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TIDAL EFFECTS IN WEST KINGFISH
PULSE TESTS, DECEMBER 1987

BY

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CONTENTS

FIGURES

TABLE

SUMMARY

On 12 and 13 December 1987 two pulse tests were carried out on the West Kingfish platform, Gippsland Basin, between the West Kingfish wells W-1 and W-6, and W-1 and W-19. The results of these tests indicate a tidal effect is present, masking the response signal. This effect corresponds to the tides at Eden, with a tidal efficiency of 0.19 psi/m tide height and a time lag of 1 hour.

When the tidal effect is subtracted, a positive first response to the pulse test between wells W-1 and W-6 can be detected, possibly indicating communication between the wells and giving results consistent with the formation properties. No communication is detected between wells W-1 and W-19.

INTRODUCTION

Pulse testing is a method for determining reservoir properties between two wells by measuring very small pressure responses due to a series of flow disturbances. In ideal cases the response amplitude and the time lag of the response can be useful to determine quantitative values of transmissibility (kh/μ) and storage (ϕch). In addition, even when the conditions are not ideal, qualitative information about flow anomalies, fractures, and between-zone communication can be obtained.

Two pulse tests were carried out on West Kingfish platform in December 1987 between the wells W-1 and W-6, and the wells W-1 and W-19. The location of these wells is shown in Figure 1. The purpose of the pulse tests was to determine whether measurable communication existed between the wells being tested. The tests were carried out using a HP quartz crystal gauge, so that responses as small as 0.01 psi could be detected.

PULSE TESTING METHOD

The tests were carried out in the following manner. A bottom-hole pressure gauge was installed in the shut-in well W-1 and pressure recording commenced at 1 pm on December 12. Well W-6 was shut-in at 2 pm, and flowed again at 7.30 pm giving a first pulse duration of 5 1/2 hours. It was shut-in again at 1 am on December 13, and flowed at 6.30 am, giving a second pulse duration of 5 1/2 hours. This completed the pulse test between W-6 and W-1 - two shut in periods of 5 1/2 hours separated by a flow period of 5 1/2 hours.

Well W-19 was then shut-in at 9 am on December 13, and flowed again at 6 pm, giving a 9 hour pulse. The well was shut-in finally at 3 am on December 14, and pressures were recorded for 5 1/2 hours after this. The W-19 pulse test thus consisted of one shut-in period of 9 hours followed by one flow period of nine hours.

Figure 2 shows the periods during which the various wells were flowing and shut-in, and the pressure response in the bottom-hole quartz crystal pressure gauge in well W-1. The data is discussed in the following section.

BASIC DATA

The uncorrected data plotted at approximately 15 minute intervals (Figure 2) show two outstanding features. These are

(i) the pressure peak at approximately 15 hours

(ii) the cyclical nature of the pressure response between 20 hours and the last pressure reading at 57.7 hours.

At first sight, the response in the later time periods appeared to correspond to typical tidal rise and fall curves. The data from 33 hours (9 am on 13 December) were shifted forward and superimposed on the earlier time data until a good match was achieved over most of the period. At the point of match the later data had been shifted 24.53 hours suggesting a tidal cycle of this duration. This is seen in Figure 3. The later data seems to show purely tidal effects. When the (shifted) later data are subtracted from the earlier data, the net response should show little or no tidal effect. This was done and is shown in Figure 4 (on the same scale as Figure 3) and in Figure 5(on an expanded scale). A strong positive response of about 0.15 psi is evident at 15 hours. A possible negative response is also evident at 20 hours.

TIDAL EFFECTS

The next step was to investigate the apparent tidal effects further, to see if they were consistent with expected tidal effects in the Gippsland basin. Clearly, the tidal effect will be the result of earth, ocean and atmospheric tides. The Gippsland aquifer, which underlies all the oil and gas reservoirs, is open in the Gippsland hills to water intake, and is believed to be open to the ocean on the continental slope. It may therefore be over-simplifying to interpret the expected tidal response only in terms of ocean tides at the location of West Kingfish.

The Australian National Tide Tables for 1987 (Department of Defence, 1986) have two "standard ports" near the Gippsland Basin - Eden and Westernport. Table 1 shows the tidal maxima and minima for the period in question at these ports. Note that the average tidal period is about 24.7 hours, not far from the figure of 24.5 hours derived only from "shifting" the pressure data to obtain a good fit. The best fit to the observed pressure data is given by the tides at Eden to the east. Interpolation between high and low tides was carried out using the graphical method described in the Tide Tables.

The resulting tide heights delayed by one hour are shown with pressure data on Figure 6. The fit with the observed pressure data is very good. The multiplying factor to achieve this good fit is 0.188 psi/m. A corresponding value of the multiplying factor for Jabiru 1A was 0.28 psi/m which is higher but of the same order of magnitude.

The result of subtracting the predicted tide pressure effect (lagged by one hour) from the basic pressure response in shown in Figure 7.

This is similar to Figure 4 and shows the unusual peak at an early time, possibly resulting from the shut-in of well W-1.

ANALYSIS OF PULSE RESPONSE

The data shown in Figure 5 can be analysed by the "tangent" method. The lines shown on Figure 5 represent approximate tangents to the pressure traces, drawn parallel to each other and touching the pressure traces at three points.

The pressure difference indicated by Δpa on the figure indicates the positive pressure response to be analysed. The time lag is the time between shutting the well in at 2 pm on December 12, time = 14 hours and the time at which this peak response occurred.

The minimum indicated by Δpb indicates a possible negative pressure response, resulting from flowing the well at 7.30 pm on December 12 (time = 19.5 hours).

First Positive Response

The well A-6 was shut in at 2pm on December 12. The maximum positive response occurs at approximately 3.15 pm, 1.25 hours later (tL_1). The producing time of the well was 5.5 hours (Δt). The time between pulses is also 5.5 hours (Δtb). The following analysis is then possible using the standard response charts.

$$R = \frac{\Delta tb}{\Delta t} = 1.0$$

$$\frac{tL1}{\Delta t} = \frac{1.25}{5.5} = 0.227$$

From charts , $\frac{kh}{\mu} \frac{\Delta p}{q} = 22$

Δp = 0.15 psi
q = 3785 stb/d
B = 1.2 res bbl/stb q = 4542 res bbl/d
μ = 0.5 cp
kh = 333 080
Assume h = 60 ft
k = 5.6 darcies

From charts , $\frac{\phi c h r^2 \Delta p}{\Delta t q} = 2.4 \times 10^{-4}$

$c = 13 \times 10^{-6}$ vol/vol/psi

$r = 3493$ ft

$\Delta t = 5.5$ hrs $= 330$ minutes

$\phi = \underline{25.2\%}$

First Inverse Response

Well A-6 was flowed at 7.30 pm on December 12. The (possible) maximum negative response occurs at approximately 7.50pm, 0.33 hours later (tL_2). Then, as before

$R = 1.0$

$$\frac{tL_2}{\Delta t} = \frac{0.33}{5.5} = 0.061$$

From charts ' $\frac{kh}{\mu}\frac{\Delta p}{q} = 64$

then $k = \frac{64}{22} \times 5.6$

$= 16.3$ darcies

From Figure $\frac{\phi c h r^2 \Delta p}{\Delta t q} = 0.24 \times 10^{-4}$

then $\phi = \frac{0.24 \times 25.2\%}{2.4}$

$= \underline{2.52\%}$

The apparent inverse pulse is therefore not consistent with likely formation properties.

DISCUSSION OF RESULTS

The first positive response between W-1 and W-6 is consistent with the known typical properties of the sands in the West Kingfish field (porosities typically 20%, permeabilities typically 2-5 darcies). The response is therefore of the right size, and occurs at the right time, to be consistent with the known bulk formation properties.

The first inverse response is much less evident. The choice of the "tangent point" is not obvious and the interpretation is subject to doubt.

Ideally in pulse tests a clear first response, first inverse response, second response etc should be observed. As a result, we cannot conclusively interpret communication between wells W-1 and W-6. However, it is clear that a significant non-tidal pressure response has been caused at W-1 close to the time of shutting-in well W-6.

The test would have been improved if more time had been left between commencing pressure recording and shut-in of well W-6, to observe the tidal effects.

The results show no evidence of communication between W-1 and W-19. Ideally the test should have been continued for a little longer so that the effects of two complete pulse shut-in periods could have been observed.

CONCLUSIONS

1. A strong cyclical pressure effect, correlated to the tides at Eden, NSW, is observed in the pulse testing of West Kingfish.

2. The effect is lagged by one hour from the expected tidal variation at Eden, and has a tidal efficiency of 0.19 psi/m.

3. When the tidal effect is removed, a significant residual pressure peak was observed at well W-6 shortly after shut-in of the West Kingfish well W-1.

4. The cause of this peak is not known. However, it is clear that it is non-tidal, and is consistent with transmission of a pulse from well W-1, indicating possible communication.

REFERENCES

1. DEPARTMENT OF DEFENCE (NAVY OFFICE), 1986 - Australian National Tide Tables 1987, Australian Government Publishing Service, Canberra

2. HEMALA, M., 1985 - Tidal Effects in Jabiru Pressure Testing (unpublished talk to SPE, Melbourne)

ACKNOWLEDGEMENTS

The assistance of Mr G. Morrison in preparing Figures 1-4 is appreciated. Figure 1 was prepared by the BMR Drafting Office.

TABLE 1

Tidal Maxima and Minima

Date	WESTERNPORT Standard Time	WESTERNPORT Height (m)	EDEN Standard Time	EDEN Height
12/12/87	0578	2.7	0116	1.0
	1106	0.9	0613	0.7
	1658	2.4	1238	1.3
	2246	0.7	1949	0.3
13/12/87	0542	2.7	0210	1.0
	1134	0.9	0723	0.7
	1735	2.4	1331	1.3
	2319	0.8	2031	0.4

NOTE: Pressure data are shown plotted against summer time (not standard time)

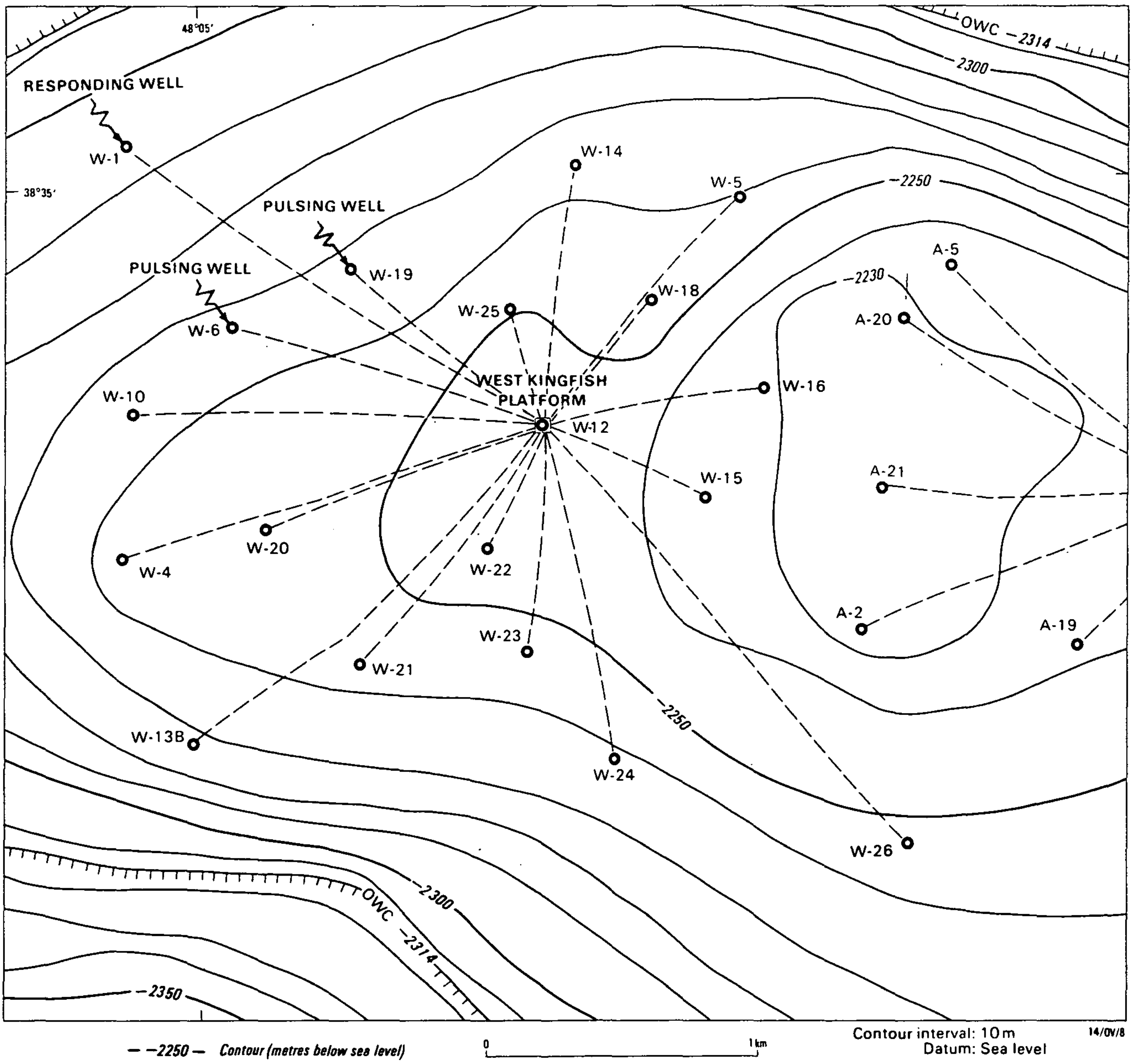
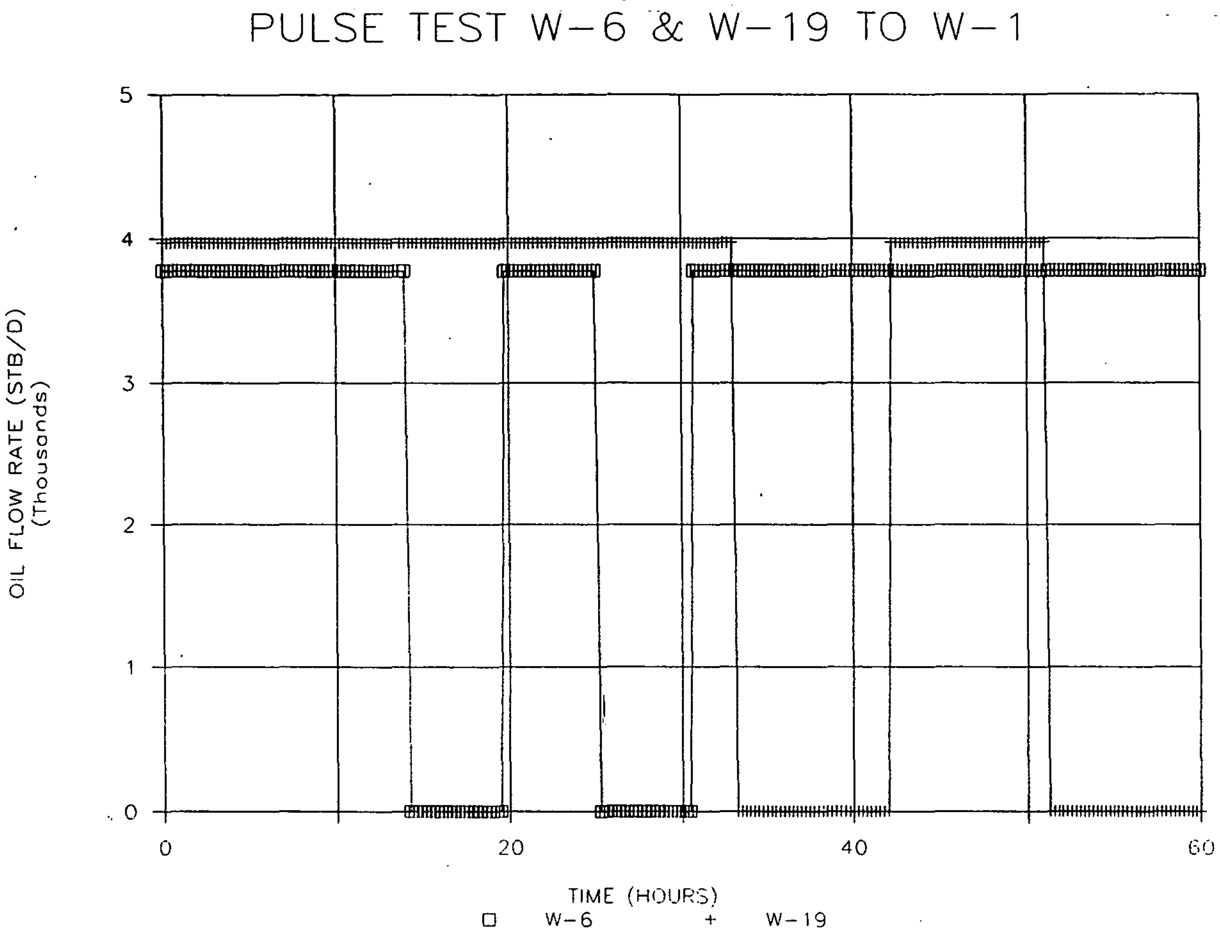


Fig 1 West Kingfish development well locations



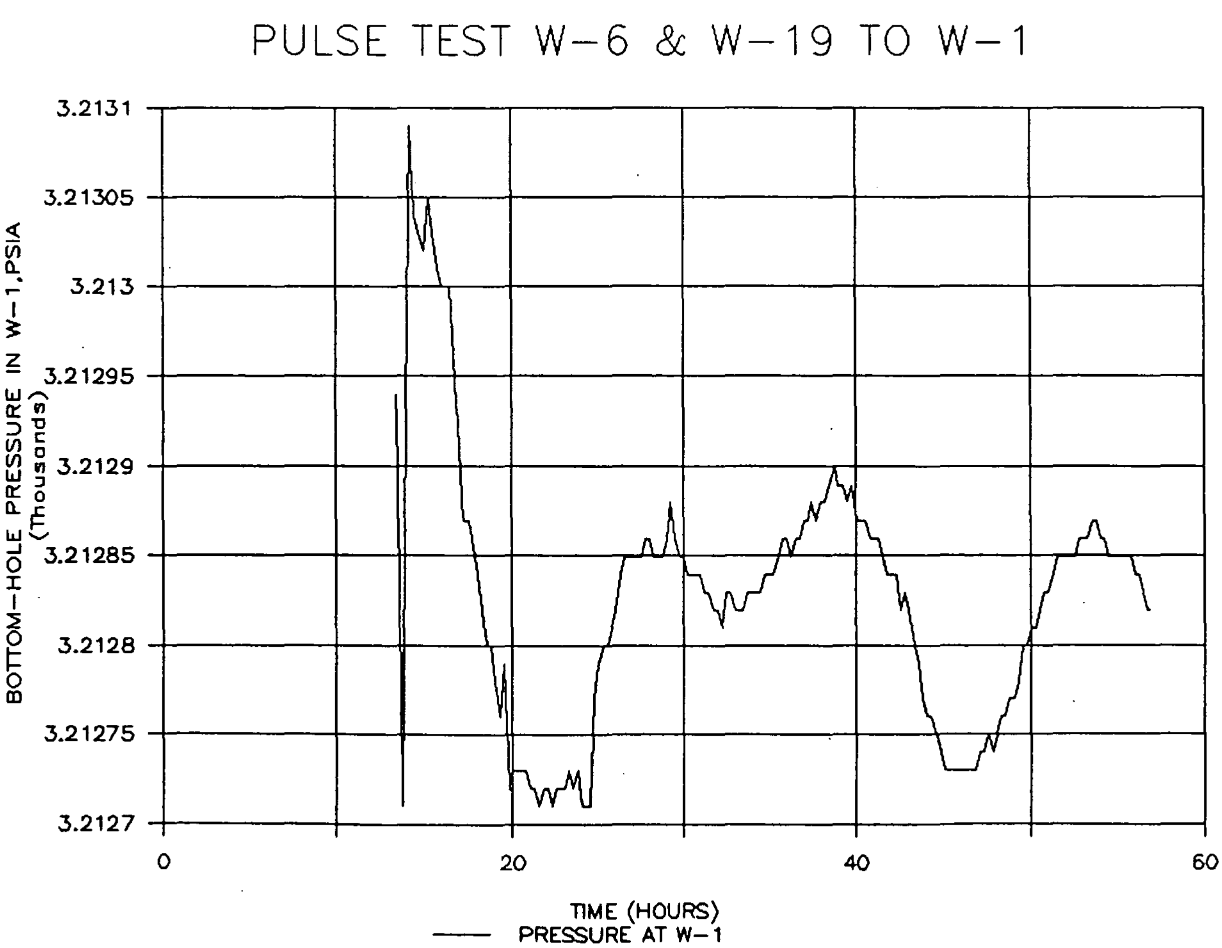


Figure 2 Well flowrates and pressure response

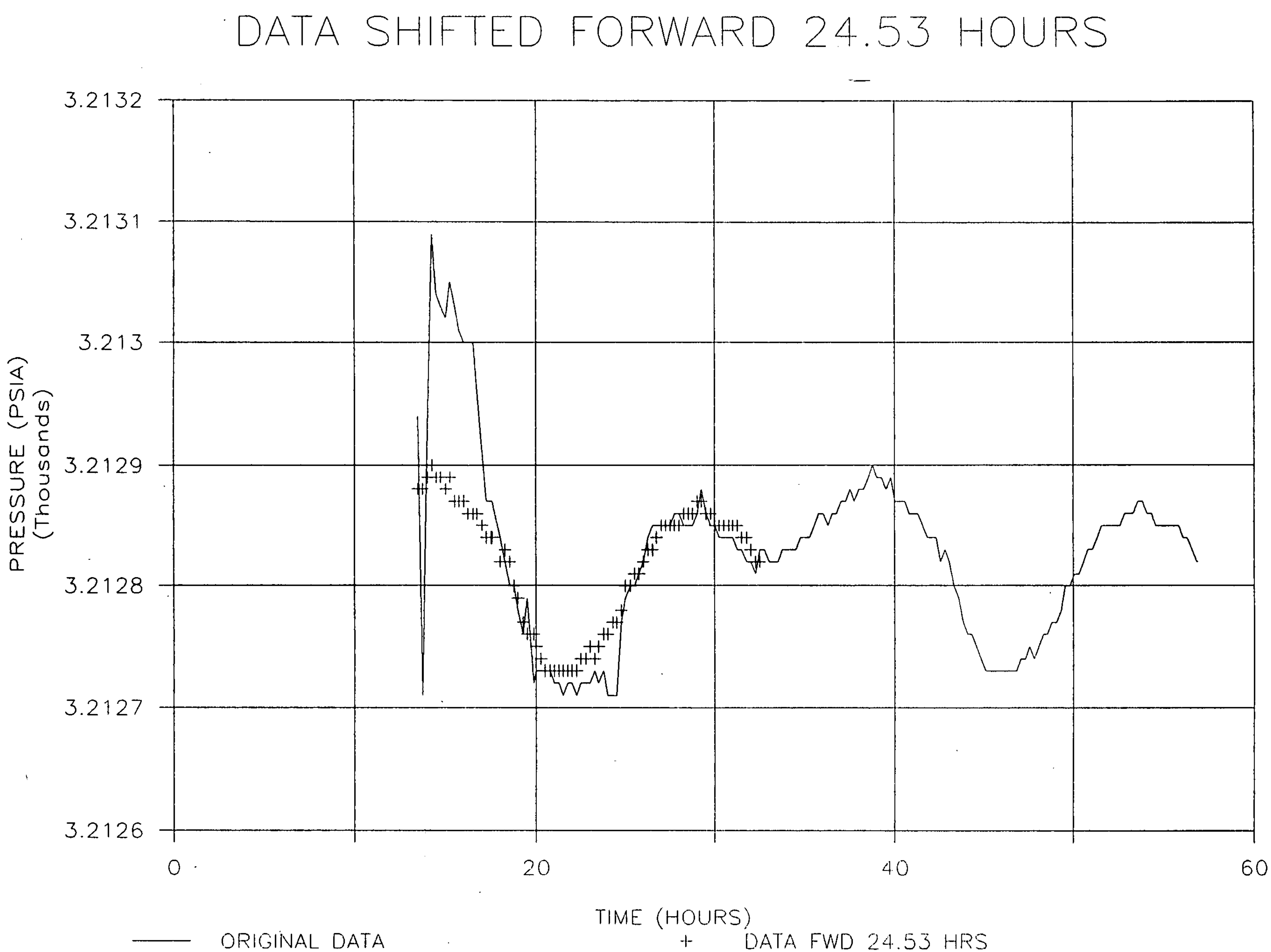


Figure 3 Pressure response with data from 33 hours shifted forward 24.53 hours

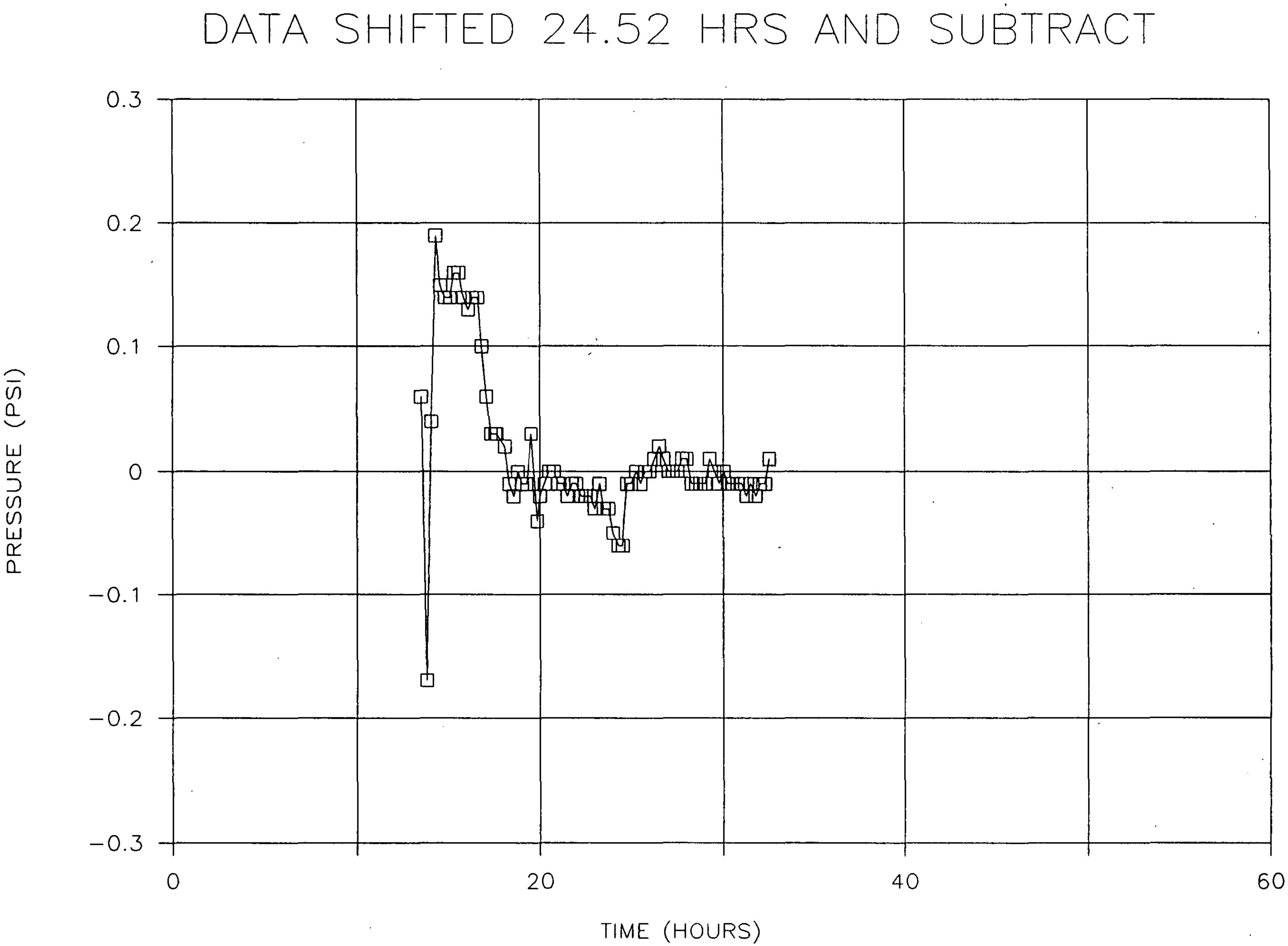


Figure 4 Pressure response without periodic effect

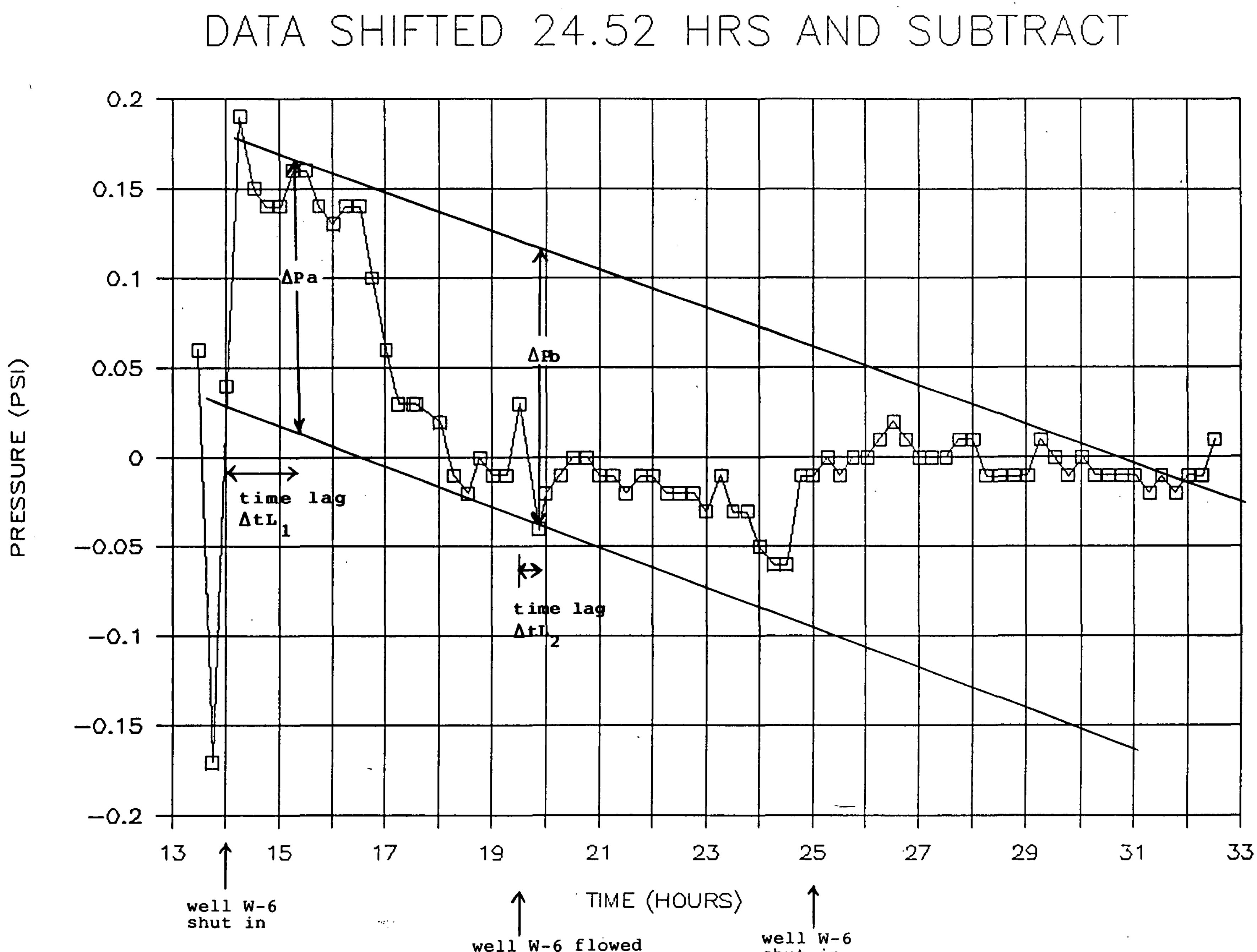


Figure 5 Pulse test analysis

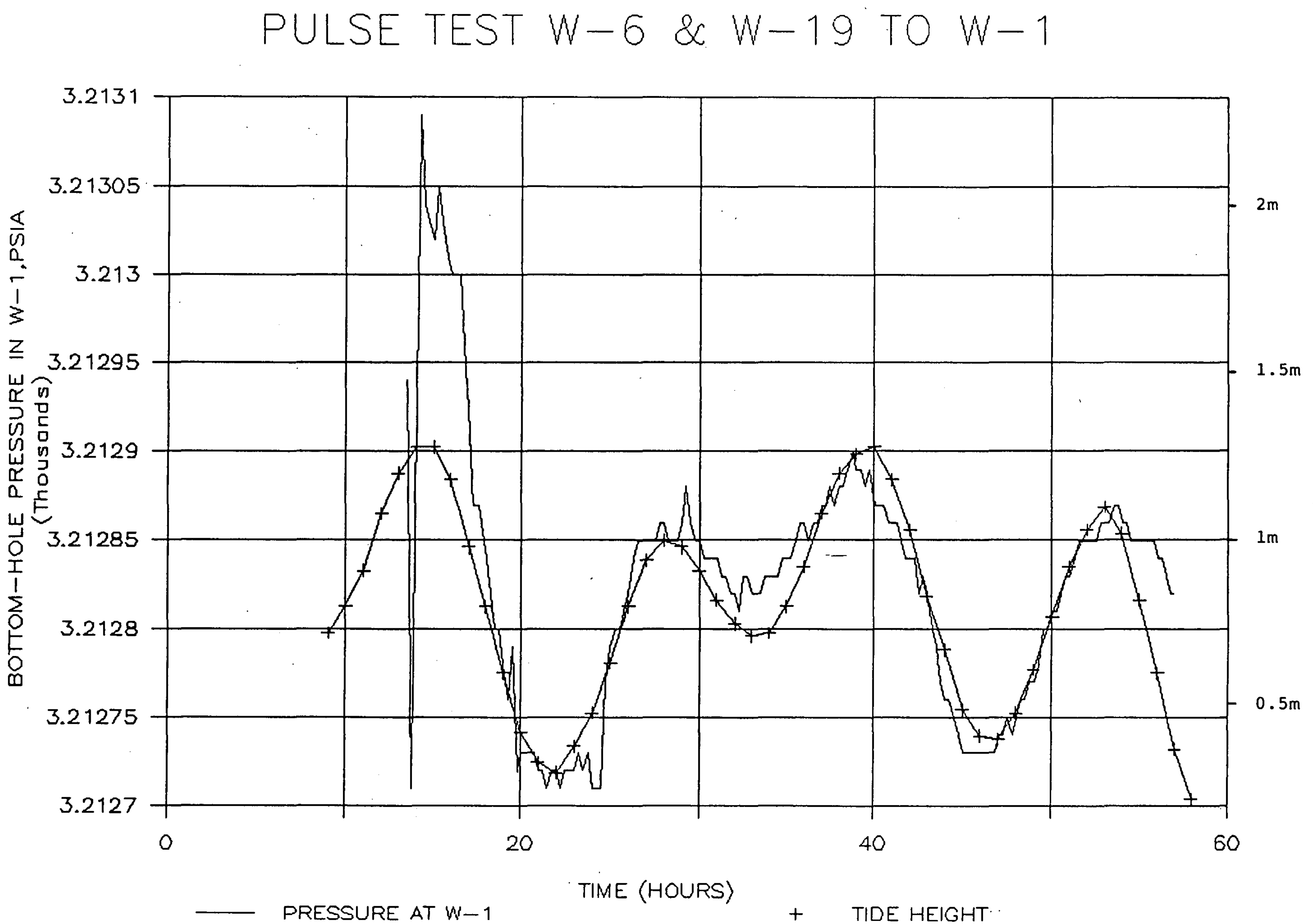


Figure 6 Pressure response and tidal effect

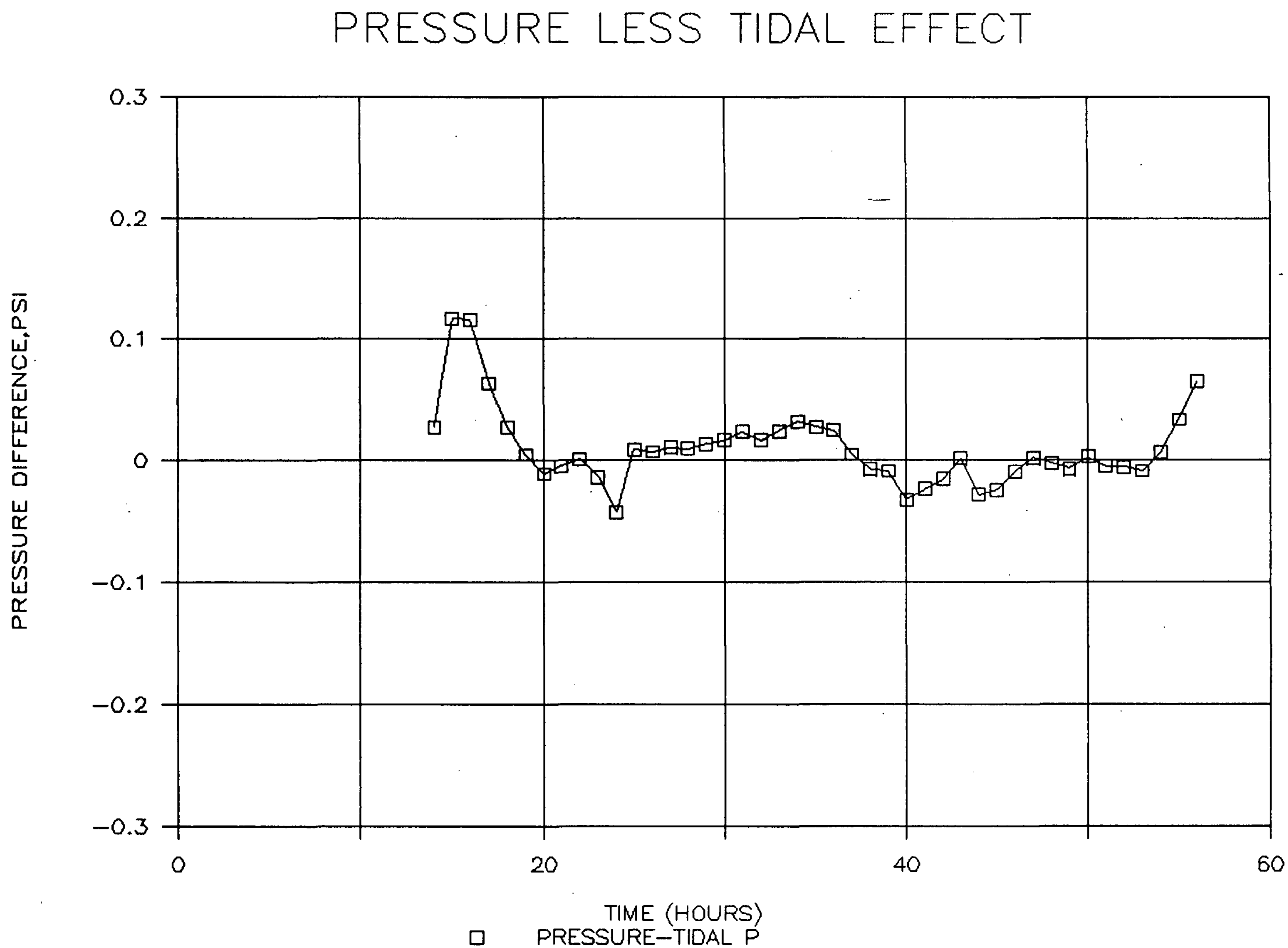


Figure 7 Pressure response without tidal effect