The impact of test site and oil content on the performance of pentachlorophenol-treated wood

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Abstract

This paper details a 5-year study on southern pine treated with pentachlorophenol in oil at various oil contents. Results from field stake tests at two Gulf Coast test sites are presented. Both biological efficacy and preservative depletion data are discussed. Results suggest that increasing oil content leads to better performance of wood treated with pentachlorophenol. Test results indicate that the test site is extremely important when evaluating systems and that sites with high calcium and alkalinity lead to greater depletion of pentachlorophenol from wood.

Pentachlorophenol (penta) has been used primarily to treat poles in the United States since the 1930s. The importance and impact of the petroleum carrier on performance has been well documented in the literature (Baechler and Roth 1962, Walters and Arsenault 1971, Arsenault 1976, Arsenault et al. 1984, Nicholas 1988, Nicholas et al. 1994). In the most recent study, Nicholas et al. (1994) showed that performance was related to the aromatic content of the carrier oil and that systems utilizing cosolvents in No. 2 fuel oil gave slightly higher depletion rates and slightly lower performance.

The use of penta has come under scrutiny in recent years, especially in coastal areas. Primarily because of some bad experiences and early failures with Cellon®-treated[1] (penta in liquefied petroleum gas) poles, several coastal utilities have removed penta from their specifications. Stake data from matched stakes in a test site on the Texas Gulf Coast are compared with those from a Florida test site in **Figure 1**. As shown, the severity of the Texas site is clear. This research was undertaken to document the performance of penta in coastal sites and to ascertain the impact of oil content on the performance of penta.

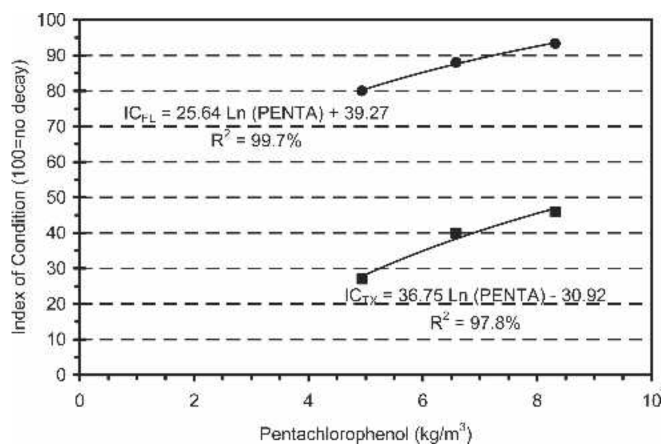

Figure 1. — Dose-response curves for matched stakes treated with penta after 5 years of exposure in Galveston (TX) and Gainesville (FL).

Methods and materials

Stake tests were conducted in accordance with AWPA Standard E-7 (2002). Penta treating solutions were prepared by dissolving a 40 percent commercial penta concentrate in an AWPA Standard P9 type A solvent. Solution strength was adjusted with toluene such that the desired penta retention and the target oil contents of 64, 96, 128, and 160 kg/m^3 were attained. Treatment was accomplished using a conventional

[1] The use of trade names is for the convenience of the readers. Such use does not constitute endorsement by Mississippi State University over similar products equally suitable.

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Table 1. — AWPA E-7 grading scale for decay (AWPA 2002).

Grade	Decay condition
100	Sound; suspicion permitted
90	Trace decay to 3% of cross section
80	Decay 3 to 10% of cross section
70	10 to 30% of cross section
60	30 to 50% of cross section
40	50 to 75% of cross section
0	Failure (>75% of cross section)

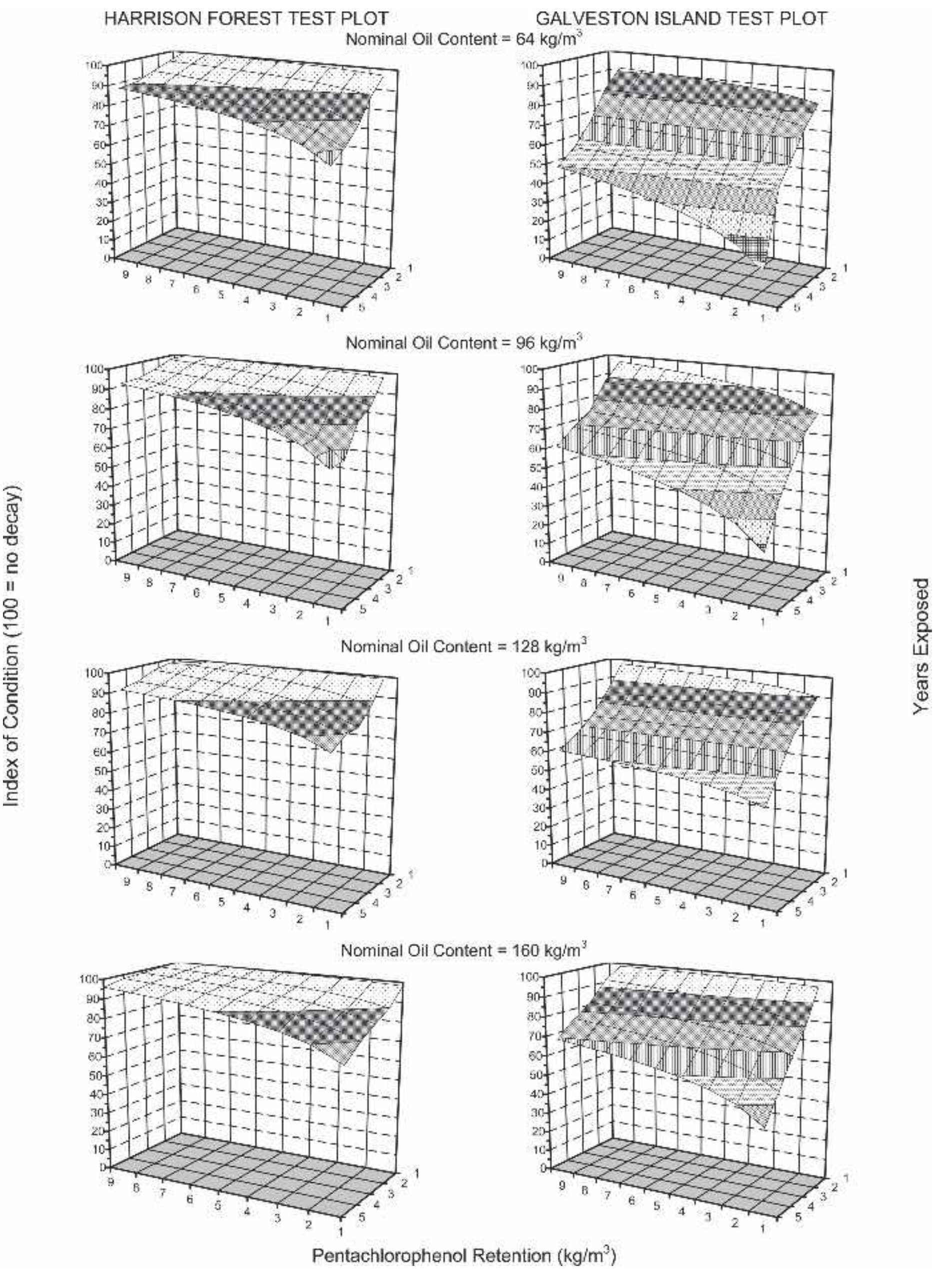

Figure 2. — Dose-response curves by year at four nominal oil contents for stakes treated with penta in AWPA P9 type A solvent and exposed at the Harrison Forest (left) and Galveston Island (right) test sites.

Bethell (full-cell) process of 30 minutes vacuum at −88kPa and 1 hour of pressure at 1035 kPa. The P9 type A solvent was a blend of No. 2 fuel oil (90%) and a still bottom ketone co-solvent (KB3, 10%). Sapwood southern pine (*Pinus* spp.) stakes measuring 1120 mm in length and 19- by 19-mm in cross section were cut into 560-mm matched halves prior to treatment. After treatment, each stake was cut to 458 mm and the remaining remnant retained for reference. One matched replicate was placed in our Harrison Forest (HF) test plot near Saucier, Mississippi, on the Gulf Coast. The other matched half was placed in the Stewart Substation test plot maintained by Houston Lighting & Power Co. (now Centerpoint Energy) on Galveston Island, Galveston, Texas. Twenty replicates per combination of oil content, retention, and test plot were treated and installed. Ten of these replicates were used as depletion analysis and 10 for performance evaluation. Decay and termite attack were evaluated annually using the American Wood Preservers' Association (AWPA) rating system shown in **Table 1**. Two stakes per combination were removed annually and assayed. Samples taken from each stake at the groundline and aboveground were sectioned into the outer 8.5 mm and remaining core and analyzed by x-ray spectroscopy using AWPA Standard A9 (AWPA 2002). Material from like zones and locations were combined for analysis. Comparison was with similar zonal analysis of the retained sample remnants just described.

Results and discussion

Efficacy tests

Decay was more severe than termite attack in both test plots so only decay data are presented in this paper. Dose-response (Index of Condition vs. Retention) curves by year at the HF and Galveston Island test plots are shown in **Figure 2** for four nominal oil contents. Yearly dose-response curves were fitted to a logarithmic function prior to graphing. The data clearly show the positive effects of increasing oil content on the efficacy of penta in oil systems.

A comparison of the effect of oil content on the performance may be seen more clearly with the 5th year data plotted in **Figure 3**. This comparison between the two test plots shows that the Galveston Island site is much more severe for decay than is the HF site. The impact of oil content is more critical for the Galveston plot than for the HF plot. At the HF plot, the improvement in performance for 5 years of exposure (**Fig. 3**) tends to be flat at penta retentions above 3 kg/m^3. For the Galveston plot, increases in performance with increasing oil content are shown across all penta retentions with the effect lessening at the higher penta retentions.

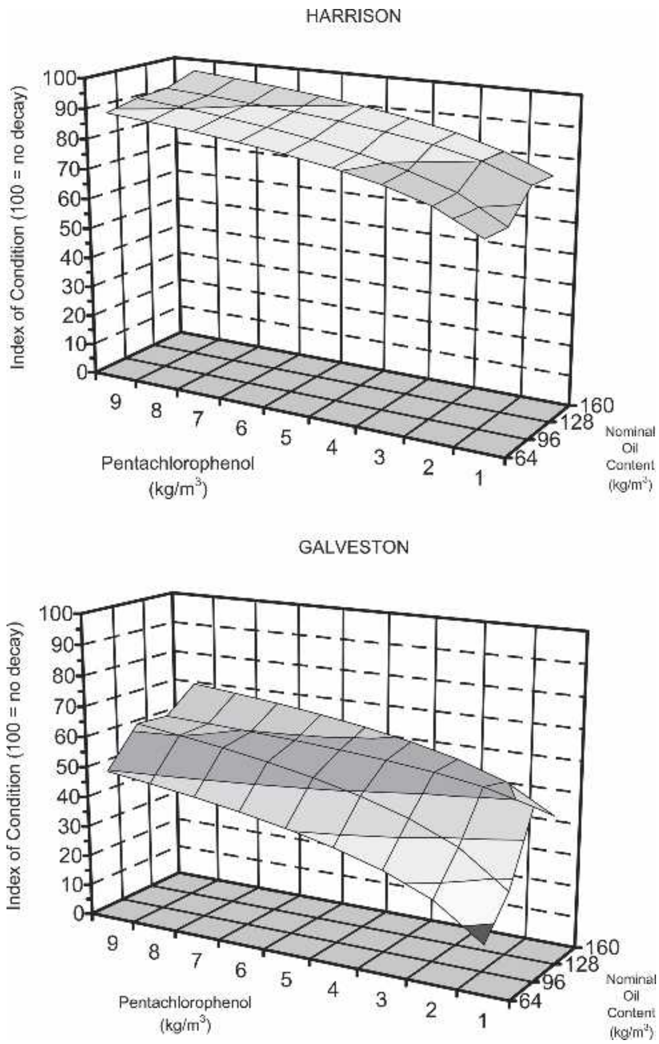

Figure 3. — Effect of oil content on the performance of penta in P9A oil after 5 years of exposure in the Harrison Forest (upper) and Galveston Island (lower) test plots.

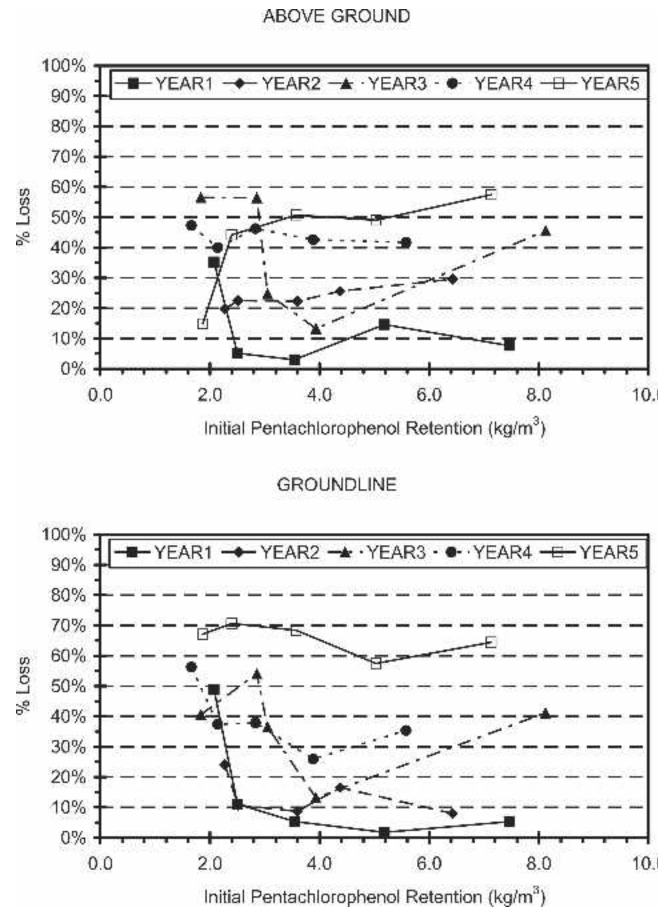

Figure 4. — An example of the data scatter by year for aboveground (upper) and groundline (lower) preservative loss vs. initial preservative retention for the 160 kg/m^3 oil content stakes in the Harrison Forest test plot.

Both coastal test sites are located in AWPA Hazard Zone 5, the most severe zone. The major differences are that the Galveston site is less that a half mile from the coast and is subject to inundation by sea water. Additionally, the Galveston site is surrounded by sea shells used in the road beds and on the site adjacent to the test plot. In contrast, the HF site is approximately 20 miles from the Gulf Coast and has a sandy loam soil not subject to salt water incursion. The alkaline soil at the Galveston site has a high calcium content. It is postulated that because of this, penta in wood will convert to salt form either as calcium or sodium pentachlorophenate. These salts are highly leachable and should result in higher depletion rates from the treated stakes, which should result in poorer performance in the Galveston plot.

Depletion tests

For ease of comparison, zonal assay data were combined to yield the weighted average preservative loss from the stake cross sections. There was no consistent trend of preservative loss vs. initial penta retention either at the groundline or aboveground for any oil content. **Figure 4** is indicative of the data scatter seen for all oil contents in both test plots. For this reason, data for all retentions for a given oil content were combined for presentation.

Aboveground exposure. — Data for loss of preservative at the groundline and aboveground are shown in **Figure 5** for the two test plots. Depletion aboveground varies only slightly with oil content in both test plots. Comparable rates are shown for both plots. This is expected since depletion aboveground reasonably can be expected to be a function of the vapor pressure of penta and the movement downward by gravity. Soil conditions would not be expected to impact the aboveground movement. Depletion rate increases gradually with exposure time. Aboveground depletion rates over time show no consistent trend with oil content, and rates tend to be equal for all oil contents, as can be seen in **Figure 6**. An almost identical trend was noted for the aboveground location in the Galveston plot, as is shown in **Figures 5** and **6**. The aboveground depletion rates for the two sites were within 3 percent of each other over the 5 years of the study.

Groundline exposure. — Different results were obtained for the groundline location. Groundline depletion tended to be more severe than aboveground loss in both plots. For the HF plot, there was little to separate the different oil contents, aside from the 160 kg/m^3 oil content. For the first 3 years, the 160 kg/m^3 oil content stakes showed a lower depletion rate than the other oil contents (**Fig. 7**) in the HF test plot. In the Galveston Island plot, the depletion rate was higher than in the HF plot and tended to reach a maximum in the 4th year of exposure (**Fig. 7**). The reason for this maximum is unclear and will

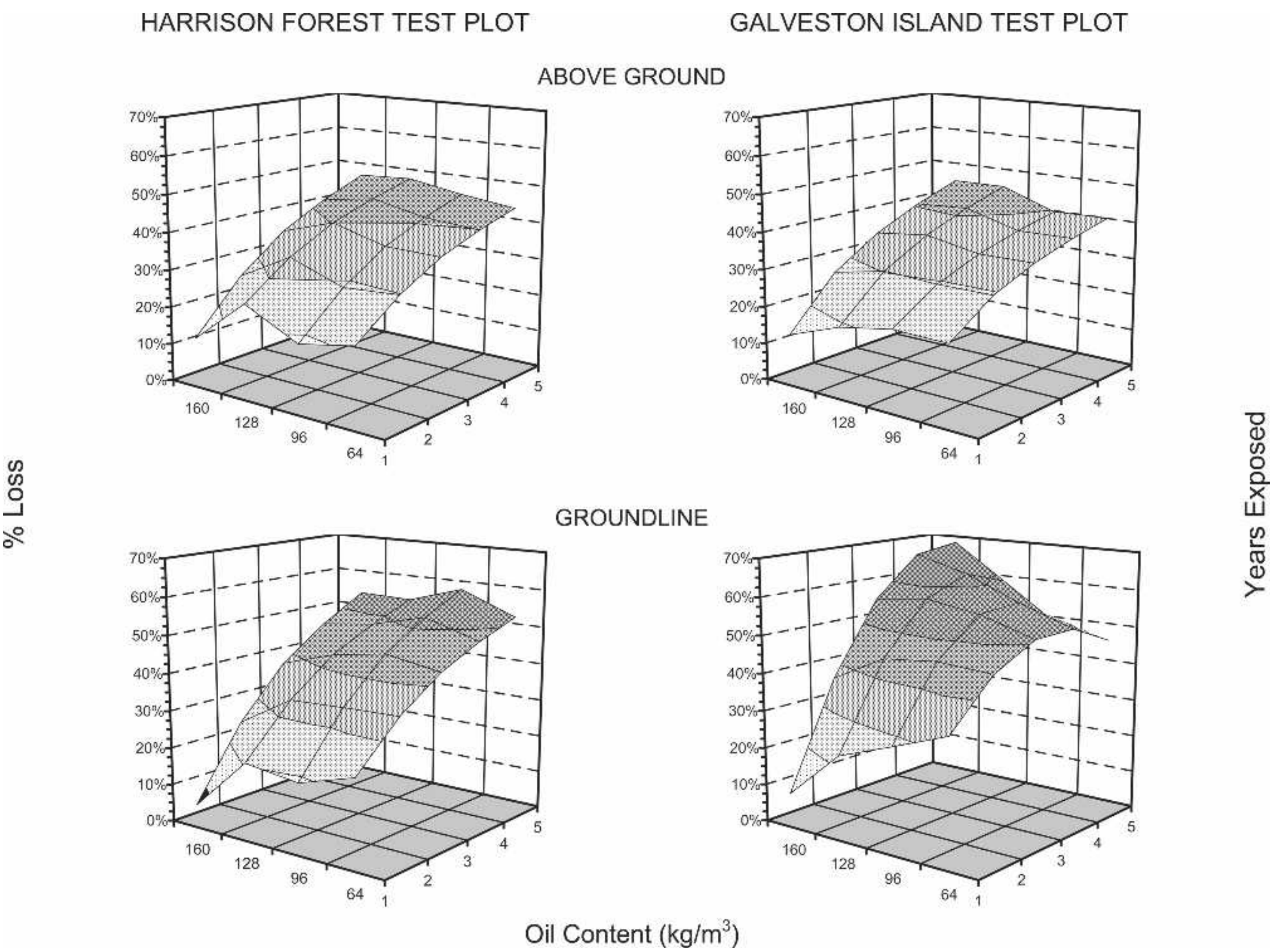

Figure 5. — Preservative depletion at the groundline and aboveground as a function of oil content and exposure period for penta-treated stakes in two Gulf Coast test sites.

require additional study. In this plot, the percent loss actually decreased with oil content for the first 2 years of exposure, leveled off in year 3, and increased with increasing oil content in years 4 and 5.

These data would indicate that oil content had, at best, a variable effect on depletion at the groundline and on average was not well correlated with preservative depletion at the Texas site. Groundline depletion rate over the 5 years of this study for the Texas site was 21 percent higher than the rate found with stakes in the HF plot. These data would lend credence to the hypothesis that exposure in the Texas site led to higher depletion rates and hence poor performance.

Summary and conclusions

These data suggest that increasing oil content has a positive effect on the biological efficacy of wood treated with penta, but other factors such as soil chemistry may have more impact on performance. Alkaline conditions, higher calcium contents, and seawater inundation found in a Texas coastal site led to higher depletion rates and hence poorer performance than in an inland coastal Mississippi site of similar hazard zone.

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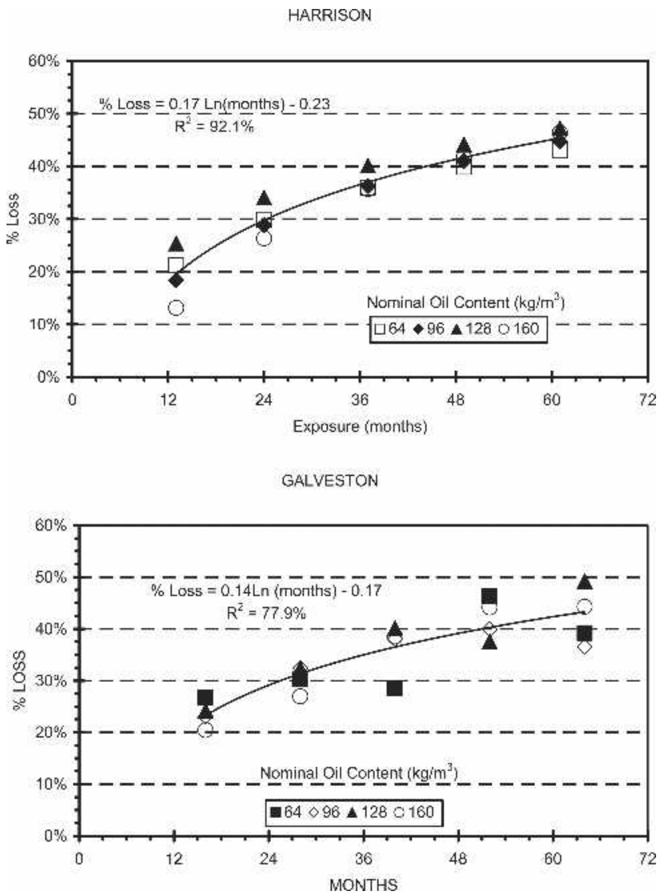

Figure 6. — Depletion rates by oil content for the aboveground zone in two test plots.

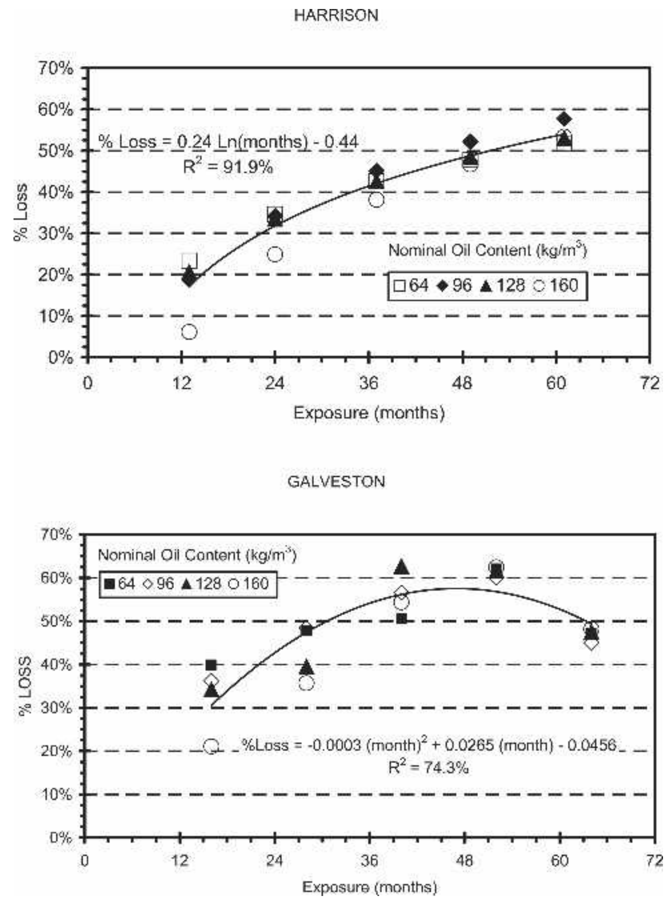

Figure 7. — Depletion rates by oil content for the groundline zone in two test plots.