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Evaluation of Tiab`s Direct Synthesis (TDS) Drawdown Test in Comparison with Other Well Test Analysis Methods

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ABSTRACT

Pressure-transient analysis supports the estimation of reservoir permeability, apparent skin and wellbore storage, but uncertainty in identifying the infinite-acting radial-flow (IARF) interval may affect conventional semilog interpretation. This study compares Tiab's Direct Synthesis (TDS) with conventional semilog analysis of a supplied pressure-drawdown dataset for an oil well described in the thesis as originating from the Niger Delta. The recorded flowing bottomhole pressures were analyzed using a production rate of 2,500 STB/day, reservoir thickness of 23 ft, oil viscosity of 0.92 cP and formation volume factor of 1.21 RB/STB. Pressure drop increased from 141 psi at 0.017 h to 3,021.2 psi at 21.6 h. The conventional method yielded permeability of 80.34 mD, apparent skin of 6.63 and skin-related pressure drop of 1,412.75 psi; TDS yielded 80.3782 mD, 6.64 and 1,410.92 psi, respectively. Both methods gave a reported flow efficiency of approximately 0.53. The permeability estimates differed by 0.0382 mD (approximately 0.0475%), indicating strong agreement rather than independently demonstrated superiority in absolute accuracy. The TDS logarithmic-pressure-derivative data exhibited an approximately horizontal plateau near 106.28 psi from 5.79 to 18.66 h, providing a clear observed IARF interval; analytical onset estimates of 2.16 and 4.13 h occurred earlier than this sustained plateau. The findings support TDS as a useful diagnostic complement to conventional analysis for identifying a defensible radial-flow fitting interval in the examined drawdown test.

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INTRODUCTION

Well-test analysis is an important reservoir-engineering technique for estimating formation and near-wellbore properties from pressure responses observed during changes in production. Common outputs include effective permeability and skin factor, while pressure-derivative behaviour can provide evidence of the flow regimes present during a test. Interpretation quality depends on reliable pressure and rate data and on selecting a time interval consistent with the assumed flow model. Recent work continues to develop pressure-transient interpretation for estimating reservoir properties and diagnosing well condition. For example, Dastkhan *et al*. (2022) examined the value of combining temperature- and pressure-transient data, while Kubota and Gioria (2022) presented a data-driven approach for estimating skin factor and average pressure during flowing periods.

Conventional semilog analysis estimates permeability from the straight-line segment of pressure change plotted against logarithmic time. The segment should represent infinite-acting radial flow; including early-time transition data may distort the slope and derived parameters. Tiab's Direct Synthesis (TDS) method uses pressure and pressure-derivative characteristics to estimate parameters and diagnose flow regimes. A sustained derivative plateau is commonly used as evidence of radial-flow behaviour. Recent studies also demonstrate

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that pressure-transient interpretation can be extended through model-based inversion and derivative-based flow-regime analysis (Malallah *et al*., 2024; Kumar *et al.,* 2024).

This study compares conventional semilog and TDS results reported for one documented oil-well drawdown test. Although the thesis intended to include pressure-buildup and drawdown analysis, only a drawdown dataset was available. No quantitative conclusion about pressure-buildup performance is therefore made.

Pressure-transient analysis (PTA) is a fundamental component of petroleum reservoir surveillance because controlled changes in the well flow condition induce measurable pressure responses that depend on rock and fluid properties, wellbore conditions, reservoir geometry, and the spatial extent of pressure propagation. Interpretation of these responses can estimate effective permeability, near-wellbore skin, wellbore storage, flow regime, and—in sufficiently informative tests—reservoir boundaries and compartmentalization (Bourdet *et al.*, 1989; Tiab, 1993; Arab Juneghani *et al.,* 2025). These dynamic estimates complement geological descriptions, petrophysical measurements, pressure-volume-temperature analysis, production histories, and reservoir models.

The distinction between pressure drawdown and pressure buildup is operational and mathematical. A drawdown test records declining bottomhole pressure while the well flows under a prescribed production-rate history; a buildup test records pressure recovery following shut-in after a known period of production. Both may contain information on storage-dominated, transitional, infinite-acting radial, linear, or boundary-influenced flow, but interpretation must account for different rate histories and corresponding superposition-time functions (Ramey, 1970; Bossie-Codreanu, 1989; Chaudhry, 2004; Ganat, 2023a). A buildup test cannot be reconstructed from a drawdown sequence without the required shut-in pressures and production history.

The conventional semilog straight-line method identifies a portion of the pressure response consistent with an assumed flow model; its slope and intercept provide reservoir properties when the selected straight line actually represents the corresponding flow regime. For constant-rate single-phase radial flow, the semilog pressure-drop slope is proportional to $q\mu B/(kh)$. Conventional interpretation remains useful because it is transparent and reproducible, but it is sensitive to an incorrectly selected time interval, inadequate rate control, and wellbore-storage contamination (Ramey, 1970; Bourdet *et al.*, 1989; Satter & Iqbal, 2016).

Pressure-derivative analysis strengthens the diagnostic process. The logarithmic derivative, commonly written $t(d\Delta p/dt)$ for a constant-rate drawdown, often reveals an approximately horizontal plateau under infinite-acting radial flow (IARF), a unit-slope interval during pure wellbore storage, and characteristic nonzero slopes for linear, bilinear, and other regimes. Derivative estimates also amplify measurement noise; valid interpretation therefore requires adequate time resolution, pressure-gauge calibration, and defensible differentiation (Bourdet *et al.*, 1989; Onur *et al.,* 1989; Shchipanov et al., 2023).

Type-curve matching compares recorded pressure/derivative trends against dimensionless analytical solutions. Numerical model matching can refine well-reservoir parameter estimates using the full data record but may be non-unique if multiple models explain a similar transient. Recent machine-learning approaches can assist pattern recognition and automatic fitting, yet still require independent physical validation and sufficient representative training data (Chu *et al.,* 2019; Dong *et al.,* 2022; Abdalla *et al.,* 2024; Omosebi, 2026). No single interpretation technique is intrinsically the most accurate under every set of reservoir and test conditions.

Tiab's Direct Synthesis (TDS) uses diagnostic points, slopes, and intersections of physically interpretable pressure/pressure-derivative features to evaluate reservoir parameters without requiring graphical type-curve matching. Its analytical basis emerged from Tiab's original contributions and later extensions for wellbore storage, skin, fractures, bounded

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reservoirs, naturally fractured reservoirs, and other geometries (Tiab, 1989, 1993, 1994, 2005; Escobar *et al.,* 2019; Escobar, 2026). In a radial-flow regime the derivative plateau provides a direct measure of effective permeability, while pressure and derivative values in the same regime allow independent constraints on skin.

Although TDS may make flow-regime identification and analytical cross-checks more convenient, it does not eliminate derivative noise, uncertain fluid properties, incorrect model assumptions, or ambiguous flow regimes. Its comparative value must be assessed through transparent quantitative comparisons, derivative-plateau stability, and consistency with independent data rather than by presupposing that it is always more precise (Escobar et al., 2019; Arab Juneghani *et al.,* 2025; Omosebi, 2026).

In conventional straight-line interpretation, the radial-flow interval is commonly selected from the pressure-versus-log(time) response. At early times, pressure behavior may be dominated by wellbore storage and transitional flow; these effects can obscure the correct interpretation interval. Although standard correlations estimate when radial flow may begin, such estimates need to be checked against the diagnostic behavior of the recorded pressure data. Inaccurate flow-regime selection may affect assessments of formation damage, well productivity and proposed interventions (Onur *et al.,* 1989; Ganat, 2023a).

Tiab's Direct Synthesis (TDS) offers an alternative analytical route by using characteristic points and slopes of pressure and logarithmic-pressure-derivative plots rather than relying on graphical type-curve matching. In a suitable single-phase radial-flow interval, a stable horizontal pressure-derivative plateau helps distinguish reservoir-dominated behavior from early wellbore-storage effects. Nevertheless, differentiation can amplify data noise, and direct-synthesis estimates still depend on appropriate flow models and the accurate identification of characteristic regimes. Therefore, the use of TDS does not, by itself, establish greater numerical accuracy than conventional methods (Tiab, 1993; Bourdet et al., 1989; Arab Juneghani et al., 2025).

A specific unresolved issue for the present oil-well dataset is whether the TDS derivative-based interpretation and conventional semilog analysis yield materially different reservoir parameters, or whether their principal difference lies in the clarity with which the radial-flow interval can be identified. Close agreement between two methods based on the same pressure record and radial-flow model is evidence of internal consistency, but it cannot establish which method is more accurate without an independent reference value or a quantified uncertainty analysis. A systematic side-by-side comparison is therefore needed for permeability, apparent skin, skin-related pressure loss, flow efficiency and the observed versus estimated onset of IARF (Escobar *et al.*, 2019; Abdalla *et al.,* 2024). This study aims to evaluate Tiab's Direct Synthesis (TDS), which is a derivative, and compare it with other existing Well Test Analysis (WTA) methods to know which would give a more precise results from drawdown tests.

METHODOLOGY

Materials

The materials needed for this work are listed below:

1. Buildup data from well testing
2. Drawdown data from well testing
3. Well data
4. Production data
5. Reservoir rock and fluid properties
6. Microsoft Excel

Drawdown Well Test Analysis

Drawdown test a series of bottom-hole pressure measurements made during a period of flow at constant production rate. In a drawdown test, the well must be shut-in to attain average pressure before production commences for the test. Usually, the well is closed prior to the flow test for a period of time sufficient to allow the pressure to stabilize throughout the formation, i.e., to reach static pressure.

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In practice, drawdown test maybe difficult to achieve due to the following reasons:

1. It is difficult to make a well flow at constant rate.
2. Initial well condition may not be static or stable.

The rate and pressure profile for a drawdown test are shown in figure 3.8.

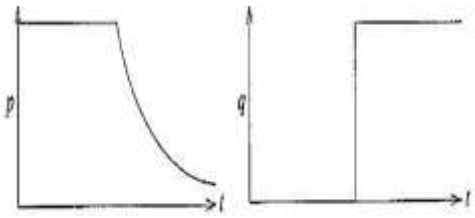


Figure 1: Rate and Pressure profile during Drawdown test

Dataset and reservoir inputs

The drawdown record covers elapsed times from 0.017 to 21.6 h. Reported pressure drop increases from 141 psi to 3,021.2 psi.

Table 1. Reservoir and fluid inputs

Parameter	Reported value
Oil production rate, q	2,500 STB/day
Net formation thickness, h	23 ft
Oil viscosity, μ	0.92 cP
Formation volume factor, B	1.21 RB/STB
Initial reservoir pressure	6,009 psi
Porosity	21%
Wellbore radius	0.401 ft
Total compressibility	8.72×10^{-6} psi^{-1}

Conventional semilog analysis

Conventional analysis plots pressure drops against $\log_{10}$ elapsed time. The semilog straight-line slope is used with the field-unit relationship.

$$k = 162.6\, q\, \mu\, B / (m\, h)$$

Where k is permeability (mD), q is oil rate (STB/day), μ is viscosity (cP), B is formation volume factor (RB/STB), h is net thickness (ft), and m is the semilog slope in psi per logarithmic decade. The thesis reports a slope of 244.88 psi/decade, permeability of 80.34 mD and apparent skin factor of 6.63.

Tiab's Direct Synthesis method

TDS evaluates pressure and pressure-derivative features. The radial-flow derivative plateau is used in the field-unit relationship.

$$k = 70.6\, q\, \mu\, B / [h\, (t \cdot \Delta p')_r]$$

Here, $(t \cdot \Delta p')_r$ represents the derivative plateau associated with radial flow. The nine derivative values reported between 5.79 and 18.66 h have a mean of 106.283 psi, sample standard deviation of approximately 0.123 psi, and coefficient of variation of approximately 0.116%. The thesis reports TDS permeability of 80.3782 mD and apparent skin of 6.64.

Comparison criterion

The absolute permeability difference is 0.0382 mD. Relative difference was calculated using the conventional estimate as the reference:

$$\text{Relative difference (\%)} = |k_{TDS} - k_{semilog}| / k_{semilog} \times 100$$

The resulting relative difference is approximately 0.0475%. This assesses agreement between methods applied to the same dataset; it is not independent validation of absolute permeability.

RESULTS AND DISCUSSION

Drawdown pressure response

Pressure drop rises from 141 psi at 0.017 h to 3,021.2 psi at 21.6 h. The thesis describes the early response as consistent with a transition influenced by wellbore storage before later radial-flow behaviour.

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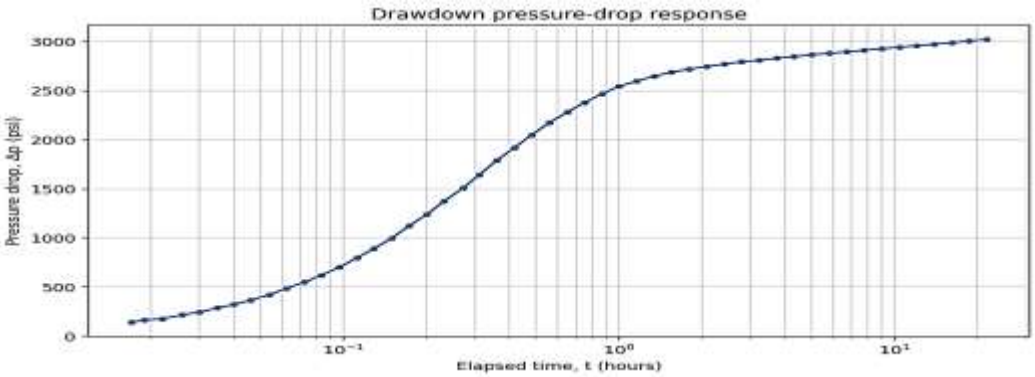


Figure 3. Drawdown pressure drop versus elapsed time (logarithmic time axis).

Permeability and skin comparison

Table 2 summarizes the reported results. The permeability estimates differ by only 0.0382 mD, or approximately 0.0475%. Apparent skin factors differ by 0.01. Skin-related pressure loss is reported as 1,412.75 psi for conventional analysis and 1,410.92 psi for TDS; flow efficiency is approximately 0.53 for both methods.

Table 2. Comparison of reported conventional and TDS drawdown results.

Parameter	Conventional semilog	TDS
Effective permeability	80.34 mD	80.3782 mD
Apparent skin factor	6.63	6.64
Skin-related pressure loss	1,412.75 psi	1,410.92 psi
Flow efficiency	≈0.53	≈0.53
Radial derivative plateau	Coefficient ≈106.33 psi	Mean ≈106.283 psi

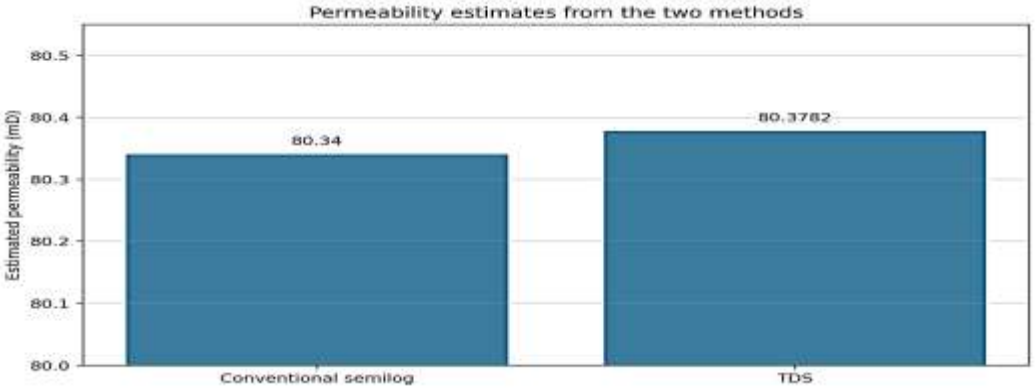


Figure 3. Permeability estimates from conventional semilog and TDS methods. The vertical axis is narrowed to show the small difference; exact values are labelled.

TDS derivative plateau

The derivative values reported from 5.79 to 18.66 h remain close to 106.28 psi, forming a near-horizontal plateau. Their small spread supports interpretation of a stable radial-flow derivative segment in the supplied dataset. The plateau provides an explicit diagnostic for interval selection, whereas conventional semilog analysis relies on identifying a straight-line pressure response over logarithmic time.

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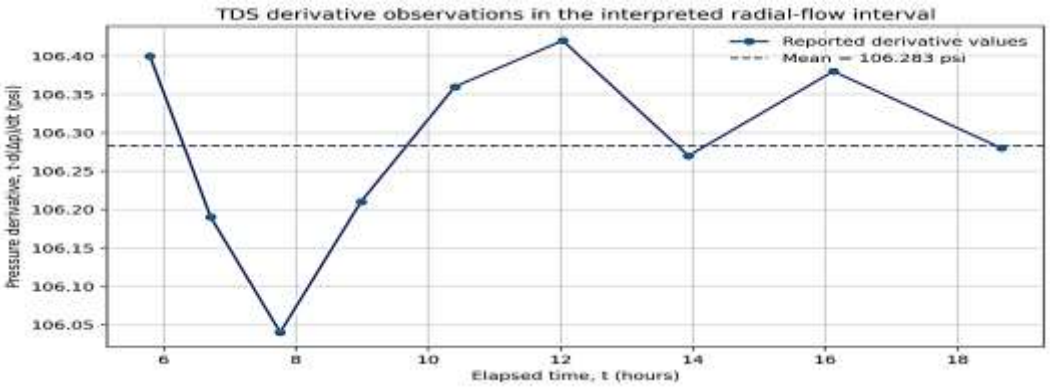


Figure 3. Reported TDS derivative observations over the interpreted radial-flow interval; dashed line indicates the mean plateau of 106.283 psi.

The close agreement between permeability estimates is consistent with the relationship between semilog slope and radial derivative plateau for radial flow. It supports using TDS as a diagnostic complement to conventional semilog analysis, with semilog results serving as a cross-check. Because both methods use the same pressure record and related flow assumptions, agreement does not establish that either estimate is the true absolute permeability. This interpretation is consistent with recent TDS-related work showing how derivative or rate-derivative features can help identify flow regimes and estimate reservoir properties, although those studies address different well/reservoir configurations and do not independently validate the present dataset (Malallah *et al.,* 2024; Saleh *et al.,* 2025).

Both apparent skin estimates are positive, indicating additional modelled near-wellbore pressure loss relative to an idealized zero-skin case. Skin does not uniquely identify the physical cause; completion restrictions, partial penetration, formation damage or other effects may contribute. The study is limited to one drawdown dataset and lacks pressure-buildup data, an independent permeability reference and formal sensitivity analysis.

CONCLUSION

Conventional semilog analysis and TDS produced closely aligned estimates for the available oil-well drawdown test. Effective permeability was 80.34 mD by conventional analysis and 80.3782 mD by TDS, a relative difference of approximately 0.0475%. Apparent skin factors were 6.63 and 6.64, while flow efficiency was approximately 0.53 for both methods. The sustained TDS derivative plateau near 106.283 psi from 5.79 to 18.66 h supports the selected radial-flow interval. The results favour complementary use of TDS and semilog analysis rather than claiming universal superiority. Since pressure-buildup data and an independent permeability reference were unavailable, conclusions remain specific to this drawdown dataset.

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