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Non-Chemical Scale Control of Water Process Systems

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Abstract

Petronas Carigali Sdn Bhd (PCSB) has had long term chronic scale problems in their Tinggi Field caused by the high scale producing "formation" water. This paper describes the elimination of these scale problems using a new concept of magnetic fluid conditioners (MFC's). The history of this mixed scale problem, the worst case on all of PCSB's numerous offshore platforms, dictated compulsory quarterly de-scaling platform shutdowns.

These very successful MFC's, unlike models supplied by others that PCSB had previously trialed with only partial success, were designed using a total engineering approach to the application of this technology and a new application mode. Two units were installed in August 2001 following successful laboratory trials that closely simulated Tinggi's scale problems.

19 months after installation of these MFC's, the results of these non-chemical de-scalers have not only met but overwhelmingly exceeded PCSB's specification in all respects and are as follows:

- New scale formation has been eliminated
- Pre-existing scale has been removed
- Reduced operating costs by eliminating quarterly de-scaling platform shutdowns.
- Production output has been increased significantly by up to 18%
- Improved plant reliability
- Platform operation (vessel pressure and liquid levels) has been stabilised
- Flow control valves remain 100% operational and life of the valves has been extended
- Environmentally safe – no chemicals used
- Return on investment within a few weeks
- Produced significant HSE benefits.

These new design concept MFC's can be applied in all industrial water process systems, not only on offshore platforms. This solution is scale type dependent and not industry type dependent.

Also discussed is the application of MFC's to industrial fluid process heat exchangers, in particular, cooling water systems (condenser/cooling tower type).

Case Study No 1 – Offshore Oil Platform

History of Scale Problems in the Tinggi Field

The "formation" water of the Tinggi Field has severe scaling properties. The offshore platform had to be shutdown for de-scaling every 3 months and production output was reduced by up to 18% due to scale bottlenecks. Various scale control mechanisms have been trialed over many years in the Tinggi field and other fields in Malaysia with minor success until 2001. Both chemical scale inhibitors and non-chemical magnetic fluid conditioners (MFC's) had been trialed.

Overview of Scale Control Mechanisms Trialed

Appendix A provides a brief overview of the effectiveness of some of the scale control mechanisms trialed in the Tinggi field and other Malaysian offshore oil fields. All except one of the mechanisms trialed had minor or no effect and in some cases actually increased the rate of scale build up. Only the Scale-X™ MFC's were totally successful.

PCSB Approach

PSCB's engineers have conducted a well documented methodical approach to solving the scale problem. They realized early on in their trials of the various scale control mechanisms and from a review of technical literature [(1)(2)(3)] that magnetic fluid conditioning had the best potential to solve the chronic scale problems provided it was engineered properly to co-ordinate with the plant design and fluid process conditions. PCSB's challenge was to find a company that applied a multi-disciplined total engineering approach to the design of the MFC's and one that would work with PCSB engineers in "controlled" trials taking into consideration the entire platform fluid process conditions and plant design. After several years of partial success, in 1999 PCSB approached Magnetic Technology of Australia (MTA), a company that has a total engineering approach. PCSB supplied MTA with extensive data on the platform scale problems, plant design and fluid process.

It is to be noted that the oil-water separation systems on offshore platforms are a "once through" system and cannot be treated with the commonly available "off the shelf" MFC's which are only suitable for re-circulating systems where the fluid has multiple passes through the MFC. MTA developed a new concept design of MFC utilizing a new mode of application and in August 2001 two "application specific" MFC's were installed in a three phase (oil / water / gas) separation vessel on its oil and water outlet stand pipes which was identified as having the most chronic scale problems in the Tinggi field.

At Petronas' request MTA also took into consideration the ease of retrofit so that no on site "hot works" or time consuming and costly modifications were required to the platform plant.

Because of the total engineering approach to the application of these MFC's, PCSB closely monitored platform operational performance parameters as well as scale control in the following categories:

1. Flow control valve operational performance
2. Production output levels
3. Separation vessel fluid levels
4. Separation vessel operating pressure
5. Ability to stop new scale build up
6. Ability to remove existing scale build up
7. Ability to reduce de-scaling maintenance shutdowns from 4 per year to the 1 per year specified by PCSB.

The Problem

A chronic scale generation problem occurs when gas is released from the severe scaling Tinggi formation water at pressure reduction points. CO_2 is released at each pressure reduction point in the platform fluid process, and this affects the solubility of $CaCO_3$ causing it to precipitate as scale.

The separation vessel selected for the trials has 3 phase separation, gas/oil/water, and presented the worst situation for scale formation because of the large amount of gas liberated. The pressure drop through the water flow control valve was a massive 1300kPa. Both the oil and water stand pipes scaled almost closed between platform de-scaling shutdowns and the flow control valves became inoperative in 15 days when chemical scale inhibitors were not used and within 28 days when the chemical scale inhibitors were used. **Note:** The liquid in the oil stand pipe and flow control valve at this point in the separation process is 3 parts crude and one part formation water.

The platform had to be shutdown every 3 months for de-scaling. Appendix B graphically shows the scale problem in the standpipes and valves. The types of scale were 95% calcite, 3% dolomite and 2% barite.

The scale build-up bottlenecks reduced ***the production output level by 18% over 3 months*** between the de-scaling maintenance shutdowns.

The Solution

Specially designed "application specific" Scale-X™ MFC's were installed internal to the separation vessel on the standpipes and replaced the vortex breakers. These MFC's incorporated vortex breaker duties and a photograph of the MFC on the water outlet standpipe is shown in Appendix D.

This new approach to the application of MFC's is a world first and took 2-1/2 years to develop specifically for this application.

Visual Inspection 8 Months After Installation

In May 2002, 8 months after installation of the MFC's, there was a general field shutdown which allowed an internal visual inspection of the separation vessel, valves and pipes to be carried out. Photographs from that inspection are contained in Appendix C and visually shows that new scale formation had been eliminated.

The Outcomes at 19 Months After Installation of the MFC's

The platform has now operated for 19 months with no descaling shutdown and all operational parameters indicate that it will be able to run continuously without a shutdown.

The outcomes resulting from the installation of the Scale-X™ MFC's exceeded the PCSB specification in all categories and:

1. completely stopped new scale build up in the standpipes and the control valves
2. removed pre-existing scale build up
3. showed that chemical scale inhibitors can be eliminated.
4. the production output has remained at 100% on a continuous basis, that is, there is no drop off in production levels.
5. operational performance of the platform has remained steady with no requirement to ramp up the vessel fluid levels and pressures to maintain production output
6. control valves remain 100% operational without chemical scale inhibitors or twice daily stroking of control valves and.
7. de-scaling maintenance shutdowns can be reduced from 4 per year to less than 1 per year and most likely totally eliminated.
8. production output has been significantly increased due to no drop off in production and also reduction/elimination in de-scaling maintenance shutdowns.
9. flow control valve life has been lengthened.
10. an economic evaluation of the Scale-X™ MFC's has a return on investment within a matter of weeks and it is a once off investment.
11. significant benefits have been achieved in HSE issues.

Appendix C photographs show the scale build ups after 3 months without the MFC's and no scale build-up at 8 months with the MFC's installed. (The photographs at 8 months were taken during the general field shutdown.) Appendices E and F show the stabilised operational performance of the platform system in maintaining full production output with the control valves remaining fully operational.

Case Study No 2 – Building Air Conditioning System

History of Scale Problems in the Cooling System

This building was located adjacent to a large brown coal open cut mine operated by the State Electricity Commission of Victoria Australia (SECV). The building cooling system (condenser and cooling tower type) suffered from a long term scale and sludge problem. The sludge was caused mostly by the ingress of foreign particles originating from the open cut coal mine.

Even though scale and corrosion inhibitors were used the system required regular cleaning twice yearly otherwise the system would trip out on high head pressure due to scale and sludge build up in the condenser tubes.

Note that the climatic conditions in Victoria are such that a building cooling tower air-conditioning system typically operates for only 4 to 6 months each year. This system required cleaning of the cooling tower and condenser at least once every 3 months during summer.

SECV Approach

State Electricity Commission of Victoria (SECV) engineers, in their search for a long term solution, decided to move away from the generally accepted methods of scale control of using chemical dosing which had proved only partially effective and to trial magnetic fluid treatment technology.

At least once every 3 months during summer.

The Problem

The main scaling problem in the air conditioning system was the build-up of calcium carbonate (calcite) on the walls of the condenser tubes and sludge settling in the tubes. The scale was forming as a result heat transfer and resultant evaporation at the tube walls. The condenser tubes had to be chemically and mechanically cleaned at least twice yearly to remove the bottlenecking effect of the build-ups and to avoid the system tripping on high head pressure. Damage (puncture) of the copper condenser tubes from mechanical cleaning was always a concern.

The second scaling point was build-up of scale on the cooling tower slats.

Another issue was the corrosion occurring in the carbon steel "bell housing" ends of the condensers.

The Solution

This re-circulating water circuit was about 15 meters (45 feet) in length and the pipe work was of thin walled copper construction. Because of the short fluid circuit length and the small number of pipe bends, the system could be treated by a single MFC.

An MFC supplied by Magnetic Technology Australia was installed on the copper piping prior to the condenser [4]. The simple "external to the pipe" clamp on type MFC was used as the plant construction details allowed this mode of application and this is a re-circulating system. Appendix G shows a schematic diagram of the air conditioning system and the location of the MFC.

Dosing of all scale and corrosion inhibitors was discontinued when the MFC was installed.

The Outcomes After 5 Years of MFC Treatment

A. The Condenser

The condenser was opened regularly for the first five years after installation of the MFC to check the condition of the condenser tubes and bell housing ends. The system was not cleaned during this period. It was noted from these visual inspections that:

1. No new scale had formed
2. Pre-existing scale was removed by the MFC treatment and the tubes became cleaner than before the MFC was installed.
3. Sludge build-up was non-existent
4. Head pressure remained constant

5. Corrosion blisters in the bell housing did not increase during the summer period when the air conditioning system was operating. During the winter period when the system was shut down, and thus there was no MFC treatment taking place, the corrosion blisters began to grow.
6. The condenser did not require de-scaling or de-sludging again after installation of the MFC.

B. Cooling Tower

The scale on the cooling tower slats became soft and was slowly washed away.

One major change noted by the SECV was that as the MFC de-scaled/de-sludged the system there was a significant increase in the amount of sludge in the basin of the cooling tower, that is, at the low velocity point in the system. The sludge remained soft and was easily flushed out.

The scale and sludge in the system provides the food chain for bacteria. It is recommended that the basin should be cleaned (flushed) on a regular basis to remove the sludge as the cleaner system reduces bacteria problems such as legionella.

C. Air Conditioning System Operational Performance

The air conditioning system operated continuously without cleaning and no longer tripped off due to high head pressure.

Note: This MFC installation is in the State of Victoria, Australia
Victorian Government Law requires that all cooling towers in Victoria are dosed with biocides. Therefore magnetic fluid conditioning technology's ability to control Legionella and algae were not monitored on this cooling tower system.

References

(1) "Study of Paraffin Crystallisation Process Under the Influence of Magnetic Fields and Chemicals" – SPE38990, Society of Petroleum Engineers – September 1997 by L C C Marques, N O Rocha, A L C Machado, G B M Neves, L C Vieira and C H Dittz – Petrobras Research Center, RJ.

(2) Federal Technologies Alerts – "Non-Chemical Technologies for Scale and Hardness Control" by the United States Department of Energy – January 1998

(3) "Lifting the Scale from Our Pipes" – New Scientist 18 February 1988 – Professor John Donaldson and Dr Sue Grimes – Chemistry Department, City University London

(4) "The Magnetic Treatment of Water for Scaling, Corrosion and Biological Control – Fact or Fiction" – The 1990 International Maintenance Management Conference - J M Lobley, State Electricity Commission of Victoria

Acknowledgements

These new magnetic fluid conditioners (MFC's) were developed by Magnetic Technology of Australia and are marketed under the name Scale-X™ Magnetic Fluid Conditioners. Further information can be obtained from **www.scale-x.com**.

Appendix A

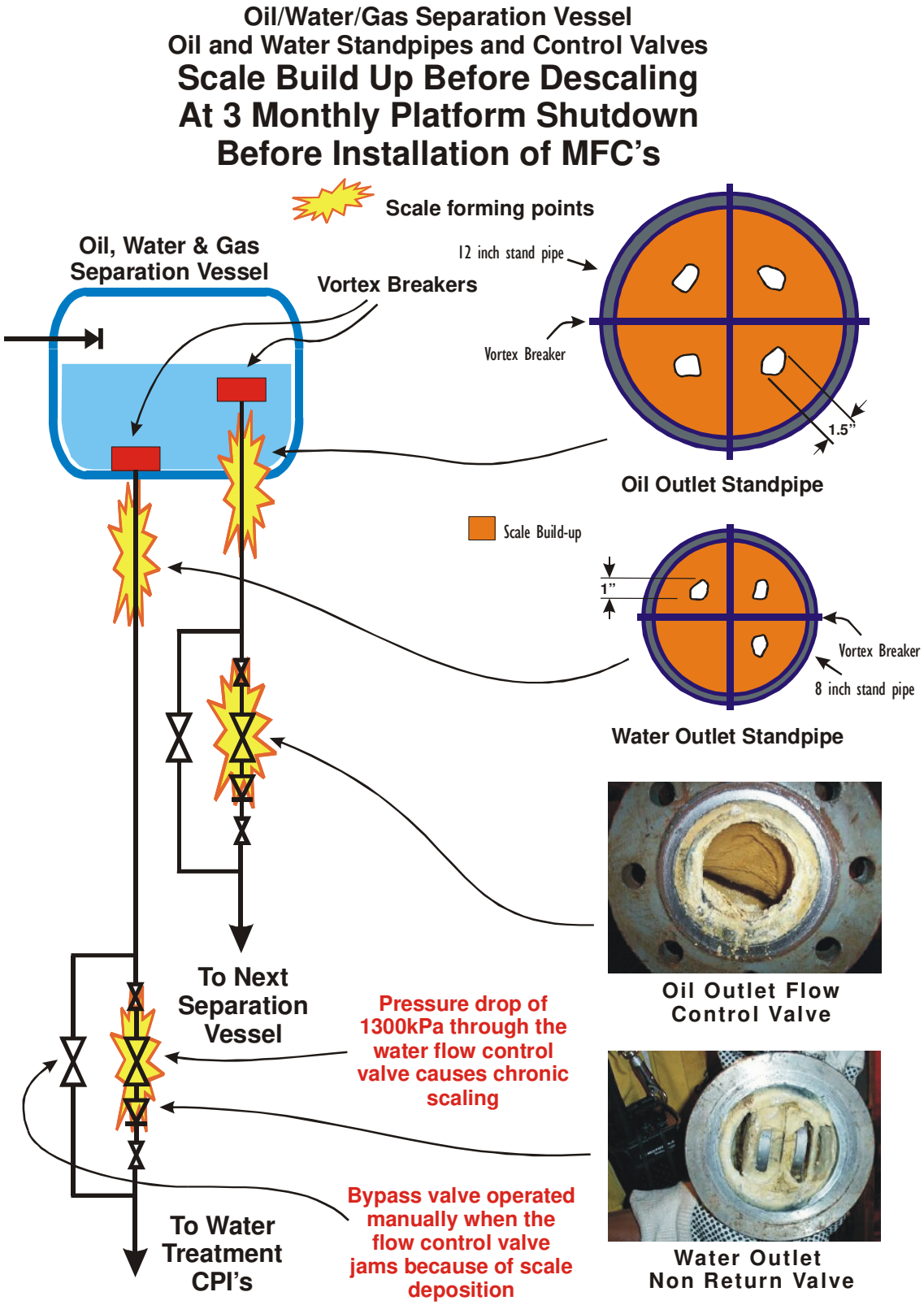
Evaluation of scale control mechanisms trialed and/or applied on Tinggi & Other Offshore Oil Fields in Malaysia

Control Mechanism	Product Name	Effectiveness (scale 1 to 10)	Comments
Magnetic Fluid Conditioner	**MFC "A"** (see Note A)	6	Cleans reduced from 2 per year to 1 per year
Magnetic Fluid Conditioner	**MFC "B"** (see Note B)	5	Cleans reduced from 3 monthly to 5 monthly. MFC units suffered from front end fouling.
Magnetic Fluid Conditioner	**Scale-X™**	**10**	Eliminated scale build up. (Reduced calcite by 100%, barite by 100% and dolomite by 100%). Removed existing scale build ups. Exceeded PCSB specification.
Chemical scale inhibitor	**Surflo SI 2750**	0	Increased scale problem - barite by 480%, calcite by 100% and dolomite by 8%
Chemical scale inhibitor	**Surflo SI 3007**	1	Reduced calcite by 33%. Increased barite by 500% and dolomite by 8%
Chemical scale inhibitor	**Scaletrol-5**	1	Reduced calcite by 19% and dolomite by 0.4%. Increased barite by 109%
Chemical scale inhibitor	**Techni-Hib 764**	6	Reduced calcite by 63% and dolomite by 14%, increased barite by 100%
Chemical scale inhibitor	**Techni-Hib 767W**	3	Reduced calcite by 47% and dolomite by 3% and increased barite by 103%
Chemical scale inhibitor	**Techni-Hib 7576**	2	Reduced calcite by 27% and dolomite by 7%, increased barite by 100%

Note A: Supplied by Magniflo

Note B: Supplied by MagWell

Appendix B


Oil/Water/Gas Separation Vessel
Oil and Water Standpipes and Control Valves
Scale Build Up Before Descaling
At 3 Monthly Platform Shutdown
Before Installation of MFC's
Scale forming points
Oil, Water & Gas Separation Vessel
Vortex Breakers
12 inch stand pipe
Vortex Breaker
1.5"
Oil Outlet Standpipe
Scale Build-up
1"
Vortex Breaker
8 inch stand pipe
Water Outlet Standpipe
Oil Outlet Flow Control Valve
To Next Separation Vessel
Pressure drop of 1300kPa through the water flow control valve causes chronic scaling
Bypass valve operated manually when the flow control valve jams because of scale deposition
To Water Treatment CPI's
Water Outlet Non Return Valve

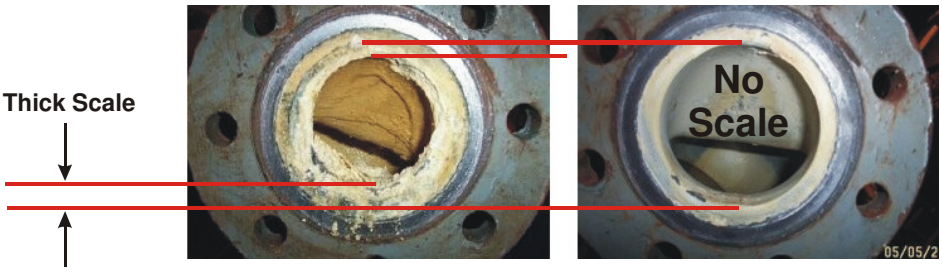
Appendix C

Scale Build Up Before and 8 Months After Installation of Scale-X™ MFC's

Photographs taken before descaling at 3 monthly platform shutdown before installation of Scale-X MFC's

Photographs taken during the general field shutdown 8 months after installation of the Scale-X MFC's

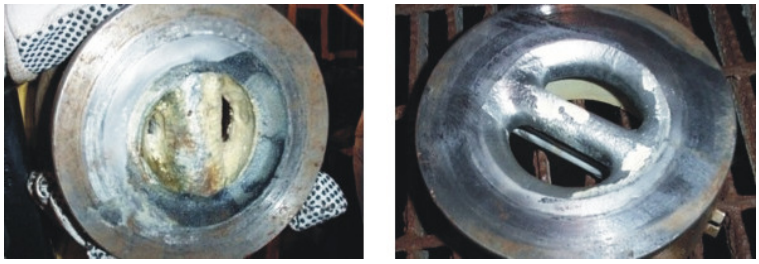
Oil Control Valve



Thick Scale Build Up
After 3 Months
Without MFC's Installed

No Scale Build Up
After 8 Months
With MFC's Installed

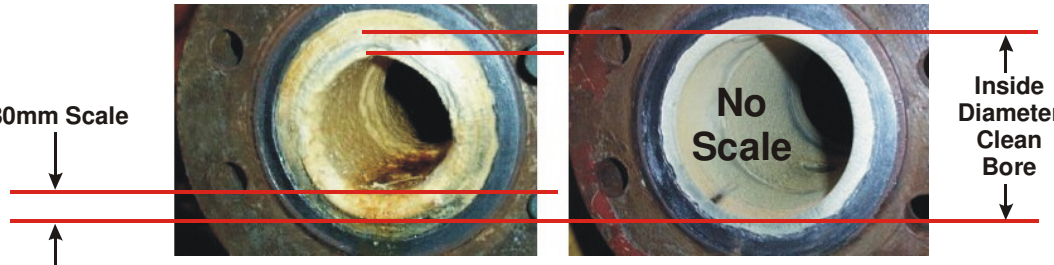
Non-Return Valve



Heavy Scale Build Up
After 3 Months
Without MFC's Installed

No Scale Build Up
After 8 Months
With MFC's Installed

Block Valve Reducer Downstream of Oil Control Valve



Thick Scale Build Up
After 3 Months
Without MFC's Installed
Thickness of Scale is 30mm

No Scale Build Up
After 8 Months
With MFC's Installed
Scale is eliminated

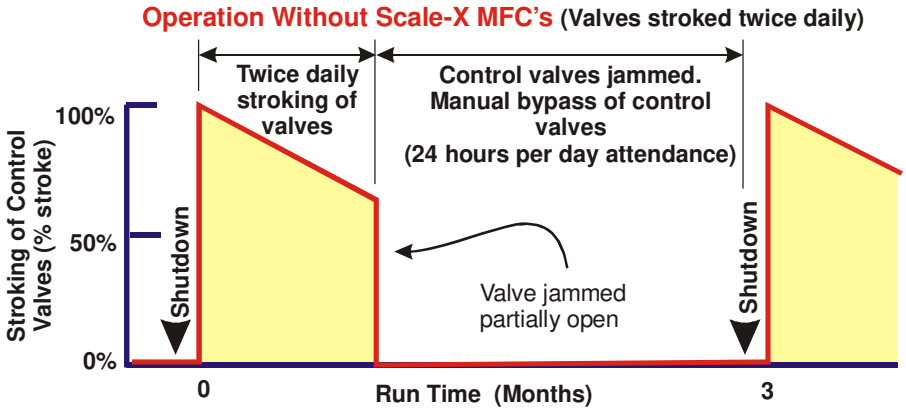
NOTE: The liquid through these valves and reducer is 3 parts crude oil and 1 part formation water.

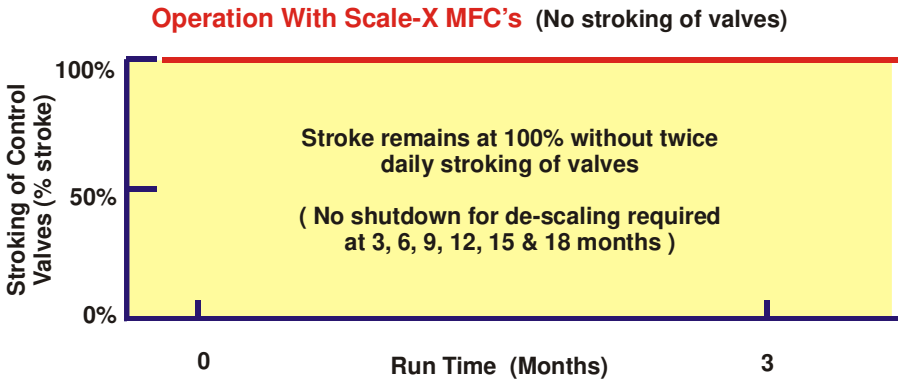
Appendix D

Scale-X™ MFC Installed on the Separation Vessel Water Outlet Standpipe

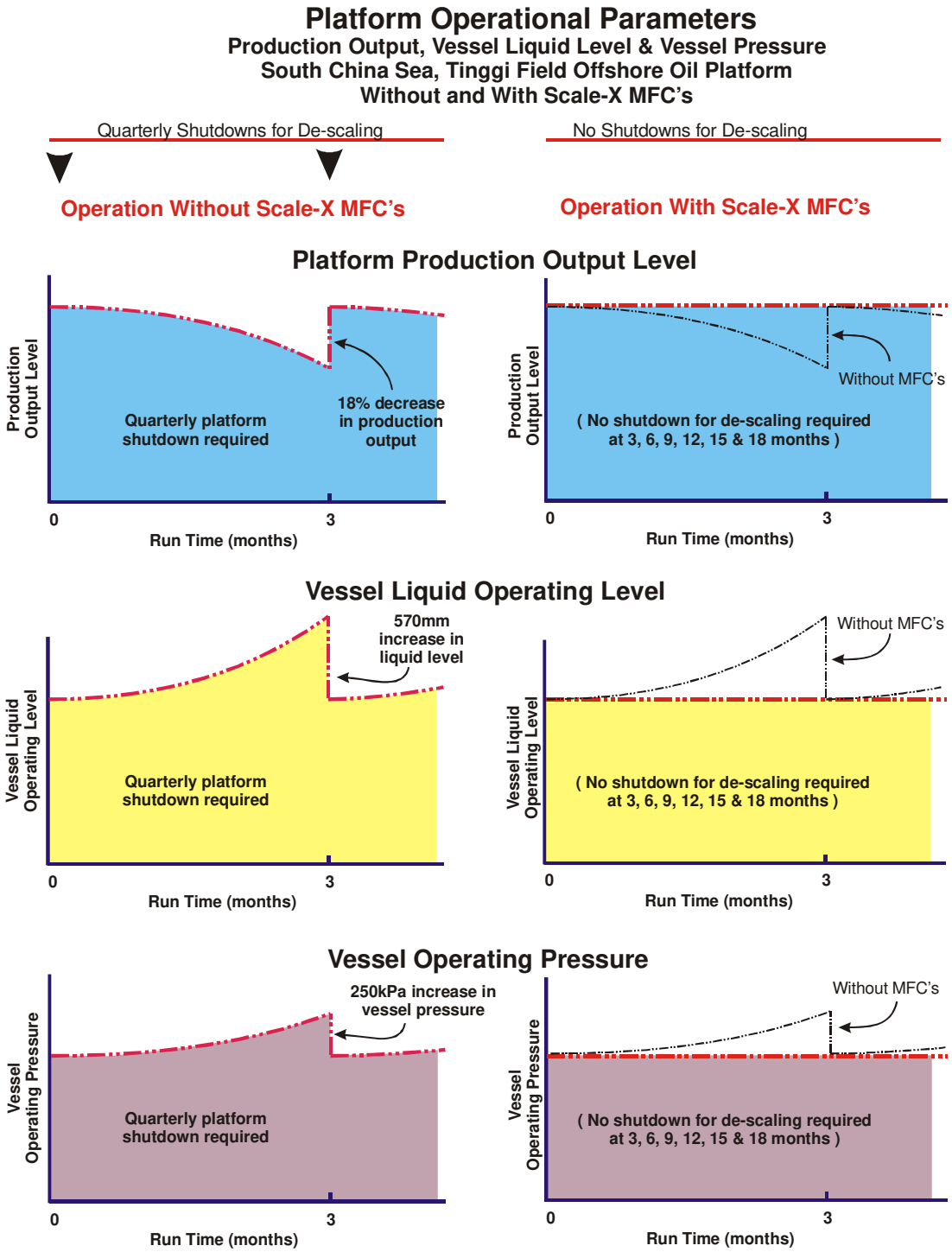
Appendix E

Stroking of Flow Control Valves
Oil & Water Separation Vessel Control Valves Without and With Scale-X MFC's





Appendix F

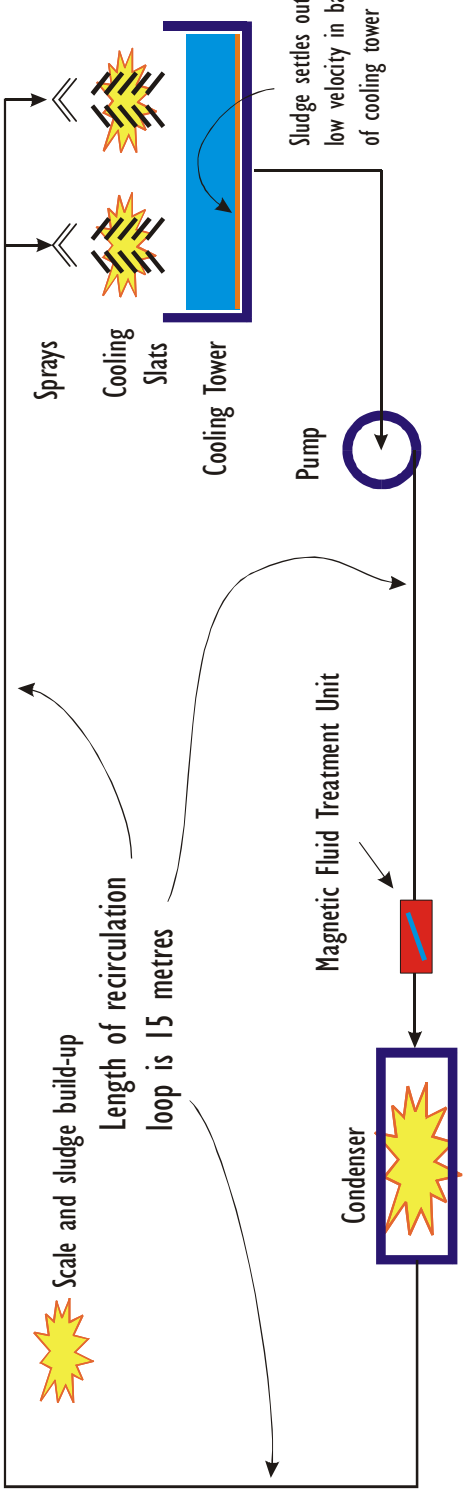

Platform Operational Parameters
Production Output, Vessel Liquid Level & Vessel Pressure
South China Sea, Tinggi Field Offshore Oil Platform
Without and With Scale-X MFC's
Quarterly Shutdowns for De-scaling
No Shutdowns for De-scaling
Operation Without Scale-X MFC's
Operation With Scale-X MFC's
Platform Production Output Level
Production Output Level
Quarterly platform shutdown required
18% decrease in production output
Without MFC's
(No shutdown for de-scaling required at 3, 6, 9, 12, 15 & 18 months)
0
3
Run Time (months)
Vessel Liquid Operating Level
570mm increase in liquid level
Vessel Liquid Operating Level
Quarterly platform shutdown required
Without MFC's
(No shutdown for de-scaling required at 3, 6, 9, 12, 15 & 18 months)
Vessel Operating Pressure
250kPa increase in vessel pressure
Vessel Operating Pressure
Quarterly platform shutdown required
Without MFC's
(No shutdown for de-scaling required at 3, 6, 9, 12, 15 & 18 months)

Appendix G

Building Air-Conditioning System
Yallourn Open Cut Brown Coal Mine Administration Building
Application of Magnetic Fluid Treatment Technology

Paper 9 - The 1990 International Maintenance Management Conference

Magnetic Units supplied by PS Australian Promotions P/L trading as Magnetic Technology



Performance of Air-Conditioning System Before MFC Was Installed

The condenser experienced fouling requiring cleaning on an average of twice per year. Also the system suffered from sludge caused by the ingress of organic materials originating from the open cut brown coal mine. Chemical scale and corrosion inhibitors were used.

Outcomes 5 Years After MFC Was Installed:

Scale and corrosion inhibitor chemicals were discontinued.

Regular checks over the next five years showed no deposition of scale or sludge in the condenser tubes. Also, scale not removed during the condenser clean before the application of the MFC was removed by the magnetic fluid treatment. The scale and sludge was deposited in the basin of the cooling tower and remained soft.

There was no deposition of scale on the cooling tower slats.

There was no increase in corrosion during the period when the AC was operating. During the three month winter period while the AC system was not operating and thus there was no magnetic fluid treatment during that period, there was an increase in corrosion.

Without Scale-X
MFC Treatment

With Scale-X
MFC Treatment