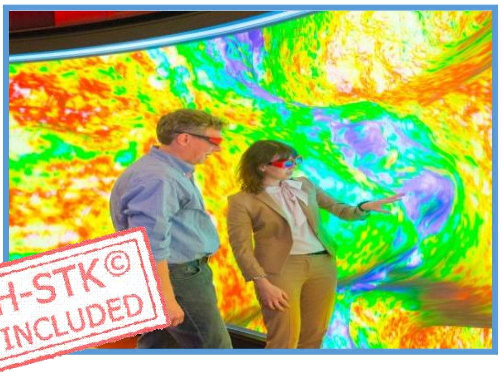
COURSE OVERVIEW DE0732
Reservoir Fluid Properties



Course Title
Reservoir Fluid Properties

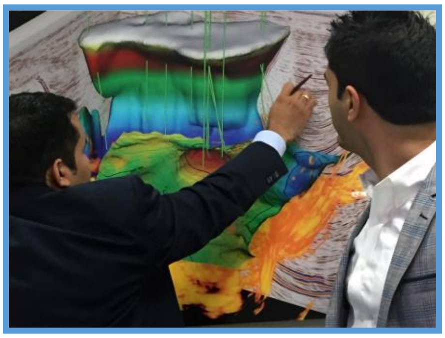
Course Reference
DE0732

Course Duration/Credits
Five days/3.0 CEUs/30 PDHs

Course Date/Venue

Session(s)	Date	Venue
1	May 12-16, 2024	Oryx Meeting Room, DoubleTree By Hilton Doha-Al Sadd, Doha, Qatar
2	September 08-12, 2024	
3	November 10-14, 2024	

Course Description



This practical and highly-interactive course includes various practical sessions and exercises. Theory learnt will be applied using our state-of-the-art simulators.

The reservoir engineer today is able to evaluate and predict reservoir performance much more precisely through the application of multi-dimensional models to mathmatically simulate reservoir behavior. The additional precision requires more attention to the reservoir fluid properties than the traditional material balance studies. This course discusses the problems involved and reviews several techniques which have been employed to achieve improved accuracy in the application of fluid properties in reservoir studies. The techniques presented attempt to consider variations in properties spatially within the reservoir as well as variations with pressure and composition.

This course is designed to provide an up-to-date overview of reservoir fluid properties as a preparation stage for reservoir engineering and simulation studies. It covers the fundamental of hydrocarbon phase behavior; the fundamentals of fluid; the type of fluid in particular reservoir and predict how that fluid will behave during production; the hydrocarbon-plus fractions characterization; the properties of natural gas; the dry gas models, brine models, wet gas models, dead oil models, black oil models, volatile oil models, gas condensate models; and fluid sampling and laboratory testing.

The course goes beyond the usual description of reservoir fluid properties. The underlying purpose is to be able to prepare the most accurate possible set of values of fluid properties for use in other engineering calculations. An understanding of the advantages of the application of both laboratory data and correlations will be provided. Extensive exercises are used to illustrate the principles and to test the consistency of measured data. Accordingly, participants are encouraged to bring their own PVT laboratory data to deconstruct in class. Equations of State calculations are introduced and a tuning exercise is conducted on commercial software.

By the end of the of the course, participants will understand the PVT properties of crude oils; reading and quality checking of PVT reports and the corrections to laboratory data; the equations of state and phase equilibria; the usage of laboratory data to determine values of fluid properties for use in engineering calculations including equation of state; the usage of correlations to determine values of fluid properties in the absence of laboratory data; selecting the best available fluid property correlations for oils, gases and oilfield waters; and shaping PVT data to get the best results out of analytical and numerical software.

Course Objectives

Upon the successful completion of this course, each participant will be able to:-

- Apply and gain an in-depth knowledge on reservoir fluid properties covering the preparation for reservoir engineering and simulation studies
- Identify the type of fluid in a particular reservoir and predict how that fluid will behave during production
- Read and QC PVT Reports
- Use laboratory data to determine values of fluid properties for use in engineering calculations, including equation of state
- Use correlations to determine values of fluid properties in the absence of laboratory data
- Select the best available fluid property correlations for oils, gases and oilfield waters
- Shape PVT data to get the best results our of analytical and numerical software
- Discuss the fundamental of hydrocarbon phase behavior covering single-component systems, two-component systems, multi-component systems, classification of reservoirs, reservoir fluids and location of gas-oil contact
- Recognize the fundamentals of fluid and identify the type of fluid in particular reservoir and predict how that fluid will behave during production
- Characterize hydrocarbon-plus fractions consisting of generalized correlations, PNA determination and splitting and lumping schemes for equation of state applications

- Identify the properties of natural gas including behavior and properties of ideal and real gases, wet gases and their behavior and analysis of gas condensate behavior
- Illustrate dry gas models, brine models, wet gas models, dead oil models, black oil models, volatile oil models and gas condensate models
- Perform fluid sampling and laboratory testing
- Describe the PVT properties of crude oils that includes crude oil properties, surface and interfacial tension, properties of reservoir water, understanding laboratory data, constant-composition expansion test, differential liberation test, separator test, liquid dropout, swelling test, slim tube test, calculations of minimum miscibility pressure and modeling of compositional variation with EOS
- Read and quality check PVT reports and identify the corrections to laboratory data
- Determine the equations of state and phase equilibria including equilibria ratios, flash calculations, Van de Waals' Equation of State, Redlich-Kwong Equation of State, Soave-Redlich-Kwong EOS, Peng-Robinson EOS, fugacity and fugacity coefficient, etc.
- Use laboratory data to determine values of fluid properties for use in engineering calculations including equation of state
- Use correlations to determine values of fluid properties in the absence of laboratory data
- Select the best available fluid property correlations for oils, gases and oilfield waters
- Shape PVT data to get the best results out of analytical and numerical software

Exclusive Smart Training Kit - H-STK®

*Participants of this course will receive the exclusive "Haward Smart Training Kit" (**H-STK®**). The **H-STK®** consists of a comprehensive set of technical content which includes **electronic version** of the course materials conveniently saved in a **Tablet PC**.*

Who Should Attend

The course is intended for reservoir engineers, production engineers and facilities engineers who have a need to model the flow of oil, gas and water through reservoirs, wellbores and surface facilities.

Course Fee

US$ 8,500 per Delegate. This rate includes H-STK® (Haward Smart Training Kit), buffet lunch, coffee/tea on arrival, morning & afternoon of each day.

Course Certificate(s)

Internationally recognized certificates will be issued to all participants of the course who completed a minimum of 80% of the total tuition hours.

Certificate Accreditations

Certificates are accredited by the following international accreditation organizations: -

- The International Accreditors for Continuing Education and Training (IACET - USA)

  Haward Technology is an Authorized Training Provider by the International Accreditors for Continuing Education and Training (IACET), 2201 Cooperative Way, Suite 600, Herndon, VA 20171, USA. In obtaining this authority, Haward Technology has demonstrated that it complies with the **ANSI/IACET 2018-1 Standard** which is widely recognized as the standard of good practice internationally. As a result of our Authorized Provider membership status, Haward Technology is authorized to offer IACET CEUs for its programs that qualify under the **ANSI/IACET 2018-1 Standard**.

  Haward Technology's courses meet the professional certification and continuing education requirements for participants seeking **Continuing Education Units** (CEUs) in accordance with the rules & regulations of the International Accreditors for Continuing Education & Training (IACET). IACET is an international authority that evaluates programs according to strict, research-based criteria and guidelines. The CEU is an internationally accepted uniform unit of measurement in qualified courses of continuing education.

  Haward Technology Middle East will award **3.25 CEUs** (Continuing Education Units) or **32.5 PDHs** (Professional Development Hours) for participants who completed the total tuition hours of this program. One CEU is equivalent to ten Professional Development Hours (PDHs) or ten contact hours of the participation in and completion of Haward Technology programs. A permanent record of a participant's involvement and awarding of CEU will be maintained by Haward Technology. Haward Technology will provide a copy of the participant's CEU and PDH Transcript of Records upon request.

- British Accreditation Council (BAC)

  Haward Technology is accredited by the **British Accreditation Council** for **Independent Further and Higher Education** as an **International Centre**. BAC is the British accrediting body responsible for setting standards within independent further and higher education sector in the UK and overseas. As a BAC-accredited international centre, Haward Technology meets all of the international higher education criteria and standards set by BAC.

Accommodation

Accommodation is not included in the course fees. However, any accommodation required can be arranged at the time of booking

Course Instructor(s)

This course will be conducted by the following instructor(s). However, we have the right to change the course instructor(s) prior to the course date and inform participants accordingly:

Mr. Saber Hussein is a **Senior Geophysicist** with **over 35 years** of extensive experience within the **Oil**, **Gas** and **Petrochemical** Industries. His specialization widely covers in the areas of Basic **Geology**, **Correlation Methods**, **Coring** & **Core Analysis**, **Core Handling**, **Overburden Effects**, **Conventional Data**, **Archie Equations**, **Mercury Injection**, **Rock Mechanics**, **Petrophysical Techniques**, **Geological**, **Geophysical** & **Petrophysical Evaluations**, **Stratigraphy & Sedimentology**, **Subsurface Maps**, **Geological Cross-Sections**, **Drilling Fluids**, **Drilling Data Analysis**, **Mud Logging**, **Porosity**, **Permeability**, **Basin Analysis**, **Reservoir Characterization**, **Facies Analysis** & **Sequence Stratigraphy**, **Structural Geology**, **Wellsite**, **Slick Line Operation** and **Fracture Characterization**. Further, he is also well-versed in rock properties, seismic analysis, petroleum risk and decision, play analysis and risk assessment. Currently, he is the **Exploration Division General Manager** and **Board Member** of one of the leading Petrochemical Plant in the Middle East.

During his career life, Mr. Saber has gained his practical and field experience through his various significant position and dedication as the **Exploration Division General Manager**, **General Manager**, **Senior Geophysicist**, **Geophysicist**, **Expert Mud Logging Assistant** and **Geologist**. He is also a **Board Member** of **SUCO Strategy Plan Committee,** wherein he was responsible for supervision of **all Geological, Geophysical** and **Petro physical Operation activities** as well as **Data Processing** and supervising all activities pertaining to the software and hardware of work station.

Mr. Saber has a **Bachelor's** degree in **Geology**. Further, he is a **Certified Instructor/Trainer** and an active member of Egyptian Petroleum Exploration Society (**EPEX**), American Association of Petroleum Geologists (**AAPG**), GSE and the Petroleum and Scientific Professional Syndicate. He has further delivered numerous trainings, courses, seminars and conferences internationally.

Course Program

The following program is planned for this course. However, the course instructor(s) may modify this program before or during the course for technical reasons with no prior notice to participants. Nevertheless, the course objectives will always be met:

Day 1

0730 – 0800	*Registration & Coffee*
0800 – 0830	*Welcome & Introduction*
0830 – 0845	***PRE-TEST***
0845 – 0930	***Fundamental of Hydrocarbon Phase Behavior: Single-Component Systems, Two-Component Systems, Multi-Component Systems, Classification of Reservoirs & Reservoir Fluids, Location of Gas-Oil Contact***
0930 – 0945	*Break*
0945 – 1200	***Fluid Fundamentals***
1200 – 1300	***Characterizing Hydrocarbon-Plus Fractions: Generalized Correlations, PNA Determination, Splitting & Lumping Schemes for Equation of State Applications***

1300 – 1315	Break
1315 – 1420	***Natural Gas Properties: Behaviour & Properties of Ideal Gases, Behaviour & Properties of Real Gases, Wet Gases & Their Behaviour & Analysis of Gas Condensate Behaviour***
1420 – 1430	***Recap***
1430	Lunch & End of Day One

Day 2

0730 – 0930	***Dry Gas Models***
0930 – 0945	Break
0945 – 1200	***Brine Models***
1200 – 1300	***Wet Gas Models***
1300 – 1315	Break
1315 – 1420	***Dead Oil Models***
1420 – 1430	***Recap***
1430	Lunch & End of Day Two

Day 3

0730 – 0930	***Black Oil Models***
0930 – 0945	Break
0945 – 1200	***Volatile Oil Models***
1200 – 1300	***Gas Condensate Models***
1300 – 1315	Break
1315 – 1420	***Fluid Sampling***
1420 – 1430	***Recap***
1430	Lunch & End of Day Three

Day 4

0700 – 0930	***Laboratory Tests***
0930 – 0945	Break
0945 – 1200	***PVT Properties of Crude Oils: Crude Oil Properties, Surface & Interfacial Tension, Properties of Reservoir Water, Understanding Laboratory Data, Constant-Composition Expansion Test, Differential Liberation Test, Separator Test, Liquid Dropout, Swelling Test, Slim Tube Test, Calculations of Minimum Miscibility Pressure, Modeling of Compositional Variation with EOS***
1200 – 1300	***Reading a PVT Report***
1400 – 1415	Break
1315 – 1420	***Quality Checks on a PVT Report***
1420 – 1430	***Recap***
1430	Lunch & End of Day Four

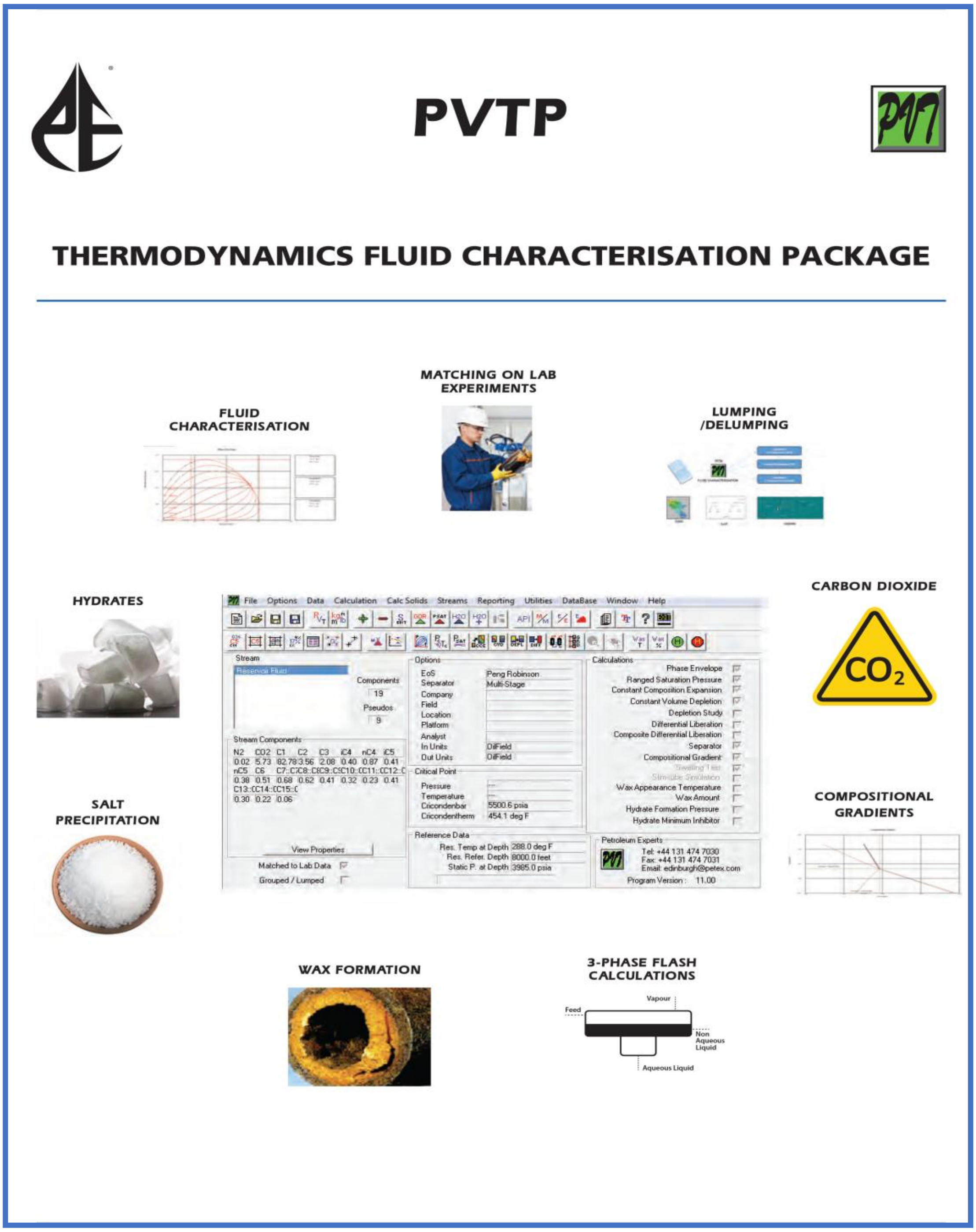
Day 5

0700 – 0930	***Corrections to Laboratory Data***
0930 – 0945	Break
0945 – 1200	***Equations of State & Phase Equilibria: Equilibria Ratios, Flash Calculations, Van De Waals' Equation of State, Redlich-Kwong Equation of State, Soave-Redlich-Kwong EOS, Peng-Robinson EOS, Fugacity & Fugacity Coefficient***
1200 – 1300	***Equations of State & Phase Equilibria (cont'd): Binary Interaction Coefficient, Volume Shift Parameter, Gibbs Free Energy, Chemical Potential, Three-Phase Flash Calculations, Simulation of Laboratory Tests by Equations of State, Compositional Gradient, Tuning of Equations of State***

1300 – 1315	*Break*
1315 – 1345	***Tuning Equations of State***
1345 – 1400	***Course Conclusion***
1400 – 1415	***POST-TEST***
1415 – 1430	*Presentation of Course Certificates*
1430	*End of Course*

Simulator (Hands-on Practical Sessions)

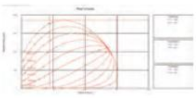
Practical sessions will be organized during the course for delegates to practice the theory learnt. Delegates will be provided with an opportunity to carryout various exercises using "PVTP".



PVTP

THERMODYNAMICS FLUID CHARACTERISATION PACKAGE

FLUID CHARACTERISATION



The IPM suite of applications was created to allow for integrated systems to be constructed, therefore eliminating artificial boundary conditions that engineers would have to impose on models of individual parts of any production or injection system. The basis of any integrated model is a solid and consistent PVT definition, which respects the behaviour of any fluid when it flows in the reservoir, in wells, in pipes and beyond. Traditional approaches of modelling each part of the system in isolation relied on PVT models that were bespoke and created for a single specific use. Integrated Models present challenges of not only ensuring that the same description is valid for any part of the system, but also in a vendor neutral environment, ensuring that different software from different vendors communicate dynamically and receive or pass PVT information that works for their own domain. An integrated model with reservoir simulation, facilities and process models from three or more vendors needs to ensure that the limited number of components or black oil models used in the reservoir simulator are translated into full blown compositions of large component numbers used in process models.

PVTP was created with the objective of not only creating thermodynamically consistent and precise Equation of State models for fluids, but also to deliver these models in ways that can satisfy the vendor neutral principles of integrated modelling. Unique lumping/delumping algorithms have been embedded into the program which satisfy this role and enable engineers to create integrated systems in a straight forward manner and with confidence that consistency in fluid thermodynamics is achieved.

MATCHING ON LAB EXPERIMENTS

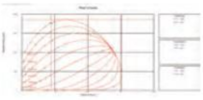
PVT analysis and EOS creation is based on lab experiments and PVTP enables the user to perform these tasks by matching compositions to data available on CCE, CVD, Differential Liberation, Separator Tests and many others. Special treatment of pseudo components exists with quality checks that enable a consistent set of parameters to be used along the process. The program has been designed with flexibility in mind, so that procedures different companies rely on as standards in their organisation can be accommodated for. When matching the EOS models to lab data, PVTP offers a variety of regression techniques. The ones Petex recommends ensure monotonicity in the properties of the components being regressed on, so that consistency in the results can be guaranteed. Unique features in this domain include, but are not limited to:

- Proprietary database of component properties
- Preconditioning of Pseudo properties based on Standing-Katz or Costald models
- Special models for BI coefficients (reliable for pseudo components)
- Proprietary algorithms for pseudo component splitting or lumping
- Volume shift initialisation based on component densities
- Ability to invoke either traditional EOS based or black oil models for viscosity
- Advanced phase detection calculations
- Modifiers that overcome traditional limitations of EOS models in CO2 rich fluids

PVTP

THERMODYNAMICS FLUID CHARACTERISATION PACKAGE

FLUID CHARACTERISATION



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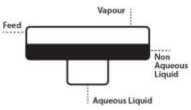
PVTP

THERMODYNAMICS FLUID CHARACTERISATION PACKAGE

WAX FORMATION

Wax deposition can create significant problems in fields where fluids have the potential to drop out paraffinic compounds. This phenomena depends on the the pressure and temperature condition of flow. Being able to understand this behaviour and create suitable operating envelopes is paramount in such situations. PVTP includes models that can predict wax deposition envelopes as well as amount of wax to be deposited at a given set of conditions. The models are based on Won's original work, which analyses the behaviour of a fluid based on a thermodynamic cycle and the changes in Gibbs free energy along various paths. Various modifications to this model have been proposed, improving on the assumptions made by Won and these are also included in PVTP. These include the Won model with solubility parameters, two versions of a model by Chung and also the wax model by Pedersen.

3-PHASE FLASH CALCULATIONS



PVTP includes two and three phase flash engines that facilitate a range of calculations depending on the desired outcome. The Soreide and Whitson method provides the basis of the three phase flash with two more models being available from Hydrafact (Cubic and Cubic Pus Association). The speed penalty that has traditionally restricted the use of these models to very specialised domains, can be overcome by using a proprietary algorithm, referred to as "Pseudo Multi Phase". This is the result of internal research on speeding up three phase flashes and achieves very similar results as the full thermodynamic models but at a fraction of the time they would require.

SALT PRECIPITATION

Salt deposition is increasingly becoming a topic that engineers in the industry are concerned with, especially when expensive offshore wells have been compromised by salt that deposits and inhibits production. This is especially relevant in wells producing gas from reservoirs that include water saturated with salts. A drop in pressure while the gas is being produced means that more water will saturate the gas, leaving the rest of the water being unable to dissolve the salt, hence the deposition in the reservoir or the wells. PVTP allows the user to study this phenomena and understand at which conditions salts will deposit as well as the amount. This can either be done from the water composition itself, or through the salinity of the water.

HYDRATES

Complementing all the flow assurance calculations in PVTP, the hydrate modelling capabilities in PVTP include both industry wide available models (such as Munc) as well as models created from research done in Hydrafact and JIPs with Heriot Watt University (Hydrafact Modified Cubic and Hydrafact CPA). Operating envelopes that would enable safe conditions of flow can be created. In the event of inhibitors needing to be introduced, the calculations allow for evaluations to be done on which inhibitor would be most effective and at what quantity it would need to be injected.

Course Coordinator
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