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## **Achieving Excellence in Water Injection Through Application of Innovative Technology**

Muhammed Akram, Chouhdary, Hussain Al-Rasheedi, Ali Mahmeed, Hisham F. Mubarak and Mubarak Al-Hajeri, Kuwait Gulf Oil Company

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### **Extended Abstract**

Paper illustrates that how the excellence in water injection can be achieved in terms of oil recovery and production enhancement with application of innovative technology in line with principles of integrated reservoir management. The paper discusses the key achievements and major challenges faced in implementation of peripheral water injection in a mature carbonate reservoir.

The Wafra field was discovered in 1954 and is located in the Neutral Zone between Kuwait and Saudi Arabia. The mineral rights in this region are shared equally by both countries. The field is now operated jointly by Saudi Arabian Chevron (100 % owned subsidiary of Chevron) and Kuwait Gulf Oil Co. The Wafra-Ratawi is a heterogeneous carbonate reservoir. The reservoir is an anticline with 2 lobes East Wafra and Main Area. The reservoir has varying oil gravity with low bubble point pressure. The Oil Production from this reservoir started in 1957.

After an extensive geologic and engineering study, the production strategy to produce it above the bubble point pressure was adopted. However, because of the weak aquifer support, the reservoir pressure started to decline rapidly. The field was shut in during the first Gulf war, and the increase in average reservoir pressure was observed, signaling for existence of partial aquifer support.

The simulation model in 1995 indicated a significant opportunity to enhance the asset value through recovery improvement (IOR) techniques.

Based on the sound reservoir engineering practices, detailed reservoir studies, low cost and higher economic benefits the peripheral water injection was selected as preferred method for initiating reservoir pressure maintenance. The pressure maintenance project (PMP) was implemented in

1998. The Pressure Maintenance Plant was designed to handle all produced waters in the Wafra field with varying salinity and H<sub>2</sub>S contents.

A depletion strategy objected at optimum reservoir management and maximum oil recovery was adopted. Following are the key features of depletion strategy.

1. Target Injection rate
  - a) Phase -1 Injection/Production rate > 1
  - b) Phase-2 Injection/ Production rate ~ 1
2. Maintain Optimum Draw Down in producing wells.
3. Take maximum benefit of water front movement.
4. Manage problems related to vertical permeability distribution.

Twenty one new injectors were drilled and 5 producers were converted to injectors to inject at required rate and designed line pressure. The water injection response was seen in a short time span by increased avg. reservoir pressure, reduction in GOR and increase in production rate. To keep optimum draw down, take maximum benefit of water injection response and to optimize the asset value an integrated reservoir management strategy was adopted. Following are the key measures implemented to achieve excellence from peripheral water injection project.

- i - Balancing Injection - Production by
  - a. Drilling Producers between injectors and first row producers,
  - b. Side tracking existing wells.
- ii - Drilling horizontal leg parallel to fracture orientation.