bleed-off. When a twin-vessel cartridge unit is used downstream from the Filter Press Unit, it provides a polish filter.

Features

- Gasketed polypropylene filter plates and cloths for zero fluid loss
- Hydraulic-ram closure with pneumatically powered hydraulic pump and manual standby pump in case of air-supply failure
- Compact, rugged carbon steel construction with transport/lifting frame and slings
- Integral slurry pan for wash-down of filter cake
- Inlet/outlet manifold in 316 stainless steel complete with blowdown system for fluid recovery

Advantages

- Removal of heavy solids contamination from high volumes of fluid



FILTER FLOC

Filtration: Filtration/Reclamation Chemistry

FILTER FLOC* polymer is a suspension designed to flocculate residual displacement solids in a manner that facilitates removal from a brine-base completion fluid. By flocculating the residual displacement solids, the contaminant can be easily transported

to the surface and removed through the brine filtration process.

For completion fluid applications, FILTER FLOC polymer is applied as a spacer in the displacement train. FILTER FLOC additive is intended for use in freshwater, seawater, monovalent,

and calcium brine fluids. FILTER FLOC additive can also be utilized in the reclamation of completion fluid brines. For reclamation applications, optimum FILTER FLOC polymer additions are determined through pilot testing.

SAFE-FLOC I

Filtration: Filtration Equipment/Filtration/Reclamation Chemistry

Advantages

- Can be separated from the carrier fluid by gravity separation, minimizing environmental impact
- Significantly reduces filtration and displacement time, saving rig costs
- Water dispersible

SAFE-FLOC* I flocculant and filtration aid is a blend of ionic and nonionic surfactants, flocculants and high flash-point solvents designed to flocculate and suspend insoluble iron solids. These iron solids normally come from fluid reaction with the mill scale left on the drill pipe, casing or, other tubular products in the wellbore. The solids are made oil-wet, emulsified and carried away from the surfaces of the steel pipe. This mechanism ensures that the solids remain in suspension and are carried out of the wellbore or float to the surface of a tank. The water or brine below the surface is decontaminated allowing faster filtration rates and longer filtration cycles.

Applications

SAFE-FLOC I flocculant and filtration aid is designed specifically for use in oil and gas wells for clean-up prior to the start of production and as a filtration aid. Applied as a spacer, it is used as a solution in fresh or seawater in solutions between 1 and 3% by volume. Higher concentrations may be used where higher levels of iron exist in the wellbore. It can also be used in the reclamation process of heavy brine systems.

No claim of personal safety is intended nor implied by the use of the name SAFE in this product. Personnel handling this material should read and follow all safety and handling procedures set forth in the Material Safety Data Sheet.

SAFE-FLOC II

Filtration: Filtration Equipment/Filtration/Reclamation Chemistry

SAFE-FLOC*II flocculant and filtration aid is a blend of surfactants and solvents designed to suspend solids from oil-base drilling fluid and transport them from the well. Solids from the drilling mud, pipe dope and mineral scale are made oil-wet and emulsified. This mechanism ensures that the solids remain in suspension and are carried out of the well.

Applications

The SAFE-FLOC*II flocculant and filtration aid is designed specifically for downhole use in oil and gas wells for clean-up prior to the start of production and as

a filtration aid. It can also be used to flocculate dispersed mud solids in a completion fluid and float the solids to the surface of a holding tank. This allows the fluid below the surface to be filtered at a much faster rate and with longer filtration cycles.

The flocculant and filtration aid is applied as a spacer, it is used as a solution in fresh or seawater in solutions between 1 and 4% by volume. Higher concentrations may be used where higher levels of hydrocarbon exist in the mud to be displaced.

Advantages

- Solids are made oil-wet and emulsified to ensure they are removed from the wellbore
- Can be separated from the carrier fluid by gravity separation, minimizing environmental impact
- Significantly reduces filtration and displacement time, saving rig costs

No claim of personal safety is intended nor implied by the use of the name SAFE in this product. Personnel handling this material should read and follow all safety and handling procedures set forth in the Material Safety Data Sheet.

Completion Products

Reservoir drill-in fluids				
Product Trade Name	Description	System Type	Primary Function	Secondary Function
DEFOAM-A*	Alcohol-base defoamer	Water	Defoamer	—
DEFOAM-X*	All-purpose liquid defoamer	Water	Defoamer	—
DI-ANTIFOAM*	Antifoaming agent for the DiPRO system	DiPRO	Defoamer	—
DI-BALANCE*	Viscosifier for the DiPRO system	DiPRO	Viscosifier	pH control
DI-BOOST*	Secondary viscosifier for the DiPRO system	DiPRO	Viscosifier	—
DI-INHIB*	Shale inhibitor for the DiPRO system	DiPRO	Shale inhibitor	—
DiPRO	Divalent Brine based biopolymer free RDF system	DiPRO	—	—
DI-TROL*	Filtration control agent for the DiPRO system	DiPRO	Filtration	Viscosifier
DUAL-FLO*	Fluid-loss reducer for the FLOPRO NT system	FLOPRO NT	Filtration	Viscosifier
DUAL-FLO HT	Fluid-loss reducer for high-temperature applications	FLOPRO NT	Filtration	Viscosifier
FAZE-MUL*	Emulsifier for FAZEPRO system	FAZEPRO	Emulsifier	—
FAZEPRO	Reversible Invert Emulsion RDF system	FAZEPRO	—	—
FAZE-WET*	Wetting agent for the FAZEPRO system	FAZEPRO	Filtration	Emulsifier
FLOPRO NT	Water based RDF System	FLOPRO NT	—	—
FLOPRO NT w/KLA-STOP	Water based RDF system with enhanced shale inhibition	FLOPRO NT	—	—
FLOPRO SF	Solids free water based RDF system	FLOPRO SF	—	—
FLOTHRU	Water based RDF system with organophillic filter cake	FLOTHRU	—	—
FLO-TROL*	Starch derivative	FLOPRO NT	Filtration	Viscosifier
FLO-VIS* L	Liquid non-dispersible, clarified xanthan gum	FLOPRO NT	Viscosifier	—
FLO-VIS PLUS	Premium-grade, clarified xanthan gum	FLOPRO NT	Viscosifier	—
FLO-WATE*	Sized-salt material	FLOPRO NT	Filtration	Density
FORMIX TECHNOLOGY	Formate based RDF systems	FLOPRO NT	—	—
GLYDRIL* MC	Medium-cloud-point polyglycol for moderate-salinity fluids and high temperatures	Water	Shale control	Lubricity
HRP*	Liquid viscosifier for oil-base fluids	Oil	Viscosifier	Thermal stability
K-52*	Potassium supplement	FLOPRO NT	Shale control	—
KLA-CURE*	Hydration suppressant	FLOPRO NT	Shale control	—
KLA-CURE II	Hydration suppressant plus detergent	FLOPRO NT	Shale control	—
KLA-GARD*	Shale stabilizer and inhibitor	FLOPRO NT	Shale control	—
KLA-GARD B	Salt-free KLA-GARD	FLOPRO NT	Shale control	—
KLA-STOP*	Shale inhibitor	FLOPRO NT	Shale control	—
LUBE-100*	Low-toxicity lubricant	Water	Lubricant	—
LUBE-167*	Low-toxicity lubricant blend	Water	Lubricant	—
LUBE-776*	Lubricant	Water	Lubricant	—
M-I CIDE*	Biocide – Not available in the U.S.A.	Water	Biocide	—
NOVAMOD*	Rheology modifier, LSRV	Synthetic	Viscosifier	—
NOVAMUL*	Basic emulsifier package	Synthetic	Emulsifier	Surfactant Filtration Viscosifier
NOVAPRO/ VERSAPRO/ PARAPRO	Invert emulsion based RDF systems	NOVAPRO/ VERSAPRO/ PARAPRO	—	—
NOVAWET*	Wetting agent	Synthetic	Surfactant	Emulsifier Thinner Thermal stability
OS-1L*	Sulfite-base oxygen scavenger	Water	Corrosion inhibitor	Thermal stability
PTS-200*	Polymeric temperature stabilizer	Water	Thermal stability	—
SAFE-CARB*	Ground marble (calcium carbonate)	Water Oil Synthetic	Filtration	Density
STARGLIDE*	Lubricant and ROP enhancer	FLOPRO NT	Lubricant	—

Reservoir drill-in fluids				
Product Trade Name	Description	System Type	Primary Function	Secondary Function
SUREMOD*	Viscosifier, gelling agent for invert-emulsion systems	Synthetic	Viscosifier	—
SUREMUL*	Primary emulsifier for invert-emulsion systems	Synthetic Oil	Emulsifier	Surfactant
SURETHIK*	Rheological modifier	Synthetic	Viscosifier	—
SURETHIN*	Thinner for invert-emulsion systems	Synthetic Oil	Thinner	Surfactant
SUREWET*	Wetting agent for invert-emulsion systems	Synthetic Oil	Surfactant	Emulsifier
SV-120*	Organic H ₂ S scavenger	Water	Corrosion inhibitor	—
THRUCARB*	Carbonate for the FLOTHRU* system	FLOTHRU	Filtration	—
THRUTROL*	Organic starch for the FLOTHRU system	FLOTHRU	Filtration	Viscosifier
TRUVIS*	Viscosifier for the TRUDRIL system	Oil	Viscosifier	Filtration
VERSAGEL* HT	Hectorite	Oil	Viscosifier	Filtration
VERSALUBE*	Oil-soluble lubricant	Oil	Lubricant	—
VERSAMOD*	Rheology modifier, LSRV	Oil	Viscosifier	—
VERSAMUL*	Basic emulsifier package	Oil	Emulsifier	Surfactant Filtration Thermal stability Viscosifier
VERSAPAC*	Thermally activated, organic thixotrope	Oil Synthetic	Viscosifier	Lost circulation
VERSAPRO LS/SF	Low Solids and Solids Free invert emulsion based RDF systems	VersaPro LS/SF	—	—
VERSAPRO* P/S	Primary emulsifier for VERSAPRO	Oil	Emulsifier	—
VERSATHIN*	Thinner and conditioner for oil-base fluids	Oil	Thinner	—
VERSAWET*	Wetting agent for oil-base fluids	Oil	Surfactant	Emulsifier Thinner Thermal stability
VG-69*	Organophilic clay	Oil	Viscosifier	Filtration
VG-PLUS*	Organophilic clay	Oil Synthetic	Viscosifier	Filtration
VG-SUPREME*	Organophilic clay	Synthetic	Viscosifier	Filtration
WARP	Micronized barite based RDF systems	Oil Synthetic	—	—

Intervention fluids

Product Trade Name	Description	System Type	Primary Function	Secondary Function
FLODENSE* AP	Water-base system to control annular pressure buildup	Water	Casing pressure control	—
FLOPRO* CT	Fluid to remove solids from well during coiled-tubing intervention	Water	Hole cleaning	—

Breakers

Product Trade Name	Description	System Type	Primary Function	Secondary Function
D-SOLVER*	Chelant filter-cake remover	FAZEBREAK BREAKDOWN	Breaker	—
D-SOLVER HD	High density chelant filter-cake remover	BREAKDOWN HD FAZE-OUT/ VERSA-OUT	Breaker	Scale Inhibitor
D-SOLVER D	Dry chelant filter cake remover	BREAKDOWN HD	Breaker	—
D-SOLVER PLUS	Chelant plus acid filter-cake remover	FAZEBREAK BREAKDOWN	Breaker	—
D-SPERSE*	Surfactant	BREAKFREE BREAKDOWN	Surfactant	—
D-STRUCTOR*	Acid precursor	VERSA-OUT FAZE-OUT		—
D-STROYER*	Encapsulated oxidizer – internal breaker	Water	Breaker	—
SAFE-BREAK* MP	Internal breaker encapsulated	Water	Breaker	—
WELLZYME* A	Enzyme breaker for water-base reservoir drill-in fluid	BREAKFREE BREAKDOWN	Starch breaker	—
WELLZYME NS	Enzyme breaker for water-base reservoir drill-in fluid	BREAKFREE BREAKDOWN	Starch breaker	—
			Density Range	
			lb/gal	kg/L
BREAKDOWN*	Enzyme-chelant-base system	—	8.3 – 12	1 – 1.4
BREAKFREE*	Enzyme-base system	—	8.3 – 12	1 – 1.4
BREAKLOOSE*	Oxidizer-base system	—	8.3 – 12	1 – 1.4
FAZE-AWAY*	Invert-emulsion-base breaker for FAZEPRO filter cakes	—	7.8 – 10.5	0.9 – 1.3
FAZE-OUT*	Water-base breaker for FAZEPRO filter cakes	—	8.8 – 10.5	1.1 – 1.3
FAZEBREAK*	Chelant-base breaker for FAZEPRO filter cakes	—	8.8 – 9.5	1.1 – 1.1
VERSA-OUT*	Water-base breaker for conventional invert-emulsion filter cakes	—	8.8 – 10.5	1.1– 1.3
VERSA-WAY*	Invert-emulsion-base breaker for conventional invert-emulsion filter cakes	—	7.8 – 10.5	0.9 – 1.3

Spacer and displacement chemicals

Product Trade Name	Description	System Type	Primary Function	Secondary Function
DEEPCLEAN	IEM displacement solvent/surfactant	Spacer	Solvent	Surfactant
DUO-VIS* L	Liquid xanthan	Spacer	Viscosifier	—
POWERVIS	Biopolymer viscosifier	FLOPRO SF	Viscosifier	
SAFE-SOLV 148	IEM displacement solvent	Spacer	Solvent	
SAFE-SOLV* E	IEM displacement solvent	Spacer	Solvent	—
SAFE-SOLV OE	IEM displacement solvent	Spacer	Solvent	—
SAFE-SOLV OM	IEM displacement solvent	Spacer	Solvent	—
SAFE-SURF* E	IEM displacement surfactant	Spacer	Surfactant	—
SAFE-SURF NS	IEM displacement surfactant	Spacer	Surfactant	—
SAFE-SURF O	IEM displacement surfactant	Spacer	Surfactant	—
SAFE-SURF W	WBM displacement surfactant	Spacer	Surfactant	—
SAFE-SURF WN	WBM displacement surfactant	Spacer	Surfactant	—
SAFE-T-PICKLE	Pipe dope pickle solvent	Spacer	Solvent	—
SAFE-VIS* E	Liquid HEC	Spacer	Viscosifier	—
SAFE-VIS OGS	Liquid HEC	Spacer	Viscosifier	—
SAFE-VIS HDE	Liquid HEC	Spacer	Viscosifier	—

Fluid-loss-control systems

Product Trade Name	Description	System Type	Primary Function	Secondary Function
PERF-N-PEEL*	Fluid-loss-control system for perforating applications	Water	—	—
SAFE-VIS	HEC	Water	Lost circulation	Viscosifier
SAFE-VIS E	Liquid HEC	Water	Lost circulation	Viscosifier
SAFE-VIS HDE	Liquid HEC	Water	Lost circulation	Viscosifier
SAFE-VIS LE	Liquid HEC	Water	Lost circulation	Viscosifier
SAFE-VIS OGS	Liquid HEC	Water	Lost circulation	Viscosifier
			Density Range	
			lb/gal	kg/L
CLEANPERF*	Fluid-loss-control system for PURE perforating applications	Water	—	—
SAFE-LINK* 110	Solids-free loss-control fluid pill using 11 lb/gal (1.3 kg/L) CaCl ₂	—	8.4 – 11	1 – 1.3
SAFE-LINK* 140	Completion fluid pill using 14 lb/gal (1.7 kg/L) CaBr ₂	—	8.4 – 14	1 – 1.7
SEAL-N-PEEL*	Fluid-loss-control system designed to seal inside sand-control screen	—	8.4 – 17.5	1 – 2.1

Clear brine fluids and additives

Product Trade Name	Description	System Type	Primary Function	Secondary Function
KLA-GARD*	Shale stabilizer and inhibitor	Water	Shale control	Filtration
KLA-GARD B	Salt-free KLA-GARD	Water	Shale inhibitor	—
KLA-STOP*	Shale inhibitor	Water	Shale control	—
SAFE-BREAK* 611	Non-emulsifier	Monovalent brine	Non-emulsifier	—
SAFE-BREAK CBF	Non-emulsifier	Divalent brine	Non-emulsifier	—
SAFE-BREAK ZINC	Non-emulsifier	Zinc brine	Non-emulsifier	—
SAFE-SCAV* HS	H ₂ S scavenger	Water Brine	H ₂ S scavenger	—
SAFE-SCAV HSW	H ₂ S scavenger	Water Brine	H ₂ S scavenger	—
SAFE-SCAVITE* II	Scale inhibitor	Water	Scale inhibitor	—
SI-1000*	Scale inhibitor	Water	Scale inhibitor	—
			Density Range	
			lb/gal	kg/L
Calcium Bromide	Single-salt inorganic brine	—	8.4 – 15.1	1 – 1.8
Calcium Bromide/ Calcium Chloride	Two-salt inorganic brine	—	11.7 – 15.1	1.4 – 1.8
Calcium Chloride	Single-salt inorganic brine	—	8.4 – 11.6	1 – 1.4
Potassium Chloride	Single-salt inorganic brine	—	8.4 – 9.7	1 – 1.2
Potassium Formate	Single-salt organic brine	—	8.4 – 13	1 – 1.6
Sodium Bromide	Single-salt inorganic brine	—	8.4 – 12.5	1 – 1.5
Sodium Bromide/ Sodium Chloride	Two-salt inorganic brine	—	10 – 12.7	1.2 – 1.5
Sodium Chloride	Single-salt inorganic brine	—	8.4 – 10	1 – 1.2
Sodium Formate	Single-salt organic brine	—	8.4 – 11	1 – 1.3
Zinc Bromide/ Calcium Bromide	Two-salt inorganic brine	—	14.2 – 19.2	1.7 – 2.3
Zinc Bromide/ Calcium Bromide/ Calcium Chloride	Three-salt inorganic brine	—	15.2 – 19.2	1.8 – 2.3

Packer fluids products and systems

Product Trade Name	Description	System Type	Primary Function	Secondary Function
DOWFROST MI*	Low-temperature product	Water	Antifreeze	—
ISO THERM*	Oil-base insulating packer fluid	—	7.5	0.9
M-I CIDE*	Biocide – Not available in the U.S.A.	Water	Biocide	—
OS-1L	Sulfite-base oxygen scavenger	Water	Oxygen scavenger	Thermal stability
SAFE-COR C	Corrosion inhibitor	Brine	Corrosion inhibitor	—
SAFE-COR EN	Corrosion inhibitor	Brine	Corrosion inhibitor	—
SAFE-COR HT	Corrosion inhibitor	Brine	Corrosion inhibitor	—
SAFE-SCAV* CA	Non-sulfur Oxygen Scavenger	Calcium brine	Oxygen scavenger	—
SAFE-SCAV NA	Oxygen scavenger	Monovalent brine	Oxygen scavenger	—
			Density Range	
			lb/gal	kg/L
SAFETHERM*	Water-base or water-miscible insulating packer fluid	—	9 – 12	1.1 – 1.4

Filtration/reclamation chemistry

Product Trade Name	Description	System Type	Primary Function	Secondary Function
FILTER FLOC*	Polymeric flocculant	Brine	Solids flocculant	—
SAFE-FLOC* I	Surfactant/polymeric flocculant	Brine	Iron flocculant	—
SAFE-FLOC II	Surfactant flocculant	Brine after IEM	Solids flocculant	—



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