

High rate water injectors with sustained injectivity, in unconsolidated and loosely consolidated sand reservoirs, are critical for the economic success of many projects around the globe. These injectors have experienced rapid loss of injectivity, non-uniform fluid distributions within a completion or between different completions within a wellbore, premature failure, and loss of fluid containment. Possible mechanisms with different solutions have been proposed and deployed to address these problems. For environmental applications high rate reinjections of produced water and waste slurry are also being used. They have similar sustained injectivity, fluid conformance, and containment challenges. The similarities between water and environmental injectors highlight the benefits of sharing lessons learned and solutions used in these applications.

The objective of this workshop is to discuss and share the latest:

- understanding on impairment and containment mechanisms,
- injector conformance and performance results in the field,
- well completion design selection, considerations, and deployment lessons learned,
- well surveillance and operating best practices, and
- advances from the industry and academia for injectors in upstream and environmental applications.

The workshop will help accelerate understanding and develop improved solutions to sustain high injection, deliver fluid conformance, and maintain fluid containment for both upstream and environmental injectors.

## Committee Members

### CHAIRPERSON

**George Wong**  
University of Houston

**Unwana Bassey**  
Total

**Bob Burton**  
Conocophillips

**Tim Ellison**  
ExxonMobil

**Claudio Furtado**  
Petrobras

**John Glenn**  
BHP

**Bulent Izgec**  
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**Steve Mathis**  
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**Michael Schexnailder**  
Halliburton

**Mukul Sharma**  
University of Texas at Austin

**Jamie Stuart Andrews**  
Equinor

**Marleen Rijkeboer**  
Shell

**Kevin Whaley**  
BP

## Who We Are

SPE is the largest individual member organization serving managers, engineers, scientists and other professionals worldwide in the upstream segment of the oil and gas industry.

## Monday, 11 November

**0700–0800** **Anacacho Ballroom Foyer**  
**Registration Check-In**

**0700–0800** **Draper Room**  
**Continental Breakfast**

**0800–0830**  
**Welcome Remarks**

**0830–1000**  
**Session 1: Factors Controlling Injector Performance: Field Case Studies—Part 1**

**Session Chairpersons:** Mukul Sharma, University of Texas at Austin; Jamie Stuart Andrews, Equinor

This session will focus on injectivity issues. Field cases will be presented that provide insight into how different design factors such as well design (cased-hole vs open-hole, horizontal vs vertical) and operational philosophy (matrix vs fractured injection) can impact well injectivity. Different techniques for the assessment of injector performance evaluation will be discussed. The objective of the session is to aid operators in making decisions related to well completion design and operating practices to ensure sustained well injectivity.

- **Start Up and Early Performance of High Rate Water Injector—Offshore Eastern Canada Example**  
 Jessica Banfield, ExxonMobil
- **Recent Experiences on Injection Well Performance in a Deep Water Field in the Gulf of Mexico**  
 Cigdem Omurlu, Shell

**1000–1030**  
**Coffee Break**

**1030–1200**  
**Session 2: Factors Controlling Injector Performance: Field Case Studies—Part 2**

**Session Chairpersons:** Bob Burton, ConocoPhillips; Mehmet Parlar, Schlumberger

This session will focus on injectivity issues. Field cases will be presented that provide insight into how different design factors such as well design (cased-hole vs open-hole, horizontal vs vertical) and operational philosophy (matrix vs fractured injection) can impact well injectivity. Different techniques for the assessment of injector performance evaluation will be discussed. The objective of the session is to aid operators in making decisions related to well completion design and operating practices to ensure sustained well injectivity.

- **An Intervention-Less Approach to Injection Well Remediation in Deepwater**  
 Aleksander Armstrong, Murphy Oil Corp.
- **Sustaining 21+Kbwipd Injection for Over 3 Years in a Gulf of Mexico Water Injector**  
 Bulent Izgec, HESS
- **Performance of Gulf of Mexico Cased Hole Frac-Pack Injectors Completed with Proppant Consolidation**  
 Carlos Stewart, BP

**1200–1330** **Draper Room**  
**Networking Luncheon**

**1330–1500**  
**Session 3: Completion Design for Conformance Control of Water Injection—Part 1**

**Session Chairpersons:** Kevin Whaley, Laurence Murry, BP; Michael Schexnaider, Halliburton

Poor vertical or areal conformance for water injection wells can lead to various problems with the offset producing wells as well as the effectiveness of an entire waterflood operation. Techniques have been employed that incorporate hardware to regulate the injection profile, initiate startup injection, and facilitate the placement of chemical treatments to seek to improve conformance. This session will look at a variety of means used to either control the injection profile, or to allow accurate placement of treating chemicals.

- **Monitoring Water Injection Conformance With Remote Surveillance & DTS in a Multi-Layer**  
 Denis Zavyalov, BP
- **Evolution of Design and Injection Performance of Limited Entry Cased and Perforated Multi-Zone Water Injection Wells with Down Hole Flow Control**  
 Innis MacLeod, Ashraf Bessada, BP
- **Optimal Open Hole Zonal Isolation to Achieve Conformance in Complex Water Injector Completions**  
 Reggie Boggs, Paul Day, Weatherford

**1500–1530**  
**Coffee Break**

**1530–1700**  
**Session 4: Completion Design for Conformance Control of Water Injection—Part 2**

**Session Chairpersons:** Steve Mathis, Chevron; Marleen Rijkeboer, Shell

Poor vertical or areal conformance for water injection wells can lead to various problems with the offset producing wells as well as the effectiveness of an entire waterflood operation. Techniques have been employed that incorporate hardware to regulate the injection profile, initiate startup injection, and facilitate the placement of chemical treatments to seek to improve conformance. This session will look at a variety of means used to either control the injection profile, or to allow accurate placement of treating chemicals.

- **Completion Design for Multizone Water Injectors—Korolev Field in Kazakhstan**  
 Mike Fuller, Chevron
- **Advanced Completions for Water Injection Wells—Latest Technology and Experiences**  
 Anabel Green, Tendeka
- **Arkutun-Dagi Water Injection Conformance Control**  
 Michael Davis, ExxonMobil

**1700–1830** **The Cascade Room**  
**Networking Reception**

# Injectors with Sustained Injectivity, Fluid Conformance, and Containment— Field Performance Results and Design Considerations

## Tuesday, 12 November

0700–0800

Draper Room

### Continental Breakfast

0800–0930

### Session 5: Injectivity Optimisation in Produced Water Re-Injection Wells—Field Results

**Session Chairpersons:** Jaime Stuart Andrews, Equinor;  
Jalel Ochi, Total

Injection of produced water for pressure support or disposal has always been challenging, in view of water quality and its potential negative effects. Achieving optimum and sustained injectivity throughout life-of-well in a cost effective manner are key objectives. This session addresses various efforts that have been implemented (successfully or not) in an attempt to achieve this desired objective. Discussions will centre on processes, procedures, laboratory experiments, analyses, simulation and/or modelling. Furthermore, PWRI wells' Injectivity restoration procedures and processes through stimulation will be addressed in this session.

- **Produced Water Re-Injection in FPSO P-57 Offshore Brazil, PETROBRAS**  
Lucas Pavan Barros, Petrobras
- **Optimization of PWRI Strategy and Injection Well Design for NCS Field Development of the Wisting Field in the Barents Sea**  
Eirik Stueland, OMV
- **PWRI Implementation on Remote N Sea NUI Debottlenecks PW Handling and Increases Value from PW**  
Laurence Murray, BP

0930–1000

### Coffee Break

1000–1130

### Session 6: Injectivity Optimisation in Produced Water Re-Injection Wells—Laboratory Results

**Session Chairpersons:** George Wong, University of Houston;  
Bob Burton, ConocoPhillips

Ensuring that the injection water remains in the target reservoir during pressure maintenance operations, or that waste fluids that are disposed remain within the disposal domain, have important economic, operability, safety/health/environmental, and license to operate implications. If an OOZI (Out Of Zone Injection) event occurs, it can involve breaching out of zone into adjacent zones or to the surface or seafloor with potentially significant consequences. Methods or processes to ensure containment, or surveillance to track and verify containment, or cases where containment is/was challenging, will be presented.

- **PWRI Plugging Parameters From Core Flooding Tests and History Matching Field Injection, EQUINOR**  
Jamie Stuart Andrews, Equinor
- **Prediction of Core Plugs Permeability Decline Curves Under PWRI Using Machine Learning Techniques**  
Jalel Ochi, TOTAL
- **Effects of Solid Particle Nature and OIW on Injectivity During PWRI—Experimental and Simulation Results**  
Oya Karazincir, Ruiting Wu, Chevron

1130–1300

Draper Room

### Networking Luncheon

1300–1430

### Session 7: Containment

**Session Chairpersons:** John Glenn, BHP;  
Tim Ellison, ExxonMobil

Ensuring that the injection water remains in the target reservoir during pressure maintenance operations, or that waste fluids that are disposed remain within the disposal domain, have important economic, operability, safety/health/environmental, and license to operate implications. If an OOZI (Out Of Zone Injection) event occurs, it can involve breaching out of zone into adjacent zones or to the surface or seafloor with potentially significant consequences. Methods or processes to ensure containment, or surveillance to track and verify containment, or cases where containment is/was challenging, will be presented.

- **Injection Pressure Limit Analysis and Workflow**  
Karim Zaki, Chevron
- **Setting Injection Pressure Limits using MDT Caprock Stress Measurements**  
Giles Duvivier, BP
- **Permanent Electrical Distributed Temp Array Enable OOZI Monitoring in Perdido**  
Mark Klein, Shell

1430–1500

### Coffee Break

1500–1700

### Session 8: Geomechanics & Water Injector Performances

**Session Chairpersons:** Bulent Izgec, HESS;  
Claudio Furtado, Petrobras

The success of a waterflood is mainly determined by the performance of water injector wells. Injector performance depends on effective stresses which affect rock deformations and fluid flows around the wellbore region and in the reservoir. They involve complex porous-thermal-mechanical processes that impact thermal fracturing, stress changes, fluid containment, and rock failures. Geomechanical studies provide insight into the underlying performance mechanisms to help us improve completion design, predict fracture extension over time, prevent injector failures, and deliver safer operating guidelines for fluid containment.

- **Impact of Strength and Stress Anisotropy on Injectivity in Deepwater Prospects**  
Cem Ozan, BHP
- **Injection Fracturing in a Multi-layered Reservoir—Applications for Reservoir Management**  
Tej Bhide, Petroleum Experts
- **Water Injection Into Soft Sands Insights into Mechanisms Through Lab & Numerical Studies**  
Rob Eve, Rob Heller, BP
- **Using Fracture Link-Up Principle to Optimize Well Design**  
Micheal Yao, Hess

Continued on Next Page

## Wednesday, 13 November

0700-0800

Continental Breakfast

Draper Room

0800-0930

Session 9: Emerging Techniques and Technologies in Water Injection

Session Chairpersons: Michael Schexnaider, Halliburton;  
Bulent Izgec, HESS

Water injection and its effectiveness have substantial impact on project economics. The industry has been on a journey to continue to improve injector well effectiveness through new technologies.

This session will discuss recently developed and emerging technologies applied to enhance water injection efficiency, manage injection points, as well as provide insight for improved analysis and field management of water injection.

- Design, Qualification and Optimization of a Deep, Multi-Zone, High-Rate Water Injection Well  
Ron Nelson, Hess Corp.
- The Role of Thermal Conduction and Poroelastic Stresses in Fracture Containment during Long-Term Water Injection  
Jongsoo Hwang, Shuang Zheng and Mukul Sharma, University of Texas at Austin
- On-Demand Seismic Monitoring with 4D DAS VSP for Well and Reservoir Management in Deepwater  
Albena Mateeva, Shell

0930-1000

Coffee Break

1000-1130

Session 10: Interactive Q&A Discussion and Wrap-Up

Session Chairpersons: George Wong, University of Houston;  
Mukul Sharma, University of Texas at Austin

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## General Information

**Accessibility:** Our events and functions are accessible to all attendees with wheelchairs. If you require special arrangements, please contact our staff at the registration desk.

**Alcohol Policy:** SPE recognizes the legitimate serving of alcoholic beverages in the process of conducting business and social activities. We also recognize that the use and consumption of alcohol carries with it the requirement for all attendees to consume those beverages responsibly.

**Commercialism:** In remaining consistent with workshop objectives and SPE guidelines, commercialism in presentations will not be permitted. Company logos should be used only to indicate the affiliation of the presenter(s).

**Continuing Education Units:** Attendees will receive 1.6 CEUs. One CEU equals 10 contact hours of participation. CEUs will be awarded through SPE Professional Development for participation and completion of an SPE workshop. A permanent record of a participant's involvement and awarding of CEUs will be maintained by SPE.

**Documentation:** Following the workshop, a URL containing released copies of the workshop presentations will be available to all attendees.

**Electronic Devices:** As a courtesy to the speakers and your fellow registrants, please turn off all electronic devices during presentations.

**Name Badges:** Please wear your badge at all times. It is a courtesy to your fellow registrants, speakers, and sponsors.

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**Workshop Format:** Workshops maximize the exchange of ideas among attendees and presenters through brief technical presentations followed by extended Q&A periods. Focused topics attract an informed audience eager to discuss issues critical to advancing both technology and best practices.

Many of the presentations are in the form of case studies, highlighting engineering achievements and lessons learned. In order to stimulate frank discussion, no proceedings are published and members of the press are not invited to attend.



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