

CASE HISTORIES

**Pyrosol ES
HDC Mk II
PentaFlow
PowerPickle**

Well Intervention Case Histories

**March 2019
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The Case Histories presented here are, for the most part, unique applications of the chemicals in differing completions and surface configurations. These have been selected on that basis in order to prevent repetition.

Also note that in many cases at the time the product was known as HDC Mk II the name which has since been changed to SD27X with new marketing initiatives. The manufacturer is still the same.

Well Intervention Chemical Case Histories

Part I of this booklet contains the specification sheets about the WellTech product line used in either cased hole well bore clean up, or in the company's intervention and stimulation operations.

Part II of this manual presents case histories as a reference guide to the different applications for which the Company intervention chemistry has been deployed. Although some Operators are named in these documents, where identification of specific fields or wells is not allowed, these are omitted. If details of these identifiers are requested in writing to the company, we will endeavour to contact the Operator responsible and make the request on behalf of the individual or company asking for it. These are examples only. For a more comprehensive list of case histories, please go to the company website; www.welltechengineering.com

As a general guideline, the products used in these case histories are:

Pyrosol ES:	Iron Sulphide and Carbonate Dissolver
SD27X:	Mud Barite, Barium, Strontium, Carbonate Compound Dissolver
PentaFlow:	Mud Cake Remover, Emulsion Breaker, Carbonate/Sulphide Scavenger
PowerPickle:	Oil Based Mud, Pipe Dope and Multi-purpose Hydrocarbon Dissolver

Part I

Product Specification Sheets

Product Specification Sheet

1. PRODUCT NAME ***Pyrosol ES***

2. COMPOSITION / INFORMATION ON INGREDIENTS AND APPLICATIONS

Pyrosol ES is a multipurpose sulphide scale and dissolver used to remove hard particularly non-biogenic sulphide scales from production streams in oil and gas and or water injection wells, or used to dissolve carbonate filter cakes in addition to sulphide scales in open hole, tubing and other oil and gas facilities.

3. PHYSICAL AND CHEMICAL PROPERTIES

Appearance	:	Clear Fluid
Odour	:	Slight.
pH	:	5.5
Boiling point	:	>100° C
Melting point	:	<0° C
Flash point	:	> N/A
Decomposition temp.	:	N/A
Auto ignition temp.	:	N/A
Solubility (water)	:	Soluble.
Density	:	1.145

4. PACKAGING

Supplied in 200 Litre plastic drums or 1000 litre plastic IBC containers

5. SHELF LIFE

Shelf life is 5 years, dependent on storage conditions

Product Specification Sheet

1. **PRODUCT NAME** ***HDC Mk II / SD27X***
2. **COMPOSITION / INFORMATION ON INGREDIENTS AND APPLICATIONS**

SD27X and variants are proprietary manufactured dissolver solutions designed to remove high volumes of solid sulphate and carbonate solids from oil and gas down-hole and surface facilities. Although all SD27X brands dissolve barium, strontium and calcium sulphate to some extent, the different brands are used to target differing well bore environments and indeed surface facility environments. SD27X and its variants are high weight/volume dissolvers of barium and calcium compounds in their scale state whereas SD27X series dissolvers are more suitable for down hole “dirty” conditions resulting from oil or water-based mud deposition. Although the products are largely interchangeable, more efficiency is attained by selecting the dissolver for the correct environment. The products react quicker in warm environments (> 40° C) but are largely not temperature dependent to reach depletion with normal reactions within 24 hours at elevated temperatures.

2a. **TYPICAL DISSOLVING CAPABILITIES:**

Chemical	BaSO ₄	SrSO ₄	CaSO ₄	CaCO ₃
SD27X	71.5 g/l (raw)	43 g/l(scale)	49 g/l (scale)	71 g/l (pure)

3. **PHYSICAL AND CHEMICAL PROPERTIES**

Appearance	:	Clear to Light Amber
Odour	:	Slight. organic
pH	:	>12
Boiling point	:	>100° C
Melting point	:	<0° C
Flash point	:	> N/A
Decomposition temp.	:	N/A
Auto ignition temp.	:	N/A
Solubility (water)	:	Soluble.
Density	:	1.25 to 1.45 depending on requirement

4. **PACKAGING**

Supplied in 200 Litre plastic drums or 1000 litre plastic IBC containers

5. **SHELF LIFE**

Shelf is 5 years, dependent on storage conditions.

Product Specification Sheet

1. **PRODUCT NAME** *PentaFlow*

2. **COMPOSITION / INFORMATION ON INGREDIENTS AND APPLICATIONS**

PentaFlow is a proprietary mixture of organic and inorganic acids and solvents. It is a multipurpose polymer, carbonate particle and scale dissolver which can be applied to oil and gas facilities with particular applications in open hole and production well cake breaking applications. With in-built corrosion sequestration and de-emulsifiers – it is widely used to break or prevent emulsion blockage and to scour metal ions from the well target. Used Neat as pre-flush or open hole cake breaker.

2a. **PRE-FLUSH FUNCTION**

Emulsion Breaking; Polymer Dissolving; Metal Sequestration; Water Wetting; De-Oiling

2b. **WELL BORE FUNCTION**

Carbonate Dissolver; Mud Cake Breaker; Clay Control

3. **PHYSICAL AND CHEMICAL PROPERTIES**

Appearance	:	Clear to pale blue – can be multiphase if stored above 30°C
Odour	:	Slight.
pH	:	1.0 – 2.0 (aqueous phase)
Boiling point	:	>86° C (solvent phase)
Melting point	:	<0° C
Flash point	:	> N/A
Decomposition temp.	:	N/A
Auto ignition temp.	:	N/A
Solubility (water)	:	Soluble.
Density	:	1.128 ± .15

4. **PACKAGING**

Supplied in 200 Litre plastic drums or 1000 litre plastic IBC containers

5. **SHELF LIFE**

Shelf life is 3 years, dependent on storage conditions.

Product Specification Sheet

1. PRODUCT NAME ***PowerPickle***

2. COMPOSITION / INFORMATION ON INGREDIENTS AND APPLICATIONS

PowerPickle is a complex blend of solvents specially selected to be effective at dissolving and dispersing pipe dope and oil-based mud prior to well stimulations and gravel packs. It has the ability to displace the organic surfactants that hold the pipe dope together and release the oil wetted solid fillers. The solvent effectively removes the very persistent viscous "sludge" which is formed when residual oil-based mud is contacted with water.

PowerPickle is designed to be user friendly so that it is safe to use and dispose of. It contains no aromatic hydrocarbons or chlorinated hydrocarbons, and is classified as non-flammable, biodegradable and has a Gold Band rating in the North Sea.

3. PHYSICAL AND CHEMICAL PROPERTIES

Vapour Pressure mm Hg @ 20°C	:	1
Solubility in water	:	<0.01 at 25°C
Specific Gravity @ 15°C	:	0.78 @ 15.5°C
Appearance	:	Clear liquid
Odour	:	Sweet
Flash Point (PMCC)°C	:	62.8
Auto Ignition °C	:	Greater than 200
Explosive Limits % air @ 25°C	:	lcl 1.0, ucl 8.0 @ 15.5°C
Products of Combustion	:	Strong oxidizers

4. PACKAGING

Supplied in 200 Litre plastic drums or 1000 litre plastic IBC containers or specialty containers on request

5. SHELF LIFE

Shelf life is 3 years, dependent on storage conditions.

Part II

United Kingdom & Europe

Production & Well-Bore Intervention Case Histories

- Barite Dissolving: Production Recovery
 - ESP Recovery
 - Water Injection Recovery
- Barium, Strontium Scale Dissolving

Case History 2.1 SD27X ESP – OBM Blockage UKCNS

- Horizontal EV – ESP
 - Pre-Packed Screen Completion
 - OBM – Dolomite / Barite Mud Solids
 - Bull-Head Operation
-

The well treated here was drilled as an EV installation with a Baker Centralift ESP set above approximately 900' of horizontal sand screens. The ESP and facilities were constantly blocked off with mud solids feeding through the screens – and probably lodged inside them as well. Cleaning with HCL/HF and competitor barite dissolvers had proven ineffective in cleaning the well up. The client decided to use SD27X behind a PentaFlow pre-flush. This was done with the ESP cleaning up to 22,000 bpd (up from a previous high of 11,000 bpd with blockages causing shutdown) without blockages and solids.

This well was drilled and completed in May 2004. It was suspended in heavy synthetic based drilling fluids for several weeks before being displaced to a “clean” SBM and completed with pre-packed screens. The well never cleaned up properly with the ESP constantly overloading with solids which testing indicated were carbonate and barite sourced from the drilling fluid.

Very large volumes of HCL were used to remove the carbonate solids with U104/U105 pumped to remove the barite. As these failed a competitor barite dissolver was pumped with no improvement seen.

The operational program using SD27X and PentaFlow was quite straightforward as it entailed bull-heading PentaFlow ahead of the SD27X with a small spacer in between. The PentaFlow was allowed to soak across the target for 90 minutes then displaced into the well with SD27X behind. The SD27X was divided into two soak stages.

The first SD27X soak was designed to lie inside and just outside the well bore for 8 to 12 hours. The second volume of SD27X was designed to push the first soak outwards (being theoretically still active) with the new volume displaced fully into the well bore so coverage was extended outside and inside the screens – up to 24 inches from the bore itself. After the last displacement the fluids were allowed to soak for 24 hours.

The ESP was started with the well cleaning up gradually (the SD27X being denser is harder to lift), and the well eventually cleaning up to 22,000 bpd – up 10,000 bpd from the previous best production seen. This was and is being maintained without solids and ESP pump over loading since the job was done in March 2005.

Subsequent to this operation, two more ESP's in the same condition were fully recovered for the same client between 2006 and 2007 contributing to a total of 60,000 bfpd during 11 operations.

Case History 2.2

SD27X: Injector- Schielhalen

- **New Drilled Well With SBM**
 - **Moderate temperature (148°F)**
 - **Gravel Packed Water Injector**
 - **SD27X Breaker System**
-

This well was drilled using synthetic oil-based mud in the North Sea off Shetland. The concept of the field trial was to attempt to inject through the oil-based mud cake without the normal procedures of producing the well conventionally to remove the filter cake by placement of the SD27X chemical in the screens.

This was deemed to be particularly challenging as this had never been successfully done before and the BHT of the well at 148° F was deemed to be very low for an unconventional or conventional dissolver of any sort.

The well was completed and the SD27X placed across the screens using coiled tubing. The CTU was pulled and the chemical was allowed to soak for 24 hours before injection was attempted.

When the well was put on injection, it was established at a high back pressure (\pm 2000 psi) with a constant rate. The pressure was deemed to be higher than expected although this part of the field and this formation had not been injected before and the productivity of the operation was still largely in doubt.

In order to determine if the filtercake had indeed been removed, the well was cleaned up conventionally using CTU/EDTA/Acid and produced – with poor results. Injectivity went to zero indicating that the acid treatment had in all probability compromised the formation and the EDTA had no effect as well.

The decision was made to perforate through the screens to establish exactly what the injectivity of the formation was. This was done and it was found that the injection rate perforated was identical to the rates and pressures established with the original clean up of the SD27X product – indicating that it had in fact, yielded total Cake dissolution and maximum injectivity at the outset.

Although the well was not in an ideal location for a injector, the establishment of the SD27X as a filtercake dissolver which could eliminate the need for CTU use and conventional flow back and clean out using OBM, has been established – even at low bottom hole temperatures.

References: Alan Austin – BHI
Alistair Roy – BP
Alan Twynam - BP

01224 – 720000 or 01224- 226000
01224-832000
TwynamAJ@bp.com

Case History 2.3

SD27X – Kerr McGee – Gryphon P4 – Gravity Feed via FPSO

- **Sub-Sea Well Head**
- **Horizontal**
- **BOT Excluder Screens**
- **Acid Damage – 100% Production Loss**
- **Gravity Feed Deployment**

The P-4 well was drilled in 2002 being badly damaged in the process using oil based mud with high losses. The well was subsequently acidised after producing circa 600 bopd – 2 x 10,000 gallon treatments. The net result was full production loss. The well was tied back via the sub-sea manifold as programmed before bringing the FPSO on with the well standing idle until late 2004 when an attempt to recover some production was made using SD27X. The operation was a partial success but the lifting of the well had to be discontinued due to problems with gas lift and the subsea choke. The well was flowed from zero to 750 bopd when lifting stopped – with a build rate of 50 – 80 bopd when the operation was halted.

The Gryphon wells are located in a high permeability, high porosity sand reservoir with enough clay elements to make acid use a high risk operation. The problems on P4 were initially caused by high volumes of oil based mud being lost during the drilling phase, then aggravated by severe acid incompatibility with the oil mud and the formation itself- resulting in the well being killed.

SD27X and **PentaFlow** were compatibility tested and selected for a trial never attempted before which consisted of a gravity displacement from the FPSO through the production riser. Lab simulations were made which indicated that the PentaFlow and the SD27X being far heavier than the seawater currently in the string would “flip” and displace themselves into the well over a relatively short period of time. However, as the well was nearly 3000’ horizontal, the exact location and ability of the fluids to access the toe of the well was questionable. Lab simulations indicated that in fact if displaced at two distinct time frames (a day apart), the Heavier SD27X would almost certainly hydraulically push the PentaFlow into the well through the toe.

The displacements were performed as programmed, however it was necessary to leave the fluids soaking in the well for over two weeks due to production issues on other wells. When the well was lifted, using gas lift from an adjacent well, the well flowed back some SD27X and liquids and gradually began to flow oil – building up to 450 bopd. Although 1000 psi differential pressure could be applied to the well – the design of the gas lift was such that sustained differential could not be maintained and the well could not be shocked or unloaded which was deemed necessary to really clean the heavier fluids from the deeper horizontal sections. Due to operational problems the lift had to be abandoned with the well unable to flow on it’s own. The well was re-accessed in January 2005 and gas lifted – with immediate oil flow building up to 750 bopd at a steady increasing rate from 50 bopd when the gas lift again had to be abandoned due to subsea manifold choke problems.

As work-overs and major maintenance was due, it was decided to side track the well when the rig arrived. Although the well could not be cleaned up due to operational issues, the exercise was considered a success with the well theoretically able to produce at its peak had sustained gas lift been available. Ref: dcorkey@kmg.com

Case History 2.4

PentaFlow + Pyrosol ES: Injector Recovery

- **New Drill - Water Injector**
 - **Moderate temperature (148°F)**
 - **Sulphide Matter and Biological Grunge**
 - **Bull Head**
-

This well was a side track from an existing injector which had dropped off injectivity quite rapidly in 2003. The sidetrack used a non-damaging water-based drill-in fluid weighted with carbonate. Upon completion, injection was poor with high back pressure and little injectivity. Subsequent HCL and HF jobs did nothing to improve the well. Pulsosonics were run in an attempt to clean it up but nothing was achieved. Flow back of the well revealed viscous black grunge from the well bore.

It was determined that the well was placed back into the area of the previous injector – where a bacterial biomass had been created previously and sulphide scale had built up substantially. As such a treating regime of PentaFlow – to break through the hydrocarbon and biological complex coating the near well bore, followed by Pyrosol ES which would operate on the exposed sulphide matter remaining.

The operation entailed stage placement of the PentaFlow near the well bore for 90 minutes then displacing the Pyrosol ES into the screens and near well bore.

The drop-in pump pressure when the PentaFlow reached the formation (this is common) was very dramatic with the well taking fluid at an extreme rate. This weakening of the back pressure became more marked as the operation continued.

After 24 hours when placed on injection, the well took 50,000 bwpd – from 9,000 bpd previously. This tapered off to 35,000 bpd.

It was learned later that the well had been used to feed a nitrate into the reservoir in an attempt to sweeten sour crude in an adjacent producer. This was found to cause more complications later on but certainly explained the initial problems seen on this well.

Case History 2.5

SD27X Production Recovery – Kerr McGee CNS

- **Recent Well**
 - **Moderate temperature (148°F)**
 - **Damaged By OBM**
 - **Bull Head**
-

This well was drilled and put on line as an oil producer in 2000. The well was completed conventionally with BOT screens. The well was thought to be impaired by the OBM drilling fluid used blocking the screens or the skin as well.

The well was bullheaded with 4,000 liters of SD27X and allowed to soak overnight. The well was opened and allowed to cleanup under its own pressure. The well cleaned up within 48 hours, doubling the production from the pre-job levels and attaining a theoretical 90% rate for the well at that time.

The well was a high angle oil producer short screen completion.

Case History 2.6

SD27X – BP – Harding ISX13

- **Oil Based Mud Blocked Screens**
 - **Failed Acid Nano Wash Operations**
 - **Bull Head operation**
-

BP in the UKCNS drilled a horizontal oil producer in the Harding field in 2006. Designed to produce an initial 10,000 bopd from a 2000' reservoir section before water break through, the well was compromised due to the collapse of the lower hole because of chronic shale instability. With less than 400' of reservoir exposed (and that included the water leg), the initial expectations were of 4000 bopd. However the well was found to be badly impaired and produced 400 blpd.

The damaging mechanism was determined to be whole synthetic oil based mud (SOBM) compressed around the screen completion, combined with possible solids drop out. Coiled Tubing intervention was carried out in late 2006 with solvent/acid based Nano wash systems. Eventually multiple attempts with an acid/surfactant/ solvent system were unsuccessful. This treatment fluid was aimed at disrupting and removing any oil wet solids and / or calcium carbonate. Although the well had been displaced to a carbonate based SOBM prior to completion, contamination by the original barite weighted drilling fluid was determined to be the main causative blocking agent in the well.

In 2007 BP chose to use an advanced **SD27X** based barite/carbonate dissolver system behind a **PentaFlow** pre-flush system in an attempt to recover the well. The operation was performed in September 2007 without CTU in a simple bull head operation. The well immediately improved in productivity and the PI increase from the start of the operation has been increased from 1.5 to a current PI of 7.5.

The stimulation using SD27X was repeated with the PI doubling until no gain in PI was seen. Overall the operation was deemed a huge success with the well producing 4000 bfpd up from 400 bfpd previously. The fact that this was accomplished with a bull head operation made the result that much more outstanding.

BP co-authored an SPE paper on this well and is listed in the archives as SPE 120762.

Case History 2.7 UKCNS

PentaFlow – Pipe Release Case History ConocoPhillips

- Oil Based Mud
 - 6” Open Hole
 - Drill String Stuck at 18000’+
-

*The drilling string became stuck during drilling operations at 18,196’. The well did experience minor fluid losses during the event and the drill string was worked whilst waiting for the **PentaFlow** to arrive on board. Although the string was jarred and worked during the delay, no evidence of the pipe coming free was seen.*

After becoming stuck the **PentaFlow** was ordered out to the location. Once on location, a 60 bbl pill of **PentaFlow** was prepared and pumped ahead of a base oil spacer. When **PentaFlow** made contact with the formation, it was noted that the losses increase slightly.

The string was jarred and rotation became possible shortly after the contact with the **PentaFlow**. The string jarred free shortly thereafter and was pulled successfully without any renewed sticking incidence.

The contact time from the first **PentaFlow** contact to the string being freed was under three hours.

Reference: Allan Cameron Allan.Cameron@contractor.conocophillips.com

Case History 2.8

Pyrosol ES – Sulphide Removal – CNR/Ninian B-3 Injector

- **Water Injector**
 - **Moderate temperature (148°F)**
 - **Sulphide Scale & Corrosion**
 - **BullHead**
-

This well was originally drilled and put on line as a seawater injector, with an initial rate of 10,000 bwpd injection rate. Over a period of 4 years, this injectivity declined to between 2000 to 4000 per day. The decline was determined to be the result of long term bacterial activity causing sulphide scale and or possible barium scale within the tubing as well as heavy accumulations around the formation.

After analysis of the solids, a treatment of **Pyrosol ES** series sulphide/sulphate dissolver was selected for injection. (injection temperature 35°C, 25,000' depth MD)

Seventy-nine barrels of **Pyrosol ES** was injected into the well, with an immediate drop in back pressure noted as the chemical reached the formation, indicating a rapid dissolution of solids. The well was shut in with the chemical soak for 24 hours, then allowed to flow back.

Analysis of the sampled returns indicated an average figure of between 550 to 650 kilograms of dissolved sulphide/sulphate scale within the solution. (Flow back analysis performed by OCT on behalf of CNR)

After flow back, a drift tool was run prior to setting a deep injection valve. This operation was notable in that it was performed without difficulty where previous attempts resulted in sticking of drift tools and packers from scale.

Samples of scale retrieved from the drift tool, indicated that the scale was very friable, meaning the **Pyrosol ES** was still reacting at the low temperature end of the upper tubing surfaces.

The well will be brought back on stream as an injector when the impact on other production issues are resolved.

This has been regarded as a very successful operation in that the weight of scale dissolved was significantly higher than would be expected under the temperature regime used and the relatively low volume of chemical deployed for the length of the target area covered.

The well was subsequently brought back on line at a rate in excess of 8,000 bwpd.

References: Paul Beilby – CNR - Ranger Guildford, +01483-401401

Case History 2.9

PentaFlow + Pyrosol ES: Injector Recovery

- **New Drill - Water Injector**
 - **Moderate temperature (148°F)**
 - **Sulphide Matter and Biological Grunge**
 - **BullHead**
-

This well was a sidetrack from an existing injector which had dropped off injectivity quite rapidly in 2003. The sidetrack used a non-damaging water-based drill-in fluid weighted with carbonate. Upon completion, injection was poor with high backpressure and little injectivity. Subsequent HCL and HF jobs did nothing to improve the well. Pulsosics were run in an attempt to clean it up but nothing was achieved. Flowback of the well revealed viscous black grunge from the well bore.

It was determined that the well was placed back into the area of the previous injector – where a bacterial biomass had been created previously and sulphide scale had built up substantially. As such a treating regime of **PentaFlow** – to break through the hydrocarbon and biological complex coating the near wellbore, followed by **Pyrosol ES** which would operate on the exposed sulphide matter remaining.

The operation entailed stage placement of the **PentaFlow** near the well bore for 90 minutes then displacing the **Pyrosol ES** into the screens and near wellbore.

The drop-in pump pressure when the **PentaFlow** reached the formation (this is common) was very dramatic with the well taking fluid at an extreme rate. This weakening of the back pressure became more marked as the operation continued.

After 24 hours when placed on injection, the well took 50,000 bwpd – from 9,000 bpd previously. This tapered off to 35,000 bpd.

It was learned later that the well had been used to feed a nitrate into the reservoir in an attempt to sweeten sour crude in an adjacent producer. This was found to cause more complications later on but certainly explained the initial problems seen on this well.

Part III

USA

Production & Well-Bore Intervention Case Histories

- Barite Dissolving: Production Recovery
 - ESP Recovery
 - Water Injection Recovery
- Barium, Strontium Scale Dissolving

Case History 3.1 SD27X Mobile Bay

- **Vertical Gas Producer**
 - **Conventional Completion**
 - **Total Scale Blockage Above Perforations**
-

The client's deep hot gas well in Mobile Bay has a history of complex scale formations. Typically, the scales have been removed using acid complexes. But it was known that not all the scales were acid soluble. This led up to an increased volume of acid insoluble solids building up in the well until production failed completely with CTU and/or wire line unable to access the well perforations at all. Bailer samples confirmed what the fluid modeling predicted, that barium scales were present with a variety of other complex minerals such as fluorites and carbonates.

Laboratory testing indicated that **SD27X** would be the product of choice for removing these particular scale species. CTU was used to place the chemicals above the obstruction where it was allowed to soak in excess of 24 hours. During the latter phase of the soak periods, the well began to pressure up indicating that communication with the perforations had been re-established.

At the end of the soak period, the well was cleaned and the blockage totally removed. The well was producing at its best gas rate possible.

Case History Shell USA 3.2 SD27X, Offshore Louisiana –Oil and Gas Well Recovery

- **Aged Oil and Gas Producer**
 - **Vertical Conventional Liner**
 - **Perforated with Pre-Packed screen**
 - **Dual Stage Perforation Bull-Head**
 - **CTU Placement & Well Flow Back**
-

The client's well had lost some production capability through apparent scale build up. From the well history, it was apparent that the scale build up had been gradual. The drop off and failure of the well suggests (theoretically) that some seed scale or process may have accelerated the damaging process resulting in the decline. Having stated this, it was also possible that the build up through the life of the well may have been a direct or contributing factor to the loss of production.

The chemistry of the scale was determined to consist of Barium/Strontium oxides, sulphate. The program implemented was built around the use of several staged placements and soaks of **PentaFlow** and **SD27X**. This dissolver was used to access the well at the perforations and near well bore from 18,006' - 18,246'.

Initially coil tubing was run with a jet blasting tool and the well was jet blasted to the bottom of the prepacked screen assembly. This procedure provided for the cleanup of the inside of the production assembly while allowing the chemical to clean up the outer portion of the screens, gravel pack, perforations and perforation tunnels.

The soaks were done in stages through the coiled tubing as this allowed direct spotting of the dissolving chemicals, without having to bullhead a lot of fluid back into the formation.

The different soak periods were required during the placement of the two chemicals as a single stage bullhead would be unlikely to achieve a uniform placement of the fluid over the severely scaled area. In addition, the **SD27X** could become depleted before the area was totally cleaned. By staging displacements, cleaning and access was optimized.

The program was implemented with the zone being cleaned – with large amounts of scale removed from the well – and production restored, achieving an increase of 1.5 mmcfpd of gas, 1400 bopd and 100 psi of pressure.

Part IV

Asia

Production & Well-Bore Intervention Case Histories

- Barite Dissolving: Production Recovery
 - ESP Recovery
 - Water Injection Recovery

Case History 4.1 SD27X - OBM Barite Dissolving Petronas Carigali – Resak A10S

- **HT Gas Well (325°F)**
 - **Deviated**
 - **Dual String Completion**
 - **OBM – Settled Barite + Acid Damage**
 - **Conventional Perforated Liner**
 - **Multi-stage Bull Head Through Short String**
 - **CTU N₂ Gas Lift**
-

Summary: Resak A10 was designed to produce 25 mmscfd, but only produced 10 mmscfd and falling. After pumping 13.0 ppg OBM to kill the well, 250 bbls of acid was pumped. Production dropped to below 1 mmscfd. Besides damage from acid, it was also believed that some of the barite from the OBM had settled and covered some of the perforations. In an attempt to recover some production, a year later almost 70 bbls of SD27X was bullheaded into the well over 26 hours resulting in production of 7 mmscfd.

Resak A10 is a dual string gas producer drilled by Carigali offshore Terengganu in 1999. The well was completed as a dual string completion to isolate a higher-pressure reservoir at the bottom from intermediate production zones above.

Due to communication between the completions and lack of heavy brine, the well was killed and suspended in 13.0 ppg OBM. On re-entry, it was found that most of the perforations (in both zones) were partially buried under settled barite and OBM.

In the upper zone, coiled tubing could not be used to attempt a wash out, so the zone was acidized with 250 bbls of SWIK Halliburton formulation.

The zone was originally designed to produce 25 mmscfd. At the time of acidizing, the zone was producing between 10 and 7 mmscfd and falling. After acidizing, the production dropped to less than 4 million, dwindling to less than 1.5 mmscfd by June 2002 with over 200 bpd water.

In preliminary meetings and subsequent lab confirmation by Petronas, it was agreed that a cost-effective trial using SD27X would entail attempting to recover some of the buried perforations and reversing if possible some of the HCL damage. Due to the high volume of acid used it was felt that attempting to reach the complete step out radius of the acid impact on the initial treatment stage was too expensive on an experimental basis.

The SD27X job design was a staged bullhead operation through a cement unit. The job design was based on staged displacements of SD27X over three-hour intervals in a “dissolve” – “wash” – “dissolve” sequence to induce removal of barite from the lower perforations and flowing through them as the chemical depleted. The final stage consisted of displacing the entire volumes into the formation and static soaking for 12 hours. The entire operation was completed in 26 hours.

At the end of 26 hours, a partial nitrogen gas lift was used although the well began cleaning up naturally. Within 24 hours of lifting, the well was producing 4.5 mmscfd, going up to 6 mmscfd within 96 hours and over 7 mmscfd after five days, with 80 bpd water, and 5 cubic meters per day of condensate. The production has continued in excess of 7 mmscfd on a 19% choke through to the last tests held 45 days after the well was stimulated. The condensate production results indicate a clear response from the previously buried perforations although the actual gas production source remains questionable.

The actual mineral species and weights dissolved as analyzed from the returns are tabulated in Table 1. (Note: The Barite used contained high volumes of Hematite)

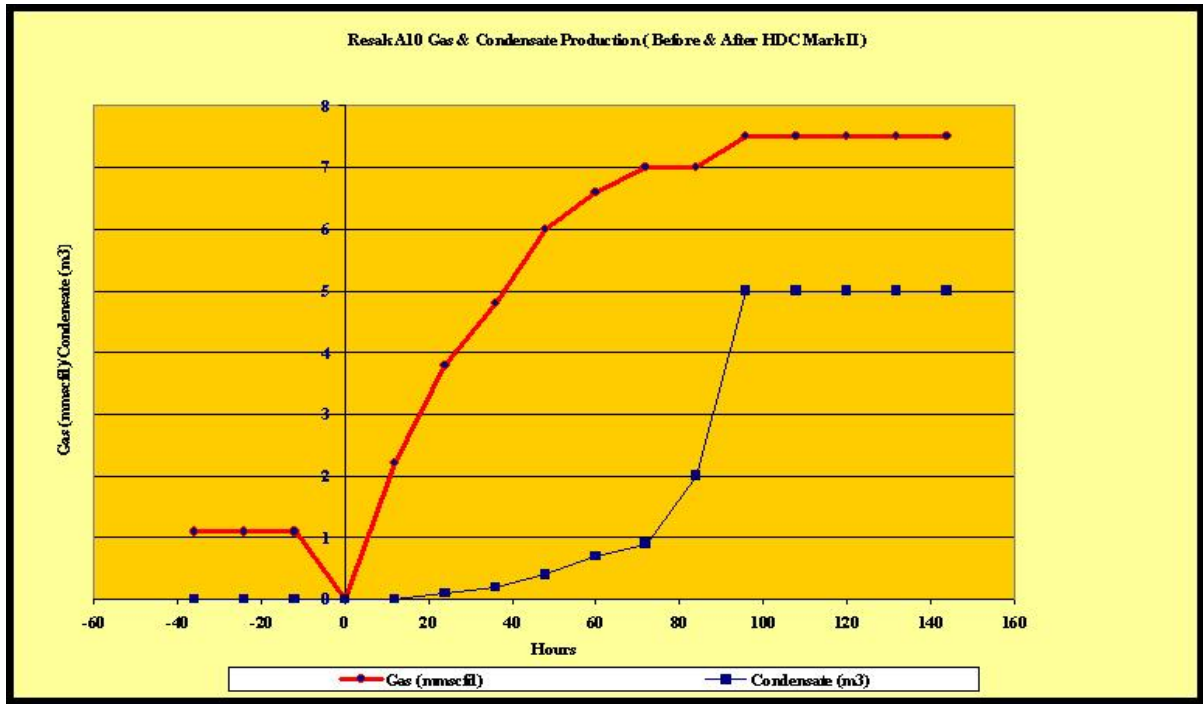
Based on the average specific gravity of the dissolved compounds, the mass of solids indicate that theoretically 63' of settled barite and mud could have been removed from the well. That stated, the figure of 63' is erroneous however, as it is impossible for the SD27X to have uniformly contacted sufficient surface area during the stage displacements to address the bulk solids in the 7". Basing the active SD27X on a 25% to 50% activity within the 7", over the period of each displacement, it is estimated with a high degree of confidence that between 19' and 30' of perforations in the lower liner was re-exposed.

Table 2 reveals the actual analytical breakdown of the liquid volume flow back and dissolving rate of the SD27X in each volume.

Table 2: Separator Volumes, Weights Dissolved/SD27X Capacity

Sample	1	2	3	4	5
Volume bbls	40	40	160	40	40
Cum. Volume bbls	40	80	240	280	320
g/l dissolved minerals	24.24	22.34	32.50	10.83	4.82
Total Litres	6392	6392	25568	6392	6392
Total Grams	154,949.62	142,794.72	830,960.00	69,247.35	30,781.32
Total Kilograms	154.95	142.79	830.96	69.25	30.78
% SD27X In Sample	28.00%	24.65%	31.50%	10.65%	5.00%
Litres HDC	1,789.76	1,575.63	8,053.92	680.75	319.60
Dissolved g/l	86.58	90.63	103.17	101.72	96.31

Chart 1: Production Gas Rates Before & After SD27X Treatment



Reference: Kasim Selamat - Senior Production Engineer
kasimse@petronas.com.my

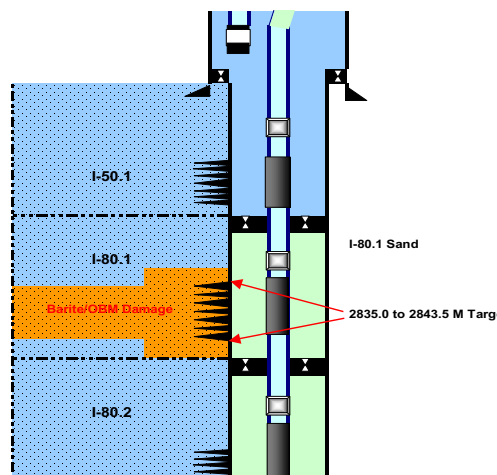
Case History 4.2 SD27X - OBM Barite Dissolving Petronas Carigali – Resak A3

- HT Gas Well (325° F)
 - Deviated
 - Dual String Completion
 - OBM Drilling Skin Damage
 - Conventional Perforated Liner
 - Multi-stage Bull Head Through Long String Sliding Sleeve
 - Lifted Using Flow From LS
-

Summary: Resak A3 is a dual string gas producer which was severely damaged in the middle target of the long string (I.80 sand) and never produced from this zone. Attempts to bull head acid through the sliding sleeve proved ineffectual. In 2004 PentaFlow cake breaker mixed with PowerPickle® Oil solvent - was bullheaded ahead of SD27X mud barite and solids dissolver system. After 24 hours, the zone was lifted producing 11mmscfd.

Resak A3 is a dual string gas producer drilled by Carigali offshore Terengganu in 1998. The well was completed as a dual string completion to isolate a higher pressure reservoir at the bottom from intermediate production zones above.

The well was badly damaged by the OBM mud used with the middle (I.80 sand) totally impaired and non-responsive to acid treatments.



The zone was isolated from the lower production and bull-headed with 3500 liters each of PentaFlow/PowerPickle® (50/50) and SD27X and allowed to soak overnight. The well was gas lifted from the SSD successfully producing 11 mmscfd and building.

Reference: Kasim Selamat – Senior Production Engineer kasimse@petronas.com.my

Case History 4.3

ESP Cleaning : Maxus/YPF/Repsol Indonesia: Tereisia AC6 PentaFlow + Pyrosol ES

- **ESP Scale : Sulfide + Formation + Corrosion**
 - **Deviated**
 - **Conventional Perforated Liner**
 - **Formation Stimulation**
-

*Summary: The ESP in Teresia AC-6 regularly trips from shale/scale build-up and normally requires pump replacement. Cleaning with the **PentaFlow** and **Pyrosol ES** regime needed only 21.5 hours to put the well back on production with no overload on the ESP. The formation was also unexpectedly stimulated when it **more than doubled the oil production**, resulting in a **payback time of 31 hours**.*

Maxus (YPF Repsol) Indonesia has chronic problems with the build-up of short term shale/scale deposits in their down hole electrical submersible pumps (ESP) in a number of fields. The pumps typically can reach overload in less than 30 days or can last 300 days (or more) of production life if chemical cleaning is successful. More often than not, it has been necessary to pull the pumps completely and replace them.

The debris on the actual pumps was examined, and concluded that the length of time a pump had been exposed down hole determined the type of treatment required to clean the pumps and remove the blockage debris.

In this approach, two distinct treatment regimes were programmed. The first was for pumps designated as “younger” or having been in place less than 180 days, with the second type designated as “older” which had been in service continuously or otherwise for much longer than 180 days.

The Teresia AC-6 ESP had been in service for 211 days producing between **150 to 175 bopd** when it went into over load and tripped out. Attempts to re-start the ESP were unsuccessful and no mechanical or electrical faults were noted. This well was noted for its high scaling potential and the tightness of the formation. It was suspected from previous pumps removed from this well that scale had built up between the diffuser and the impeller.

A treatment of 150 litres of **PentaFlow** was programmed for spotting across the pump in a single 90-minute soak as a pre-cleaning solution. The second stage entailed placing 155 gallons of **Pyrosol ES**, a high-performance sulphide and carbonate scale dissolver, across the pump and allowing it to soak for 8 hours. After 8 hours, the **Pyrosol ES** was displaced to 155 gallons of fresh **Pyrosol ES** and the well shut in for 12 hours. **PentaFlow** and **Pyrosol ES** are non-corrosive.

After total treatment period 21.5 hours, the pump was engaged and operating at full potential without tripping. After seven hours of start up, the well began producing 175 BOPD with no over load on the ESP, cleaning up to **396 bopd** after 36 hours of

continuous production and then levelling to **300 bopd**. The payback time was 31 hours but more importantly, the pump did not require replacement.

BEFORE : Typical ESP impeller and diffuser – pulled due to scaling.



AFTER : The same components as above after cleaning with PentaFlow and Pyrosol ES.



References: Robbie Soekama – Maxus Production Technology
rsoekama@notes.maxus.com

Eddie Suparti Yusuf – Maxus Production Engineering
eyusuf@notes.maxus.com

Case History 4.4

ESP Cleaning: Maxus/YPF/Repsol Indonesia: Zelda AC-1 PentaFlow + Pyrosol ES

- **ESP Scale : Sulfide + Formation + Corrosion**
 - **Deviated**
 - **Conventional Perforated Liner**
 - **Formation Stimulation**
-

*Summary: The ESP in Zelda AC-1 went into overload losing production of between 279 to 387 bopd. The well as treated with **PentaFlow** and **Pyrosol ES** with the chemicals left in the well bore after verifying the restoration of the ESP function. The tubing was pulled and replaced, leaving the **PentaFlow** and **Pyrosol ES** spotted across the perforations during this period. On re-running the tubing, with the original ESP, production was found to have increased to **1046 BOPD – a 300% increase**.*

CNOOC Indonesia (formerly Maxus YPF Repsol) has chronic problems with the build-up of short term shale/scale deposits in their down hole electrical submersible pumps (ESP) in a number of fields. The pumps typically can reach overload in less than 30 days or can last 300 days (or more) of production life if chemical cleaning is successful. More often than not, it has been necessary to pull the pumps completely and replace them.

The debris from the actual pumps was examined, and concluded that the length of time a pump had been exposed down hole determined the type of treatment required to clean the pumps and remove the blockage debris.

In this approach, two distinct treatment regimes were programmed. The first was for pumps designated as “younger” or having been in place less than 180 days, with the second type designated as “older” which had been in service continuously or otherwise for much longer than 180 days.

The Zelda AC-1 well had been in service producing **279 BOPD** when it went into over load and tripped out. Its peak production had been in excess of **1000 BOPD in 1999** but has declined steadily since. The ESP on this well failed and attempts to re-start the ESP were unsuccessful and no mechanical or electrical faults were noted.

A treatment of 150 litres of **PentaFlow** was programmed for spotting across the pump in a single 90-minute soak as a pre-cleaning solution. The second stage entailed placing 155 gallons of **Pyrosol ES**, a high performance sulphide and carbonate scale dissolver, across the pump and allowing it to soak for 8 hours. After 8 hours, the Pyrosol ES was displaced to 155 gallons of fresh Pyrosol ES and the well shut in for 12 hours. **PentaFlow + Pyrosol ES** are non-corrosive.

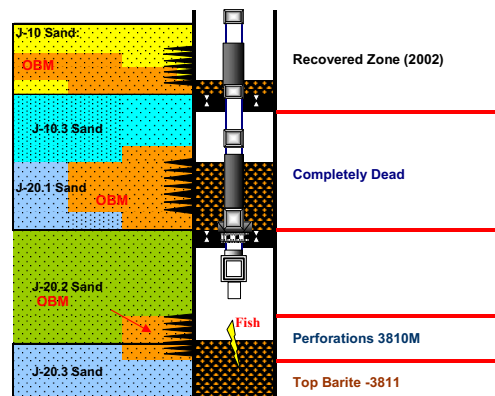
After a total treatment period 21.5 hours, the pump was engaged and operating at full potential without tripping. The pump was disengaged and the **Pyrosol ES** and **PentaFlow** pumped back down through the pump and allowed to soak across the perforations. During this soak period, the ESP was pulled and the tubing replaced. After the intervention the well began producing **1046 BOPD** with no over load on the ESP, maintaining this production without decrease for over one month before this report was prepared and is still producing at that rate.

Case History 4.5 SD27X - OBM Barite Dissolving Petronas Carigali – Resak A10-L

- HT Gas Well (325° F)
- Deviated
- OBM – Settled Barite + Acid Damage
- Conventional Perforated Liner
- Multi-stage Bull Head Through Short String
- CTU N₂ Gas Lift

*Summary: Resak A10L was designed to produce 50 mmcfd, but only produced 20 - 25 mmcfd and falling. After pumping 13.0 ppg OBM to kill the well, during a zonal communication problem in 2001 – the well was impaired badly by settled OBM and solids in the formation. Coil tubing washing was attempted with a resulting loss of the jetting head and production was resumed after a poor acid job result. In November 2004 **PowerPickle** oil solvent was bull-headed as a pre-flush to **SD27X**. The well was allowed to build up pressure naturally until it came on stream and flowed 45 mmscfd.*

Resak A10 is a dual string gas producer drilled by Carigali offshore Terengganu in 1999. The well was completed as a dual string completion to isolate a higher pressure reservoir at the bottom from intermediate production zones above. Due to communication between



the completions and lack of heavy brine, the well was killed and suspended in 13.0 ppg OBM. On re-entry, it was found that most of the perforations in the short string and long string zones were partially buried under settled barite and OBM. In the upper zone, **SD27X** had been used to restore the well to productivity in 2002, so the same methodology was programmed for the deeper long string which was partially buried under OBM solids. The zone was originally designed to produce 50 mmscfd. At the time of acidizing, the zone was producing between 20 and 22 mmscfd and falling. As CTU was not available – it was decided to bull head the Power Pickle and SD27X although there was no gas lift available. The decision was made expecting the well to take time to clean itself up.

Using 4,000 liters (50/50) **PentaFlow** and **PowerPickle** as a preflush, the lower zone was stage displaced to 9,000 liters of **SD27X**. The well was allowed stand static as the pressure built up over time until it cleaned up and was placed on stream producing 45 mmscfd.

Case History 4.6

ESP Cleaning – Maxus/YPF/Repsol Indonesia: Farida A11 PentaFlow

- **ESP Scale : Sulphide + Formation + Corrosion**
 - **Deviated**
 - **Conventional Perforated Liner**
-

Summary : Maxus (YPF/Repsol) Indonesia has chronic problems with the buildup of short term shale/scale deposits in their down hole electrical (ESP) pumps in a number of fields. The pumps typically can reach overload in under 30 days, or can last as long as three hundred days or more of production life if chemical cleaning is successful. More often than not, it has been necessary to pull the pumps completely and replace them.

The debris from the actual pumps was examined and determined that the length of time a pump had been exposed down hole determined the type of treatment required to clean the pumps and remove the blockage debris.

In this approach two distinct treatment regimes were programmed. The first was for pumps designated as relatively “young” – or having been in place less than 180 days, with the second type designated as “older” which had been in service continuously or otherwise for much longer than 180 days.

The Farida A11 ESP had been in service less than 30 days producing **300 to 350 bopd** when it went into over load and tripped out. Attempts to re-start the ESP were unsuccessful and no mechanical or electrical faults were noted.

A treatment of 800 litres of **PentaFlow** was programmed to be spotted across the pump in two 45 minute soak stages. The first 400 litres was spotted above, through and just below the pump for 45 minutes, with the second stage used to flush the second through the pump and itself allowed to soak for 45 minutes. At the end of the full 90 minutes, the pump was engaged and the well brought onto production immediately. The pump has been producing **310 bopd** since the outset without any overload or tripping since the treatment over the twenty day observation period.

This was a highly successful operation demonstrating that the **PentaFlow** worked very efficiently and quickly in these younger pump blockages. **The payback time for the operation for the PentaFlow was 20 hours production time.**

References For **PentaFlow** Pump Cleaning:

Robbie Soekama – MAXUS Production Technology
rsoekama@notes.maxus.com

Eddie Suparti Yusuf – MAXUS Production Engineering
eyusuf@notes.maxus.com

Case History 4.7
OH-Perforation Cleaning –: Carbonate Reservoir Stimulation
CNOOC: Indonesia
PentaFlow

- **Carbonate Reservoir Stimulation**
 - **Acid Damaged**
 - **Weighted OBM Damage**
-

Summary :

*Summary: The Yani AC-1 well was unsuccessfully stimulated using HCL to cleanout the perforations after completion. Although no chemical explanation could determine what the incompatibility was exactly, the take was that the de-emulsifier and solvent package with the crude was incompatible downhole and the acid by products were in fact causing possible side carbonate liquefaction. **PentaFlow** was used as a last attempt to get the well to flow. Not only did it get the well to flow, but brought the well on stream at 20% more than the anticipated production of 3000 bpd.*

A treatment of 3150 litres of **PentaFlow** was programmed for bull heading into the well bore through the perms and outward. The chemical was pumped and allowed to soak across the perms – inside and out for 90 minutes, then displaced approximately 36” outward using fresh PentaFlow and water. After allowing to soak for 8 hours, the well was allowed to flow back and clean up on its own which was successful after 24 hours.

Parti Yusuf – Maxus Production Engineering eyusuf@notes.maxus.com

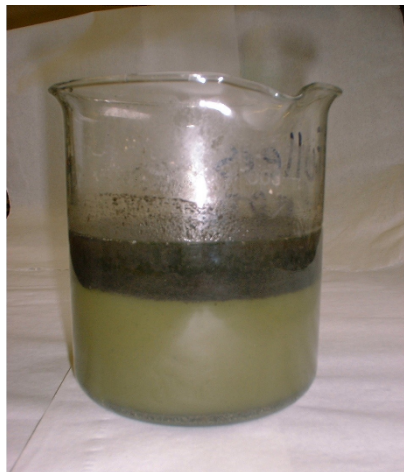
Case History 4.8

ESP Cleaning – Private Contractor For Pertamina Retrieved Pump – De-scaling Operation On Surface

- **ESP Scale : Sulphide + Formation + Corrosion**
 - **Pump on Surface**
-

Summary : *Summary: The rate of ESP failure in the fields off Indonesia are extremely high due to scale build up and formation solids plating out on the impellers. Although cleaning these downhole had been field proven with some Operators – others were still pulling ESP's and having them treated at surface. **PentaFlow** was used to soak the ESP's in a bath at ambient temperature to see if this could be done cost effectively. The pumps were soaked in an open tank of **PentaFlow** and allowed to soak overnight. The pumps were removed and proved to be in pristine condition .*

Photo of fluid removed from soak – note the oil separation from the dissolved scale and corrosion products below:



Typical Before & After Condition of ESPs Being Treated With *PentaFlow*



Case History 4.9

Injector Well Restoration Using SD27X – Monobore - Thailand

- **New Drilled Water Injector**
 - **Conventional Perforated Liner**
 - **Plugged With OBM – no injection**
-

Summary :

The well was drilled and completed as a conventional monobore using weighted oil based mud. After cementing the casing, the well was perforated but failed to inject. Reverse flow back and CTU sampling indicated whole oil based mud was in the perforations. Acid failed to make an impact.

The well information was examined and a treatment consisting of **SD27X** was programmed. The programme called for a two stage soak inside the casing and outside into the perforations and matrix to eliminate the barite which appeared to be plugging the well bore.

Due to the urgency of the situation, the Operator decided to proceed with a trial job even though only 50% of the required chemical was available at the particular window for the operation.

CTU was used to place the **SD27X** into the well. The well was bull headed with a solvent pre-flush to remove any gross oil, the followed with the first stage **SD27X** soak.

The **SD27X** was allowed to soak in place for 8 hours, then was displaced into the formation with new **SD27X** lying across the perforations and in the matrix, and the well shut in for 24 hours.

After 24 hours the well was gas lifted using CTU to assist a quick cleanup, then the well placed on injection. ***The well went operational with an injection rate of 8500 bfpd under 1500 psi.***

Case History 4.10

Well Recovery Using PentaFlow and SD27X – Natuna - Indonesia

- **Well killed and shut-in for 5 years**
 - **Formation damage due to well kill operations**
 - **Very low permeability, average 1.8 mD**
-

Summary :

The well was drilled and tested in March 2012 and at the time produced 18MMSCF on a 48/64" choke, from a lower gas sand. It was killed with a barite pill and shut in for 5 years without any production. The upper zones were produced until depleted.

While drilling the well, up to 800 bbls of mud was lost. Losses were cured with 2 each pills of Form-A-Squeeze and CaCO₃. In the well kill operation after the DST a 20 bbls pill of 200 ppb CaCO₃ LCM was pumped, then 20 bbls of a CaCO₃ pill, 10 bbls of Polypac HT and 60 ppb CaCO₃, and 20 bbls of a 20 ppg barite pill were all pumped.

A program was designed to stimulate the target zone taking into account probable formation damage during well kill operations referenced above. The stimulation/scale dissolver **PentaFlow** was used as a preferred pre-flush treatment, follow by **SD27X** which is a non-damaging stimulation fluid as the main treatment.

The well was re-entered and recompleted as a lower sand gas producer. The well was flowed through a DST package installed on the rig before being hooked back up to the platform system.

The well has very low permeability, average 1.8 mD. During the drill out of the cement plug in the re-entry, it was anticipated to encounter gas, built up over the 5 year's shut-in. However no gas was seen, most likely because of the low permeability/well kill operations. During initial injection of **PentaFlow** the pressure was high at 1,800 psi, but it soon went down indicating that **PentaFlow** was going into reservoir (and doing its job). **PentaFlow** was soaked 2 hours. The program continued with **SD27X** which was injected at low pressure and soaked 12 hours.

After the stimulation, the well initially produced 12 MMSCFD and cleaned up after a day to 26 MMSCFD on a 40/64" choke. The well is now being run thru Clients production facility and capable to produce up to 41 MMSCFD on a 2" choke (full open).

As the lower sands have never been produced before this gas is a new development for Client, it opens up opportunity for new gas sales that can go into the pipeline direct to Singapore.