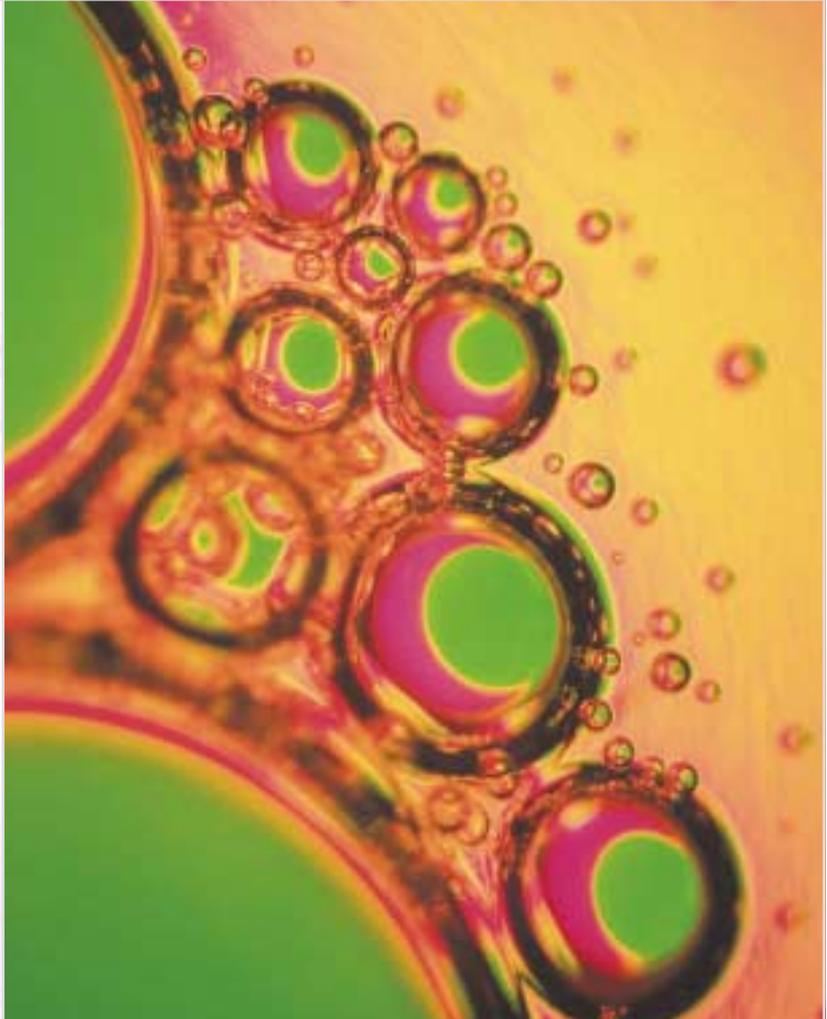


# The APHRON ICS Invasion-Control System

*Micro bubbles.  
Macro results.*



**Mi SWACO**

*Customer-focused, solutions-driven*



*The APHRONICS® system is an engineered, high-performance drilling fluid that reduces your risks of invasion and lost circulation while lowering your overall well-construction costs.*

## Features

- Tough, stable microbubbles
- High LSRV
- Reduces the effects of high-pressure differentials
- Good cuttings transport
- Can be used in low-pressure environments
- Customized design and selection software

## Benefits

- Improved drilling efficiency
- Easier drilling in high-angle and horizontal wells
- Reduces lost circulation and risk of stuck pipe
- UBD alternative
- Improved field economics
- Environmentally acceptable
- Significantly reduces cleanup times and costs

# APHRON ICS technology closes the door on formation invasion, opens the door to a range of drilling applications



## APPLICATIONS

Wells being drilled in depleted reservoirs or any geology characterized by porous sands or laminated sequences of sand and shale. Also, some applications where underbalanced drilling is the only option.

## PROBLEMS

When drilling sand and sand/shale sequences, operators must often use extra casing strings or costly underbalanced-drilling techniques.

## SOLUTIONS

The water-base APHRON ICS\* system uses microbubble (“aphron”) technology to stabilize problem zones. When a low-pressure zone is encountered, the tough aphones enter the formation and expand to equalize formation pressure.

## ECONOMICS

The APHRON ICS system gives operators a way to access reserves economically in depleted reservoirs. By reducing lost circulation and stuck-pipe incidents, the system further reduces drilling costs.

## ENVIRONMENTAL

Its water-base formulation makes the APHRON ICS system acceptable in most drilling areas. The organic, biodegradable polymers and non-caustic pH materials provide a balance between operational efficiency and environmental acceptability.

The APHRON ICS (Invasion-Control System) system is an engineered drilling-fluid system that controls losses in depleted, high-porosity sands while stabilizing pressured shales. This means you can use conventional drilling equipment to successfully complete many reservoirs that previously would have been candidates only for underbalanced drilling.

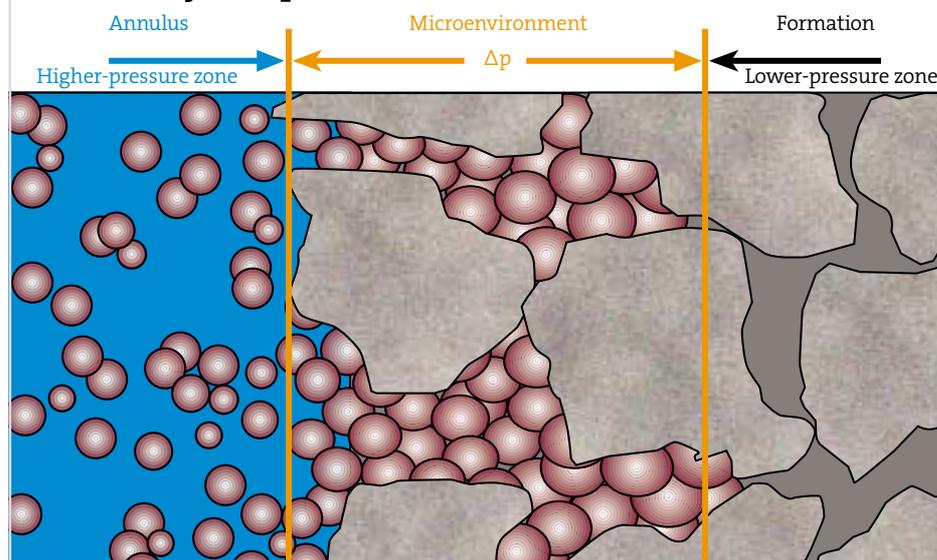
The system increases shale stability, thereby greatly reducing drilling problems commonly associated with laminated sand/shale sequences. The APHRON ICS design software, which tailors the system to your well, and the fluid’s ability to control losses significantly decrease the potential for differential sticking and other fluid-related problems.

The outstanding performance of this system makes it a sound economic option for:

- Underbalanced drilling
- Areas where lost-circulation material has proven ineffective in controlling drilling-fluid losses or in providing desired bridging
- High-angle/horizontal wells
- Depleted formations coexisting with normally pressured formations

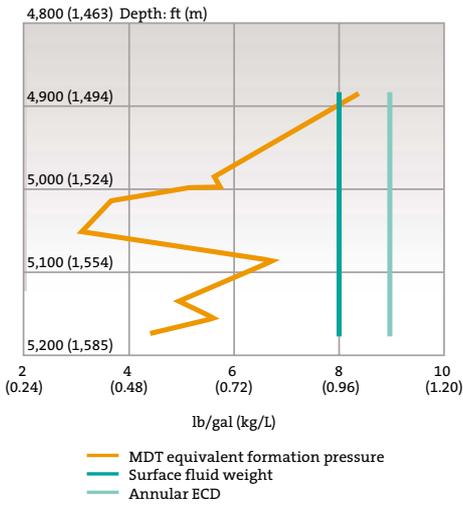
The excellent condition of the final borehole significantly improves the acquisition and quality of data obtained with electronic logs, and promotes optimum results from MWD tools.

## How the system protects sensitive formations



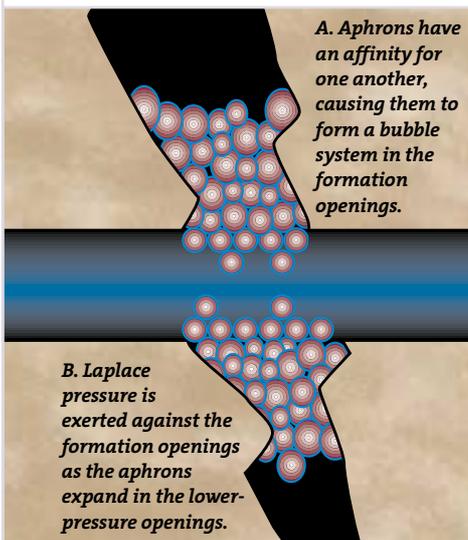
The water-base APHRON ICS invasion-control system uses stable, energized microbubbles of air (“aphrons”) to control losses to troublesome formations. When a low-pressure zone is drilled, the aphones enter the formation where they expand to equalize formation pressure, effectively protecting the formation from fluid invasion. Standard rig equipment and mixing-hopper turbulence are the only requirements for creating the aphones. This system should not be confused with foam drilling; it requires no external air source.

## Pressure Analysis of APHRON ICS Performance



Although this interval had a severe drop in pore pressure (from 7 to 3 lb/gal [0.84 to 0.36 kg/L] equivalent), the APHRON ICS system controlled losses to the formation. A 9-lb/gal (1.08-kg/L) APHRON ICS fluid, exhibiting an 8-lb/gal (0.96-kg/L) surface density, was being used.

## APHRON ICS bridging mechanism



## Energized aphrons have an attraction for each other and low-pressure zones

Each aphron contains a gas nucleus of encapsulated air, and this enclosed air compresses when the micro-bubbles circulate down the hole. The internal pressure of these micro-bubbles increases at a rate proportional to the external pressure being applied. The combination of increasing pressure and temperature serve to energize the individual aphrons.

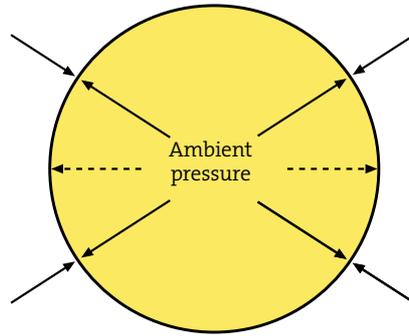
Once the bit exposes a depleted formation, the aphrons immediately

aggregate within the openings of low-pressure zones. There, a portion of the energy stored within each aphron is released, causing it to expand. The expansion continues until the internal and external pressures on the wall of the aphron are in balance.

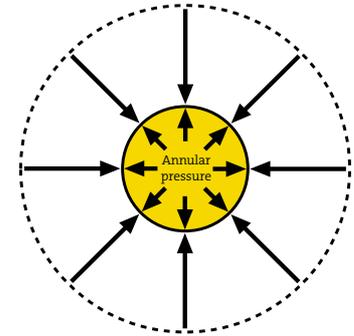
As the energized microbubbles enter formation openings, they carry energy equal to that of the annulus. As they crowd into an opening, external Laplace forces increase dramatically, causing aggregation and an increase in the internal LSRV. The microenvironment created by this phenomenon assists in reducing fluid invasion.

## The aphron energizing process

Aphron before compression



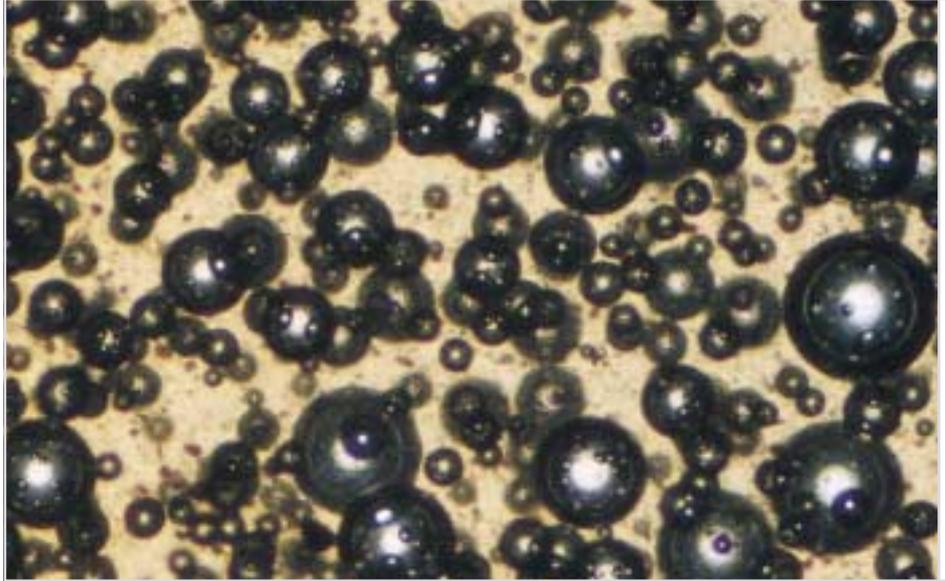
Aphron after compression



## Formulation of a Typical APHRON ICS System

Component	Functions	Formulation
Base fluid (freshwater or brine)	Provides continuous phase for system	0.974 bbl/final bbl
Soda ash	Hardness buffer	0.25 lb/bbl (0.11 kg/bbl)
GO DEVIL II*	Viscosifier	5.0 lb/bbl (2.27 kg/bbl)
ACTIVATOR I*	Fluid-loss-control and thermal stabilizer	5.0 lb/bbl (2.27 kg/bbl)
ACTIVATOR II*	pH controller	0.5 lb/bbl (0.23 kg/bbl)
BLUE STREAK*	Aphronizer	1.0 lb/bbl (0.45 kg/bbl)
M-I CIDE*	Biocide	5.0 gal/100 bbl (2.27 kg/100 bbl)

*As the aphrons crowd into a formation pore throat, external Laplace forces cause them to aggregate, while their tough outer layers cause them to form a network without coalescing or collapsing.*



## Lower drilling costs in depleted reservoirs

The APHRON ICS system's Low-Shear-Rate Viscosity (LSRV), combined with its stable microbubbles, helps you control losses when drilling through depleted reservoirs.

In addition, the flexible microbubbles enable operators to economically access reserves where depletion has altered the mechanics of the field, forcing the use of additional casing strings or costly under-balanced-drilling techniques.

## Components designed for ease of engineering and maintenance

There is nothing unusually complicated about building an APHRON ICS system or maintaining its excellent rheological properties during drilling. The high-LSRV base fluid consists of a High-Yield Stress-Shear-Thinning (HYSST) polymer coupled with proprietary components that create and stabilize the aphrons within the system. An exclusively formulated aphronizer is incorporated to reach the desired concentration of microbubbles, which typically is 8 to 14% by volume. As the concentration builds, it is not uncommon to see the Brookfield LSRV increase to between 120,000 and 160,000 cP.

Once the system is circulating, the rheological properties are easily maintained to provide optimal hole cleaning, cuttings suspension and a high degree of control over the invasion of whole drilling fluid.

Well data

Depth (ft)	3,000
APHRON ICS system mud weight (ppg)	8.33
Estimated Pore Pressure (psi)	900

Note : The orange colored fields need an input value

Depth scroll bar

Mud weight scroll bar

Pore pressure scroll bar

APHRON ICS Drilling Fluid Selection Module  
Target zone pore pressure criteria

**APHRON ICS system applicability**  
Target zone pore pressure criteria

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APHRON ICS Drilling Fluid Design Module  
Bridging material considerations

Calculated Hydrostatic Pressure (psi)	1,299
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Note: Do not type any value in the white cell above

**APHRON ICS system design**  
Bridging material considerations

Note: See the graph above for recommended bridging materials

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APHRON ICS Drilling Fluid Risk Analysis  
Type of formation criteria

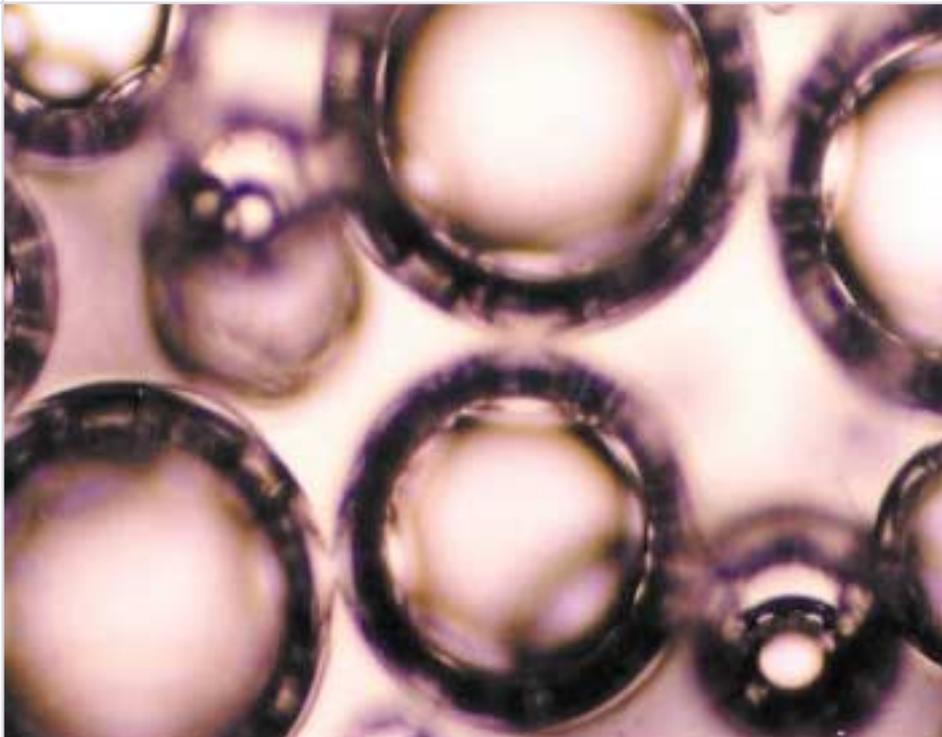
Type of Formation

- 1. Low permeability sandstone
- 2. Microfractured limestone
- 3. Microfractured shales and marls
- 4. Permeable sand or gravel
- 5. Microfractured dolomite
- 6. Fractured limestone
- 7. Fractured dolomite
- 8. Vugular/cavernuous formations

**APHRON ICS system risk analysis**  
Type of thief formation criteria

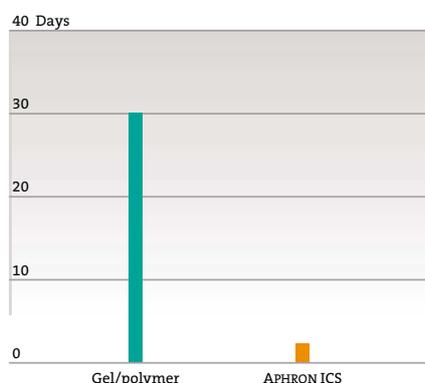
Note: Please read the help file for defining the relation between the type of formation and the bridging agent design.

Note: If the APHRON ICS system design/Bridging material considerations criteria allows, the system can be designed solids-free



*Each afoam is composed of a core of air surrounded by a tough non-coalescing shell of viscous water and the afoamizing surfactant.*

## Cleanup



*The APHRON ICS system has proved itself in the field, resulting in wells that show greatly reduced cleanup times and costs.*

## A proven producer

In hundreds of wells the world over, operators have seen firsthand the economic advantages of the APHRON ICS system. Many have been high-angle or horizontal wells, where wellbore stability and drilling efficiency have been shown to reduce construction days by as much as 50%. In some situations, intermediate casing strings have been eliminated, resulting in even greater cost savings. The microenvironment bridging has consistently and substantially improved well construction economics by mitigating drilling problems and delivering highly stable boreholes.

The APHRON ICS system simplifies completions, too. In fact, cleanup has consistently been reduced to as few as two days in high-porosity sands where 30 days had been the norm.

## A microenvironment compatible with the macro-environment

The organic, biodegradable polymers and non-caustic pH materials that make up the APHRON ICS system provide a healthy balance between operational efficiency and environmental acceptability. The system meets or exceeds regulatory statutes, such as those for the Gulf of Mexico, Canada and the North Sea.

## Start getting macro results today

Contact your local M-I SWACO\* representative and ask to see case histories of the APHRON ICS system in action. Then find out how your next project could experience big results from our microbubble technology.



## The APHRON ICS system is *not* an air- or foam-drilling product

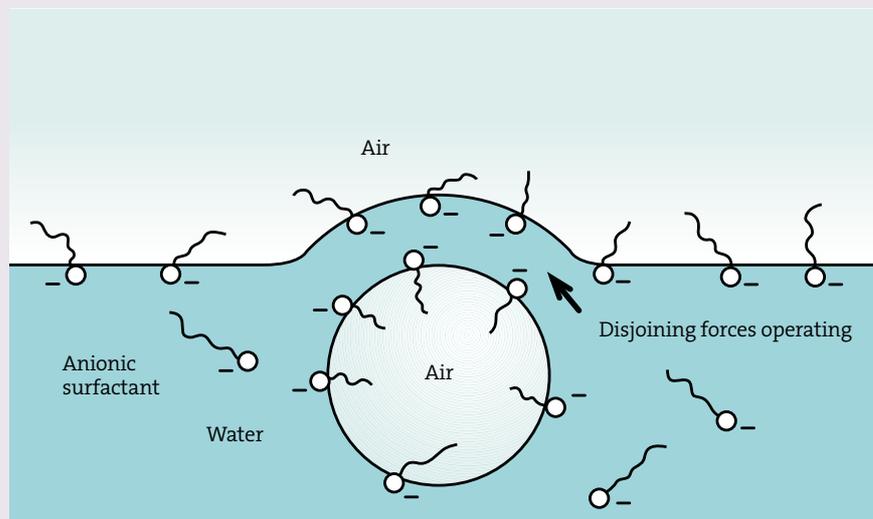
One of the more attractive features of the APHRON ICS system is that it doesn't require any of the extra equipment used in air or foam drilling. There are no compressors, high-pressure hoses or connections to add costs and safety concerns. The system uses conventional fluid-mixing equipment to form the tough, flexible microbubbles.

Once formed, these aphones differ from the bubbles produced in air or foam drilling in two significant ways:

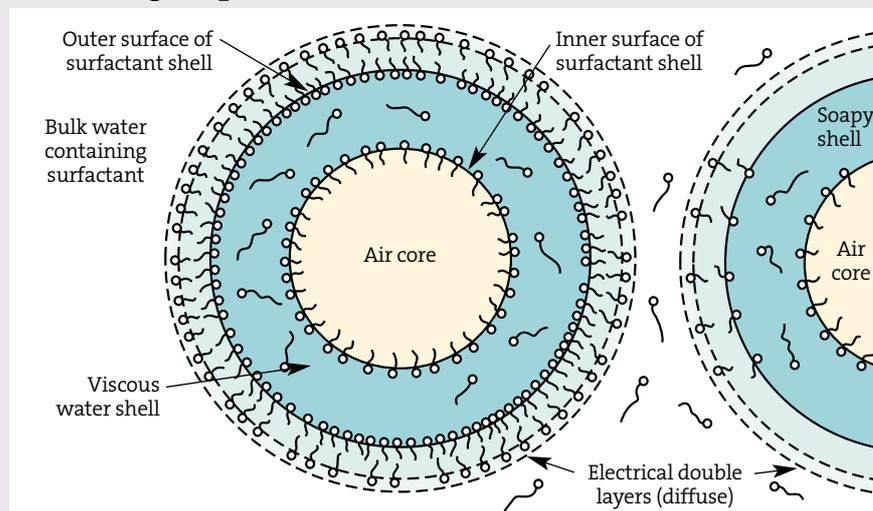
First, they do not coalesce into larger bubbles. These aphones are attracted to lower-pressure regions in the formation but remain discreet from each other, forming a strong network of individual microbubbles. In addition, each one is energized by bottom-hole pressure and acts as a flexible "shock absorber" to protect formations from fluid invasion.

Second, APHRON ICS microbubbles are tough and stable. They are comprised of a core of air surrounded by layers of a proprietary polymer and a tensoactive additive. Once formed, those aphones that remain in the drilling fluid, flow through the shale shaker and are recirculated downhole.

### Standard foams



### Colloidal gas aphone





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