

Low Perm Reservoir

Cement Energy Analysis

Note - Spreadsheet Annotation is in Appendix X

Input Data

Geometry Data

Hole Dia **7.00** in
 Pipe OD **5.50** in
 Pipe ID **5.00** in
 Cemented Interval **1,000** ft

Formation Data

Formation YM **1.E+06** psi

Frac History

Bottom	Top	Pressure
8,000	7,000	8,500
7,550	7,400	8,200
7,210	6,990	8,000
6,700	6,490	7,700

Current Zone

6,250 **6,000** **7,500**

Pressure Loading Schedule

Pressure	Total Applied Energy --> Applications	Applied Energy in - lbs
8,500	1	2.00E+09
8,200	1	1.93E+09
8,000	1	1.88E+09
7,700	1	1.81E+09
-	-	0.00E+00
-	-	0.00E+00
7,500	1	1.77E+09

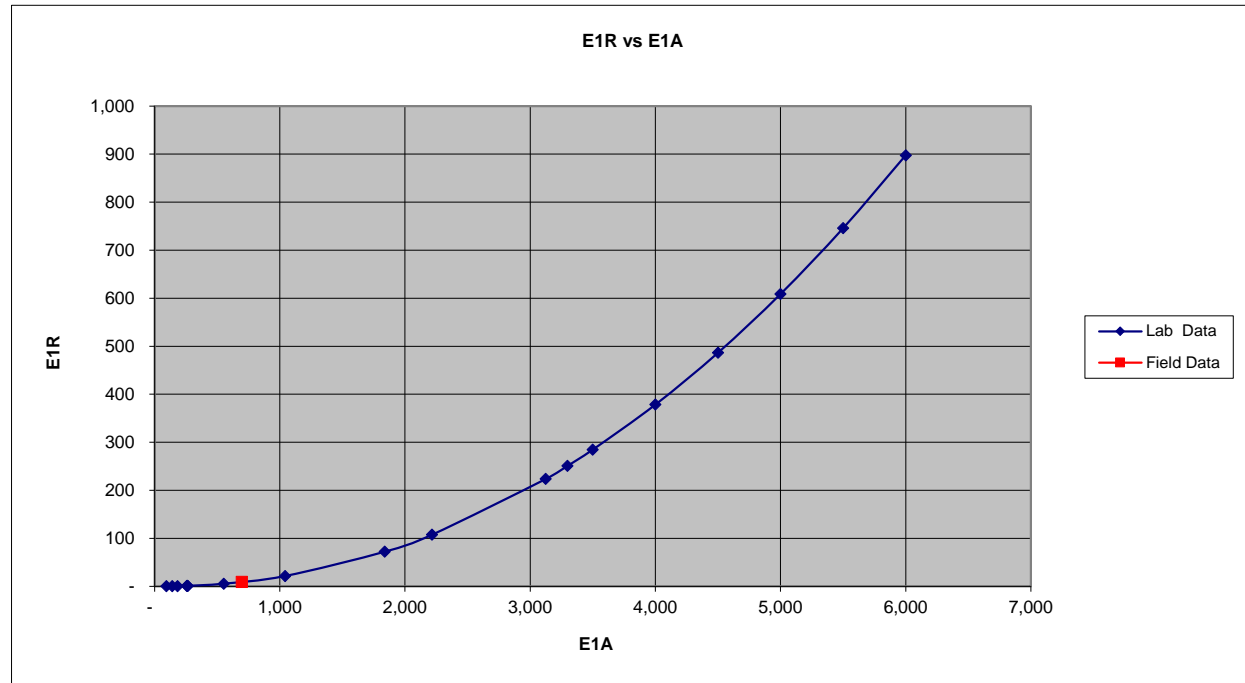
Known Cement Properties (enter two and only two)

Tensile Strength psi
 Young's Modulus **100,000** psi
 Anelastic Strain **3.75E-09**

Output Data

Required Cement Properties

Min Tensile Strength 363 psi
 Max Young's Modulus 100,000 psi
 Max Anelastic Strain 3.75E-09



MMS Annular Seal Energy Analysis
Pressure Analysis

Spreadsheet Annotation:

- 1) Change only **Bold Red** cells on Input_Output Tab
- 2) Spreadsheet estimates field scale cement annular seal failure by comparing calculated energy application and energy resistance factors with laboratory data.

Input Data

Field Scale		
Geometry Data		
Hole Dia	7.00	in
Pipe OD	5.50	in
Pipe ID	5.00	in
Cemented Interval	1,000	ft

Cement Data

Density	15.0	lb/gal
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Formation Data

Young's Modulus	1,000,000	psi
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Calculated Data

Hole Radius	3.500	in
Pipe OR	2.750	in
Pipe IR	2.500	in
Pipe Steel CS	4.123	sq in
Pipe Internal CS Area	19.635	sq in
Pipe Internal Volume	235,619.449	cu in
Formation Factor	0.500	
Annular Radius	0.750	in
Annular CS Area	14.726	sq in
Annular (Cement) Volume	176,714.59	cu in
Cement Mass	11,474.97	lbm

Applied Energy, Field	9.40E+09	in-lb
E1A Field	695.4	
E1R Field	9.11	

E1R Minimum	9.11	
E1C Minimum	968,831	
AS cmt	3.75E-09	3.75E-09
TS cmt	-	363
YM cmt	100,000	100,000

Pressure Loading Schedule

Pressure	Applications	Applied Energy in - lbs
8,500	1	2.00E+09
8,200	1	1.93E+09
8,000	1	1.88E+09
7,700	1	1.81E+09
-	-	0.00E+00
-	-	0.00E+00
7,500	1	1.77E+09

Cement Properties				
	Ten Str	Tens YM	AS Slope	AS Intercept
Bead	400	60,000	1.46E-07	3.53E-08
Foam	253	32,300	1.08E-07	3.94E-08
Latex	539	53,200	6.44E-08	6.28E-08
Type 1	394	81,600	4.95E-08	7.85E-09

Formation Properties		
	Tens YM	Form Factor
Hard	2,000,000	1.0000
Intermediat	500,000	0.2500
Soft	200	0.0001

Lab Data

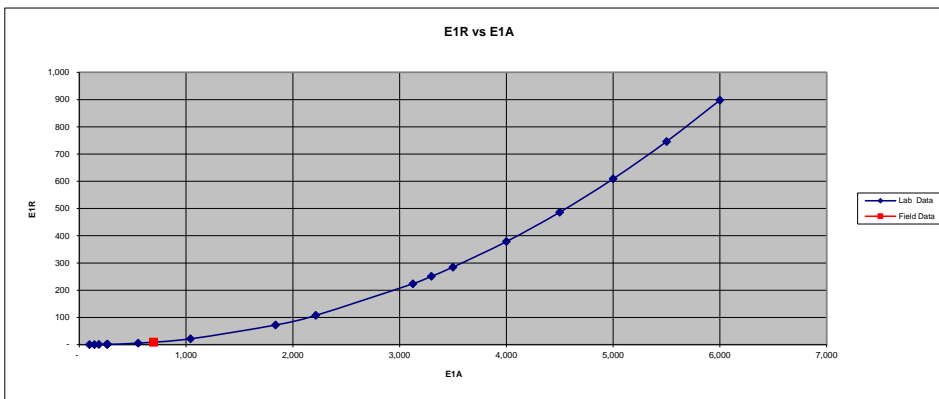
Energy at Failure, in-lbs

	Hard	Int	Soft	Density	Mass Cmt
Bead	162,224	28,628	13,360	12	9,179.98
Foam	95,426	54,075	9,543	12	#REF!
Latex	149,501	17,813	6,362	15.6	#REF!
Type 1	222,660	17,813	9,543	15.6	#REF!

Lab Data Failure Control Curve

Multiplier	8.02E-06
Power	2.1304

E1A calc	E1R Fit
94	0.13
141	0.31
184	0.53
257	1.09
264	1.16
264	1.16
551	5.55
1,041	21.52
1,838	72.18
2,215	107.41
3,124	223.55
3,299	250.97
3500	284.75
4000	378.45
4500	486.38
5000	608.78
5500	745.84
6000	897.73
695	9.11 <-- Fld Data Pt



E1R vs E1A

