Plot of s versus t/r^2 on semilogarithmic paper by using a simple stencil

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In this paper it is shown how to plot s (drawdown) versus t/r^2 (time divided by the square of distance to the observation well) by using a stencil, which can easily be constructed to fit any dimension of the logarithmic decade.

When more observation wells in a pumping test of an aquifer are available, the composite semilogarithmic and logarithmic graphic plot of s versus t/r^2 is recommended instead of the usual plot of s versus t, because the composite plot gives at the same time data about spatial distribution of the hydraulic properties of the aquifer.

In earlier works (references 1 and 2) the plotting procedure and its application in the analysis of pumping test data is described and discussed in detail. However, for plotting data on semilogarithmic paper as described in the abovementioned papers, a series of auxiliary curves must be constructed and transparent semilogarithmic data sheet or a light-table is required in the plotting procedure.

In this article a more simple way of plotting s versus t/r^2 on semilogaritmic paper by using a stencil is presented.

Construction of the Stencil

1. Take a semilogarithmic paper with desired decade length and mark the ordinate t in minutes as shown on the far left side in fig. 1.
2. Find on the abscissa axis in fig. 2 values for points of intersection between the straight line and the t axis.
3. Plot the found values on the semilogarithmic paper and draw the curve through the plotted points, as shown in fig. 1. In this case values for points of intersection in the range from 1 to 160 min. (fig. 2) are sufficient to make the stencil.

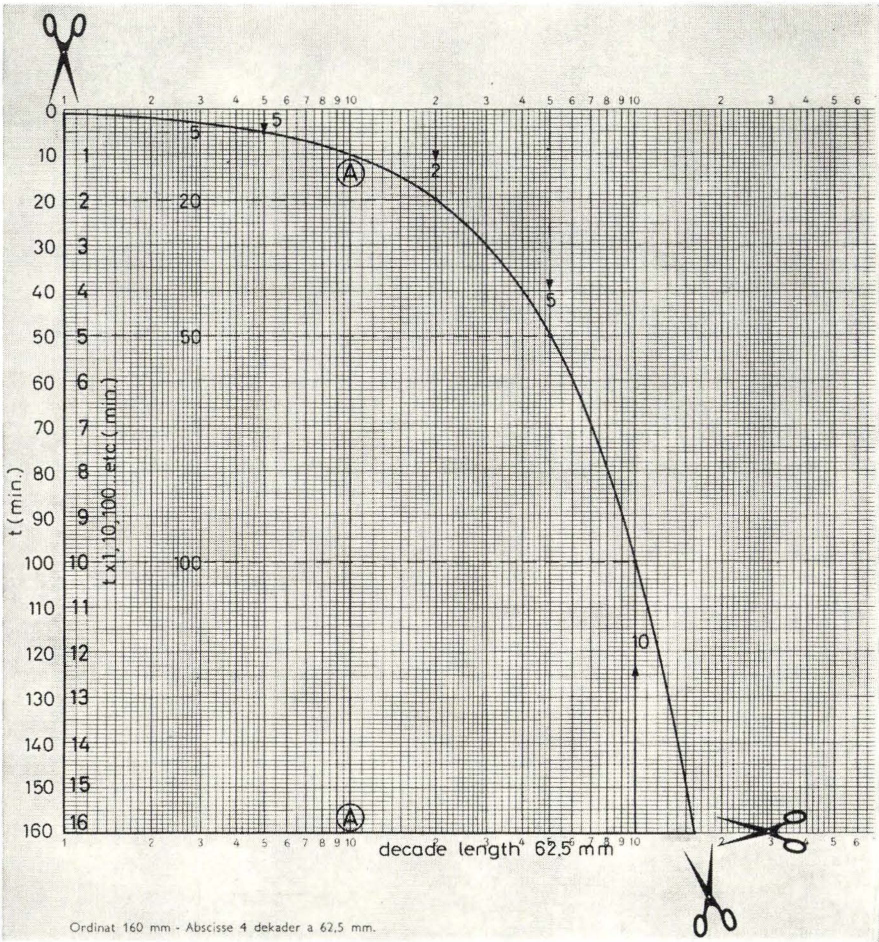

Fig. 1: Example illustrating construction of the stencil.

4. Mark intervals from 0–16 on the ordinate inside the stencil, as shown in fig. 1.
5. Cut the paper as indicated on fig. 1. It is important that the stencil is cut correctly and smoothly, and that abscissa and ordinate axis form an angle of 90 degrees. When this is done, the stencil is ready for use.

Plot of s Versus t/r^2 by using a stencil

Time-drawdown data for one observation well (table 1) are used to explain the procedure of plotting s versus t/r^2 by using the stencil.

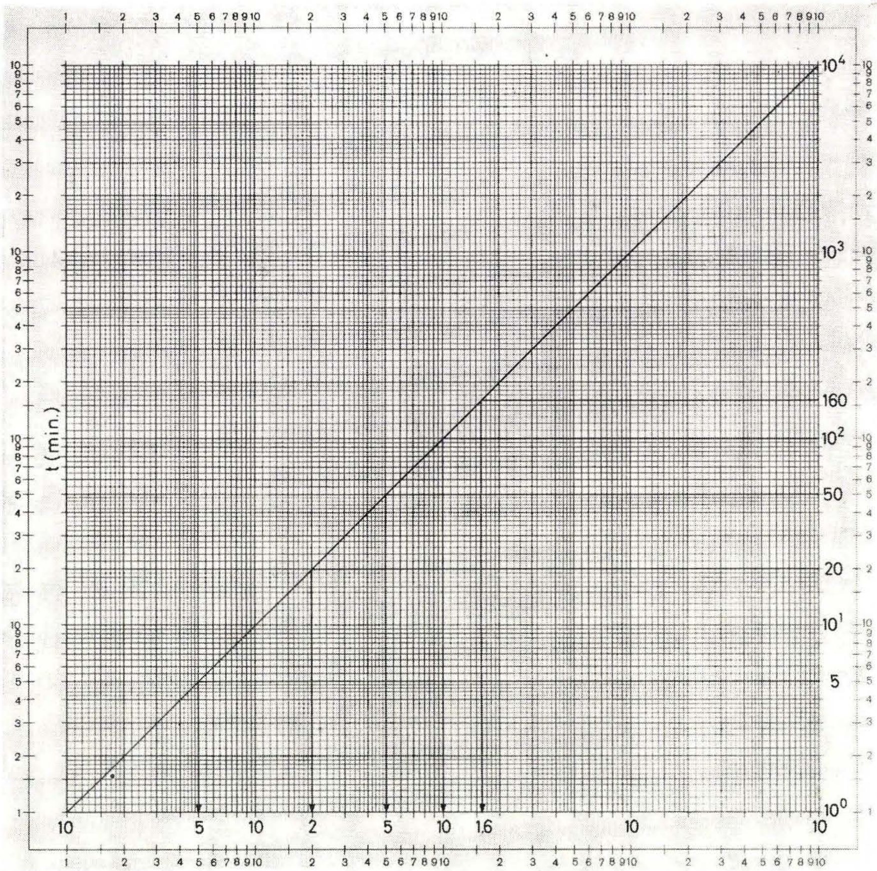

Fig. 2: Example ilustrating construction of the stencil.

1. Find t/r^2 for t = 1 min., 5,700 min., r = 121.8 (from table 1).

   1:14,835 = 6.74×10^{-5} min./m²
   5,700:14,835 = 3.84×10^{-1} min./m²

2. Indicate the interval $10^{-6} \leqslant t/r^2 \leqslant 10^0$ min./m² on the abscissa axis of the semilogarithmic data sheet (scale 62.5 mm per logarithmic decade) as shown in fig. 3.

3. Choose a convenient scale for s (m) on the ordinate axis of the semilogarithmic data sheet.

4. Place the line on the stencil marked A–A over $t/r^2 = 6.74 \times 10^{-5}$

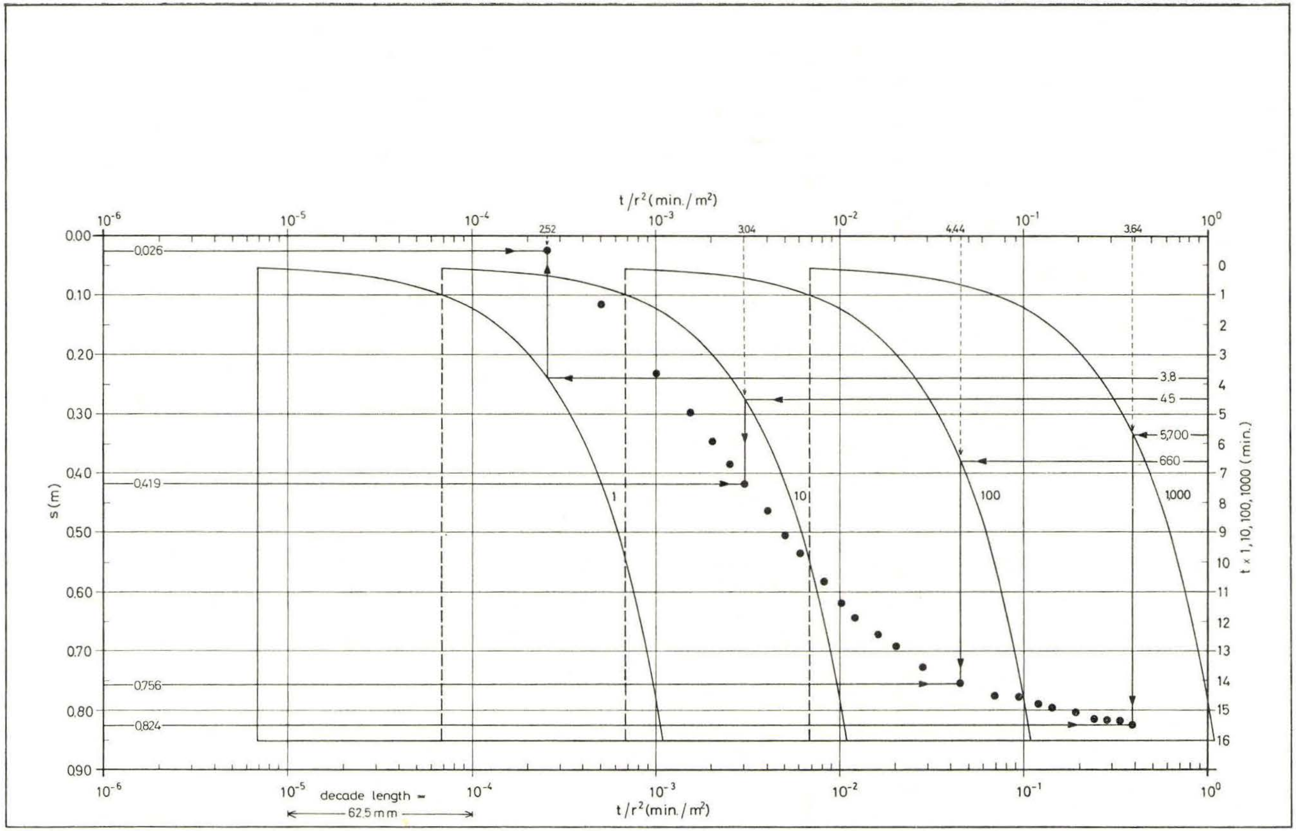

Fig. 3: Plot of s versus t/r^2 by using a simple stencil.

Time t in min.	Drawdown s in m	t/r^2 min./m^2
0	0.000	
3.8	0.026	2.52×10^{-4}
7.5	0.116	
15.0	0.232	
22.5	0.198	
30.0	0.348	
37.5	0.386	
45.0	0.419	3.04×10^{-3}
60.0	0.466	
75.0	0.507	
90.0	0.538	
120.0	0.583	
150.0	0.618	
180.0	0.643	
240.0	0.673	
300.0	0.693	
420.0	0.728	
660.0	0.756	4.44×10^{-2}
1,020.0	0.777	
1,380.0	0.780	
1,740.0	0.790	
2,100.0	0.797	
2,820.0	0.807	
3,540,0	0.814	
4,260.0	0.816	
4,980.0	0.817	
5,700.0	0.824	3.64×10^{-1}

Distance from the observation well to the pumping well $r = 121.8$ m
$r^2 = 14{,}835\ m^2$

Table 1. Time-drawdown data used for illustration of the plotting procedure, s versus t/r^2 by using a stencil.

min./m^2 on the semilogarithmic data sheet, keeping corresponding axes parallel.

5. Trace the curve with the stencil using a thin sharp pencil point, then move the line marked A-A one decade to the right, trace the next curve, and so on. The number of curves depends on the duration of the test, and in this case 4 curves (marked 1, 10, 100, 1000 multipliers of t (min.) axis) are sufficient to plot all drawdown data.

6. Mark intervals 0–16 from the stencil on the right ordinate of the semilogarithmic data sheet, taking care that zero value for each particular curve corresponds to the position of the zero on the stencil when the curve was drawn. The most practical way is to keep zero point at the same level for all curves (see fig. 3).
7. Find t (min.) for the respective drawdown s (m) on the t axis (to the right), follow the horizontal line to the intersection with the respective curve, then follow the vertical line to the intersection with the corresponding s (m) value. Intersection point represents plot of s versus t/r^2.

In fig. 3 the plotting procedure for four different sets of s–t values from table 1 is demonstrated. As shown in fig. 3, t/r^2 values found graphically correspond to calculated t/r^2 values from table 1.

If data from more observation wells are available, the curves on the semilogarithmic data sheet should be drawn in different colours. This will easily distinguish curves for different observation wells during plotting.

It is preferable to leave all the curves drawn by stencil on the semilogarithmic data sheet, so that the time for the respective point of drawdown may easily be determined directly from the plot.

For permanent use the stencil can be constructed from hard plastic folio.

Conclusion

As shown by this example, drawdown data can easily be plotted graphically versus t/r^2 on semilogarithmic paper by using a simple stencil. Besides the fact that calculations of t/r^2 values are avoided, the advantage of using the stencil is that no light-table or transparent data sheet used with a series of auxiliary curves is required, and that the time for the respective point of drawdown may easily be determined directly from the plot.

References

La Rocque, A. J. Jr., 1963. Graphic Method for Plotting Aquifer Test Data. Short Cuts and Special Problems in Aquifer Tests. Geological Survey Water Supply Paper 1545–C, pp. 4–9.

Haman, Z., 1972. Kombineret afbildning af s versus t/r^2 som hjælpemiddel ved undersøgelse af grundvandsreservoirer, metode og anvendelse. Vannet i Norden, 5. årgang nr. 4.