



# **BH-WEI Drilling Fluid System**

China National Petroleum Corporation



CNPC's proprietary BH-WEI drilling fluid system is used for high-temperature, high-pressure and high-gypsum salt-content formations. It has overcome the shortage of traditional drilling fluids of its kind such as high solid content, poor stability and weak inhibition, which may affect the rheological property of drilling fluid and cause borehole collapse or hole shrinkage.

In the R&D of BH-WEI drilling fluids, we incorporated three technical countermeasures: 1) increasing base brine density to minimize the quantity of added weighting materials in order to avoid affecting the rheological property; 2) offering a reductive environment to remove dissolved oxygen in order to increase temperature resistance of additives; and 3) enhancing the inhibition to reduce filtrate activity in order to reinforce the anti-collapse ability.

### Technical Features

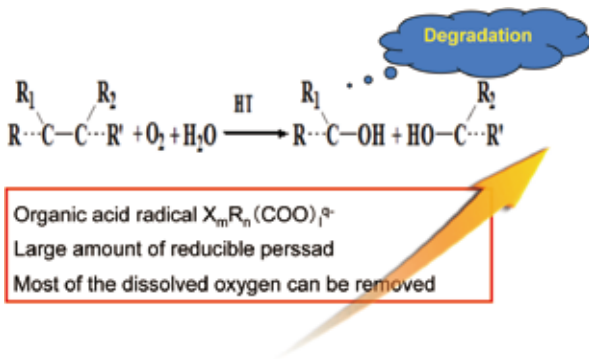
- ✔ Strong inhibition
- ✔ 220°C temperature resistance
- ✔ Maximum density up to 2.6g/cm<sup>3</sup>
- ✔ Saturated gypsum salt resistance
- ✔ Gypsum insolubilization

### Key Additives

- Complex organic salt → BZ-WYJ-I, II, III
- Filtration reducer → BZ-Redu-I, II, III
- Anti-gypsum salt viscosifier → BZ-VIS
- Inhibitive anti-caving agent → BZ-YFT
- Inhibitive lubricant → BZ-YRH



### Temperature Resistance Mechanism



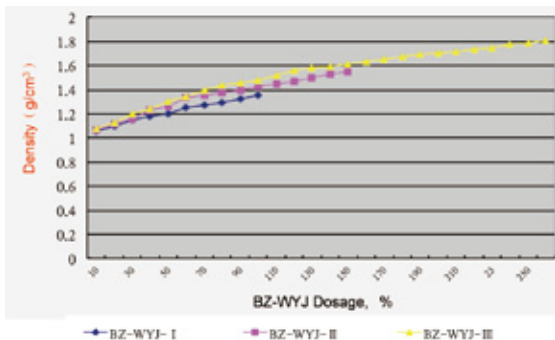
### Gypsum Salt Resistance Mechanism

Dissolution of NaCl, CaSO<sub>4</sub> in organic salt solution (%)

BZ-WYJ-I	NaCl	Gypsum	BZ-WYJ-II	NaCl	Gypsum
20	38.3	0.1	20	31.7	0.1
30	26.6	0	30	19.7	0
40	19.8	0	40	14.1	0
50	13.6	0	50	11.6	0
60	8.5	0	60	7.5	0
70	6.6	0	70	5.4	0
80	4.2	0	80	3.1	0
90	3.5	0	90	1.5	0

### High Density with Low Solid Content Mechanism

Relationship between complex organic salt dosage and density



### Inhibition Mechanism

Water activity of different organic salt solutions

Water Activity	Water	50%BZ-WYJ-I	50%BZ-WYJ-I + 70%50%BZ-WYJ-I	100%BZ-WYJ-II	260%BZ-WYJ-III
20	38.3	0.1	20	31.7	0.1

Because water activity of organic salt solution is lower than most inorganic saturated salt water, the water in drilling fluid will not permeate into the rocks. Contrarily, the water in the rocks will permeate into the drilling fluid. Hence, rock debris and clay expansivity will be greatly reduced in the BH-WEI drilling fluid, so as to ensure stability of the borehole walls.

## Thermostability Evaluation

Properties of the drilling fluid system with the density range of 1.80-2.60g/cm<sup>3</sup> and 220OC thermostability

T °C	ρ g/cm <sup>3</sup>	AV mPa.s	PV mPa.s	YP Pa	Gel Pa/Pa	FL <sub>API</sub> mL	FL <sub>HTHP</sub> mL	pH
70	1.80	66.0	59.0	7.0	0.5/1.5	3.4	13.0	8.5
70	2.10	76.0	67.0	9.0	0.5/1.5	4.0	14.2	8.5
70	2.50	83	74	9	0.5/1.5	3.6	14.0	8.5
70	2.60	99	88.5	10.5	0.5/1.5	3.8	13.8	8.5

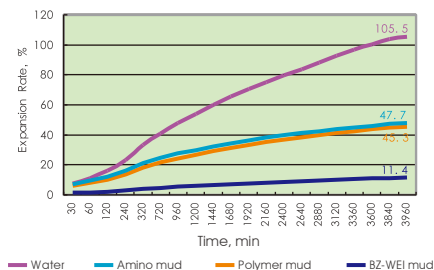
## Pollution Resistance Evaluation

Pollution resistance evaluation of BH-ATH ( ρ =2.5g/cm<sup>3</sup>, 220°C heating)

System	AV mPa.s	PV mPa.s	YP Pa	Gel Pa/Pa	FL <sub>API</sub> mL	FL <sub>HTHP</sub> mL	pH
BH-ATH	74	60	14	1.5/4.5	4.8	13.0	8
BH-ATH+5%soil	78	62	16	1.5/5.5	5.2	14.0	8
BH-ATH+5%NaCl	69	59	10	1.5/4.5	4.4	13.0	8
BH-ATH +1%gypsum	70	58	12	2/4	4.6	12.8	8
BH-ATH+5%G cement	72	59	13	1.5/5	4.6	14.0	8

## Inhibition Evaluation

Intevep Lab of PDVSA in Caracas, Venezuela



The mudstone sample immersed in the BH-WEI fluid recorded an expansion rate of only 10% after 40 hours, and eventually 11.4% after 66 hours.

## Reservoir protection evaluation

Intevep Lab of PDVSA in Caracas, Venezuela



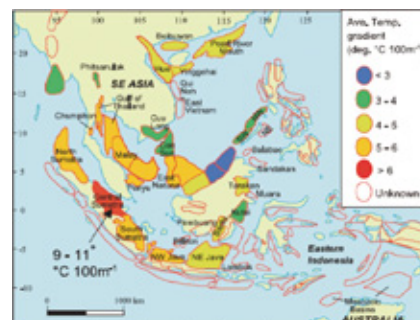
Experimental condition: core permeability 215×10<sup>-3</sup>μm<sup>2</sup>, 150°C.  
Final return permeability was 87%.

## Field Application

Applied in 205 wells and 200 of them have been completed in China: Hainan, Tarim, Qinghai, Chenghai, and Dagang Oilfields

Iraq: Halfaya and Missan Oilfields

- ✔ Max. depth : 7,265m
- ✔ Highest density: 2.41g/cm<sup>3</sup>
- ✔ Highest temperature: 206°C
- ✔ Saturated gypsum salt resistance



## Case Studies

### Well Qungu-1, Tarim Oilfield

- ✔ Successful wire logging and casing running
- ✔ After 41 days incidents management (not related to drilling fluid), the drilling fluid still ensured smooth POOH and RIH
- ✔ High-yield at formation test



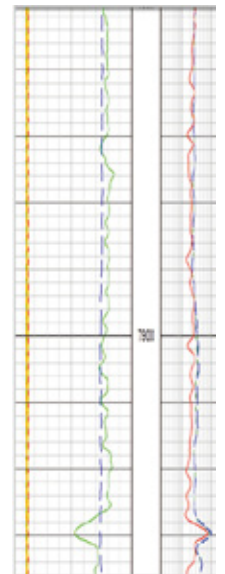
### Madura oilfield, Indonesia

- ✔ Strong hydration and dispersion in upper mudshale formation
- ✔ Mid-lower limestone is highly permeable with high pressure
- ✔ Pruph limestone is friable and contains gas

More than 10 wells had been drilled since the discovery of the field, but were all abandoned because of frequently occurred drilling troubles such as borehole instability, well kick and lost circulation.

BH-WEI drilling fluid was used in well Maderderop-1 and well Dungok-1, achieving good results.

- ✔ Smooth POOH and RIH
- ✔ Successful wire logging and casing running
- ✔ Strong inhibition, no lost circulation
- ✔ No reservoir damage, density reduced by 0.12-0.24g/cm<sup>3</sup>



Dungok-1 caliper line



Approved inhibition and cuttings carrying ability

Return cuttings from the 5<sup>th</sup> spud section in Dungok1 with 6" bit

### Iraq

20 wells were successfully drilled and completed by using BH-WEI drilling fluids, without incidents, problems or discharge.

In Halfaya, the first directional well was successfully drilled at the first attempt with the maximum density up to 2.35g/cm<sup>3</sup>. In Missan, the record of shortest drilling period of 45.96 days was achieved with the daily footage of more than 400 meters.