Basic Concepts in Decline Curve Analysis

By Mike Fetkovich

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Using the Equations one can exactly match Arps empirically derived equations	GWRTA_UsingEquationsMatchArps.wmv	1 m 35 s

Oil Well Rate-Time Analysis

Calculation of NP_i = OOIP x Recovery factor	OWRTA_Calculation of NPi.wmv	4 m 30 s
Oil Well Inflow Performance	OWRTA_OWInflowPerformance.wmv	4 m 15 s
Oil Well Backpressure Curves	OWRTA_OWBackpressureCurves.wmv	3 m 37 s

Tape 2 Click here to watch the entire Fetkovich Course from beginning to end of Tape 2. 2 h 10 m 4 s

Subject Title	Video File Name	Time
Oil Well Rate-Time Analysis (Continued)		
Oil Well with n=1=>b=.33 for average rel. perm. For Poor Set of K_g/K_ob may as low as 0.1	OWRTA_n1 to Poor Set. wmv	2 m 28 s
Definition of D_i for Oil Wells	OWRTA_Definition Di.wmv	0 m 40 s
Type Curve for Arp's Rate-Time Equations For Homogeneous reservoir, single layer system the expected b value is never >.5 Layered No Crossflow b values range from .5 to 1 As b increases above .5 it gives an indication of the ratio of Hi Perm to Low Perm.	OWRTA_Type Curve for Arps.wmv	4 m 4 s
Impact of Choice of b on Development Forecasts	OWRTA_Impact of Choice.wmv	4 m 13 s
Reference to Risk Analysis	OWRTA_Risk Analysis.wmv	4 m 57 s
Recovery Factors of Oil – Reference Cole	OWRTA_Recovery Factors.wmv	2 m 1 s
Impact of Arp's Relative Perms on busing 3240	OWRTA_Impact of Arps Rel Perm.wmv	1 m 35 s
Reference to Pseudo-Time & Total Compressibility Plot Data in Real Time – Easier to Forecast	OWRTA_Ref to Pseudo-Time.wmv	2 m 18 s
Clyde Cowden Example, Secondary b Value is same as Primary	OWRTA_Clyde Cowden Example.wmv	3 m 0 s

Constant rate infinite conductivity type curve Turnover for constant pressure type curve	OWRTA_Constant rate and turnover.wmv	3 m 23 s
2/4 B24 Type Curve Match	OWRTA_2-4 B24.wmv	2 m 29 s
Basis for Log-Log Typecurve Matching	OWRTA_BasisLogLog.wmv	3 m 57 s
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Example of Backpressure Change – Thunder Creek	OWRTA_Example of Backpressure - TC.wmv	5 m 6 s
q_d – t_d Type Curve	OWRTA_qd-td Type Curve.wmv	3 m 30 s
North Slope Example Sag Delta	OWRTA_North Slope.wmv	4 m 23 s

Development of the Fetkovich Type Curve

Composite QD_d – tD_d Type Curve	DFTC_Composite QDd-tDd Type Curve.wmv	4 m 8 s
Arps Example – Arbuckle – Full Water Drive	DFTC_Arps Example Arbuckle FWD.wmv	10 m 47 s
Arps Example for Exponential Decline	DFTC_Arps Example Exponential Decline.wmv	2 m 18 s
Locke - Sawyer Type Curve Single vertical fracture	DFTC_Locke Sawyer Type Curve.wmv	1 m 38 s
Agarwal Example – Gas Well Massive Hydraulic Fracture also comment on spacing	DFTC_Agarwal Example.wmv	4 m 33 s
Carthage – Cotton Valley Example	DFTC_Carthage Cotton Valley.wmv	3 m 24 s
Kansas Low Pressure Gas Well Example	DFTC_Kansas Low Pressure GW.wmv	6 m 18 s
Oklahoma Undersaturated Oil Well Example	DFTC_Oklahoma Undersaturated OW.wmv	1 m 56 s
Ability to Overlay Wells	DFTC_Ability to Overlay Wells.wmv	1 m 15 s
Overlay Fields – California Examples	DFTC_Overlay Fields - California.wmv	8 m 55 s
Overlay of Wells From Thunder Creek - Wyoming need to look at a group of wells and get a consistent answer	DFTC_Overlay of Wells – Thunder Creek.wmv	3 m 3 s
Dual Porosity Q_d-t_d Type Curve	DFTC_Dual Porosity.wmv	13 m 50 s
Middle East Stimulated Well Example Depleting Fractures – Implied – Ans. Transient	DFTC_Mid-East Stimulated Well.wmv	2 m 29 s
Edda 10X Well Example	DFTC_Edda 10X.wmv	2 m 0 s
Question of b Values > Than 1	DFTC_Questions of b Values.wmv	5 m 13 s

Tape 3 Click here to watch the entire Fetkovich Course from beginning to end of Tape 3. 2 h 10 m 22 s

Subject Title	Video File Name	Time
Field Examples		
Agarwal's Data Matched to the Van Everdingen & Hurst solution and Vertical Fracture Solution. Quick Forecast didn't need to use a Model	FE_Agarwals Data.wmv	4 m 40 s
Canadian Gas Well Example – Winestock Colpitts Rate Normalization	FE_Canadian GW - Winestock.wmv	6 m 43 s
West Virginia Gas Well Example Constant Pressure & Constant Rate Solution	FE_West Virginia.wmv	19 m 58 s
Cullender Gas Well Example – Back Pressure Deliverability curve & Rate-Time Plot Retrace Orig. q_d-t_d on every new transient	FE_Cullender GWE.wmv	2 m 49 s
Comment on Multiphase Rate Analysis	FE_Comment on MRA.wmv	2 m 23 s
Sooner Trend Field Example – Impact of Well Count	FE_Sooner Trend.wmv	3 m 34 s
San Juan Basin Example – Data Smoothing Example	FE_San Juan Basin Example.wmv	4 m 21 s
San Juan Well Example – Volume Doesn't Change Due to matching on different r_e/r_w's	FE_San Juan Well Example.wmv	1 m 28 s
San Juan Basin Example 2 – Data Smoothing Can not Determine Volume in Place for Cases with b values > .4	FE_ San Juan Basin Example 2.wmv	2 m 14 s
Gentry – McCray Example of b > 1	FE_Gentry-McCray.wmv	3 m 29 s
Wattenburg Field Example of b > 1	FE_Wattenburg.wmv	2 m 3 s
Gas Well Forecast Affect of Different Skin on a Low Permeability Well	FE_GW Forecast Affect.wmv	2 m 21 s
West Virginia Gas Well Example, b Value Can Impact Calculation of Inplace Volume	FE_ West Virginia GWE.wmv	2 m 49 s
Cotton Valley Field Example – Liquid Loading	FE_Cotton Valley.wmv	0 m 55 s
Edda Field Example	FE_Edda Field Example.wmv	9 m 44 s
Closing of Day 1	FE_Closing Day 1.wmv	5 m 10 s

Layered Reservoir No Crossflow – Depletion Performance

Wall Lease Rate-Time Plot 9 Ft Pay Zone with Layered No Crossflow character	LRNC-DP_Wall Lease Rate-Time.wmv	4 m 19 s
Example of Erroneous Extrapolation of Primary using b=0 for Layered No Crossflow System	LRNC-DP_Erroneous Extrapolation.wmv	14 m 55 s

Red Cave Field Example

Red Cave Field/Reservoir Data	RCFE_ Red Cave Field Reservoir Data.wmv	2 m 56 s
Red Cave Semi-Log Plot	RCFE_Semi-Log Plot.wmv	3 m 4 s
Red Cave Log-Log Rate-Time Plot Layered No Crossflow Yields High b Values. Greater the b value the more Hydrocarbon in the Low Perm Layer.	RCFE_Log Log Rate-Time Plot.wmv	0 m 51 s
Red Cave 10 Well Overlay b = 0.9	RCFE_10 Well Overlay.wmv	4 m 39 s
No Crossflow – Rate-Time Equation	RCFE_No Crossflow Rate-Time Equations.wmv	3 m 4 s
Effect of Layer Skins For Volume Ratio = 1 and Perm Ratio = 10	RCFE_Effect of Layer Skins.wmv	7 m 16 s
Red Cave p/Z Well H Plot Must Honor Initial Pressure/Z Plot	RCFE_PZ Well H Plot.wmv	5 m 21 s

Tape 4 Click here to watch the entire Fetkovich Course from beginning to end of Tape 4. 2 h 4 m 19 s

Subject Title	Video File Name	Time

Red Cave Field Example (Continued)

p/Z vs. Cumulated Prod. Vol. Ratio = 1 and Perm Ratio From 1 to 1000	RCFE_PZ vs Cum Prod.wmv	11 m 34 s
Log-Log Rate-Time Plot for Perm Ratios 3 to 1000	RCFE_Log Log Rate-Time Perm Ratios.wmv	4 m 35 s
Simulated p/Z Plot for a Layered System Perm Ratio 10/1, Vol Ratio of ½	RCFE_Simulated PZ Plot.wmv	7 m 7 s
Table of b values as f(VR,(0 MAX)/G_i for Gas	RCFE_Table of b values for Gas.wmv	2 m 58 s
Table of b values as f(VR,[(0 MAX)/N]R) for Oil	RCFE_Table of b values for Oil.wmv	0 m 47 s

Oklahoma Hugoton Field Example

Hugoton Gas Field – Cross Section	OHFE_Hugoton Gas Field Cross Section.wmv	4 m 27 s

Plat Map – Showing Sections Studies	OHFE_Plat Map.wmv	1 m 5 s
North – South Cross Section Reference to Risk Analysis	OHFE_North–South Cross Section.wmv	4 m 3 s
East – West Cross Section	OHFE_East–West Cross Section.wmv	0 m 32 s
Cross Section Generated by Conscientious Operator – Shown at Hearing. Shales	OHFE_Cross Section by Operator.wmv	2 m 4 s
Same Operator. North – South Cross Section Well Log With Layer Pressures	OHFE_NS Cross Section and Well Logs.wmv	8 m 20 s
BUF No 3 Well Log Expendable Well	OHFE_BUF No 3 Well Log.wmv	2 m 19 s
p/Z plot – Mesa Cromwell 1 and Replacement Well No Reserve Addition Cromwell 1 & 3 Backpressure Curves Well Stimulated Equally – Same Deliverability	OHFE_PZ plot – Mesa Cromwell 1.wmv	2 m 13 s
Rate-Time Plot and Pressure vs. Time	OHFE_Rate-Time Plot.wmv	2 m 27 s
Table of Two Layer Correlating Parameters Need to Get a Large Negative Skin on Low Perm Layer. Differential Depletion Behavior Can Result Simply Due to Volume Contrast Between Layers.	OHFE_Table of Two Layer.wmv	2 m 54 s
Gas Material Balance Equations – Two Layer p/Z Plot for Layered System Discussed	OHFE_Gas Material Balance Eq.wmv	3 m 33 s
Reference to Stacked Reservoirs – Gulf Coast Layered Systems – Can give long Production Time	OHFE_Reference to Stacked Reservoirs.wmv	5 m 15 s
p/Z Plot for Equal Layer Skins, VR=½	OHFE_PZ Plot for Equal layer Skins.wmv	2 m 15 s
p/Z Plot for KR Range 1 to 1000, VR=1	OHFE_PZ Plot for KR Range 1 to 1000.wmv	1 m 7 s
p/Z Plot Two Layered System VR=½, 72 Hr. Shutin	OHFE_PZ Plot Two Layered System.wmv	0 m 33 s
p/Z Plot VR=1, KR=10 Equal Skin Differential Depletion can be Rate Sensitive	OHFE_PZ Plot Equal Skin Differential.wmv	1 m 10 s
Infill Drilling in Layered System Doesn't add Reserves	OHFE_Infill Drilling.wmv	2 m 27 s
Abandonment Pressure Question, Economic Limits on Two Layered Systems Need to look at Abandonment Rate	OHFE_Abandonment Pressure Question.wmv	3 m 14 s

BUF No 1 Well Effect of Layering On Depletion and Time to Limit	OHFE_BUF 1 Well Effect of Layering.wmv	21 m 47 s
Oklahoma Hugoton Map – Replacement Well Study	OHFE_Replacement Well Study.wmv	2 m 31 s
4 In 1 Plot – Original & Replacement Well gas rate vs. time, p/Z plot, backpressure curve and perforation depths	OHFE_4 In 1 Plot.wmv	1 m 54 s
Another Well – Mobil in Kansas – 4 in 1 Plot	OHFE_Mobil in Kansas 4 In 1 Plot.wmv	2 m 45 s
Another Replacement Well Example	OHFE_Another Replacement Well 1.wmv	1 m 44 s
Another Replacement Well Example 2	OHFE_Another Replacement Well 2.wmv	1 m 35 s
Panhandle Eastern Burris – Center of Field well example	OHFE_Panhandle Eastern Burris.wmv	1 m 0 s
Similar Example From Texas Hugoton	OHFE_Similar Example Texas Hugoton.wmv	1 m 47 s
Conclusion and Summary	OHFE_Conclusion and Summary.wmv	3 m 25 s

Tape 5 Click here to watch the entire Fetkovich Course from beginning to end of Tape 5.

Subject Title	Video File Name	Time
Oklahoma Hugoton Field 3D Model Layered No Crossflow Study		
3D Model Grid Oklahoma Hugoton Study	OHF3D_3D Model Grid.wmv	6 m 21 s
Initial Flow After Flow Tests for Wells in Study Area	OHF3D_Initial Flow After Flow Tests.wmv	3 m 17 s
Type Curve Match of Data from 1946 Infinite Conductivity Solution	OHF3D_Type Curve Match.wmv	1 m 32 s
Superposition Analysis – Flow After Flow Test Layered Systems Give Backpressure Slopes Less Than 1 – w/o Non Darcy Flow	OHF3D_Superposition Analysis.wmv	1 m 25 s
3D Graph of Herrington Perm Variation	OHF3D_3D Graph Herrington.wmv	1 m 20 s
3D Graph of Krider Perm Variation	OHF3D_3D Graph Krider.wmv	1 m 10 s
3D Graph of Winfield Perm Variation	OHF3D_3D Graph Winfield.wmv	0 m 31 s
Detailed Distribution of Reservoir Data	OHF3D_Detailed Distribution.wmv	0 m 31 s
BUF #3 (Key Well) p/Z Plot & Match	OHF3D_BUF 3 Key Well pZ Plot.wmv	3 m 35 s

BUF #3 Well Deliverability Plot	OHF3D_BUF 3 Well Deliverability Plot.wmv	1 m 8 s
Replacement Well (Strat 1,2) p/Z Plot	OHF3D_Replacement Well pZ Plot.wmv	0 m 56 s
BUF #3 p/Z Plot	OHF3D_BUF 3 pZ Plot.wmv	1 m 39 s
Unique Match of Layer Pressures	OHF3D_Unique Match.wmv	4 m 47 s
Strat Well Deliverability Plot	OHF3D_Strat Well Deliverability Plot.wmv	0 m 45 s
Match Plot p/Z for All Wells in Study Area	OHF3D_Match Plot pZ All Wells.wmv	0 m 50 s
Deliverability Match All Wells in Study Area	OHF3D_Deliverability Match All Wells.wmv	1 m 45 s
p/Z Match Plot for Case Where Section Lines Have Been Sealed – A single well study is misleading	OHF3D_pZ Match Plot.wmv	1 m 23 s
Deliverability Match Plot with Section Lines Have Been Sealed – Not a Point to Point Match	OHF3D_Deliverability Match Plot-Sealed.wmv	0 m 44 s
Sensitivity Case K_v/K_h = 0.05 p/Z Plot Indicated Complete Crossflow	OHF3D_Sensitivity Case.wmv	0 m 37 s
Deliverability Match for K_v/K_h = 0.05	OHF3D_Deliverability Match for KvKh.wmv	0 m 20 s
p/Z Match with Crossflow. Needed to throw away 20% of volume	OHF3D_pZ Match with Crossflow.wmv	0 m 44 s
Deliverability Match 20% Volume Reduction Didn't Match Layer Differential Pressures	OHF3D_Deliverability Match 20.wmv	1 m 21 s
Table Listing Economic Rates – Long Life	OHF3D_Table Listing Economic Rates.wmv	3 m 31 s
Press Distribution in Herrington - Simulated	OHF3D_Press Dist - Herrington.wmv	1 m 7 s
Press Distribution in Krider - Simulated	OHF3D_Press Dist - Krider.wmv	0 m 30 s
Press Distribution in Winfield - Simulated	OHF3D_Press Dist - Winfield.wmv	0 m 24 s
Summary of Model Results	OHF3D_ Summary of Model Results.wmv	1 m 23 s
Table Showing Life for Wide Open Production	OHF3D_Table Showing Life.wmv	2 m 7 s
Table Showing Time to Abandonment	OHF3D_Table Showing Time.wmv	1 m 2 s
Rate-Time Plot – Decline After Constant Rate Period	OHF3D_Rate-Time Plot.wmv	1 m 57 s
Texas Hugoton Example Supporting Previous Slide	OHF3D_Texas Hugoton Example.wmv	0 m 21 s

General Layered No Crossflow Cases

Handwritten Reconditioning Report 11/25/1955	GLNCC_Handwritten Reconditioning.wmv	3 m 43 s
4 in 1 Plot – Morrow Well Well Log – Wall Well 9G	GLNCC_4 in 1 Plot – Morrow Well.wmv	2 m 48 s
Cross Section – Schematics Layers are Continuous, Properties May Vary	GLNCC_Cross Section – Schematics.wmv	2 m 45 s
Means San Andres Unit – Production Graph	GLNCC_Means San Andres Unit.wmv	1 m 9 s
Plot of Continuity Progression – Did Not Recognize Layered No Crossflow Behavior	GLNCC_Plot of Continuity Progression.wmv	2 m 3 s
Ghost River Unit - Map	GLNCC_Ghost River Unit Map.wmv	0 m 50 s
Ghost River Well / Reservoir Data	GLNCC_Ghost River Well Reservoir data.wmv	0 m 27 s
Ghost River Production Forecast – AFE With Sophisticated Risk Analysis	GLNCC_Ghost River Production Forecast.wmv	1 m 57 s
Deep High Press Condensate Near Chatom Field has been Cycled. If history matched model was used to predict performance against a constant wellbore press = >b = .7	GLNCC_Deep High Press Condensate.wmv	1 m 20 s
Chatom Unit – p/Z Plot	GLNCC_Chatom Unit pZ Plot.wmv	1 m 40 s
Updated Performance Plot – From Red Cave	GLNCC_Updated Performance Plot.wmv	0 m 55 s
Kroth Air Well – Well Log – Texas Hugoton	GLNCC_Kroth Air Well.wmv	1 m 3 s
Table Showing Sidetrack Deliverabilities No Areal Variation At All	GLNCC_Table Showing Sidetrack.wmv	2 m 46 s
APX Elliot #1 – MHF – Poor Work	GLNCC_APX Elliot 1.wmv	0 m 55 s
High Pressure Gas Well High Pressure Expect b=0	GLNCC_High Pressure Gas Well.wmv	1 m 23 s
Isobaric Maps – Guymon Hugoton	GLNCC_Isobaric Maps.wmv	3 m 7 s

Exercises

Introduction to Exercises	Exercise_Introduction.wmv	6 m 25 s
Exercise – Forecast of Layered System – Gas Well	Exercise_Forecast of Layered System.wmv	21 m 13 s

Exercise Calculate Cum. Production and p/Z – at End of Five Years	Exercise_Calculate Cum Production.wmv	8 m 56 s
Exercise Calculate Crossflow Case Production Forecast and p/Z and Cum. After Five Years	Exercise_Calculate Crossflow.wmv	9 m 59 s

Tape 6 Click here to watch the entire Fetkovich Course from beginning to end of Tape 6. 1 h 4 m 28 s

Subject Title	Video File Name	Time
Exercises (Continued)		
Exercise to Appreciate Q_{max}/G_i Ratio	Exercise_Qmax Gi Ratio.wmv	16 m 13 s
INFILL DRILL RESPONSE	Exercise_INFILL DRILL RESPONSE.wmv	35 m 27 s
Production Forecast For Ten Acre Spacings	Exercise_Production Forecast.wmv	7 m 42 s

The End