Hydraulic Evaluation of an Off-Shore Pumping Station

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PEMEX Exploracion y Produccion

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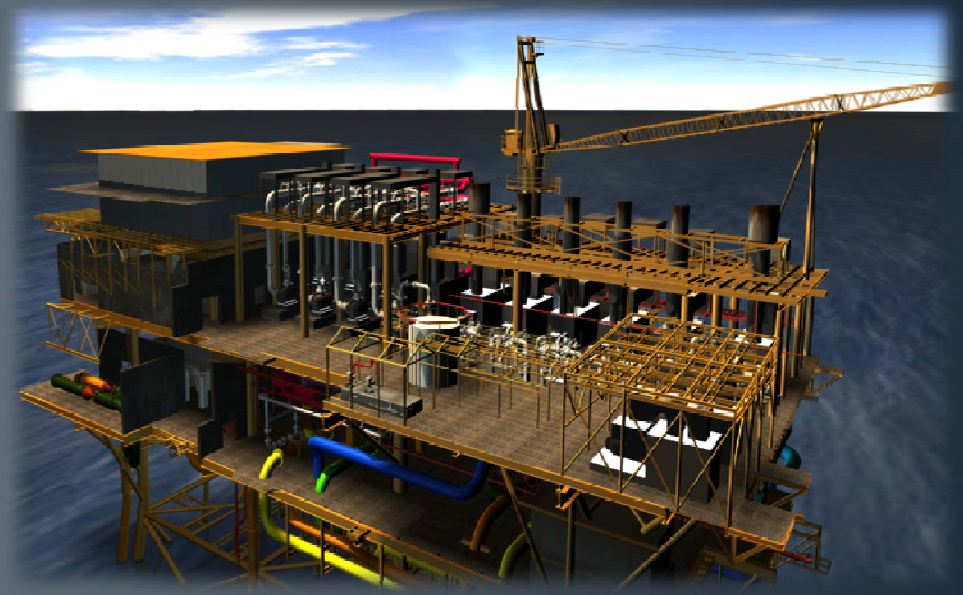
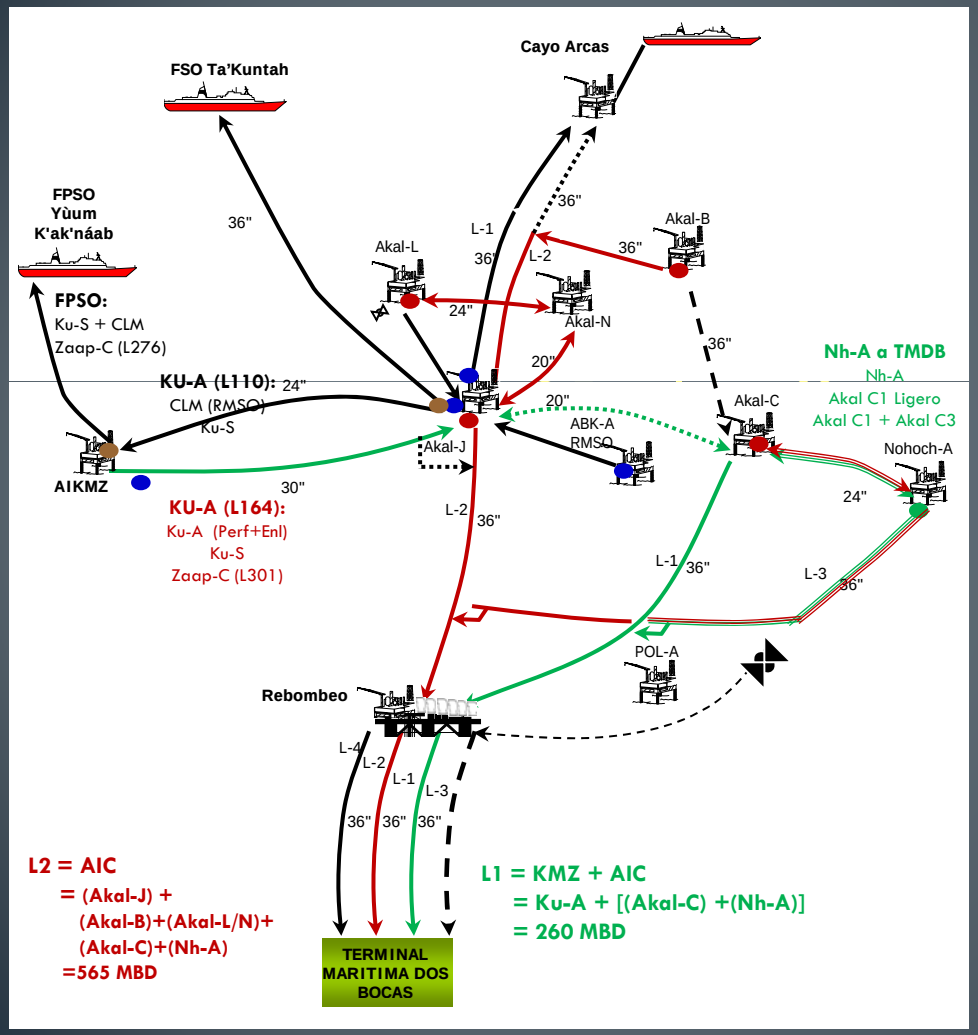


Background

- PEMEX Exploration and Production off-shore pumping system transports between 46%-52% of the national crude oil production.
- The current system operates with crude oils in the range of 19° API, expected new mixtures of approximately 16° API.
- Complex interconnected platform network where different crude oils are mixed and pumped into various pipelines.
- An upgrade of the facility and pumping equipment is required to handle new crude oil mixtures (16° API).

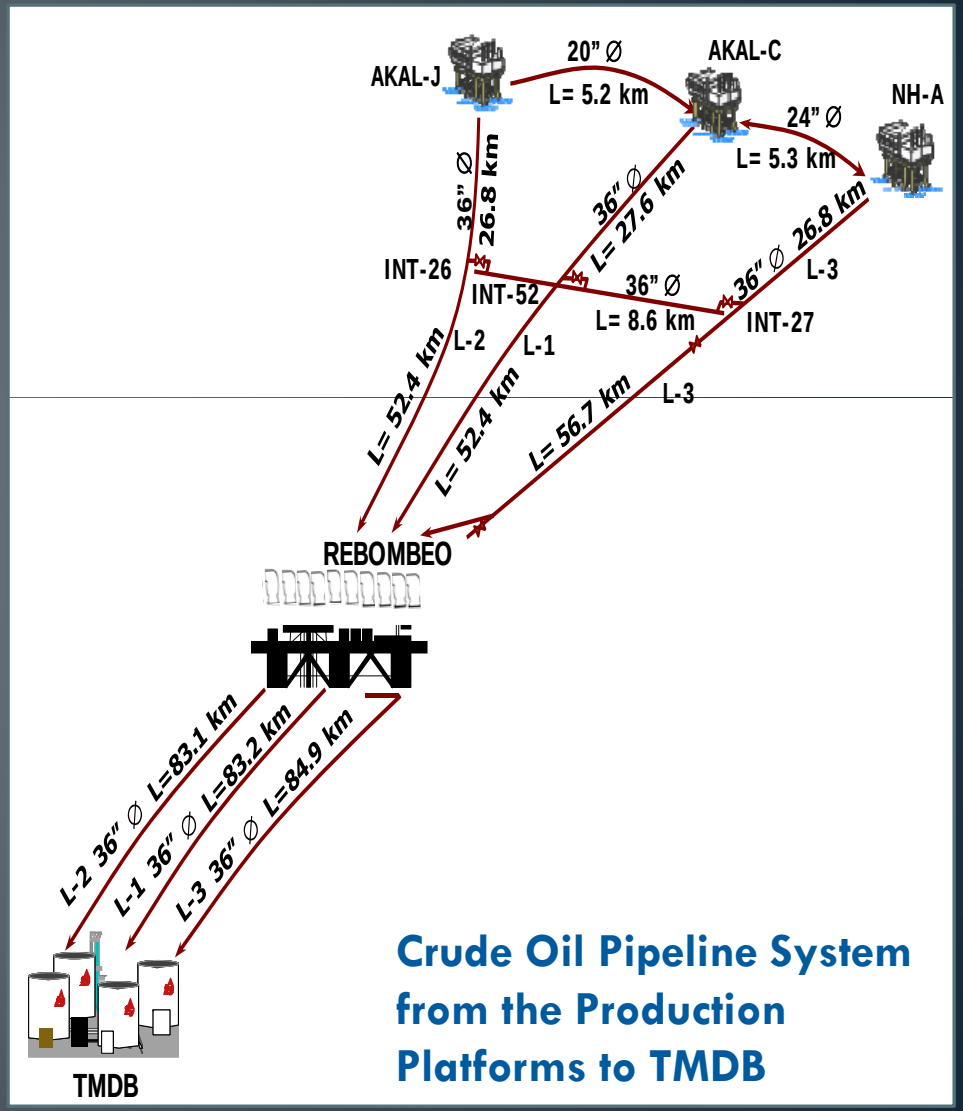
Introduction



- Two 36-inch sub-sea pipelines travel 52 miles.
- The booster platform "Rebombeo" is located in the Gulf of Mexico approximately 25 miles off-shore.
- Crude oil production from several platforms is collected and transported (19-21° API crude oil emulsions).
- Ten centrifugal pumps are installed in the booster platform.

Pipeline Model

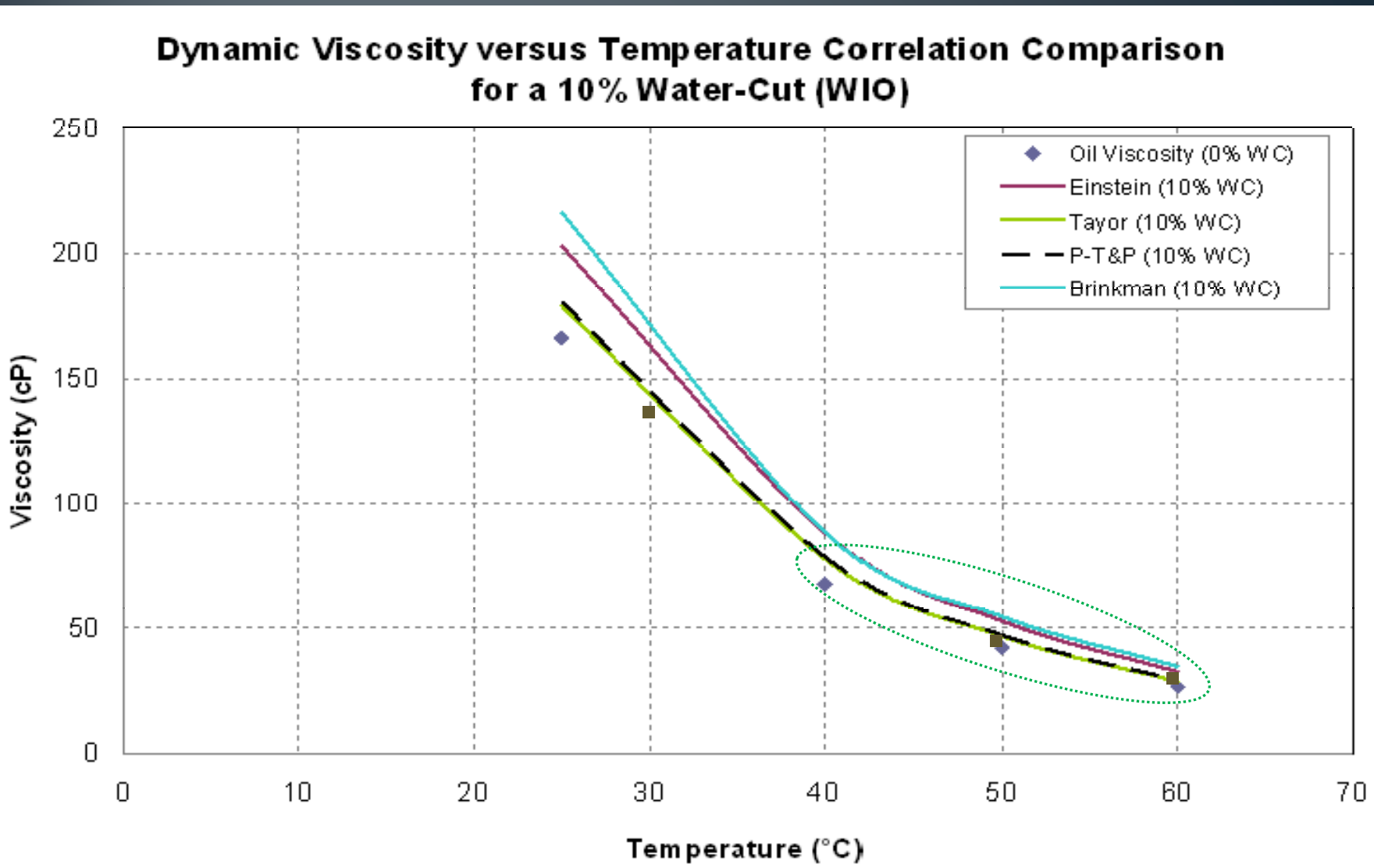
- 1-D pipeline fluid model of the existing facility including L1, L2, and L3 lines.
- Field measurements of the pump performance curves.
- Various emulsion of water-in-oil up to 30% water-cut.
- Flow, pressure, and temperature field data was used to validate the hydraulic model within 1.12%.



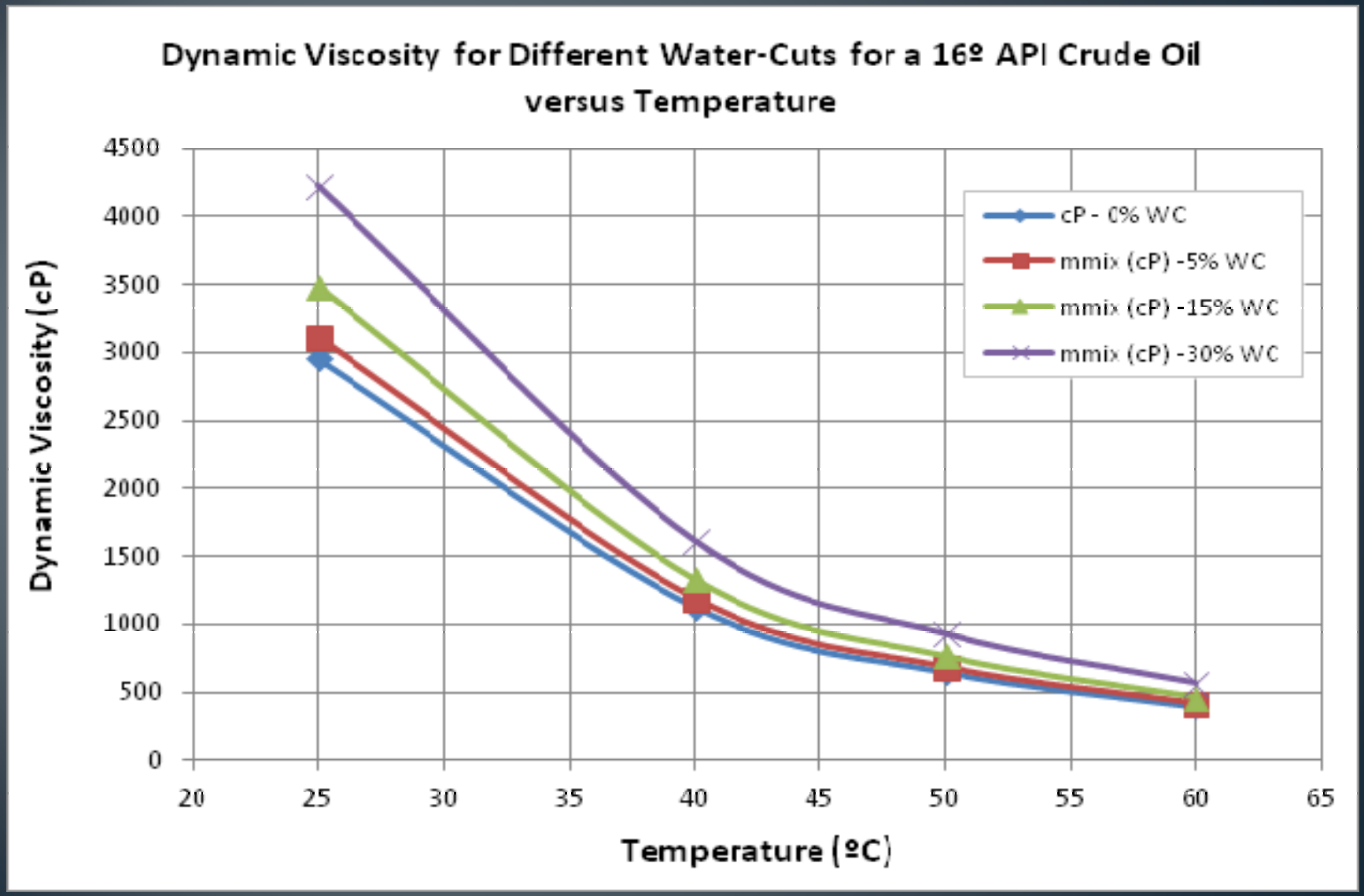
Emulsions Viscosity Model

- Transported crude oils with different rheological properties, 19-21° API, water-cuts 5%-30%.
- Viscosity of water-in-oil emulsions tend to increase with the water-cut.
- Field measured fluid properties were used to compare and validate the emulsion viscosity models.
- After a detailed comparison, it was found that the Phan-Thien & Pham (P-T&P) correlation and Taylor correlation yield very similar results.

Viscosity Model Selection

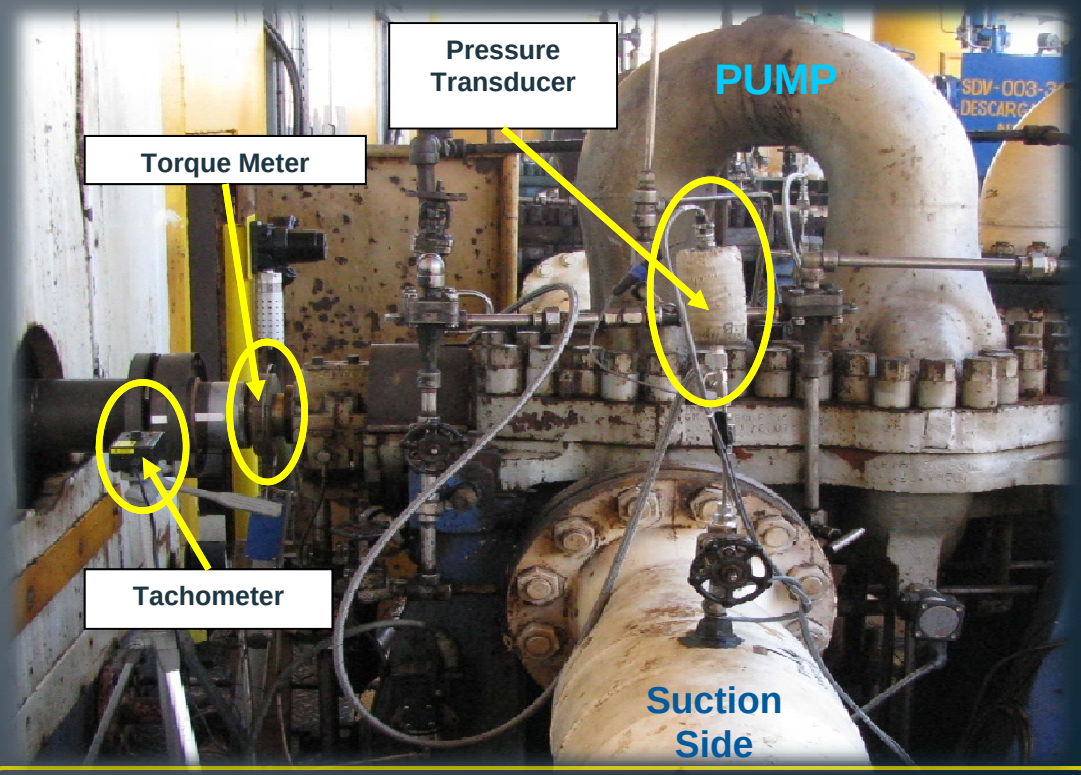


Phan-Thien & Pham Model



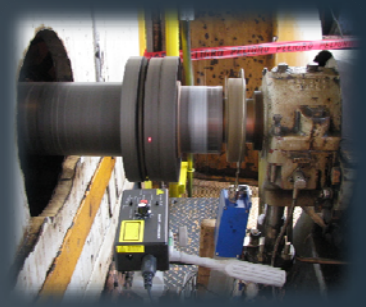
Field Activities & Testing

- Two visits to the Rebombeo platform of PEMEX.
- Operational data and performance testing of various pumping equipment.
- The tests were performed following the guidelines provided in the ASME PTC 8.2.
- Transient and steady-state data including start-up, shutdown, and steady-state for each pump.



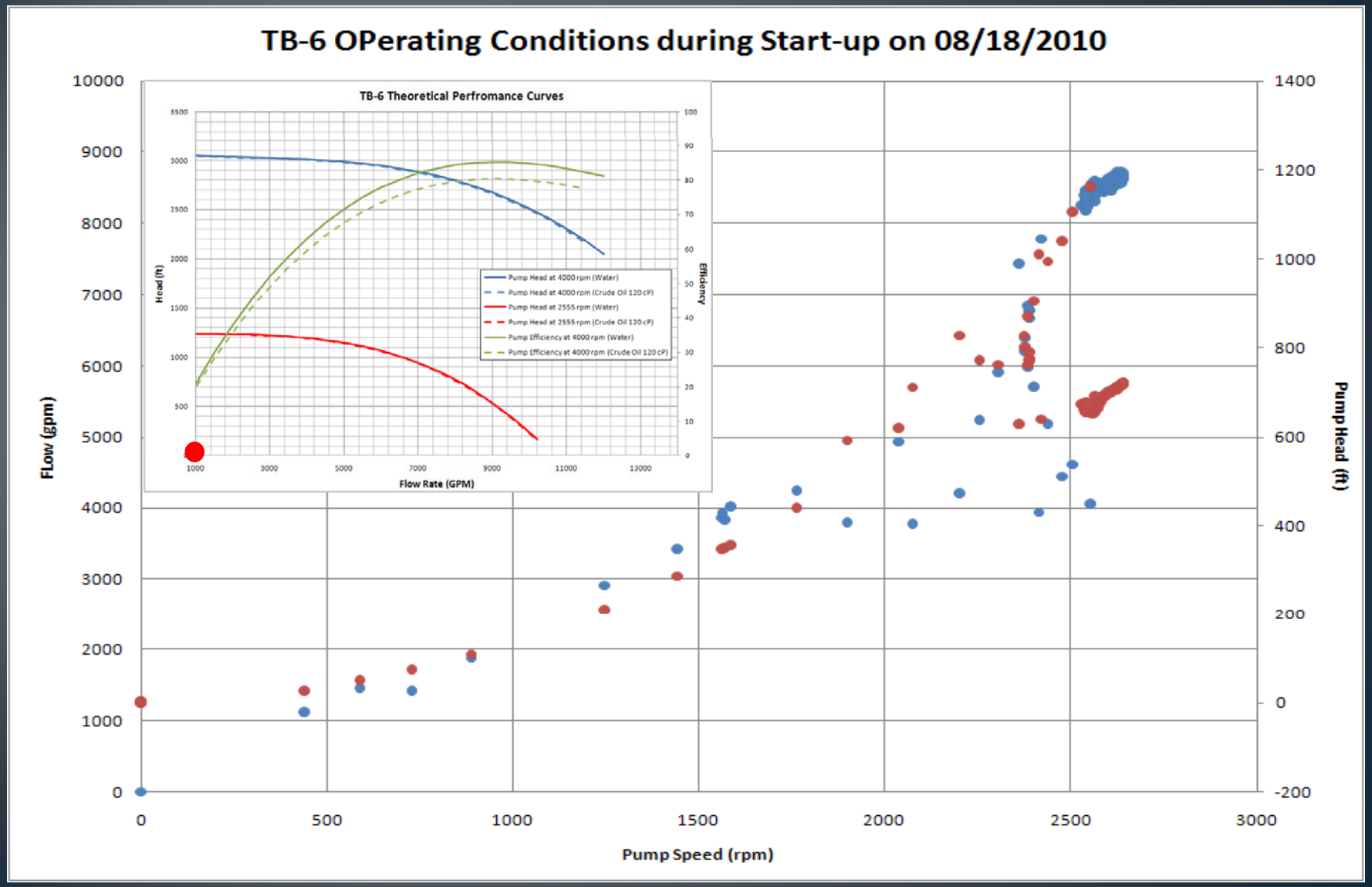
Field Measurements

- Measured Parameters:
  - Pump speed (digital tachometer)
  - Flow rate (doppler, ultrasonic, and orifice plate)
  - Shaft torque (telemetric system)
  - Suction, discharge, and differential pressure (PTs and DPT)
  - Inlet and outlet pump temperature (RTDs)
  - Accelerometers

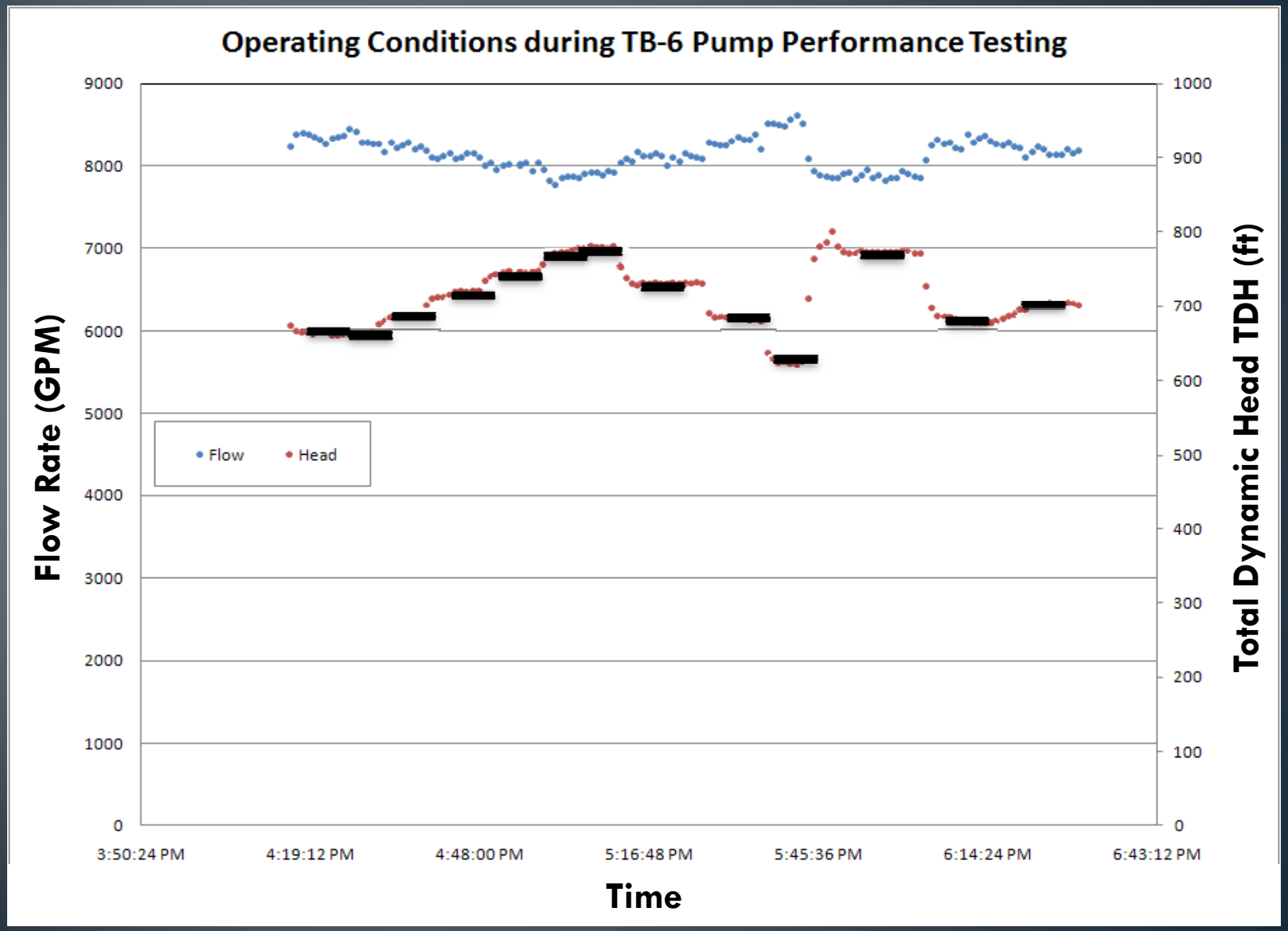


- Test characteristics:
  - At least 8 points between the 25% of the specified capacity or minimum and maximum flow of the pump for test capacity
  - The tests were performed based on the Performance Testing Code ASME PTC 8.2, considering the limitation of the system and operation constraints (flow control logistic)

Transient Data – Pump Start-Up

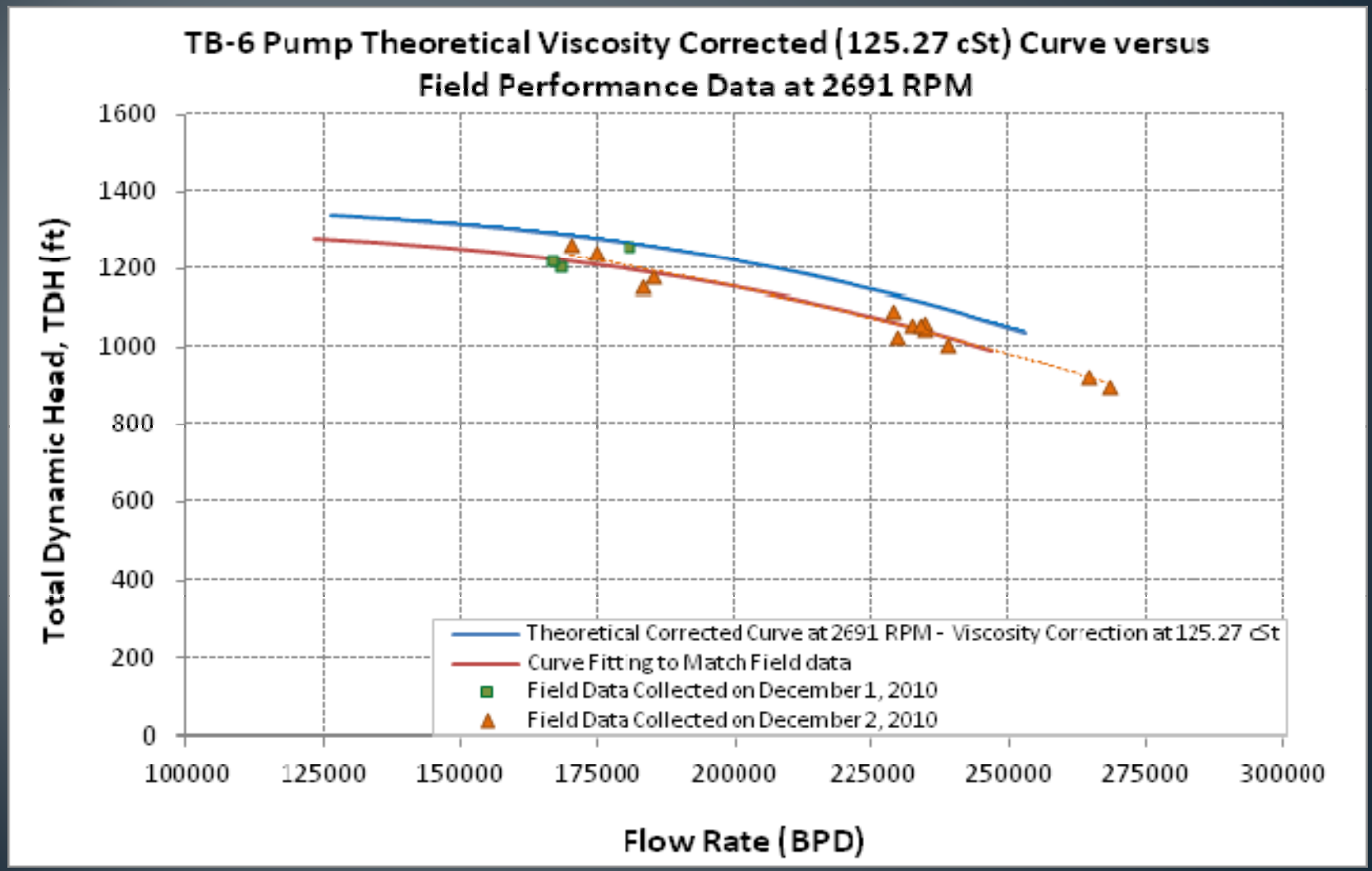


Performance Testing of TB-6

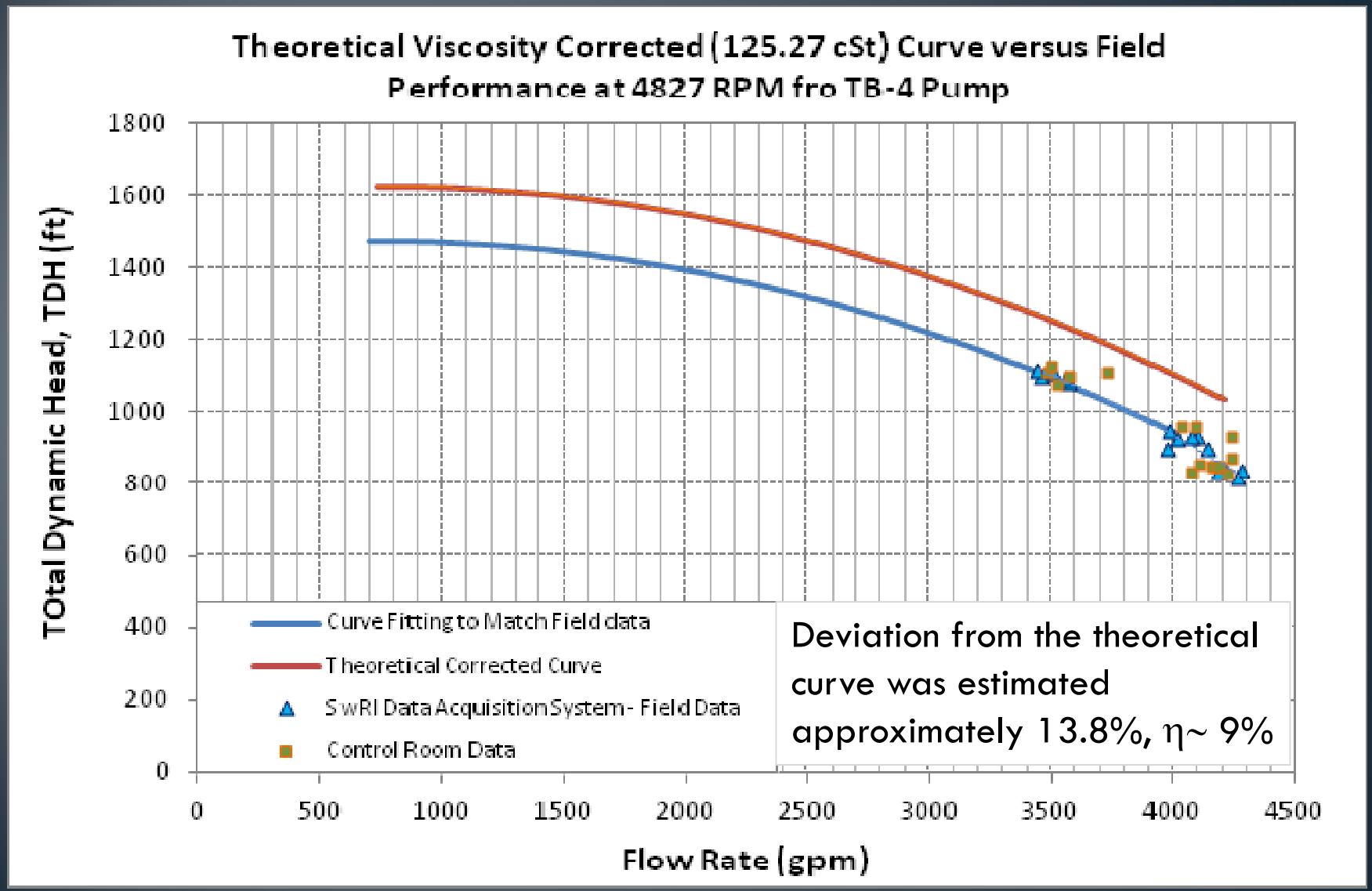


Performance Test Results – TB6

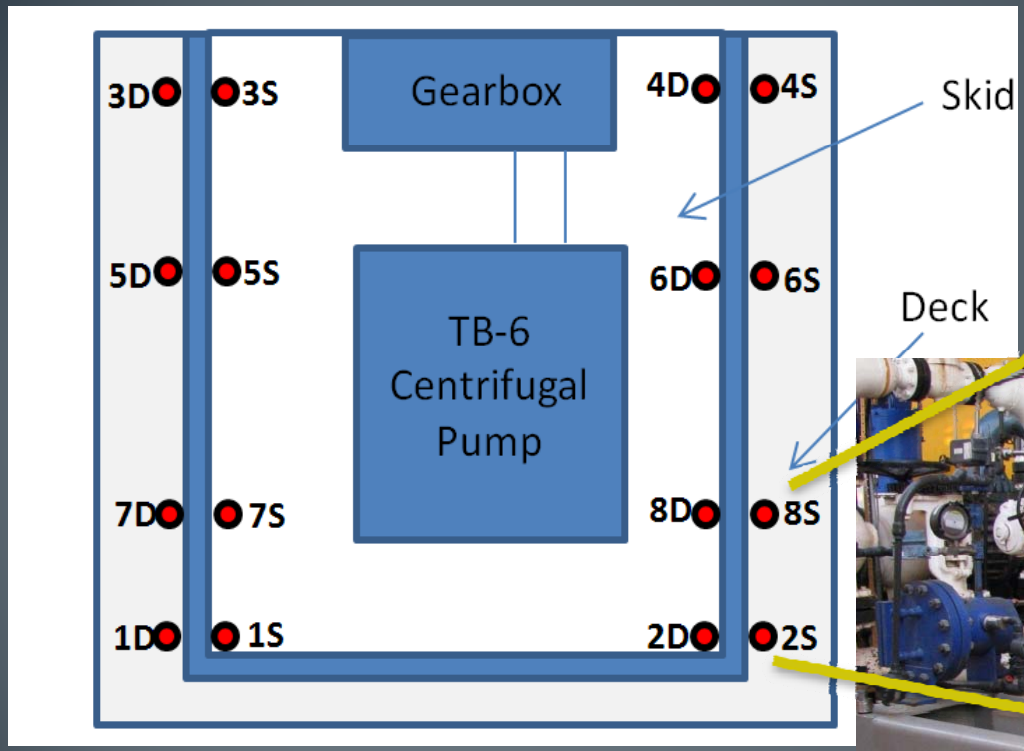
Average deviation from the head curve was estimated about 4.47%

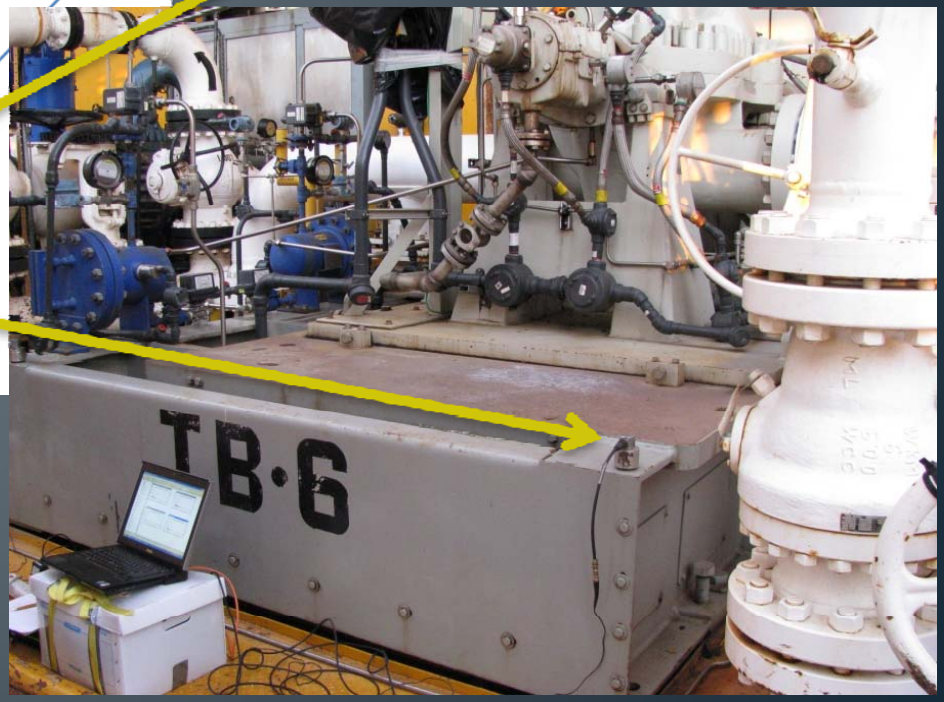


Performance Test Results – TB4

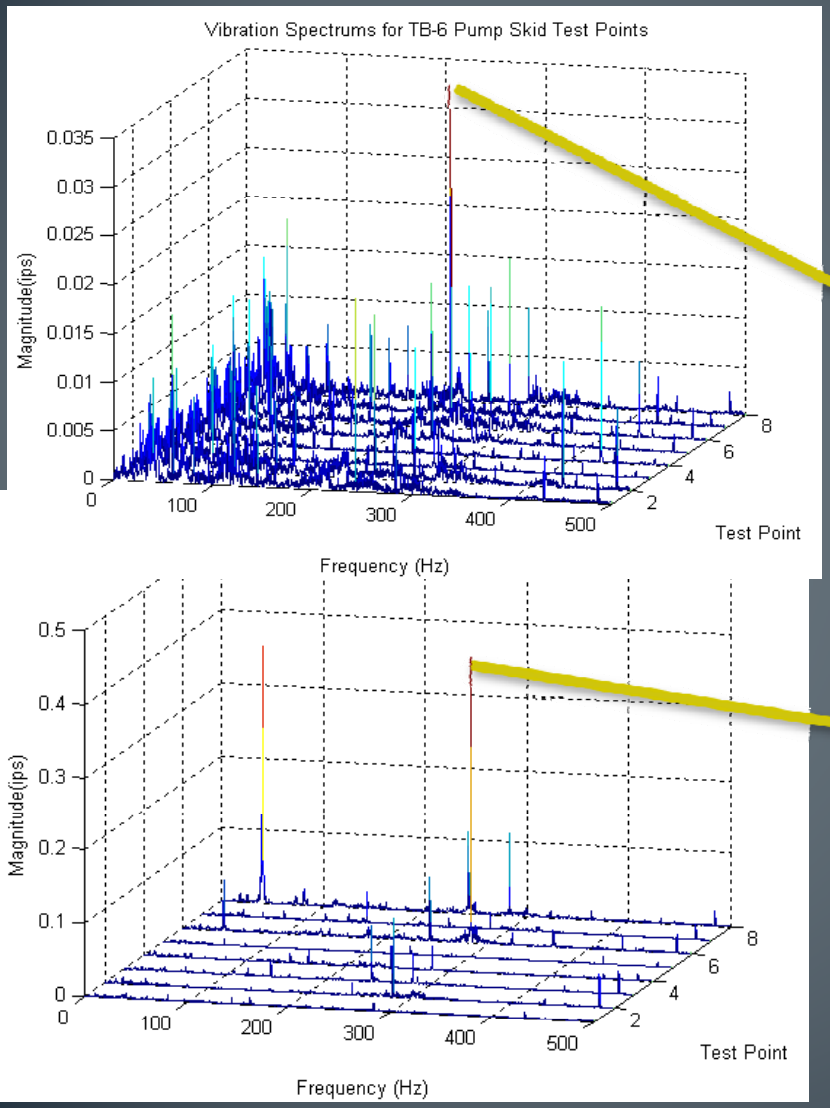


Vibration Measurements



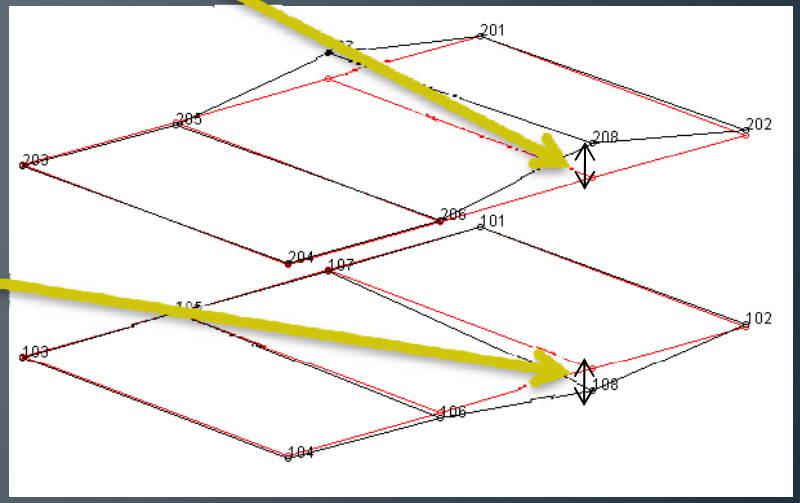


Vibration on the TB-6



This values only apply to the frame side (201-208)

Classification of Vibration	Velocity (0-pk), Inches/sec	Velocity (0-pk), mm/sec
Smooth	**< 0.2**	**< 5.1**
Acceptable	**0.2 – 0.3**	**5.1 – 7.6**
Marginal	0.3 – 0.4	7.6 – 10.2
Planned Shutdown Repairs	0.4 – 0.6	10.2 – 15.2
Immediate Shutdown	> 0.6	> 15.2

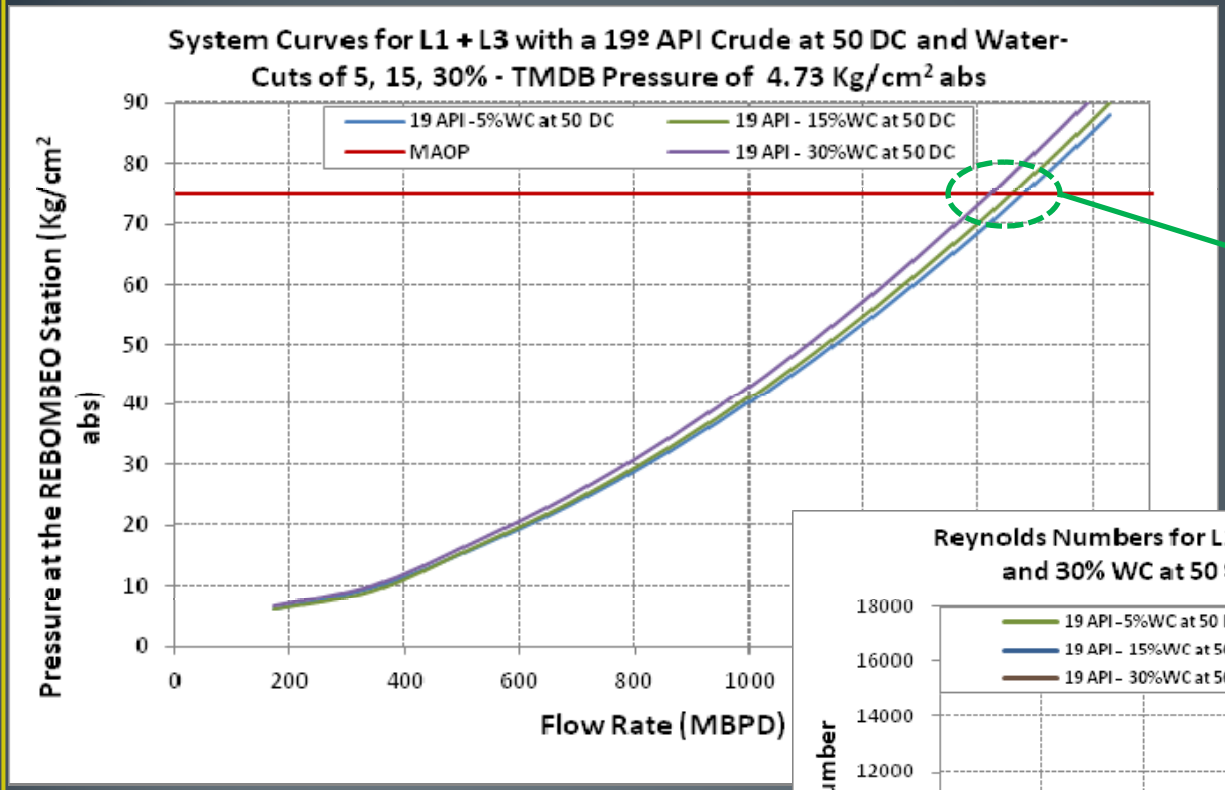


The maximum obtained vibration values were within 0.1-0.3 ips (inch per seconds) at 1X which are considered low and acceptable

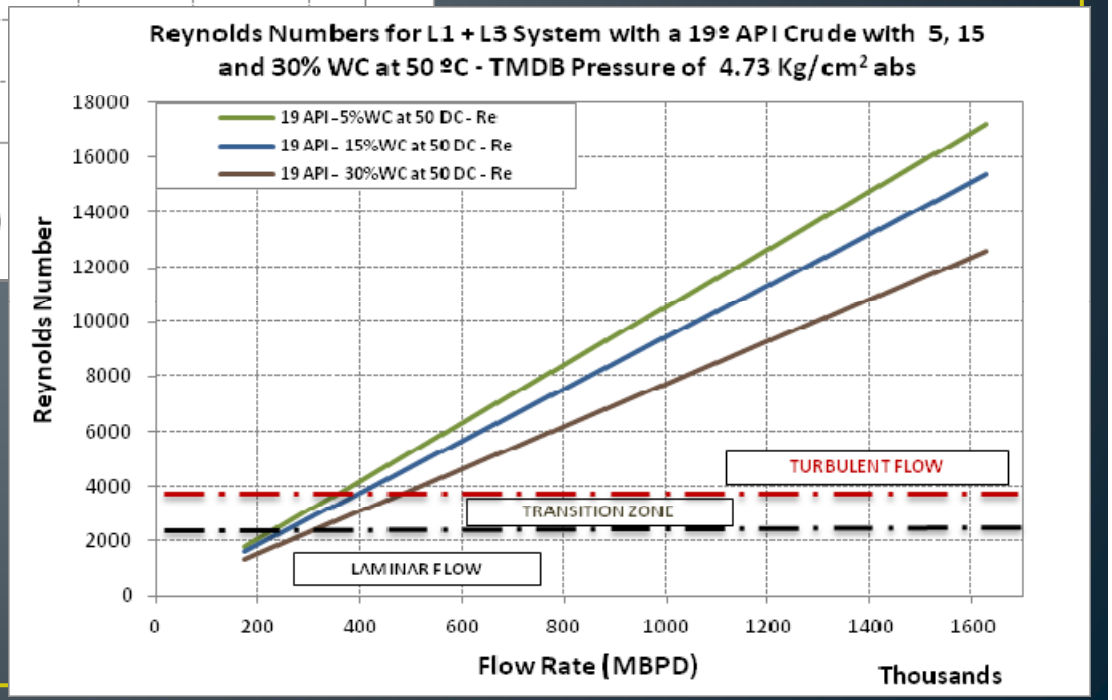
Modeling Analysis

- The conditions evaluated include:
  - Two different crude oils, 16° API and 19° API
  - Two temperatures, 50°C and 61°C
  - Three water-cuts, 5%, 15%, and 30%
  - Two pipeline configurations, L2 and L1+L3
  - Two suction pressures, normal (7.5 kg/cm^2) and minimum (4.5 kg/cm^2)
- Equipment configuration:
  - 6 centrifugal pumps (4 low capacity + 2 high capacity)
  - 4 low capacity centrifugal pumps
  - 4 double screw pumps (future configuration)

System Curves

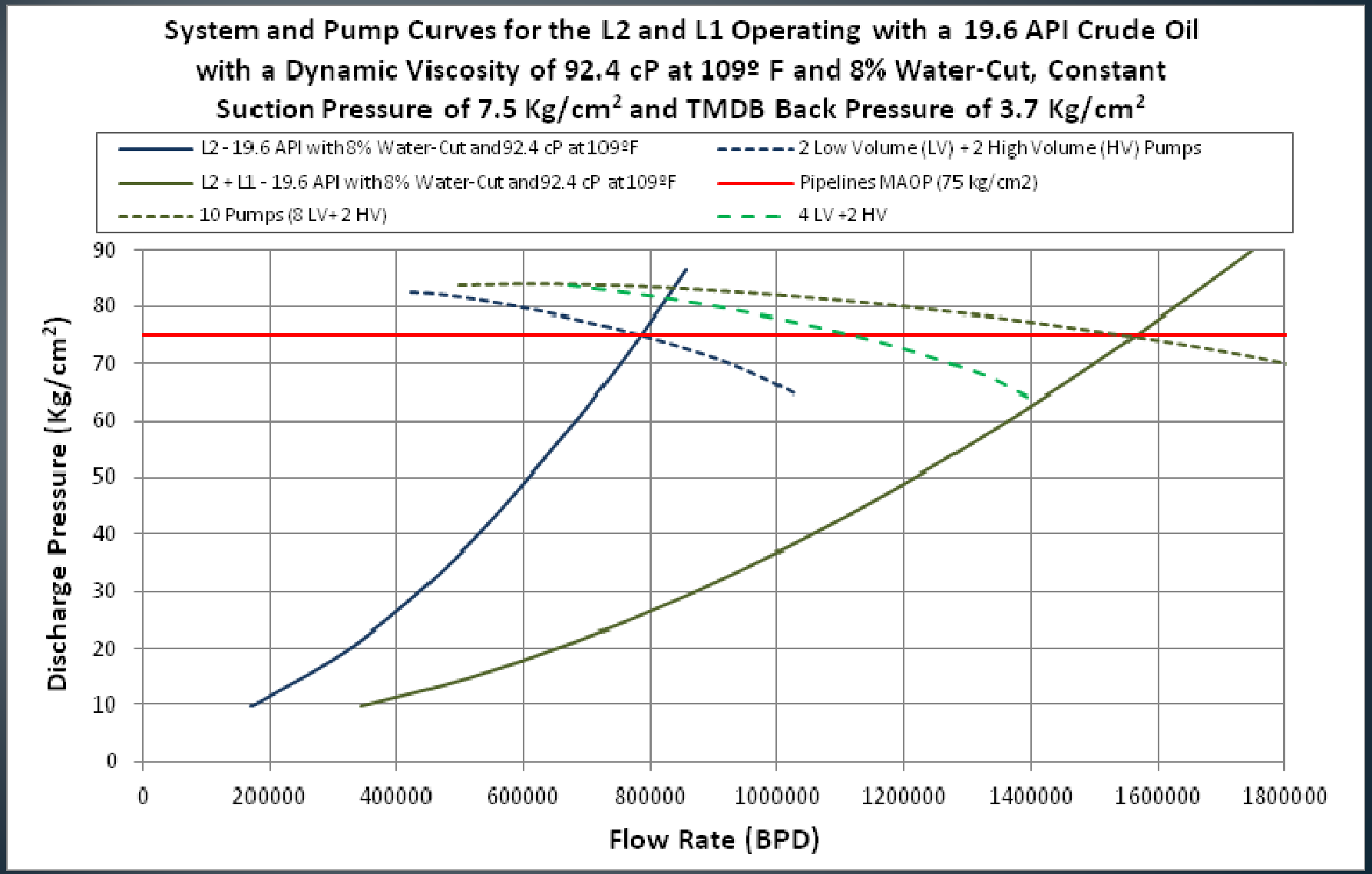


Calculated capacity of approximately 1.42-1.47 MMBOPD for the presented conditions

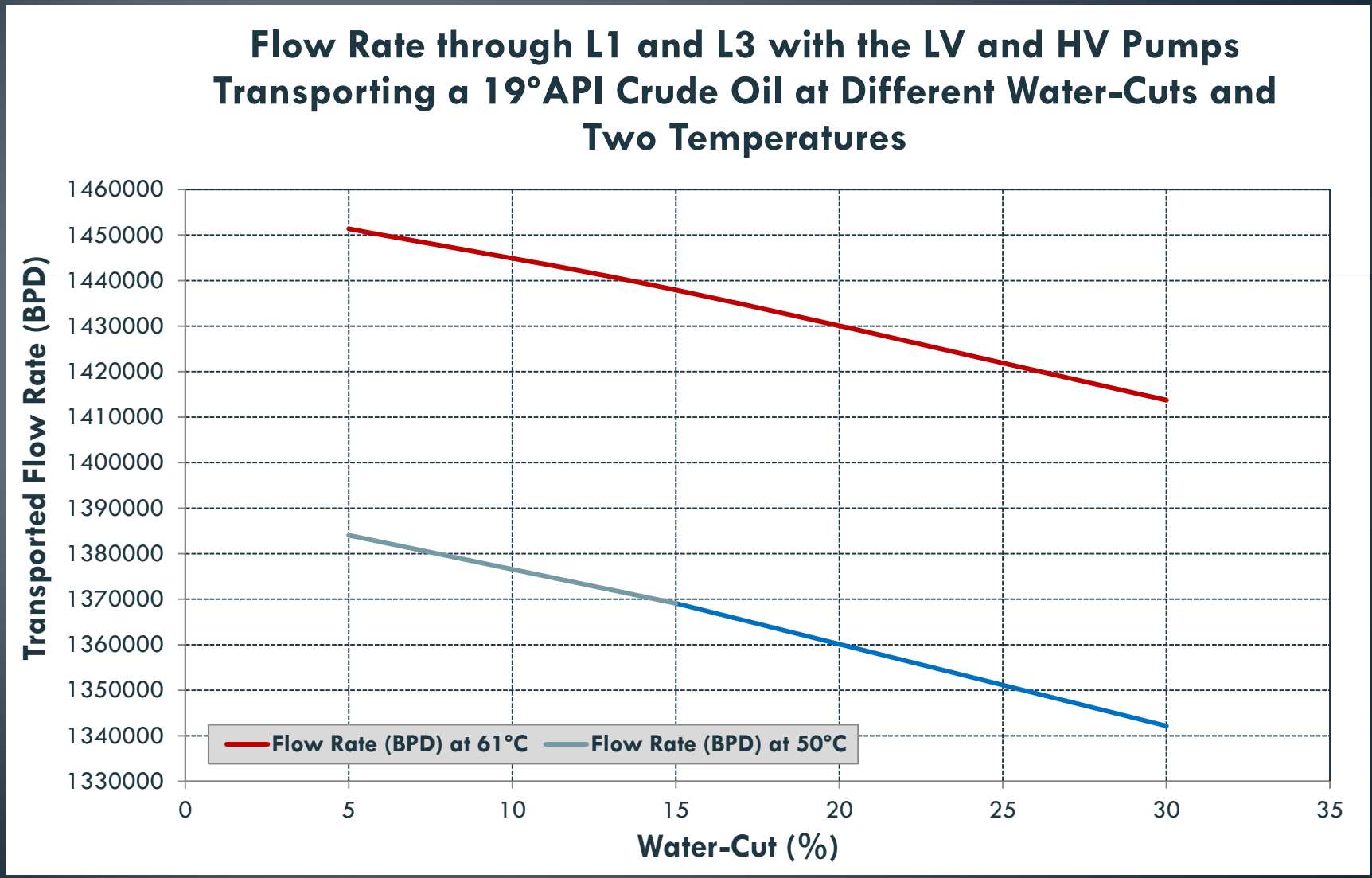


Regimen transition at very low flow rates

System and Pump Curves



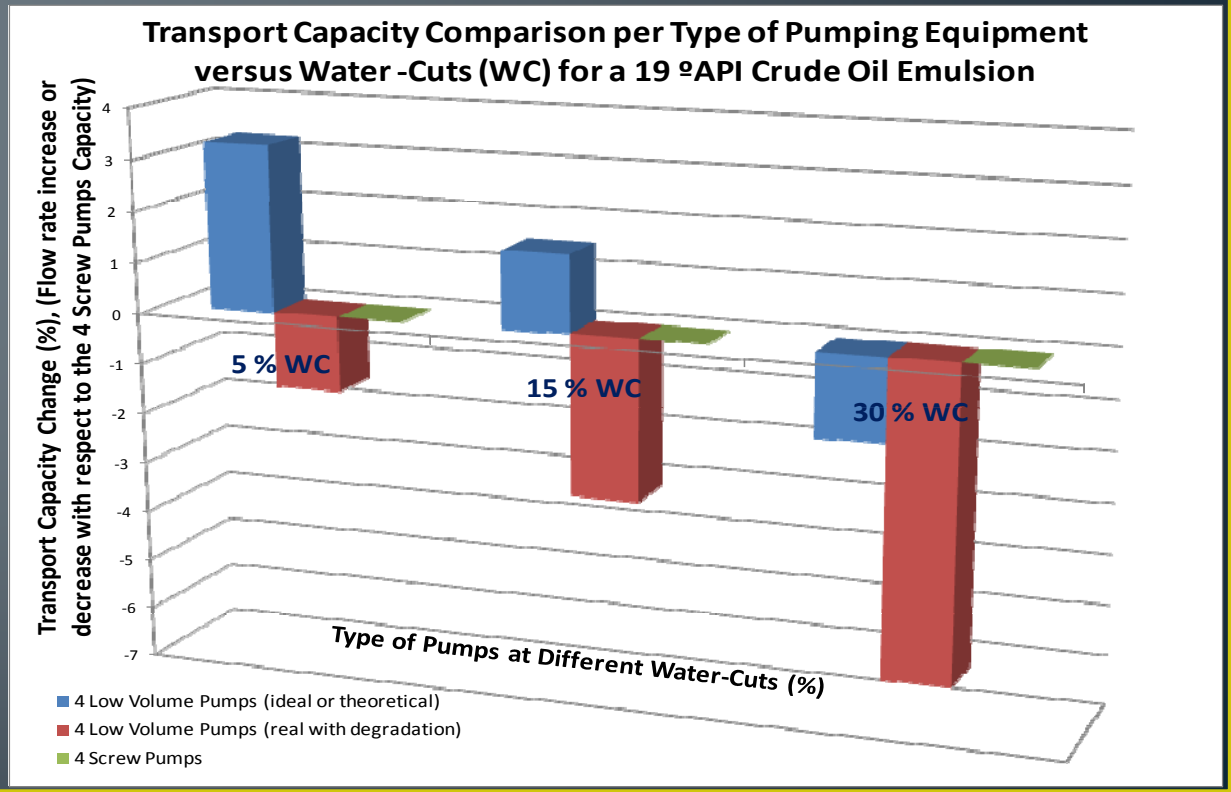
Effect of the Water-Cut on the Capacity



Double Screw Pumps Modeling Results

- 4 new double screw pump trains with 19.6° API
- Higher flow rate of about 1.48% to 6.19% with the screw pumps for water cuts of 5% and 30%, respectively
- 4 new double screw pump trains with 16° API

It was estimated an increase in pumping capacity of approximately 13.28% with the double screw pumps when the system is operated with 16° API and 4 LV pumps only.



Summary and Conclusions

- Volumetric pumps degradation was measured in the field and incorporated in the hydraulic model.
- High viscosity fluid affect significantly the performance, efficiency, and power consumption of the centrifugal pumps. The ANSI/HI 9.6.7-2004 provides a good methodology for correcting the performance curves within a 3-5% difference against measured data.
- Simulation cases allowed calculating the system curves and the current maximum capacity and the forecasted future flow condition with a heavier crude oil.
- System capacity calculated with the existing centrifugal pumps was compared against new screw pumps yielding a 6.19% and 13.24% increase in capacity for the 19° API and 16° API, respectively.
- The results obtained in this study provided good basics for supporting the selection of the new screw pump equipment.

Acknowledgements

The authors would like to thank PEMEX Exploration and Production for allowing us to present the results of this project.

We also are grateful to the Rebombeo platform personnel that supported us during the performance testing and data collection tasks of this project.


THANKS!

Platform Location