COMPACT LOGGING

Issue

2

Reeves Oilfield Services

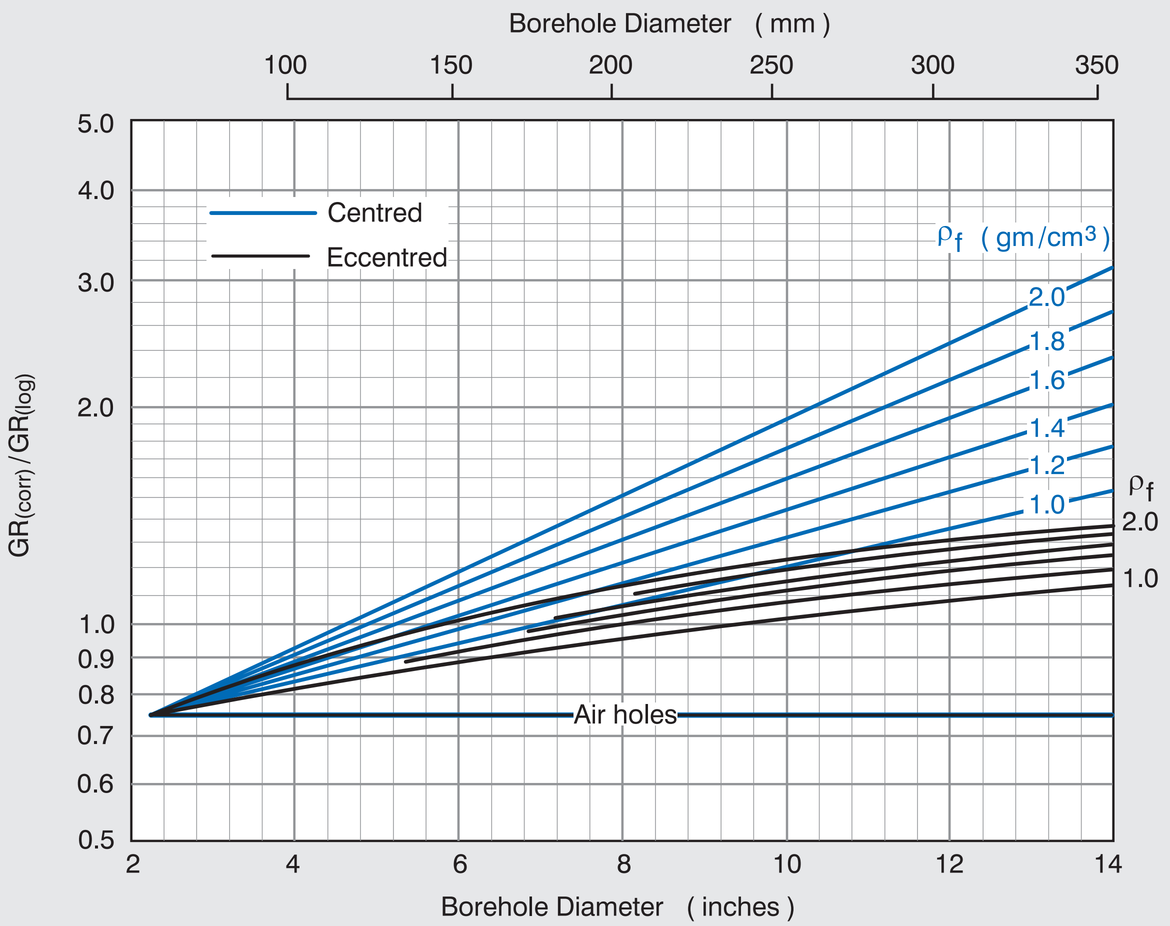
Compact Chart Book

Revised April 2003

Gamma Ray Borehole Correction

Compact Systems

Applicability: Compact Series (MCG & MGS) tools.
KCl free muds.



Use this chart to correct Gamma Ray logs from Compact series tools for the effects of borehole size and mud weight.

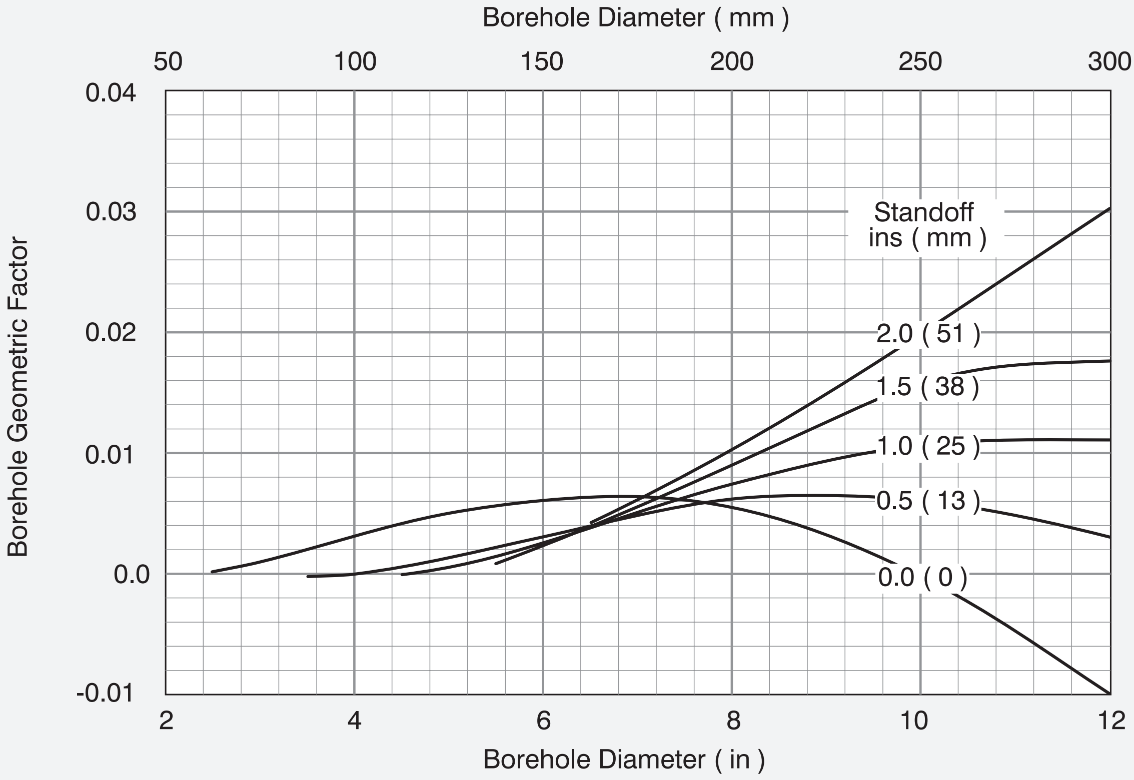
The standard condition is an eccentred tool in a 203 mm (8 inch) diameter well with KCl free mud of density 1.2gm/cm^3. Corrections for non-standard conditions are approximated by:

$$GR_{(corr)}/GR_{(log)} = 0.75 \exp\left[0.35\, \rho_f \left(\frac{d - 2.25}{5.75}\right)\right] \quad \text{for centred tools}$$

$$GR_{(corr)}/GR_{(log)} = 1.75 - \exp\left[-0.24\, \rho_f \left(\frac{d - 2.25}{5.75}\right)\right] \quad \text{for eccentred tools}$$

where d = caliper in inches
ρ_f = mud density in gm/cm^3

Applicability: Compact Series (MAI) tools.



Field logs are corrected for bit size, nominal standoff and borehole fluid salinity.

Corrections are applied to each sub-array. The chart shows the composite correction after construction of the Shallow output curve.

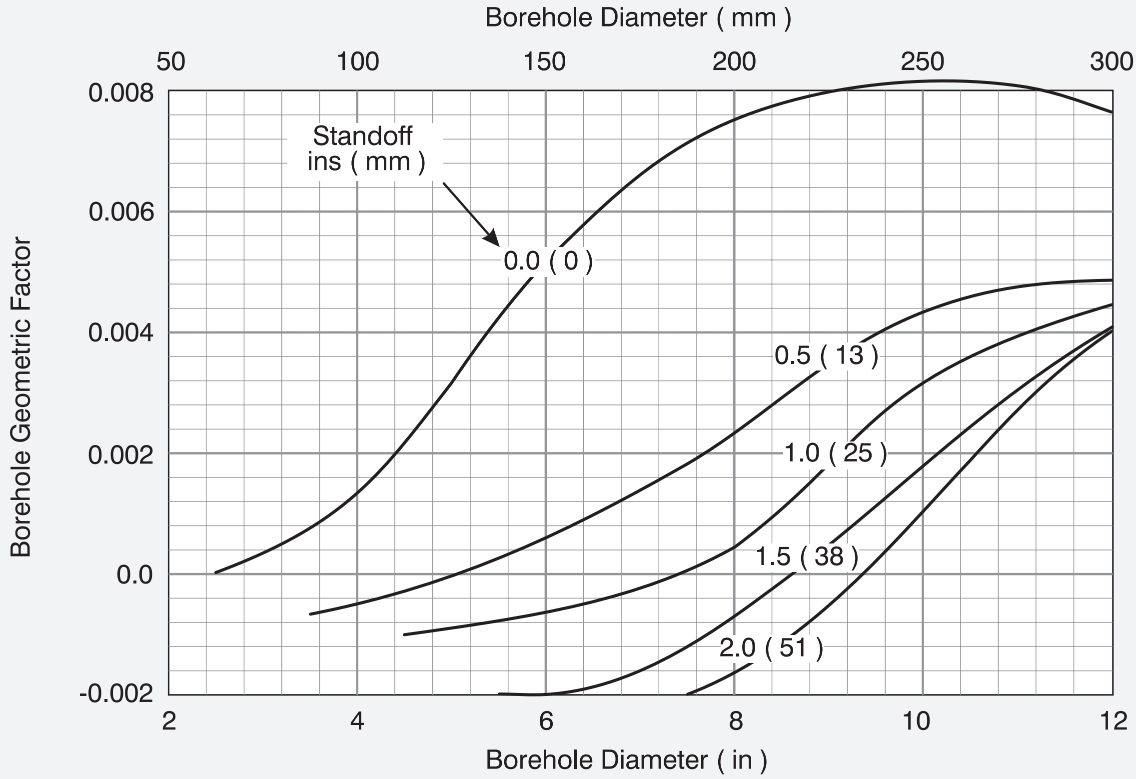
If borehole conditions depart significantly from nominal, new borehole corrections may be computed and applied to the processed logs after first removing the field corrections.

Borehole corrected conductivities are given by:

$$\sigma_{corr} = \frac{\sigma_{app} - g_b \sigma_m}{1 - g_b}$$

Where σ_{app} is the apparent conductivity, σ_m the borehole fluid conductivity, and g_b the borehole geometric factor.

Applicability: Compact Series (MAI) tools.



Field logs are corrected for bit size, nominal standoff and borehole fluid salinity.

Corrections are applied to each sub-array. The chart shows the composite correction after construction of the Medium output curve.

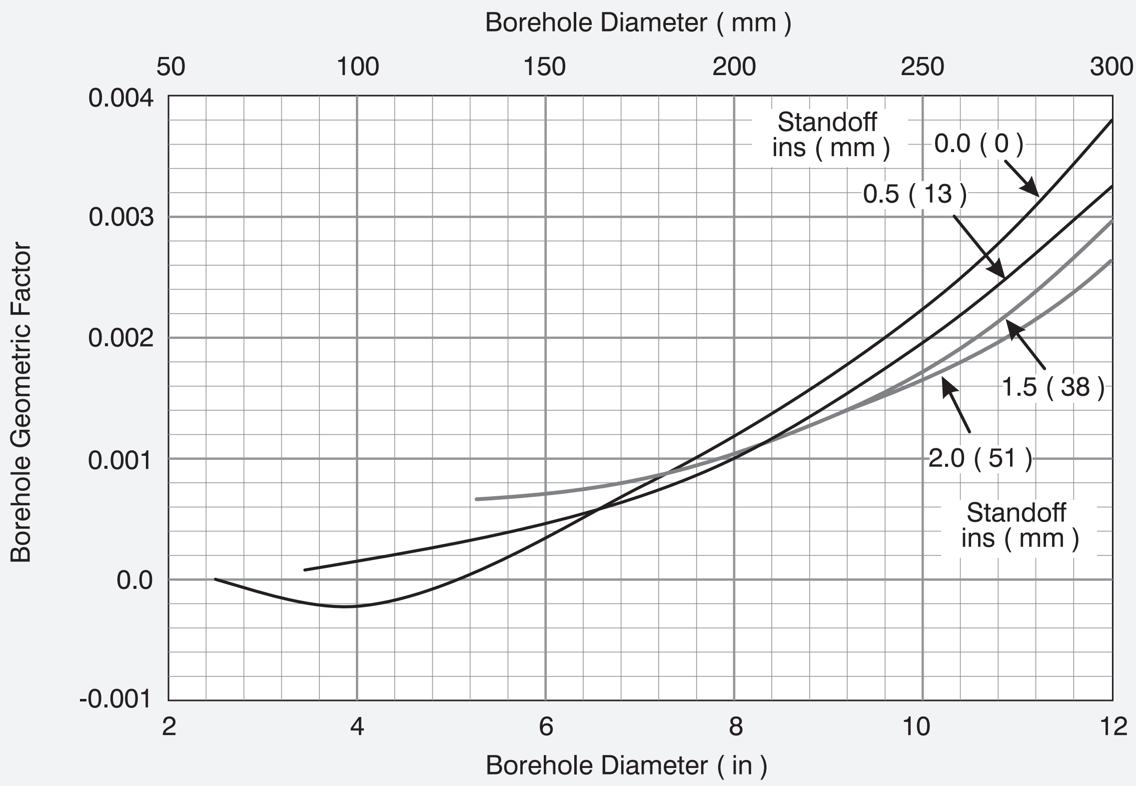
If borehole conditions depart significantly from nominal, new borehole corrections may be computed and applied to the processed logs after first removing the field corrections.

Borehole corrected conductivities are given by:

$$\sigma_{corr} = \frac{\sigma_{app} - g_b \sigma_m}{1 - g_b}$$

Where σ_{app} is the apparent conductivity, σ_m the borehole fluid conductivity, and g_b the borehole geometric factor.

Applicability: Compact Series (MAI) tools.



Field logs are corrected for bit size, nominal standoff and borehole fluid salinity.

Corrections are applied to each sub-array. The chart shows the composite correction after construction of the Deep output curve.

If borehole conditions depart significantly from nominal, new borehole corrections may be computed and applied to the processed logs after first removing the field corrections.

Borehole corrected conductivities are given by:

$$\sigma_{corr} = \frac{\sigma_{app} - g_b \sigma_m}{1 - g_b}$$

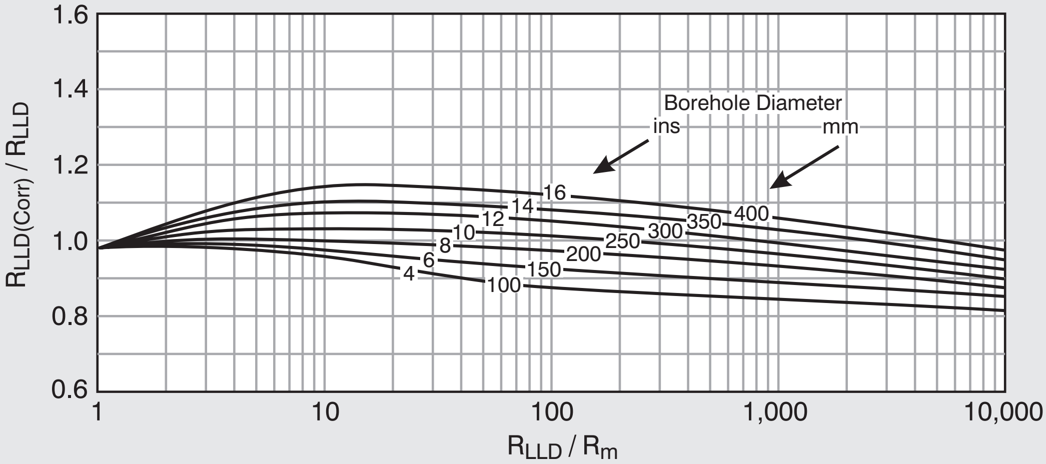
Where σ_{app} is the apparent conductivity, σ_m the borehole fluid conductivity, and g_b the borehole geometric factor.

Compact Deep Laterolog Borehole Correction

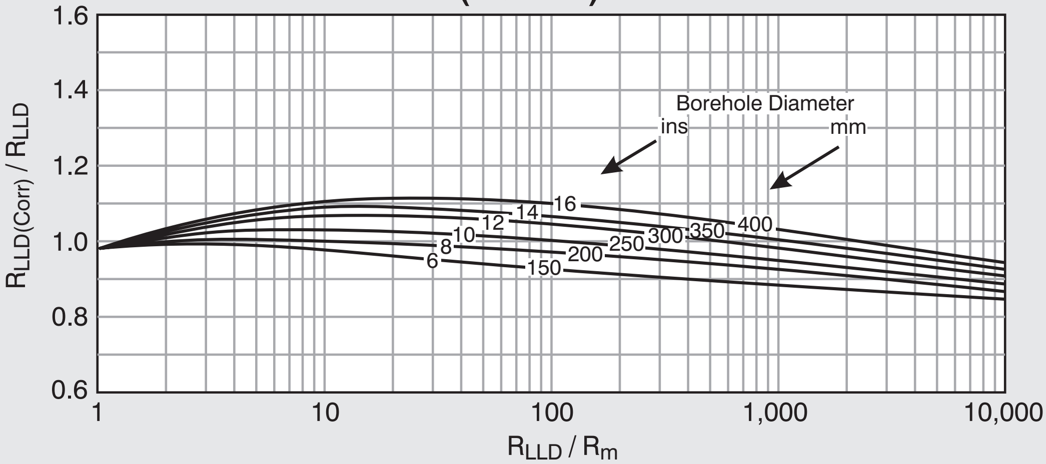
Compact Systems

Applicability: Compact Series (MDL) tools, Operating Mode A.
Standard condition is 13 mm (0.5 inch) standoff in a 200 mm (8 inch) well, Ra/Rm = 20.

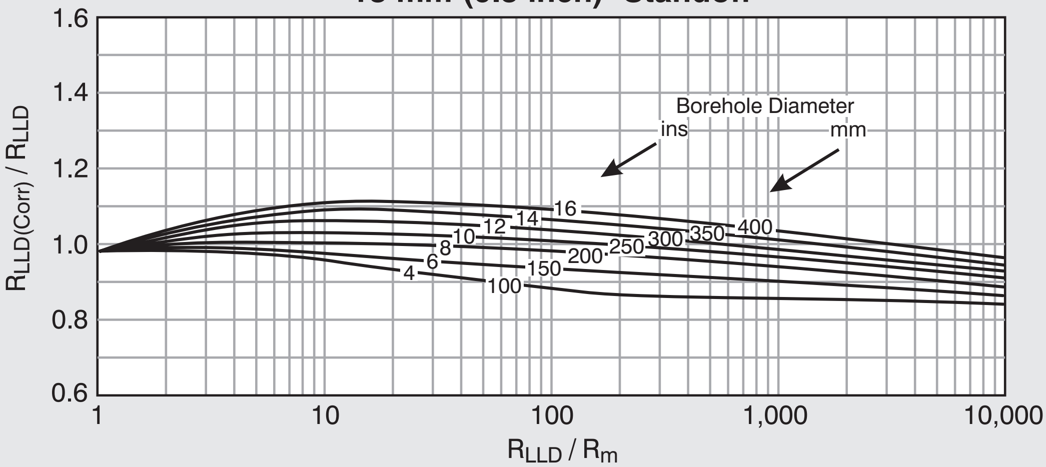
Centred



38 mm (1.5 inch) Standoff



13 mm (0.5 inch) Standoff

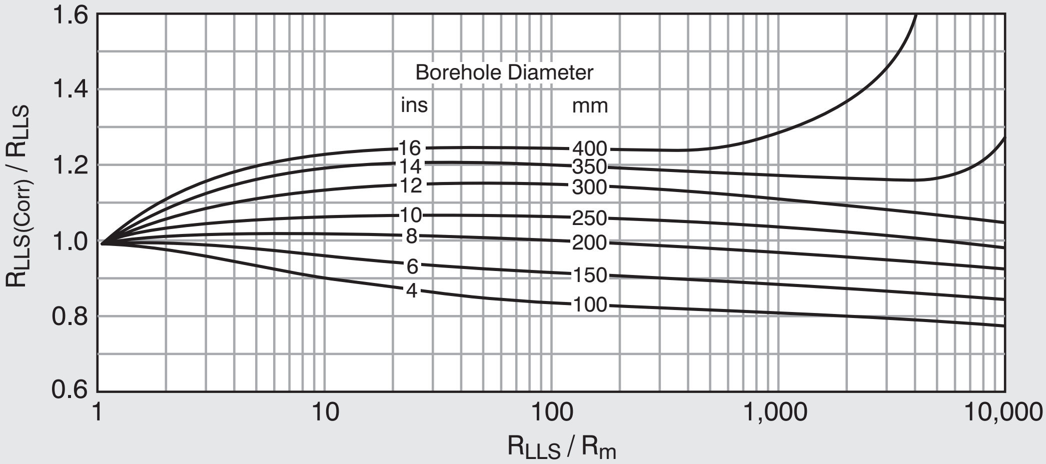


Lat - 4

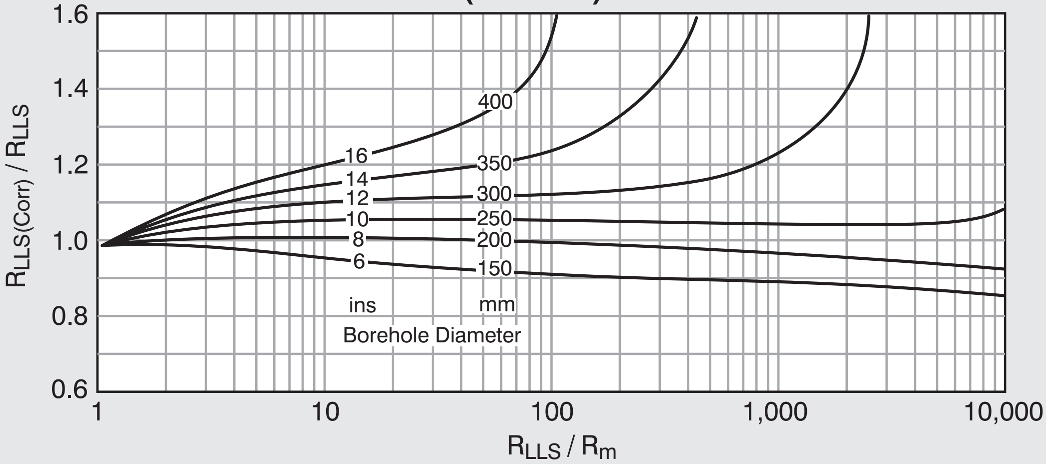
Compact Shallow Laterolog Borehole Correction

Applicability: Compact Series (MDL) tools, Operating Mode A.
Standard condition is 13 mm (0.5 inch) standoff in a 200 mm (8 inch) well, Ra/Rm = 20.

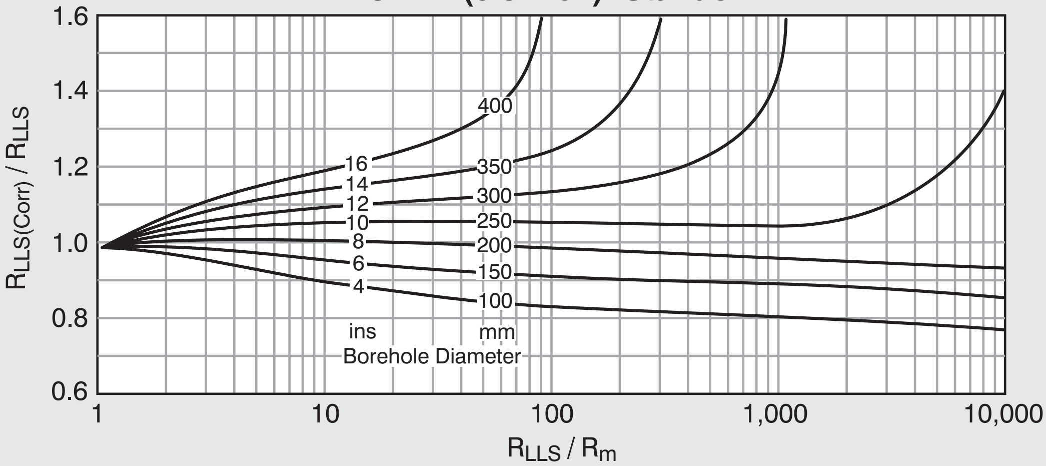
Centred



38 mm (1.5 inch) Standoff



13 mm (0.5 inch) Standoff

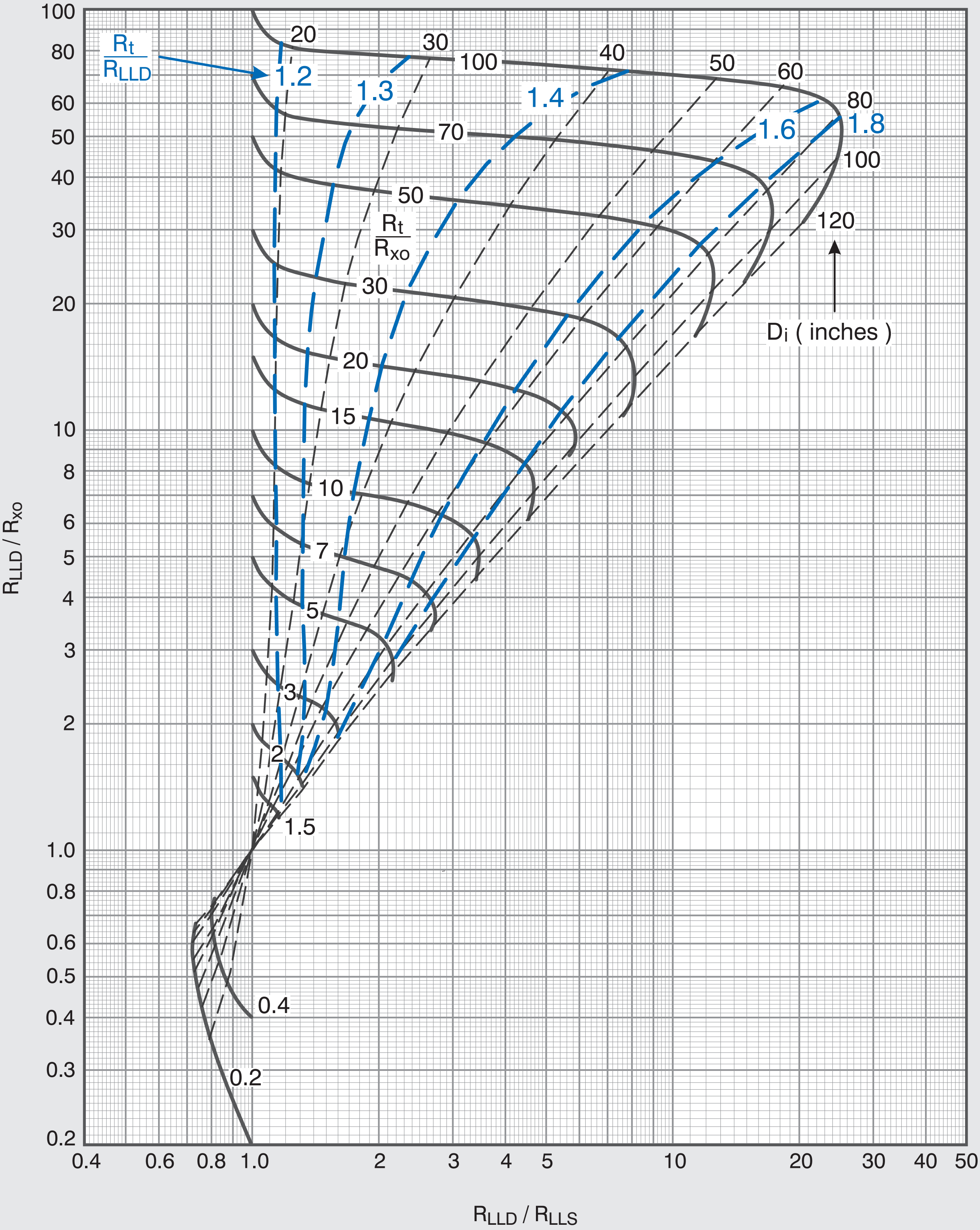


Reeves

Compact Dual Laterolog Tornado Chart

Compact Systems

Applicability: Compact Series (MDL) tools. Operating Mode A.
Thick beds, 8 inch (203 mm) hole, step invasion profile, Rxo/Rm = 50.
Use Borehole corrected data.



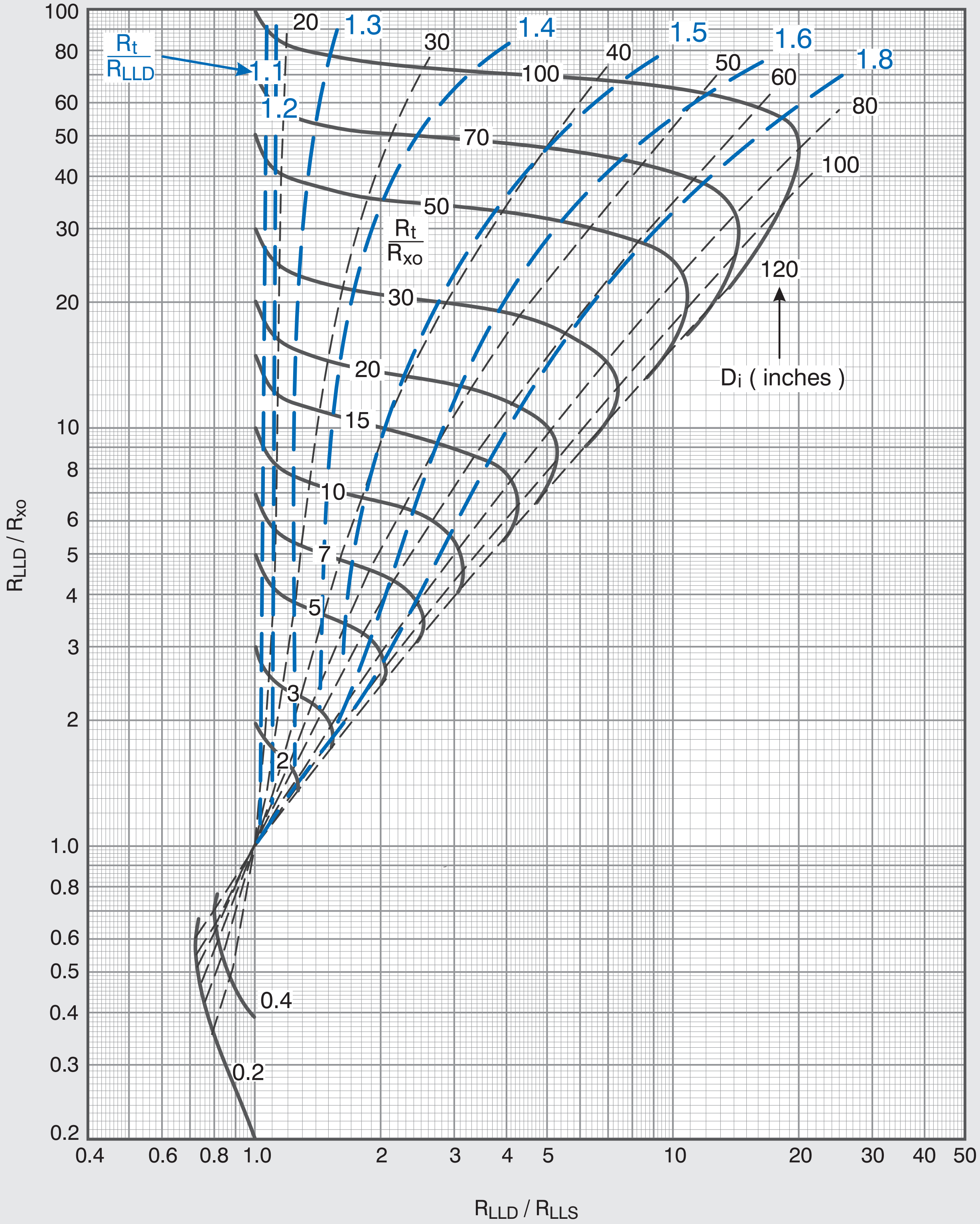
Lat - 6

Reeves

Compact Dual Laterolog Tornado Chart

Compact Systems

Applicability: Compact (MDL) series tools. CML operating mode.
Thick beds, 8 inch (203 mm) hole, step invasion profile, Rxo/Rm = 50
Use Borehole corrected data.

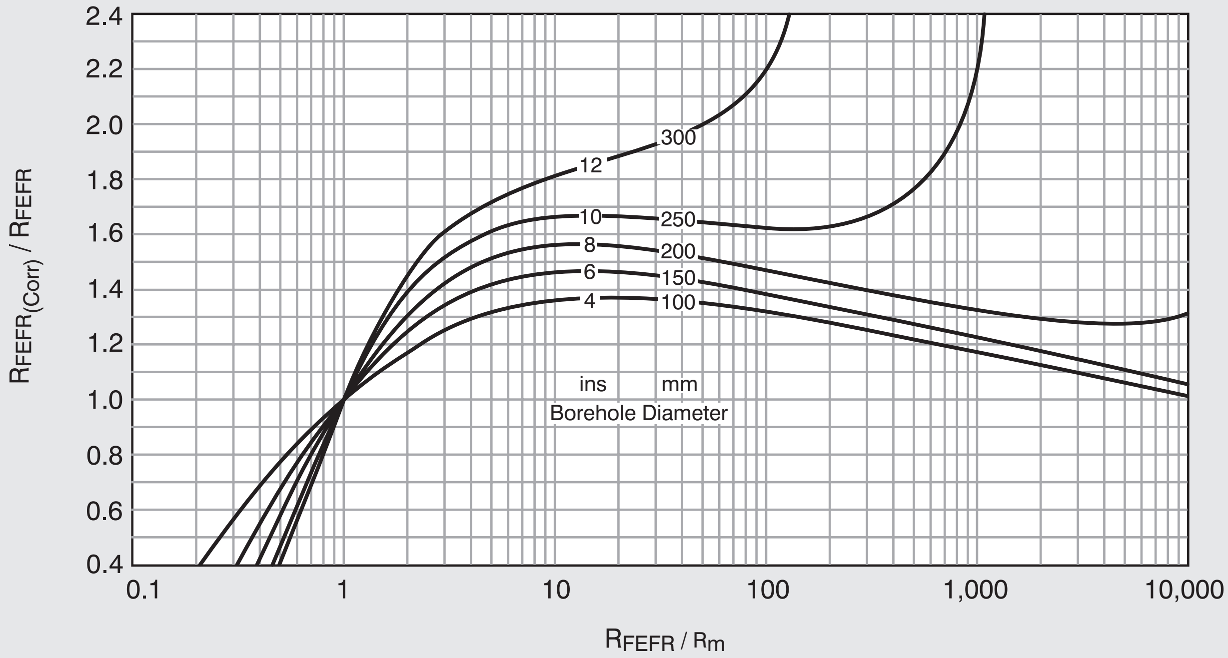


Lat - 7

Compact Systems

Applicability: Compact Series (MFE) tools.

Centred



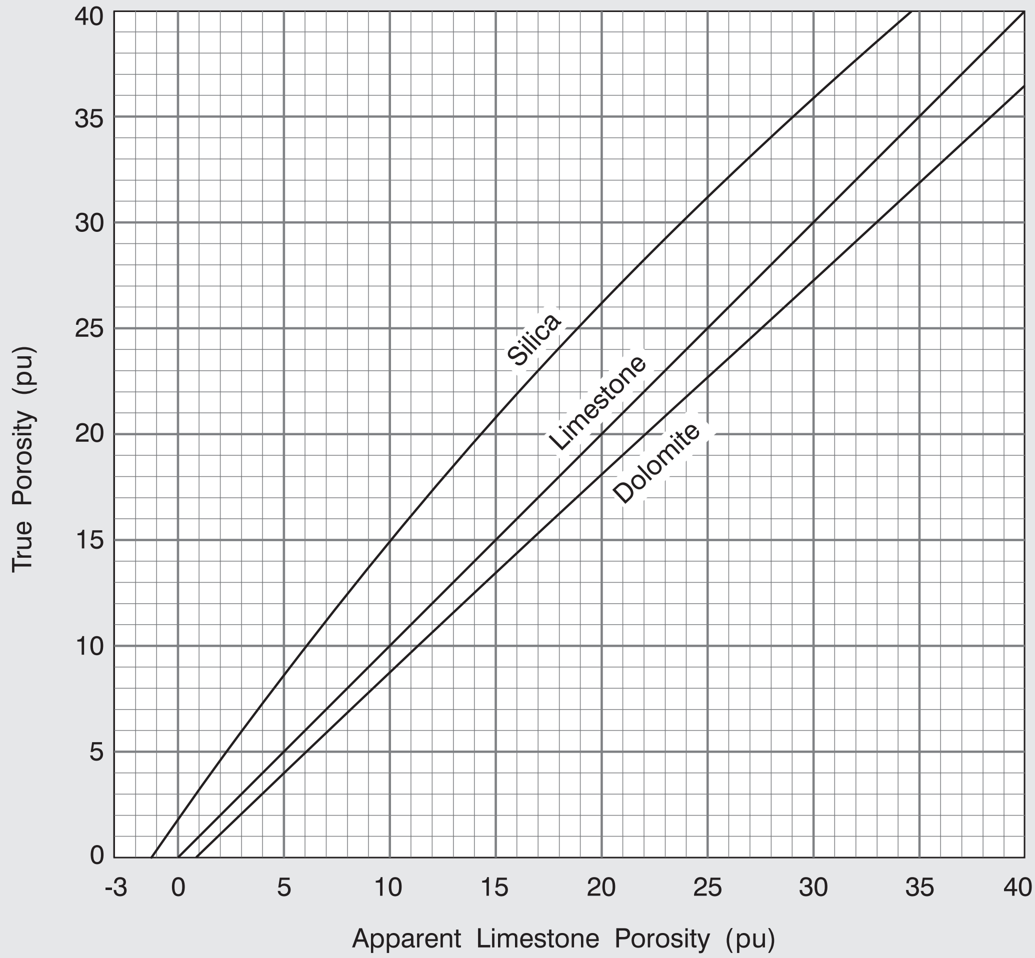
The Corrected Shallow Resistivity curve FEFE has been corrected for bit size and Rm. To apply an alternative correction, enter the chart using the Raw Shallow Resistivity curve FEFR.

Corrections are approximated by: $R_{FEFR(Corr)} / R_{FEFR} = a_0 + a_1x + a_2x^2 + a_3x^3 + ...$
where $x = \ln(R_{FEFR}/R_m)$. Coefficients for 4,6,8,10 and 12 inch wells are (left to right):

Centred					
a_0	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000
a_1	0.3515411	0.5245657	0.6591658	0.7950933	0.9368961
a_2	-0.1259589	-0.2158732	-0.2848466	-0.4006034	-0.4659671
a_3	0.0209587	0.0404045	0.0570030	0.1119412	0.1453734
a_4	-0.0018341	-0.0037254	-0.0056788	-0.0172275	-0.0286625
a_5	0.0000652	0.0001324	0.0002223	0.0010960	0.0026412

Applicability: Compact Series (MDN) tools. Σ_{fl} value: 22.2 cu.

Σ_{ma} values: Silica 4.26 cu Limestone 7.10 cu Dolomite 4.70 cu



Use Chart Npor - 5 to transform Compact Series neutron porosity logs recorded in apparent limestone units into true sandstone and dolomite porosities.

Enter the apparent limestone porosity and move vertically to the appropriate matrix line. Read the true porosity from the vertical axis.

The transforms are described by the following equations:

$$\Phi_{sand} = 0.000075\,\Phi_{lim}^{3} - 0.012\,\Phi_{lim}^{2} + 1.43\,\Phi_{lim} + 1.76$$

$$\Phi_{dol} = 0.000025\,\Phi_{lim}^{3} - 0.0022\,\Phi_{lim}^{2} + 0.982\,\Phi_{lim} - 0.88$$

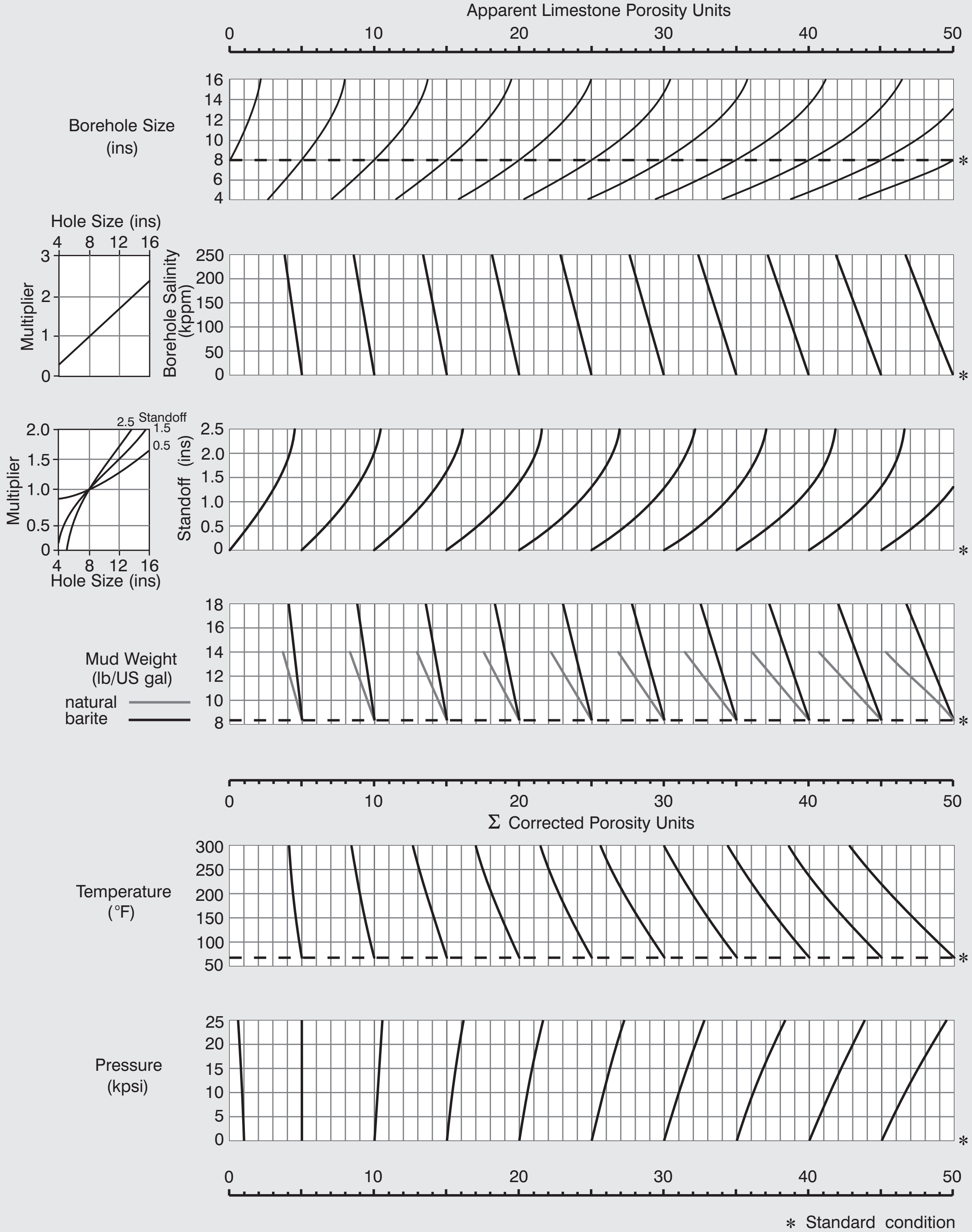
When formation Σ_{ma} values depart significantly from standard conditions, use chart Npor - 7 to make additional corrections.

Npor - 5

Neutron Porosity Environmental Corrections

Compact Systems

Applicability: Open hole logs from Compact Series (MDN) tools.



Npor - 6a

Reeves

Neutron Porosity Environmental Correction Equations

Compact Systems

Applicability: Open hole logs from Compact Series (MDN) tools.

Porosity (Φ) in pu. Range: as Chart Npor - 6a

General

To determine whether a particular environmental correction was applied during acquisition, refer to the correction parameter value recorded on the log tail; if it is equal to the standard condition value, then no correction was applied. Corrections are additive.

To compute corrections for borehole size, borehole fluid salinity, standoff and mud weight based on alternative parameter values, use the relevant equations applied to the raw Apparent Limestone Porosity curve (mnemonic NPOR). Temperature and pressure corrections should be applied after matrix and formation fluid salinity corrections have been made.

Borehole Size

$$\Delta\Phi = f(\Phi) \cdot f(c)$$

where

c = (caliper - 8.0) inches

$f(\Phi) = -0.0000027\,\Phi^3 - 0.00137\,\Phi^2 + 0.1484\,\Phi + 1.61$

$f(c) = -0.00017\,c^3 + 0.0131\,c^2 - 0.232\,c$

Borehole Fluid Salinity

$$\Delta\Phi = k \cdot (0.05\,\Phi + 1.0)\,\text{MDNACL} / 250$$

where

k = (caliper - 2.25)/5.75 inches

MDNACL = NaCl equivalent salinity in kppm

Standoff

$$\Delta\Phi = f(\text{standoff}) \cdot f(\Phi) \cdot (\text{caliper}^3/2048 + \text{caliper}^2/256 + \text{caliper}/16)$$

where

$f(\text{standoff}) = 0.8s^2 - 4.4\,s$

$f(\Phi) = -0.0005\,\Phi^2 + 0.034\,\Phi + 0.6$

s = standoff / k inches

k = (caliper - 2.25)/5.75 inches

Mud Weight

Natural Muds

$$\Delta\Phi = (0.0143\,\Phi + 0.1786) \cdot (w - 8.345)$$

Barite Muds

$$\Delta\Phi = (0.0057\,\Phi + 0.0714) \cdot (w - 8.345)$$

where

w = mud weight in lbs/US gallon

Borehole Temperature

$$\Delta\Phi = (0.0007\,\Phi + 0.001) \cdot ({}^\circ F - 68)$$

Pressure

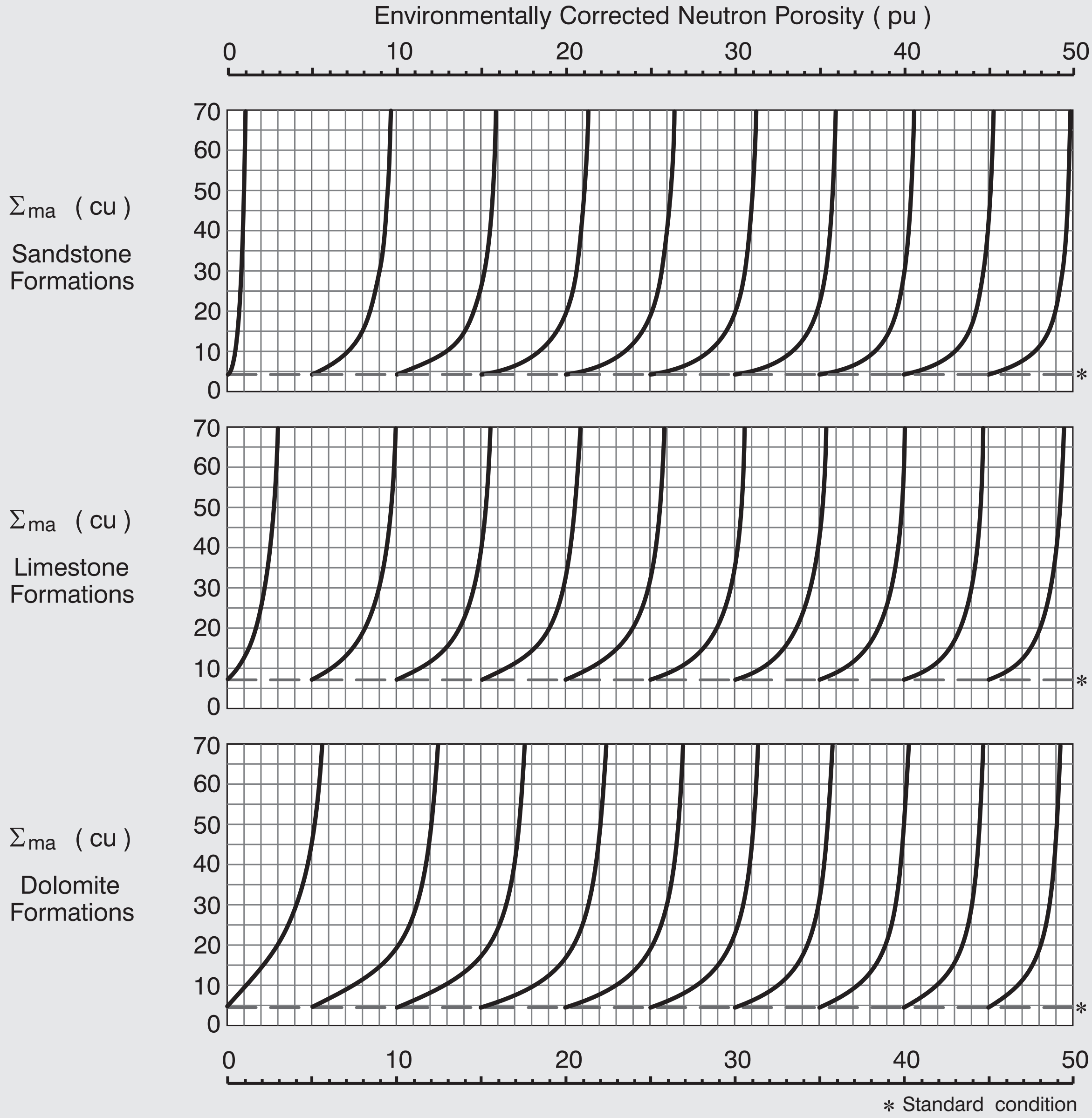
$$\Delta\Phi = (0.02 - 0.004\,\Phi) \cdot \text{kpsi}$$

Revision 1 Septembe 2001

Neutron Porosity Matrix Cross Section Correction

Compact Systems

Applicability: Open hole logs from Compact Series (MDN) tools.



Use the appropriate nomogram to deduce corrections for variations in matrix sigma values. Sigma corrections associated with variations in formation fluid salinity are specified in Chart Npor - 8. Matrix sigma corrections are given by:

sand $\Delta\Phi = (-2.51a^2 + 11.34a - 8.83)\cdot(0.08\,\Phi\exp(-0.04\,\Phi) + 0.05)$

lime $\Delta\Phi = (-1.37a^2 + 8.78a - 7.41)\cdot(0.08\Phi\exp(-0.045\,\Phi) + 0.25)$

dolomite $\Delta\Phi = (-7.09a^2 + 16.98a - 9.89)\cdot(0.11\,\Phi\exp(-0.06\,\Phi) + 0.20)$

where: Φ = borehole corrected neutron porosity in appropriate matrix units

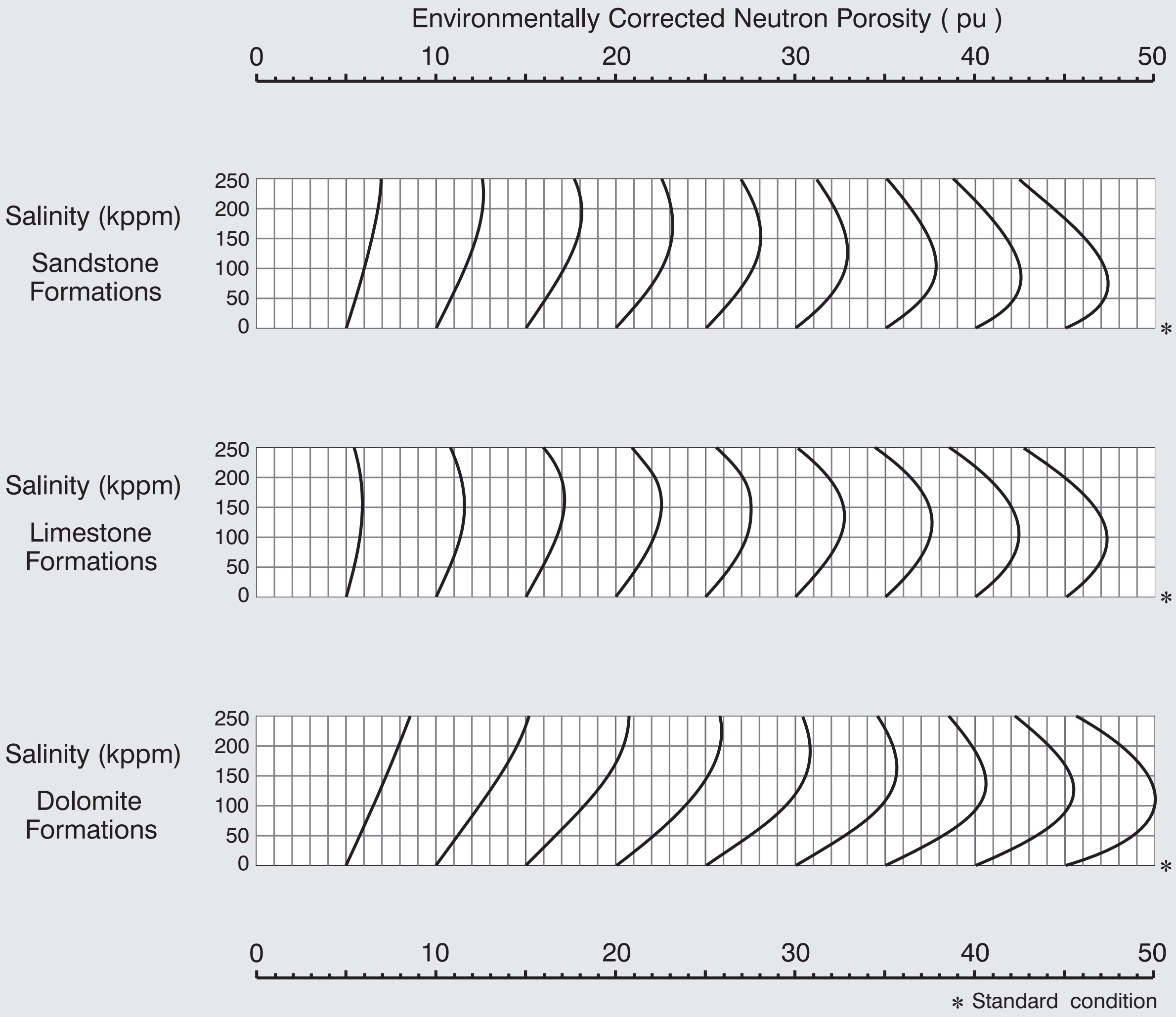
and $a = \Sigma_{ma(std)} / \Sigma_{ma}$

and $\Sigma_{ma(std)}$ = 4.26, 7.10 and 4.70 cu respectively for standard sand, lime and dolomite.

Neutron Porosity Formation Salinity Corrections

Compact Systems

Applicability: Open hole logs from Compact Series (MDN) tools.



Use the appropriate nomogram to deduce corrections for variations in formation salinity. If the matrix cross section is known, a correction should first be made using Chart Npor-7. Salinity corrections are approximated by:

sand $$\Delta\Phi = (-0.07\,\Phi^2 + 2.0\,\Phi - 3.0)\cdot kppm^3\cdot 10^{-8} + (0.031\Phi^2 - 0.4\Phi + 1.0)\cdot kppm^2\cdot 10^{-5} - (1.4\,\Phi + 2.0)\cdot kppm\cdot 10^{-3}$$

lime $$\Delta\Phi = (-0.066\,\Phi^2 + 3.0\,\Phi - 1.0)\cdot kppm^3\cdot 10^{-8} + (0.024\,\Phi^2 - 0.6\,\Phi + 1.2)\cdot kppm^2\cdot 10^{-5} - (\Phi + 1.0)\cdot kppm\cdot 10^{-3}$$

dolomite $$\Delta\Phi = (-0.02\,\Phi^2 + 0.4\Phi - 1.0)\cdot kppm^3\cdot 10^{-8} + (0.022\,\Phi^2 - 0.1\Phi + 1.0)\cdot kppm^2\cdot 10^{-5} - (2.0\,\Phi + 2.0)\cdot kppm\cdot 10^{-3}$$

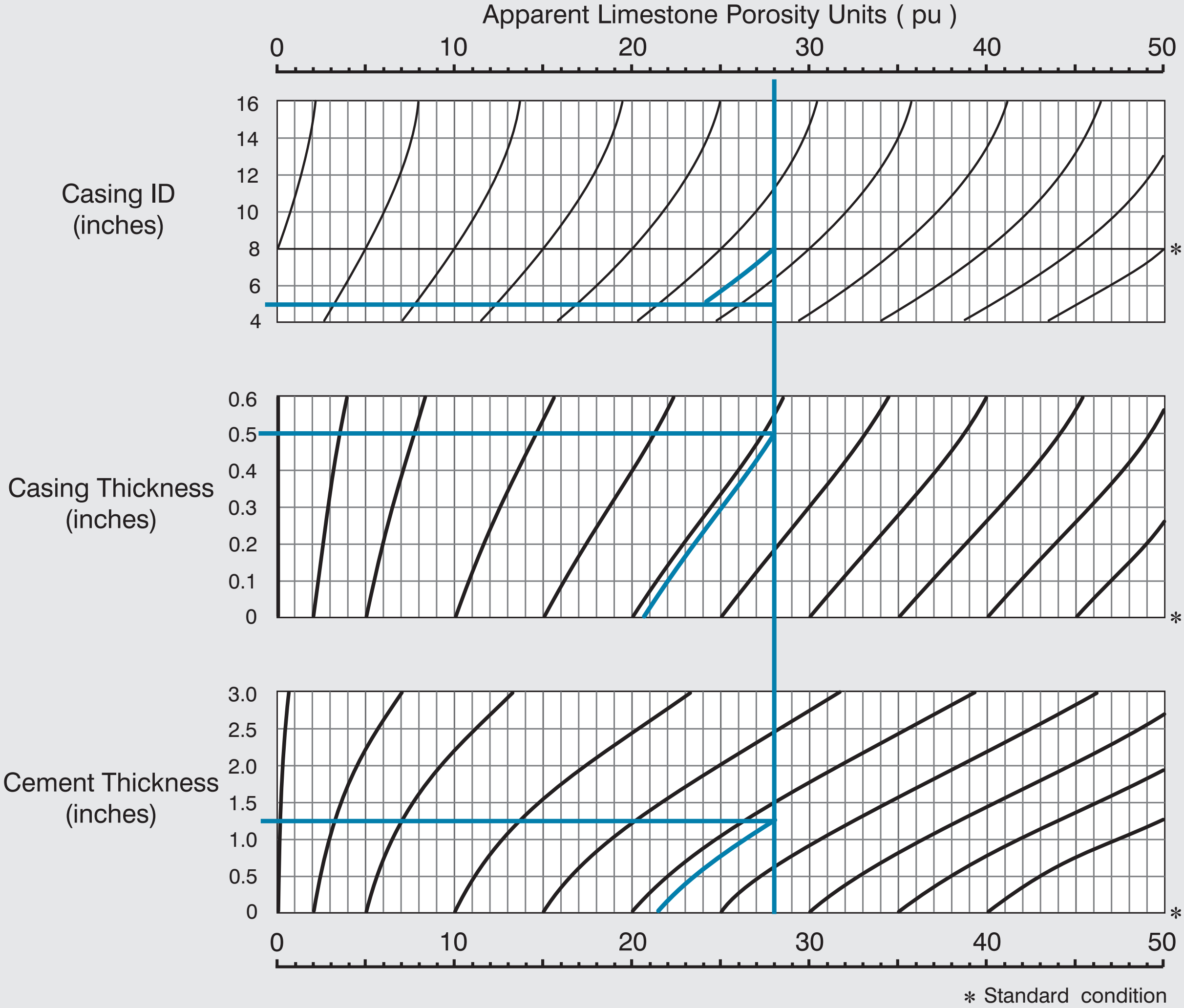
where: Φ = borehole corrected neutron porosity in appropriate matrix units

Reeves

Compact Systems

Neutron Porosity Cased Hole Corrections

Applicability: Cased hole logs from MDN Series tools.



In cased holes substitute Npor-9a for the open hole borehole size correction. Enter the chart with uncorrected porosity in apparent limestone units (NPOR or uncorrected NPRL) and draw a vertical line through each nomogram. Derive ΔΦ values from each nomogram by marking the intersection with the given casing ID, casing thickness and cement thickness values, then move parallel to the nearest curve to the standard condition. Sum the ΔΦ values to find the total correction. Apply any remaining environmental corrections at this point.

Example: casing ID = 5 inches, casing thickness = 0.5 inches, cement thickness = 1.25 inches
For NPOR = 28 pu., corrected porosity = 28 + (3.9 - 7.5 - 6.6) = 17.8 pu.

Casing ID $\Delta\Phi = f(\Phi) \cdot f(c)$

where $f(\Phi) = 0.0000027\,\Phi^3 - 0.00137\,\Phi^2 + 0.1484\,\Phi + 1.6$

$f(c) = -0.00017\,c^3 + 0.0131\,c^2 - 0.232\,c$

$c = (\text{caliper} - 8.0)$ inches

Casing Thickness $\Delta\Phi = (0.00004\,\Phi^3 - 0.0135\,\Phi^2 + 1.0877\,\Phi) \cdot (0.59\,t^3 - 0.235\,t^2 - 0.75\,t)$

t = casing thickness in inches

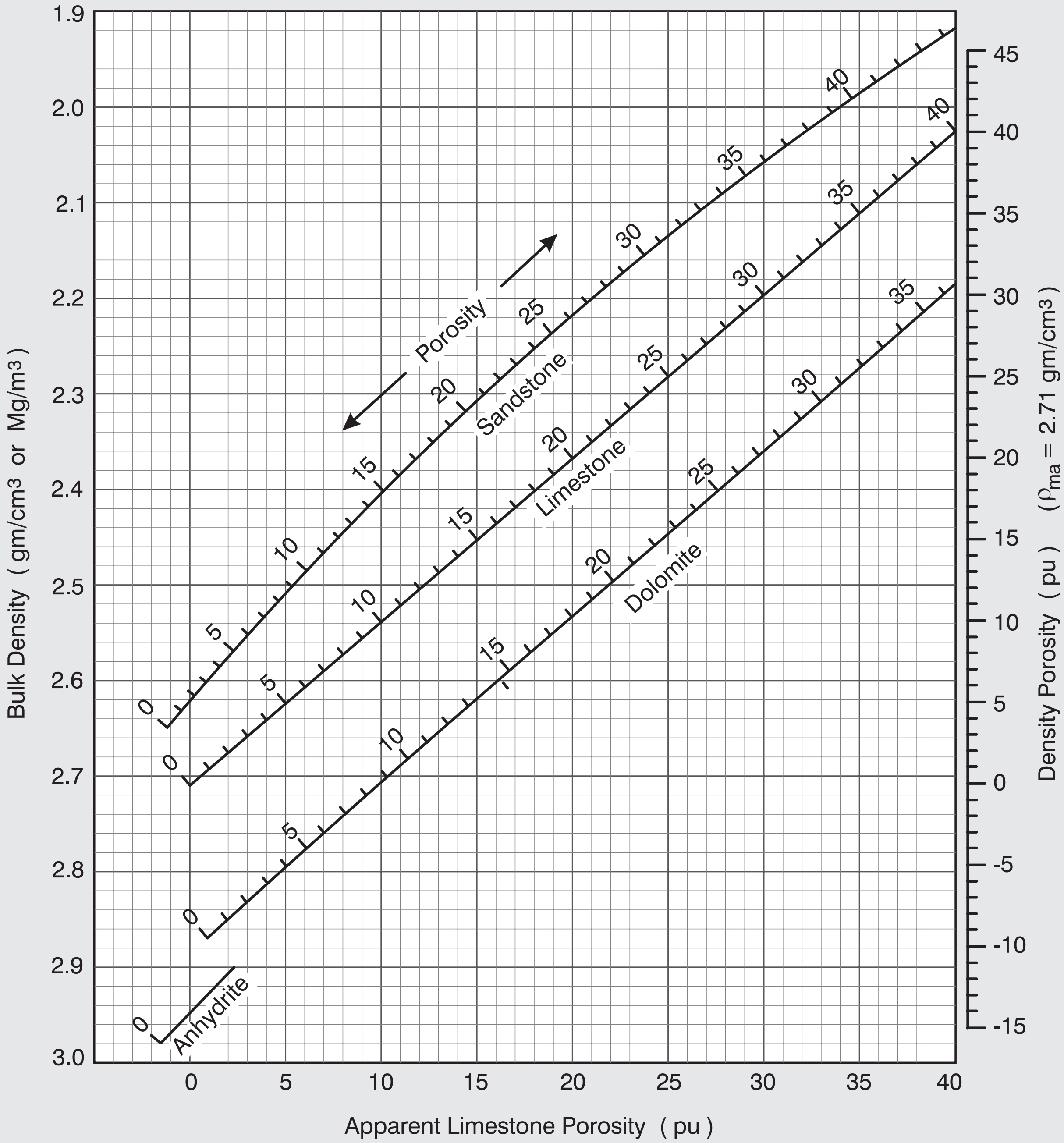
Cement Thickness $\Delta\Phi = (-0.0009\,\Phi^2 + 0.13\,\Phi + 0.05) \cdot (0.087\,h^3 - 0.33\,h^2 - 1.5\,h)$

h = cement thickness in inches

Npor - 9a

Lithology-Porosity from Density-Neutron Crossplot

Applicability: MPD and MDN tools, environmentally corrected.
Formation fluid density = 1.0 gm/cm3 (Mg/m3)



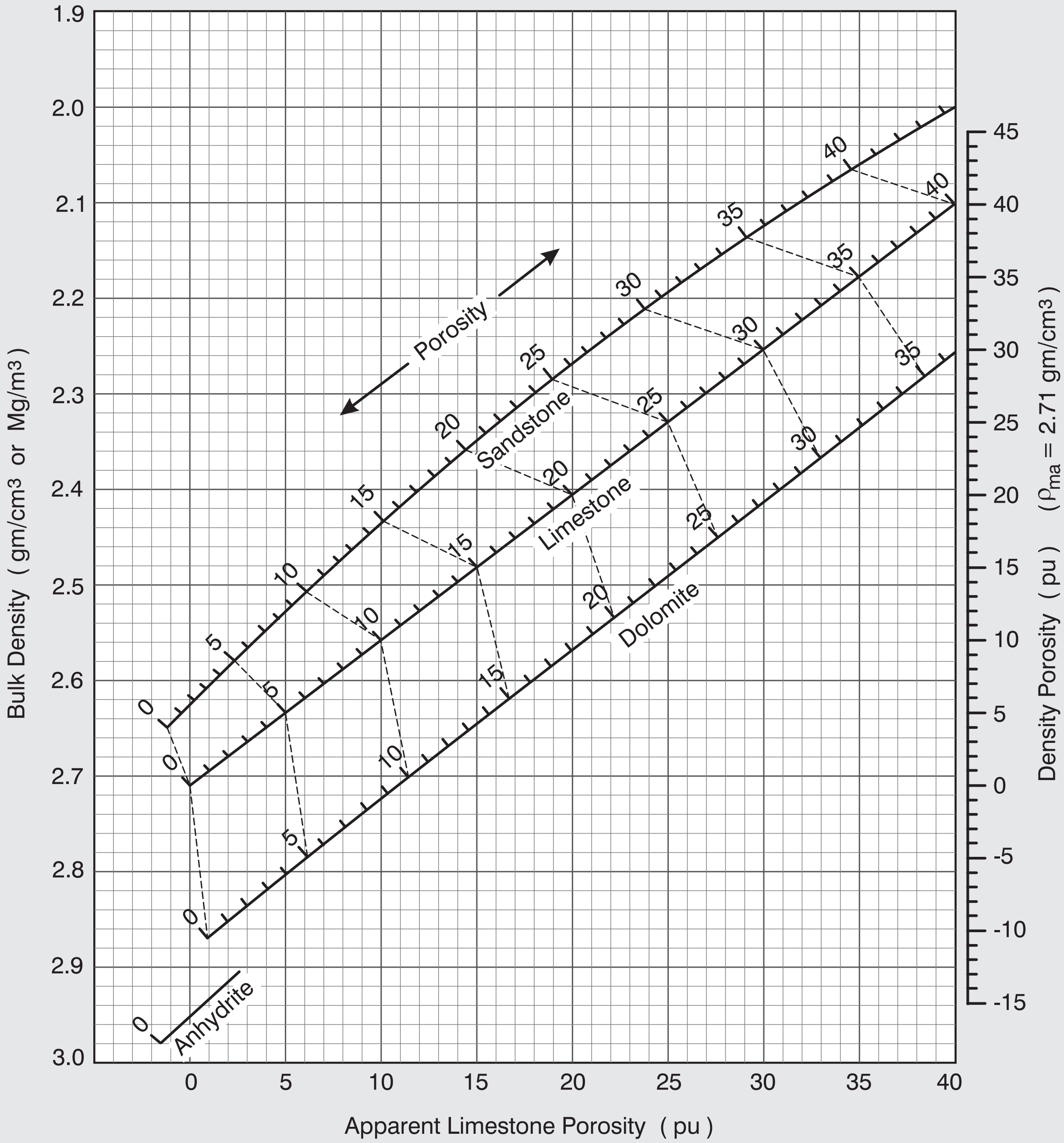
LPC - 1

Reeves

Lithology-Porosity from Density-Neutron Crossplot

Compact Systems

Applicability: MPD and MDN tools, environmentally corrected.
Formation fluid density = 1.19 gm/cm3 (Mg/m3)



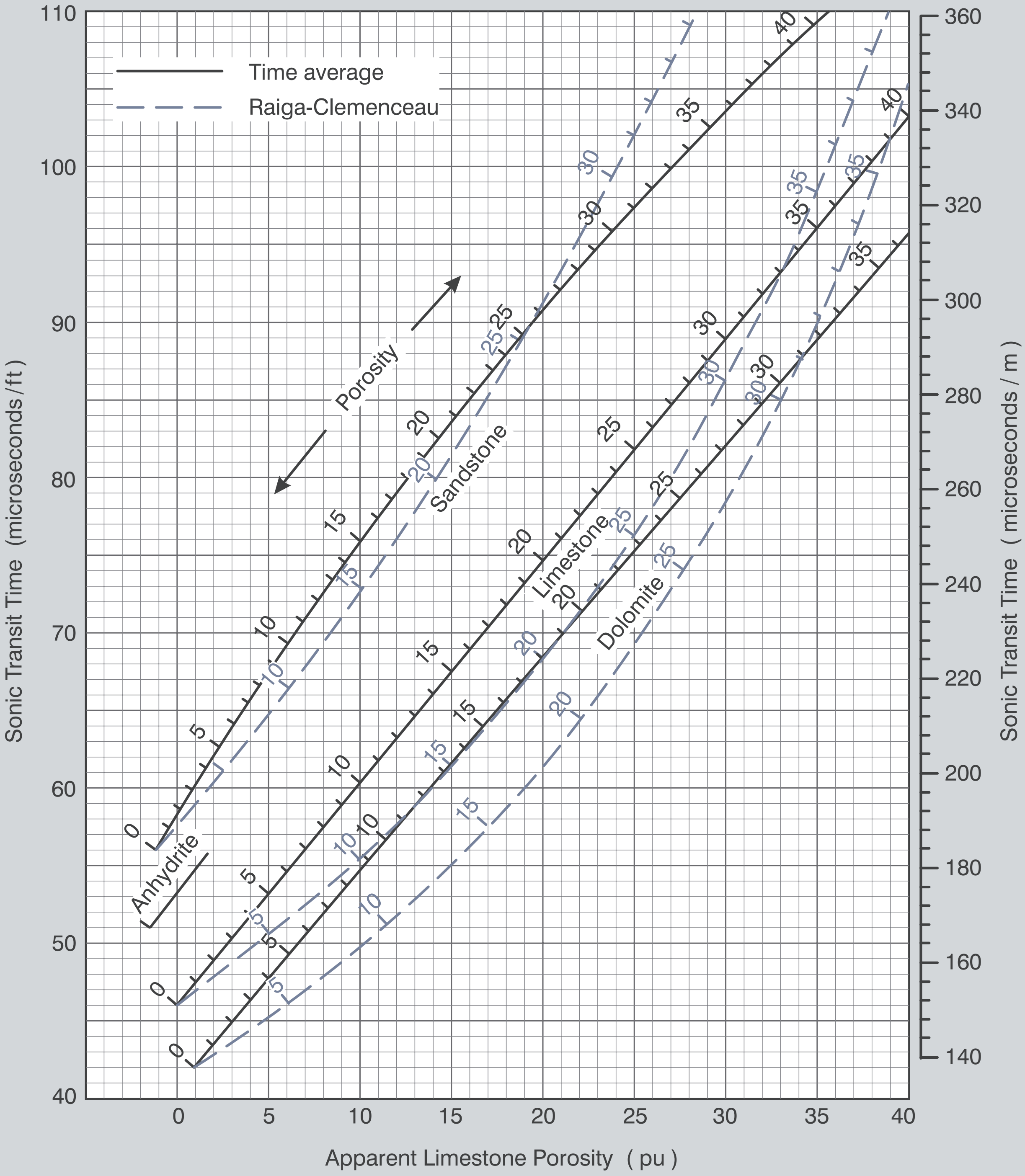
LPC - 2

Reeves

Lithology-Porosity from Sonic-Neutron Crossplot

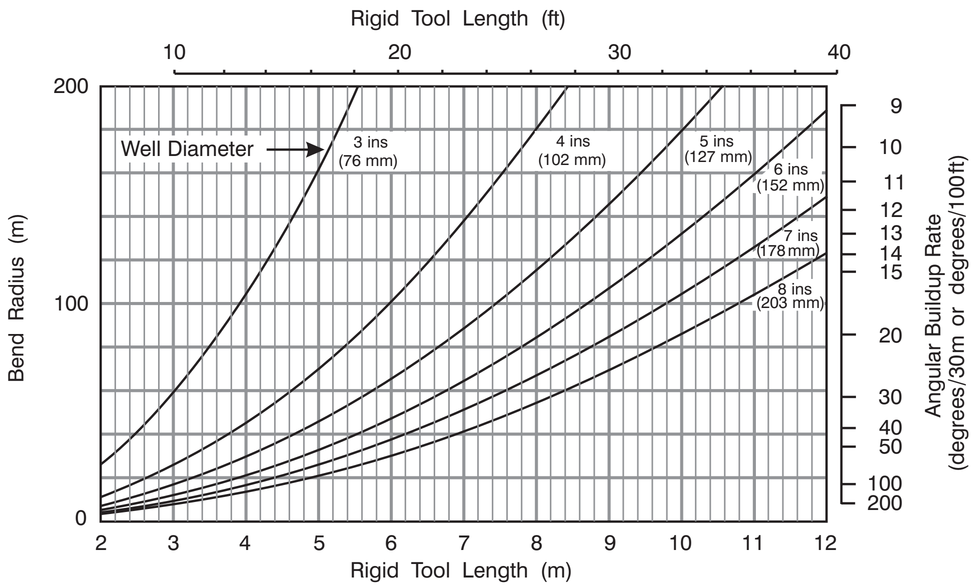
Compact Systems

Applicability: MDN tools, environmentally corrected.
Formation fluid slowness = 189 microseconds/ft (620 microseconds/m)

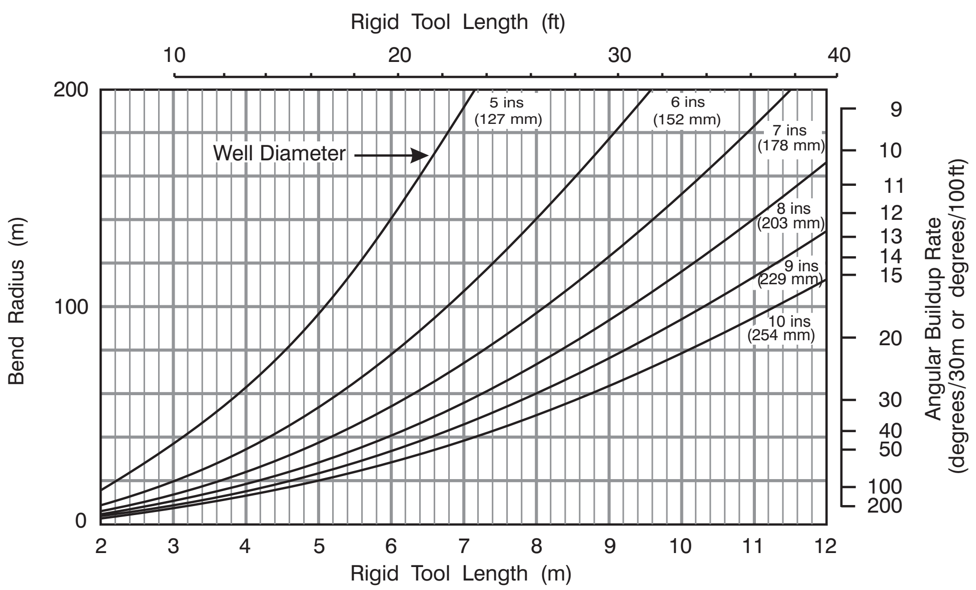


LPC - 5

57 mm (2 1/4 in) tools



95 mm (3 3/4 in) tools



For a given tool diameter t, the maximum rigid tool length L that will traverse a well of diameter d and bend radius R is given by:

$$L = 2\{(R+d)^2 - (R+t)^2\}^{1/2}$$

Angular build rate (degrees / 30 m) = 1718/R (R in m)