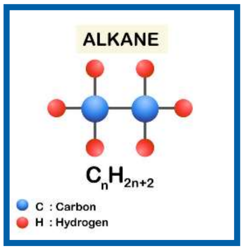
Wax / Paraffin in Petroleum Production
A Technology Primer

Introduction

Produced fluids may contain insoluble microparticles—such as clay, silica, and asphaltenes—suspended as colloids. However, most deposit problems in production operations are caused by compounds that are soluble under downhole conditions. Salts and paraffins, for example, crystallize as the production fluid rises in the well, accumulating in preferential areas such as valves, pumps, and rough surfaces. These deposits can continue to grow until the well becomes completely plugged. Early reduction or prevention of these deposits is critical, as once a well is plugged, costly treatments are needed, and production may be shut down for several days.

What is Paraffin?

Paraffins are high-molecular-weight saturated hydrocarbons (alkanes, CnH2n+2) that occur in crude oil, with chain lengths sometimes exceeding C100. They may have normal (straight) or branched structures. Crude oils can contain 2–15% paraffin, which may solidify at temperatures ranging from 140 °F (60 °C) down to –4 °F (–20 °C). Paraffins include straight-chain hydrocarbons (normal paraffins), branched chains (iso-paraffins), and chains with cyclic structures (cyclo-paraffins or naphthenes).



What Causes Paraffin Deposition?

Linear paraffins exhibit higher melting points than branched paraffins of equivalent size, and the melting point increases with chain length. Consequently, the largest molecules precipitate first, causing the deepest downhole deposits to consist primarily of higher-molecular-weight paraffins. In the reservoir, paraffins are initially in equilibrium under specific temperature and pressure conditions. When production alters these conditions, this equilibrium is disturbed, leading to paraffin deposition. Paraffin formation is favored by:

- A reduction in pressure, which causes cooling and the loss of light fractions that naturally dissolve paraffin
- Contact with cold or rough surfaces
- Laminar flow conditions
- The presence of inorganic deposits

Paraffin deposition is primarily temperature dependent. Cooling during production—caused by gas loss, gas-lift operations, or other factors—can lead to wax precipitation when temperatures drop below the cloud point. The cloud point serves as an indicator of potential paraffin problems, while the paraffin content reflects the severity of these issues. Viscosity and flow rate also influence deposition: higher viscosity reduces transport to cold surfaces, decreasing deposition, while higher flow velocities can lead to harder deposits. Paraffins create operational problems through deposition in formation, tubing, flowlines, and pipelines; settling in tank bottoms or at interfaces; and solidification, which can make restarting production difficult or require extremely high pressures to pump.

Paraffin Removal and Control

Paraffin deposits can be managed using mechanical methods, such as pigging or wireline cutting; thermal methods, such as circulating hot fluids (commonly hot oil); or chemical treatments, including solvents and/or dispersants. Solvents are typically applied to existing paraffin deposits and are left in contact for several hours to dissolve the wax before mechanical removal. Dispersants, on the other hand, act preventively by inhibiting crystal growth. These macromolecules have structures similar to paraffins but feature a polar group at the end of the carbon chain. While their hydrocarbon-like structure allows them to participate in and even initiate crystallization, the polar group generates repulsive forces that hinder crystal growth. As a result, the insoluble paraffin remains dispersed in the crude oil as colloidal particles.

Mechanical Removal

Mechanical removal is the oldest method for removing heavy hydrocarbon deposits. It involves physically scraping the tubing, while for line cleaning, soluble or insoluble pigs are injected to remove a part of the buildup as they travel through the lines. Although effective for cleaning tubes and pipelines, this method does not remove deposits within the formation. Mechanical removal is labor-intensive, and disposal of the collected deposits can be costly.

Hot Fluid Removal

Another early method for removing heavy hydrocarbon deposits involves circulating hot fluids—such as hot oil, hot water, or steam. This can be done through the well conduit to remove deposits or by injecting into the formation to clear plugged areas. The method works by melting the hydrocarbon deposits; however, care must be taken to prevent re-deposition within the formation. Re-deposition can occur when the hot fluid becomes saturated with melted paraffin and asphaltenes, or when the formation temperature is below the cloud point of the fluid, leading to precipitation, reduced permeability, and potential formation damage. While hot oiling has been a widespread practice, it can have adverse effects, particularly when used repeatedly. For this reason, the use of hot or cold water or chemical solvents is strongly preferred. Paraffin deposits can increasingly damage the formation, especially after multiple hot oil treatments.

Chemical Removal

Common chemical solutions for paraffin control include solvents, mutual solvents, water-based dispersants, oil-based dispersants, and crystal modifiers. Large quantities of solvents are typically needed to dissolve paraffin deposits. For example, xylene dissolves just over 6 lb of C36 paraffin per 100 lb of solvent at 100 °F, but less than 1 lb at 50 °F. Treatment procedures must ensure thorough contact between the solvent and the deposit, with sufficient soak time for effective dissolution.

Water-based surfactant dispersants—surface-active agents that prevent particles such as pigments, dirt, or oil from clumping—work by penetrating deposits and dispersing paraffin. Fresh water is recommended over brine for field applications, and adequate contact time is critical. Oil-based dispersants similarly disperse paraffin, improve pipe wetting, and reduce sticking. Batch treatments are commonly used, while continuous treatment is preferred for more severe paraffin problems. For very severe cases, wax crystal modifiers may be applied continuously or through squeeze treatments to prevent paraffin crystallization.

Use of Solvents

Solvents are among the most popular methods of paraffin removal. Commonly used solvents include carbon disulfide, chlorinated solvents, benzene, xylene, and toluene. Carbon disulfide is widely regarded as an excellent solvent for eliminating waxy deposits; however, it is extremely dangerous to handle, it is very poisonous, it is explosive (flash point: -22 °F, auto ignition temperature: 212 °F), and its use is banned in most countries.

Chlorinated solvents are highly effective, but they can damage refinery catalysts and pose both fire and health hazards. Therefore, even minimal detection of chlorinated solvents in any crude oil will immediately lead to the rejection of that crude by the refineries. Benzene is an excellent solvent; however, it is extremely flammable and is carcinogenic. Xylene and toluene are also excellent solvents; however, they quickly reach their saturation point.

Solvents dissolve heavy hydrocarbon deposits until they reach their saturation limit. If they are not removed from the well promptly, the dissolved paraffin can precipitate of solution. This recrystallization may lead to more blockage because the redeposited material can accumulate in previously clean areas. Therefore, solvents should be managed with caution and should be removed promptly after treatment.

Use of Dispersants

Dispersants are also popular chemicals for the removal of paraffin deposits. The dispersants do not dissolve paraffin but disperse them in oil or water through surfactant action. Dispersants are usually added to crude oil or to water before they are circulated.

Use of Crystal Modifiers

Crystal modifiers function by targeting the nucleating agents within hydrocarbon deposits, thereby preventing the formation and agglomeration of paraffin crystals. They achieve this by keeping the nucleating agents—typically asphaltene particles—in solution. When these particles remain dispersed, the buildup of paraffin deposits is significantly reduced. For crystal modifiers to be effective, they must be continuously present in the crude stream. Consequently, they are often injected continuously into the well or, alternatively, squeezed deep into the formation to extend their contact time with the produced fluids.

Paraffin Solution

Revive Production's custom treatment uses products that combine paraffin dispersants with crystal modifiers. These compounds are effective on most types of paraffin molecules, including linear (normal and iso-paraffins) and cyclo-paraffins. Large, consolidated paraffin deposits are broken apart and sloughed off. The treatment reduces paraffin into smaller, shorter-chain molecules that act like a solvent to help mobilize the remaining larger paraffin fragments.

In the presence of liquid oil, the fragmented paraffin molecules are absorbed into the fluid, their crystal structure is altered, and the cloud point is lowered. The colloidal chemistry of the treatment enhances penetration into the wax and improves the oil–water interface. In addition, the colloidal surfactant component helps keep paraffin suspended in solution by reducing its tendency to solidify.

As a result, paraffin deposition is controlled, API gravity increases, viscosity decreases, and both cloud and pour points are reduced.

Paraffin Treatment Product

RP-WaxFlo - Paraffin Solvent and Crystal Modifier

RP-WaxFlo is a paraffin control product based on non-aromatic compounds. It does not contain any petroleum hydrocarbons. It is specifically formulated to dissolve and break down long-chain paraffin molecules into shorter chains that remain stably incorporated in the crude phase. *It also provides the added benefit of liquefying and releasing newly mobilized hydrocarbons from the surface media and converts the surface to a water-wet condition.*

Applications

- Cleaning and maintenance of frac tanks, storage tanks, rail cars, pipelines.
- Paraffin removal from production strings, flow lines, and equipment.
- Paraffin removal from blocked wells.
- Effective stimulation of oil-producing wells to enhance output

[Paraffin Treatment Examples]

The following example illustrates expected results, based on actual paraffin samples collected in the field.

PONA - Boiling Point Curve Testing Samples:

- Raw Residual from Major Oil Company Tank
- Recirculated HCO/RP-WaxFlo/Tank Residual
- RP-WaxFlo/Tank Residual – 10% by Volume (RP-WaxFlo)

The RP-WaxFlo/HCO treated sample exhibits a lower initial boiling point (IBP), and all temperatures corresponding to the specified recovery factors are reduced. This indicates a shift from longer to shorter carbon chains, producing a lighter product that requires less energy to refine. These results demonstrate the effectiveness of the treatment in breaking down higher-molecular-weight hydrocarbons.

Chromatographic analysis indicates an increase in paraffin content in the treated sample, accompanied by a decrease in naphthenes. The naphthenes—cyclo-paraffins—were broken down by the treatment and converted into shorter, lighter paraffins, accounting for the observed increase in paraffin content. Aromatics are also positively affected, proving that the treatment is effective for both paraffinic and heavier crude fractions.