CONTROL ROD INSERTION PROBLEM

REACTOR ENGINEERING-WPO

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1.0 SUMMARY AND CONCLUSIONS

The 53 control rods positioned in the Indian Point 3 (IP-3) core are fully operable based on drop times measured prior to mid-cycle startup in June 1995. The plant has operated approximately 60 effective full power days (EFPD) since these drop times were measured. The drop times measured were all between 1.23 and 1.37 seconds considerably below the tech spec maximum of 1.8 seconds. At restart, there was no increase in drop times for control rods in assemblies with burnup as high as 37.2 Gigawatt Days/Metric Ton Uranium (GWD/MTU) compared to the measurements made at the start of Cycle 9. The Cycle 8 rod drop times varied from 1.15 to 1.36 seconds with burnup as high as 31.8 GWD/MTU. Based on the data, we are confident that the control rods in IP-3 are operable.

We will continue to follow the investigations underway to determine the root cause of the rod insertion problems experienced at Wolf Creek and South Texas. IP-3 operators have been briefed on the incident and will be trained on what actions are necessary in the case of a rod insertion problem. New York Power Authority (NYPA) staff has been closely following investigations to determine why control rods did not properly insert in two Westinghouse plants with 17x17 fuel rod arrays. Our investigation has included participation in Westinghouse Owners Group (WOG), Westinghouse Fuel Users Group, and direct contact with Westinghouse and other utilities' staff. Based on industry-wide experience, the 15x15 fuel rod array used in IP-3 is less likely to encounter control rod insertion problems than 17x17 fuel.

2.0 INTRODUCTION

The failure of 5 control rods to insert at Wolf Creek and 3 control rods to insert at South Texas Unit 1 is being investigated by Westinghouse. We have been following this investigation closely and are aware of the higher than expected assembly elongations measured at Wolf Creek. Based on evaluations, we have concluded that the control rods in IP-3 are fully operable and are less likely to experience rod insertion difficulties. There is no reason to suspect that they will not fully insert on demand if so required.

Our long-term evaluations include a comprehensive review of the root cause investigations underway at Westinghouse. We will continue to cooperate with the various industry groups

while conducting our own independent review. Our review will encompass the post irradiation evaluations (PIE) investigation being planned at various Westinghouse plants.

3.0 DISCUSSION

3.1 Fuel Assembly Design and Materials

All control rodded assemblies are of the Vantage 5H design manufactured by Westinghouse. The characteristics of these assemblies are given in Table 1. A comparison of many of the design characteristics of Vantage 5H fuel in IP-3 with the design characteristics in the two plants that had rod insertion problems is presented in Table 2. A review of these designs is underway to better understand the reasons for the rod insertion problems sustained at the two 17x17 plants. Lessons learned will be incorporated in selecting future IP-3 assembly designs.

3.2 Control Rod Operation During Cycle 9

Prior to the restart of Cycle 9, (in June 1995) after the long shut down, the drop times for all 53 control rods in IP-3 were measured in the fuel assemblies where they are presently positioned. The drop times measured from 1.23 to 1.37 seconds (well below the requirement of $\leq$ 1.80 seconds) were independent of the assembly burnup ranging from 19.1 to 37.2 GWD/MTU as shown on Tables 6 and 7. Forty-four control rods are positioned above Vantage 5H Reload 7 fuel assemblies with 9 above Reload 6 fuel assemblies.

At the beginning of Cycle 9 (BOC) control rod drop times were measured and found to be acceptable ranging from 1.21 to 1.29 with no dependency on burnup between 12.8 and 31.1 GWD/MTU. A comparison among the values at the beginning of Cycle 8 (BOC), the values at BOC 9, and the mid-cycle data shows no significant increase in rod drop times.

Our review of the control rod drop times measured for Cycle 8 also showed values ranging between 1.15 and 1.36 seconds well below the maximum 1.8 second time allowed. During Cycle 8, the control rods were positioned above assemblies from Reloads 4, 5 and 6 with burnups ranging from 10.8 to 32.8 GWD/MTU at the time of the test. Once again, there was no effect of burnup with an average drop time of 1.25 seconds for the assemblies above 30 GWD/MTU and essentially the same 1.25 seconds for assemblies between 10.8 and 17.6 GWD/MTU.

Since the completion of the drop test at the restart of Cycle 9 in 1995, our fuel assemblies have sustained an increase of ~60 EFPD (~2 GWD/MTU) and all rodded assemblies are currently below 40 GWD/MTU. There is no reason to believe the IP-3 Vantage 5H assemblies could have sustained any significant mechanical distortion during this short exposure time. This has been discussed with and agreed to verbally by Westinghouse staff and is in agreement with the Westinghouse Owners Group letter OG-96-029, dated March 28, 1996, where intervals of less than 2.5 GWD/MTU are excluded.

3.3 Previous Control Rod History at High Burnup

As summarized on Table 3 during Cycles 6 and 7, there were reactor trips with control rods positioned over assemblies with burnups over 40 GWD/MTU. In these cases, control rods fully inserted without any anomalies.

Table 4 gives the number of assemblies above 40 GWD/MTU at EOC for Cycles 6, 7 and 8 and the projected Cycle 9 data showing that IP-3 had many control rods over high burnup assemblies. Drop times were not measured after the end of Cycle 8, but will be measured at the end of Cycle 9 when there will be 21 control rods over high burnup assemblies. It is also our intention to measure drop times, if there is an outage of sufficient duration before the EOC 9.

3.4 Projection to EOC 9

A core map showing the burnup of each rodded fuel assembly at current conditions and the projected burnup at the EOC 9 is enclosed as Table 6. Twenty-one of the 53 rodded assemblies will have burnups greater that 40 GWD/MTU (the burnup at which rod insertion problems were experienced in the two 17x17 plants). The 9 control rods in the center of the core are projected to reach burnups from 45.4 to 50.2 GWD/MTU.

Based on the drop tests performed at the beginning of Cycle 9 and again after the June startup, including the preliminary evaluations of the root cause for the insertion problems, as well as an I&C review of prior control rod surveillance tests (3.6.2), the operability of Indian Point 3 control rods is confirmed..

There are a number of reasons to project acceptable performance out to EOC Cycle 9 burnup.

- There have been no reported problems for control rod insertion in 15x15 Westinghouse fuel assemblies in the industry.

- Generally, 15x15 fuel assemblies are more robust than 17x17 as they have larger diameter guide tubes (see Table 2). Overall, they tend to sustain less assembly bow both as fabricated and as a function of burnup.

3.5 Plans to Resolve this Issue

We have discussed possible mechanisms for the rod insertion problem with Westinghouse staff and are in correspondence with them to perform a design review. Discussions have been held with key Westinghouse staff working on the root cause. We have reviewed documents from Westinghouse which summarize the inspections at Wolf Creek and their preliminary conclusions concerning the root cause.

A thorough design review will be completed before the mechanical design of Reload 9 is fixed. As presently planned, this will be our first assembly with ZIRLO guide tubes and grids. Since ZIRLO has lower irradiation growth than Zr-4, axial elongation of the assembly should be lower with an associated lower risk of rod insertion problems.

At the EOC 9, we plan to measure drops times for all RCCAs. If there is an unplanned outage, we will consider measuring drop times depending on the length of the outage, the burnup at the time of the outage, and what has been determined from the Westinghouse root cause investigation.

3.6 Additional Information

3.6.1 Control Rod R89 Removal Incident

During the insert change-out sequence at the EOC 8, RCCA 89, an original equipment control rod, required a larger than normal force to withdraw it from its associated high burnup fuel assembly U64 (burnup ~46 GWD/MTU). This RCCA was inserted with no difficulty at the EOC 8. Since this fuel assembly was scheduled for removal at the EOC 8, the fuel assembly and R89 were placed in the spent fuel pool for off critical path examination. A new RCCA, R830 was installed in the core instead.

A series of operations, outlined in Table 5, were then performed to help determine the cause of the difficulty in removing R89. The portable RCCA change tool was employed, which enabled operators to clear the overload trip as required before removing the RCCA. As shown in Table 5, binding occurred up to ~ 24 inches from the bottom during

the second removal. R89 was subsequently inserted with no difficulty in a dummy fuel assembly with the same dimensions as a new fuel assembly. R89 was also placed in a spent fuel assembly in the pool with no difficulty.

A visual examination of RCCA R89 and the U64 fuel assembly did not reveal any mechanical damage. No measurements were taken of either the RCCA R89 or the U64 fuel assembly. No further work was performed on this RCCA assembly at that time although we plan on conducting further evaluations after the EOC 9 refueling outage.

From these operations and inspections, we concluded that the mechanical condition of RCCA R89 was not the probable cause of the binding. Rather we suspect that the cause of the binding was in the discharged assembly U64. There are a number of possible reasons for the binding including unusual fuel assembly bowing, unusual guide tube mechanical distortion independent of bowing, some type of mechanical or materials defect in the guide tubes, and/or some type of debris in one or more guide tubes.

3.6.2 Indian Point 3 Shutdown Margin

Technical Specifications requirement for Indian Point 3 is 1.3% $\Delta\rho$. The actual shutdown margin for Cycle 9 is 3.2% $\Delta\rho$. This is the largest excess reactivity between the actual and the required shutdown margins that were calculated by Westinghouse for eighteen or the cores of which they are cognizant. The 3.2% has already assumed the highest worth rod is stuck out and we are at the insertion limits at time of trip. An additional 10% is removed. None of these conservatisms is expected at time of trip.

3.6.3 I&C Engineering Review

I&C Engineering has also reviewed Bulletin 96-01 and has determined that no concern exists at the present time to prevent start-up from the current F95A outage. This statement is based on the following information:

3.6.3a Rod drop time testing was last performed on 6/21/95 in accordance with I&C surveillance test procedure 3PT-R004. I&C Engineering has reviewed the data obtained from this procedure and has determined that all of the 53 control rods met their respective operability criteria with respect to "drop times." In addition, each of the control rods exhibited "recoil" which the NRC defines in the technical bulletin as the dampening

effect that is normally seen in the drop time visicorder traces as a result of contact of the control rod assembly spider hub spring against the fuel assembly. A "recoil" trace was copied from one of the drop time traces recorded in surveillance procedure 3PT-R004 performed on 6/21/95 and is included as Attachment 1. All of the drop time traces for all of the control rods exhibited this type of trace. 3PT-R004 was last performed on 6/21/95 as part of the overall acceptance test phase following the reactor vessel flange "O-ring" replacement activity performed during outage F95.

3.6.3b Data was obtained from the last 10 performances of surveillance test procedure 3PT-R004. Trend Graphs were developed to determine if any control rod exhibited an adverse trend with respect to rod drop time. The trend graphs indicate that neither the Technical Specifications limit of 1.8 seconds or the administrative limit of 1.65 seconds was close to being approached. Table 7 provides summary data for BOC 9 and the latest new mid-cycle tests in June 1995.

3.6.3c All of the rod bottom bistables were last calibrated in September 1995. These bistables are scheduled to be recalibrated in accordance with I&C surveillance test 3PT-V46 with the unit between 0 and 2% power operation. The as-left values associated with the procedures performed in September 1995 were satisfactory.

3.6.3d In 1995, the unit experienced two reactor trip signals. The dates of these events were 6/29/95 and 9/14/95. DERS generated on these two days indicate no anomalous behavior associated with control rod position following the reactor trip signals.

3.6.3e Based on the research conducted with regards to this topic and accumulated data, I&C Engineering has determined that no operability concern exists with regards to the rod control system at the IP-3 facility.

3.6.4 On April 2, 1996, Indian Point 3 was manually tripped. All control rods fully inserted.

Table 1. Summary Of Fuel Assemblies in Cycle 9 Rev. 3

Component	Material Characteristics
Fuel Assembly	Westinghouse Vantage 5 H 15X15 fuel array
Fuel Rods	Zr-4, and ZIRLO clad
End Grids, Top and Bottom	Inconel 718
Mid Grids (5)	Zr-4
Guide Tubes	Zr-4
Inner Diameter (above dashpot)	0.499 in. (nominal)
Inner Diameter (below dashpot)	0.455 in (nominal)

Table 2. Comparison between IP-3 and two plants which had rod insertion problem

Data provided by Westinghouse

Rev. 3

	Parameter	IP-3	Wolf Creek[1]	South Texas Project
1	Fuel array	15X15	17X17	17X17
2	Fuel type	OFA Vantage 5H (W)	Vantage 5H (W)	XLR twice burned (W)
3	Assemblies burnups (GWD/MTU)	20-50	47	43
4	Active fuel length (ft)	12	12	14
5	Weight (lbf)	1454	1445	1692
6	Hold down force	994	1000	1242
7	Hydraulic lift force (lbf)	1387	1387	1652
8	Avg. spring force (lbf)	1074	1072	1372
9	# of RCCA	53	53	57
10	CR insertion length (in)	150.574	150.585	170.37
11	Control rod travel (in)	143.75	143.125	162.2
12	*CR radial clearance (in)*			
13	Dashpot	0.008	0.006	0.006
14	Above dashpot	0.0365	0.035	0.035
15	Avg. guide tube normal stress (psi)	3158	2732	3490
16	Guide tube overall length (in)	152.93	154.117	178.695
17	Guide tube ID/OD (in)	.499/.533	.450/.482	.450/.482
18	Guide tube wall thickness (in)	0.017	0.016	0.016
19	Guide tube ID (in) (dashpt)	0.455	0.397	0.397
20	Guide tube OD (in) (dashpt)	0.49	0.430	0.429
21	Dashpot length (in)	23.995	23.69	33.845
22	Dashpot wall thickness (in)	0.0175	0.0165	0.016
23	# of Mid grids	5+2(end grids)	8	10
24	Mid grid pitch (in)	26.19	20.55	19.81
25	*Mid grid height*			
26	Bottom, top	1.522	1.522	1.322
27	Mid	2.25	1.322	1.322
28	Guide tube sleeve length (in)	2.281 (top grid)	2.59	2.59
		0.75 (mid grid)	0.75	2.59

[1] Standard parameters are assumed

Table 3. Summary of Experience in IP-3 Acceptable Control Rod Trips over High Burnup Assemblies (>40 GWD/MTU)

Rev. 3

Cycle No.	No. of Assemblies	Burnup (GWD/MTU)
6	4	41.7
	4	43.5
7	4	40.3
	4	40.5
	5	40.8
	4	43.6

Table 4. Number of fuel assemblies with control rods that have burnups over 40 GWD/MTU at End of Cycle

Cycle		No. of Assemblies
6		10
7		19
8		16
9	(projected)	21

Table 5. Summary of RCCA R89 Rod Operations Employed to Help Determine the Cause of the Control Rod Binding

Rev. 3

RCCA Observation	Sequence [a]
Binding noted from bottom 1'	First removal at the EOC8 from U64
Minor interaction 2' from bottom	First reinserted in U64
Greater difficulty than first removal till 2' from bottom	Second removal from U64
No difficulty in insertion and removal:	Tested in dummy fuel assembly
No difficulty in insertion and removal:	Tested in another spent fuel assembly

[a] Portable RCCA change tool used in spent fuel pool.

NEW YORK POWER AUTHORITY (IP-3 CYCLE 9)

Table 6 Rev

All assemblies are 15X15 OFA VANTAGE 5H

	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
R															
P						W-37 22138 34116		W-36 26161 38526		W-20 22138 34116					
N			W-46 20404 29268		W-43 21490 35687		W-01 27074 40512		W-21 27074 40512		W-63 21490 35687		W-66 20404 29268		
M				W-23 26637 39912				W-17 26907 40837				W-26 26637 39912			
L			W-55 21720 35868						W-04 26110 39876				W-56 21720 35868		
K		W-03 21873 33893				V-45 37675 49589		V-23 38944 50214		V-46 37675 49589				W-15 21873 33893	
J			W-05 26962 40420		W-31 26197 39944								W-11 26962 40420		
H		W-10 26161 38526		W-25 26907 40837		V-25 38944 50214		V-42 32279 45409		V-13 38944 50214		W-22 26907 40837		W-13 26161 38526	
G			W-18 26962 40420								W-27 26197 39944		W-28 26962 40420		
F		W-06 21873 33893				V-47 37675 49589		V-11 38944 50214		V-41 37675 49589				W-12 21873 33893	
E			W-61 21720 35868				W-02 26110 39876						W-72 21720 35868		
D				W-32 26637 39912				W-07 26907 40837				W-33 26637 39912			
C			W-45 20404 29268		W-51 21490 35687		W-16 27074 40512		W-09 27074 40512		W-68 21490 35687		W-71 20404 29268		
B						W-30 22138 34116		W-14 26161 38526		W-39 22138 34116					
A															

ASSEMBLY ID
PRESENT BURNUP 7000 MWD/MTU
EOC BURNUP 19300 MWD/MTU (est.)

3/22/96

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NEW YORK POWER AUTHORITY (IP-3 CYCLE 9)

Table 7 3

All assemblies are 15X15 OFA VANTAGE 5H

	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
R															
P						W-37 1.28 1.28		W-36 1.29 1.31		W-20 1.27 1.33					
N			W-46 1.25 1.28		W-43 1.25 1.31		W-01 1.26 1.32		W-21 1.27 1.30		W-63 1.27 1.29		W-66 1.20 1.27		
M				W-23 1.23 1.29				W-17 1.29 1.36				W-26 1.23 1.28			
L			W-55 1.23 1.27						W-04 1.27 1.32				W-56 1.22 1.28		
K		W-03 1.25 1.30				V-45 1.25 1.33		V-23 1.27 1.32		V-46 1.25 1.30				W-15 1.26 1.30	
J			W-05 1.24 1.27		W-31 1.23 1.28								W-11 1.25 1.32		
H		W-10 1.24 1.26		W-25 1.28 1.36		V-25 1.27 1.32		V-42 1.26 1.32		V-13 1.25 1.33		W-22 1.26 1.30		W-13 1.25 1.27	
G			W-18 1.23 1.25								W-27 1.25 1.33		W-28 1.21 1.25		
F		W-06 1.25 1.28				V-47 1.21 1.30		V-11 1.28 1.35		V-41 1.26 1.33				W-12 1.23 1.27	
E			W-61 1.21 1.25				W-02 1.27 1.32						W-72 1.23 1.27		
D				W-32 1.21 1.26				W-07 1.27 1.30				W-33 1.21 1.28			
C			W-45 1.20 1.23		W-51 1.33 1.37		W-16 1.24 1.29		W-09 1.26 1.30		W-68 1.25 1.32		W-71 1.23 1.30		
B						W-30 1.23 1.28		W-14 1.29 1.27		W-39 1.23 1.28					
A															

ASSEMBLY ID
Rod drop time @ 0 MWD/MTU
Rod drop time @ 5109 MWD/MTU

Prepared by: B. Nakhai & R. Motko
3/22/96

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Rod drop time (sec.)	Avg.	Avg.	Avg.	Avg.	Tech. Spec.	FSAR*	Design basis accident analysis*
					1.8	2.4	2.7
@ 0 MWD/MTU	1.24	1.25	1.26	1.26			
@ 5109 MWD/MTU	1.23	1.29	1.30	1.32			

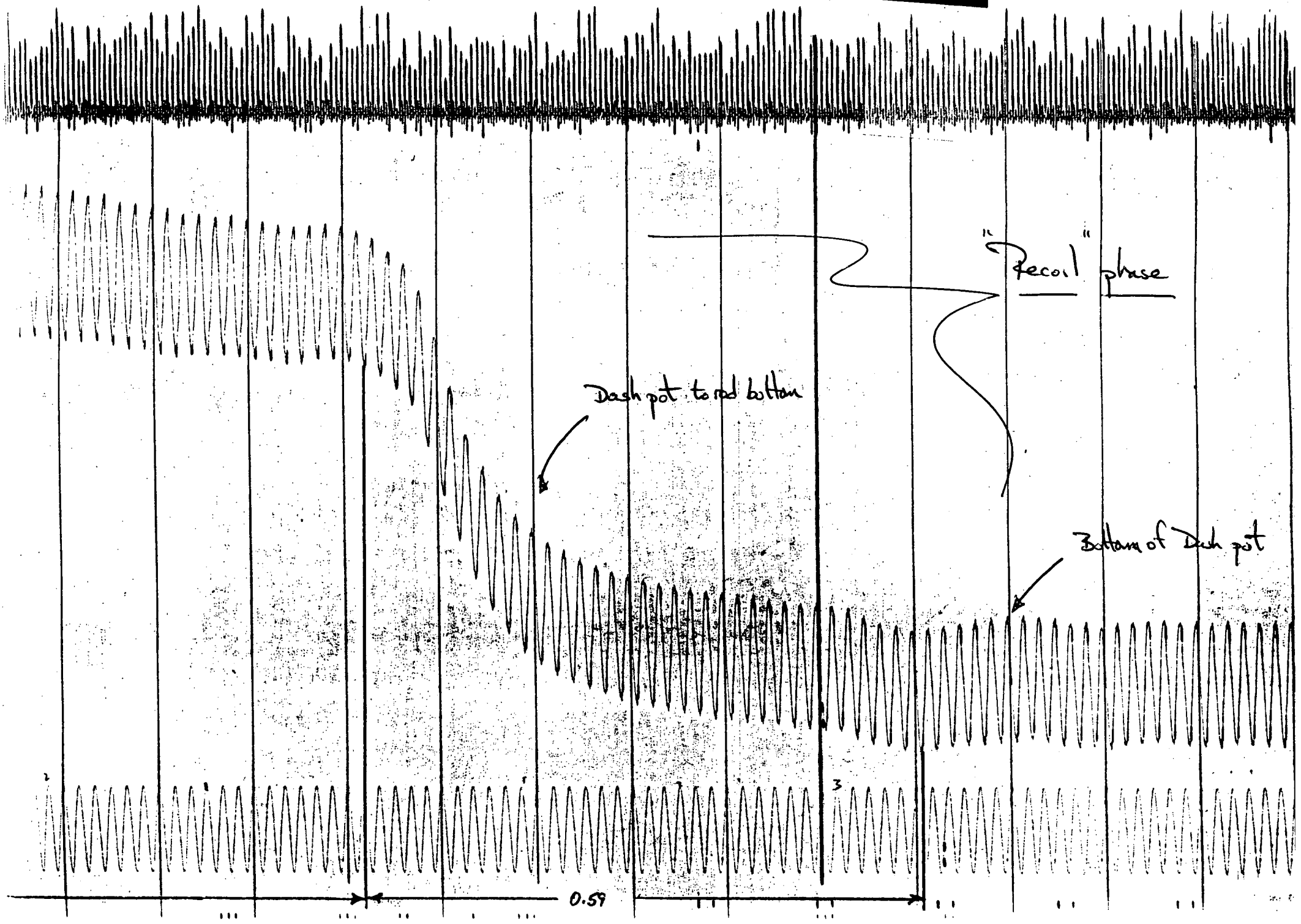
* Analyzed for seismic event

Behrad Nakhai, FCY9RODT.XLS

ATTACHMENT 1

TYPICAL CONTROL ROD DROP TEST TRACE

Attachment A

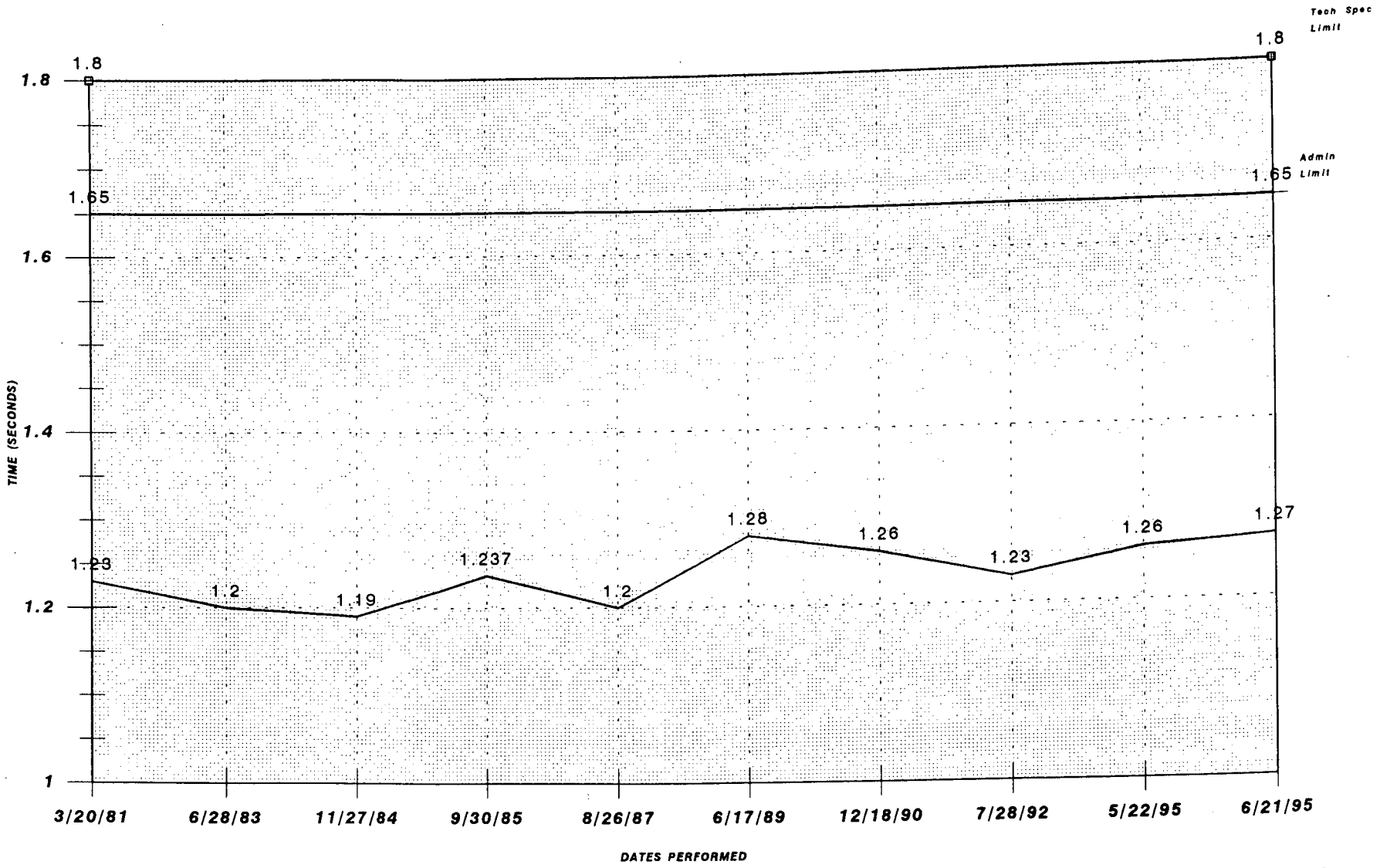


ATTACHMENT 2

CONTROL ROD DROP TIME TRENDS

ROD E-3

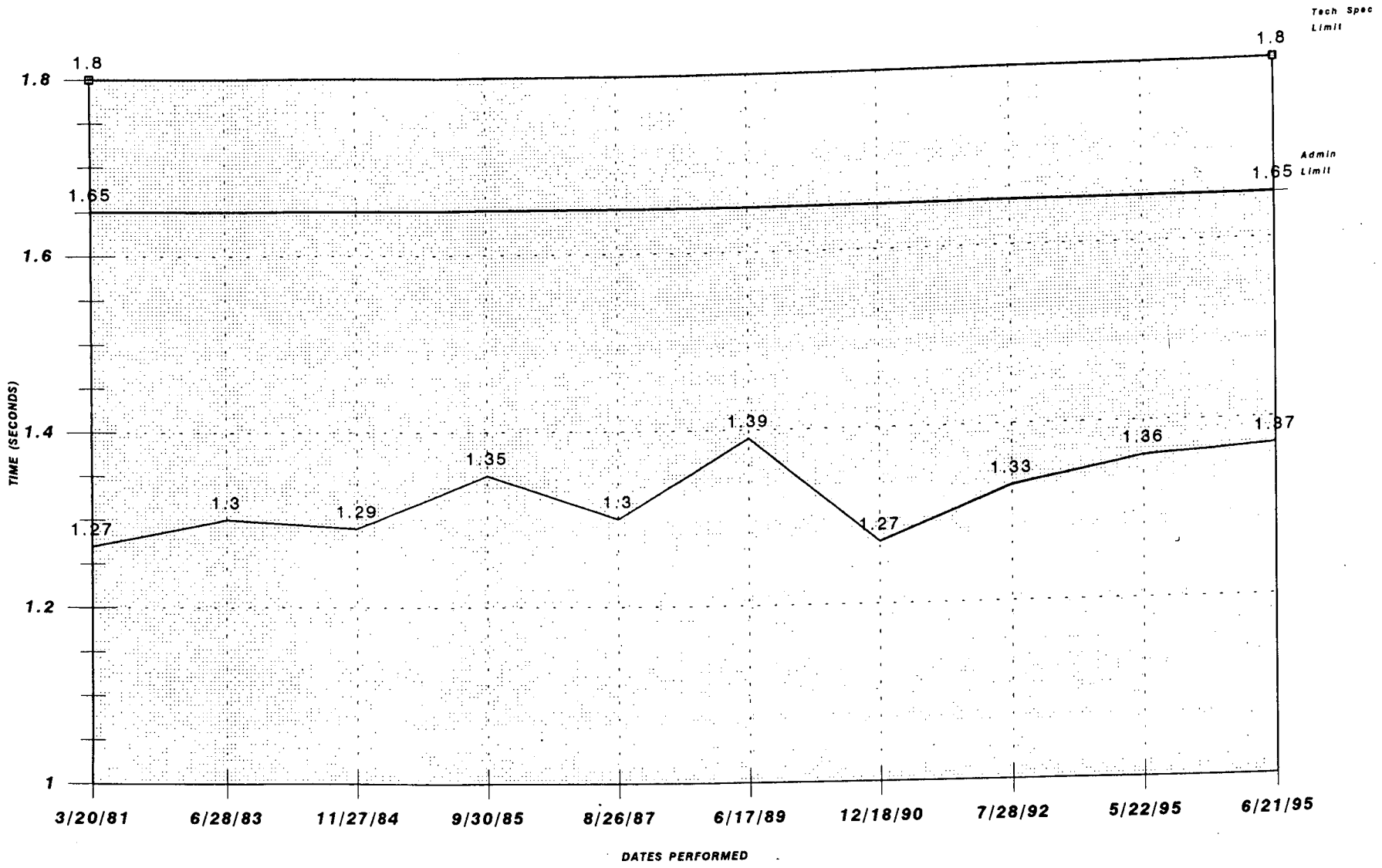
FULL LENGTH ROD DROP TIME TESTS



Attachment 2.1

ROD C-11

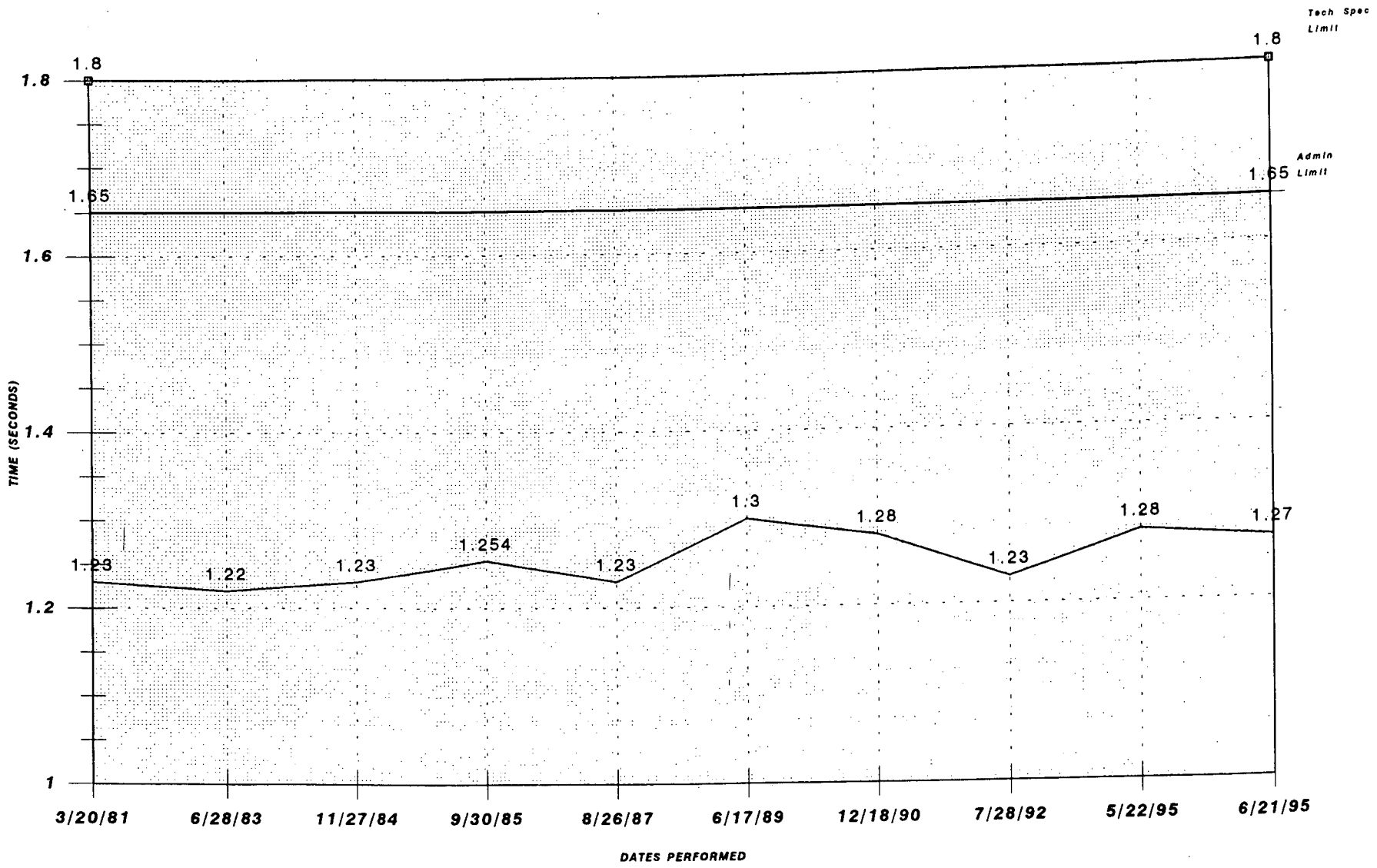
FULL LENGTH ROD DROP TIME TESTS



Attachment 2.2

ROD L-13

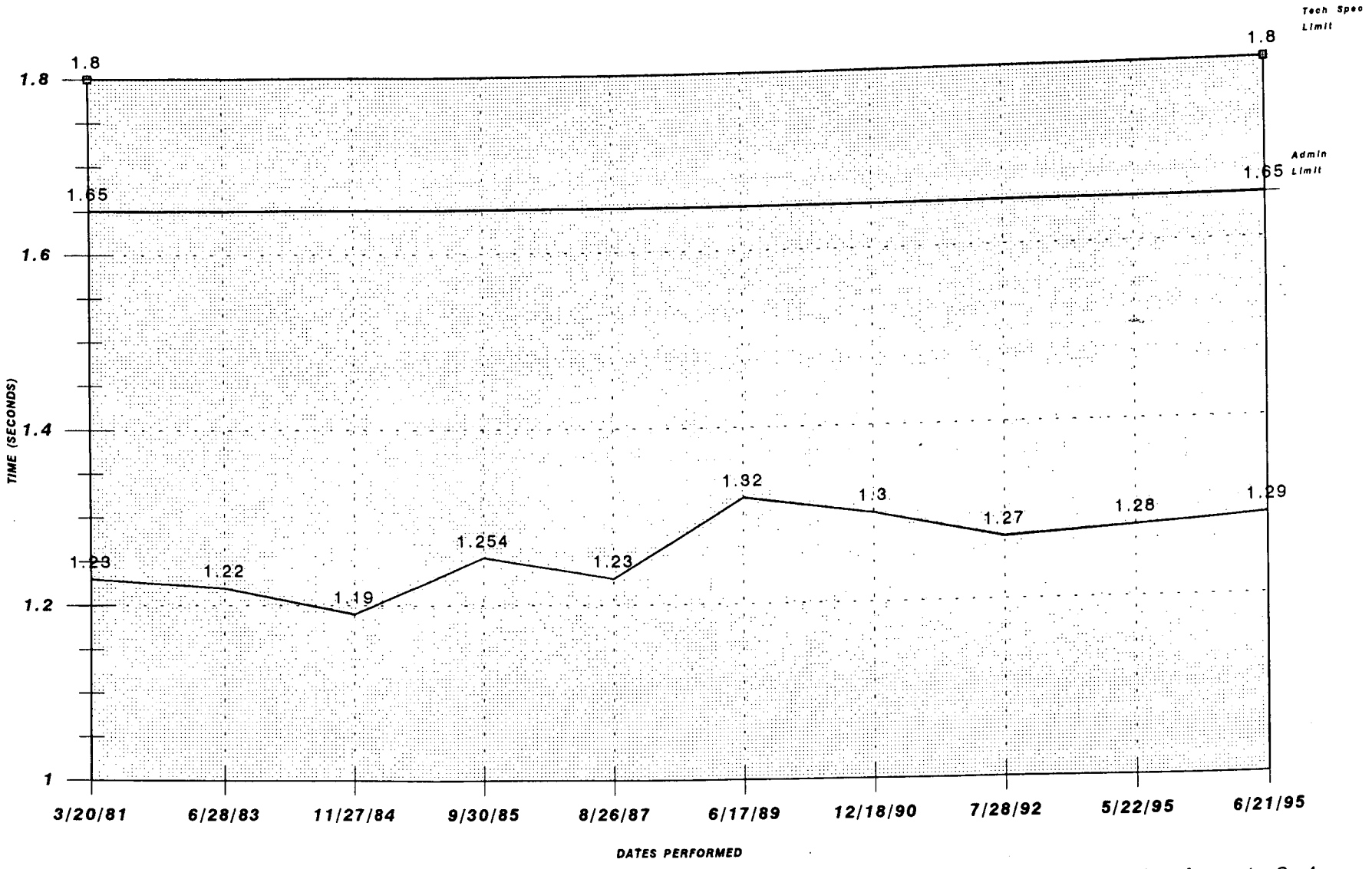
FULL LENGTH ROD DROP TIME TESTS



Attachment 2.3

ROD N-5

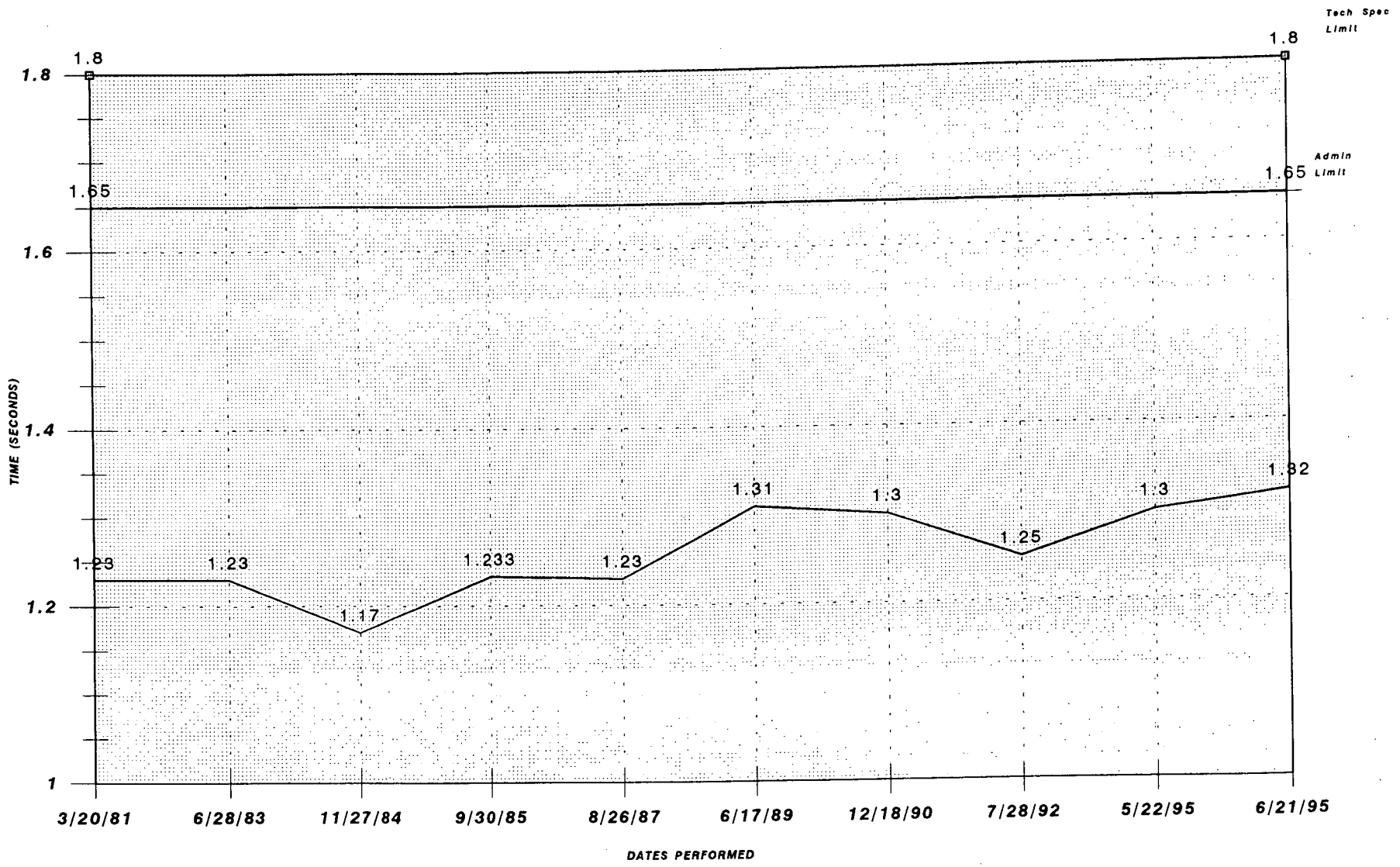
FULL LENGTH ROD DROP TIME TESTS



Attachment 2.4

ROD C-5

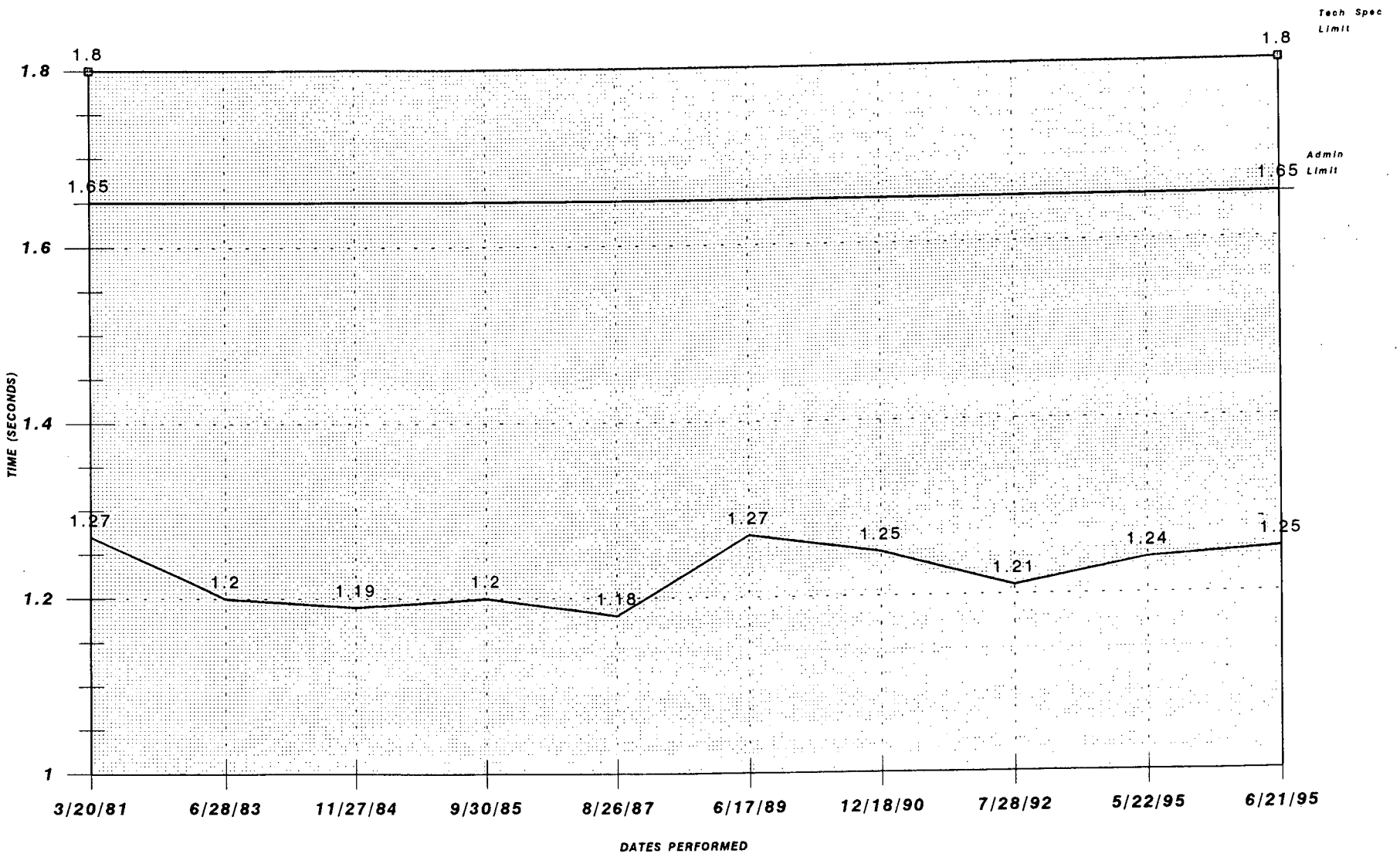
FULL LENGTH ROD DROP TIME TESTS



Attachment 2.5

ROD E-13

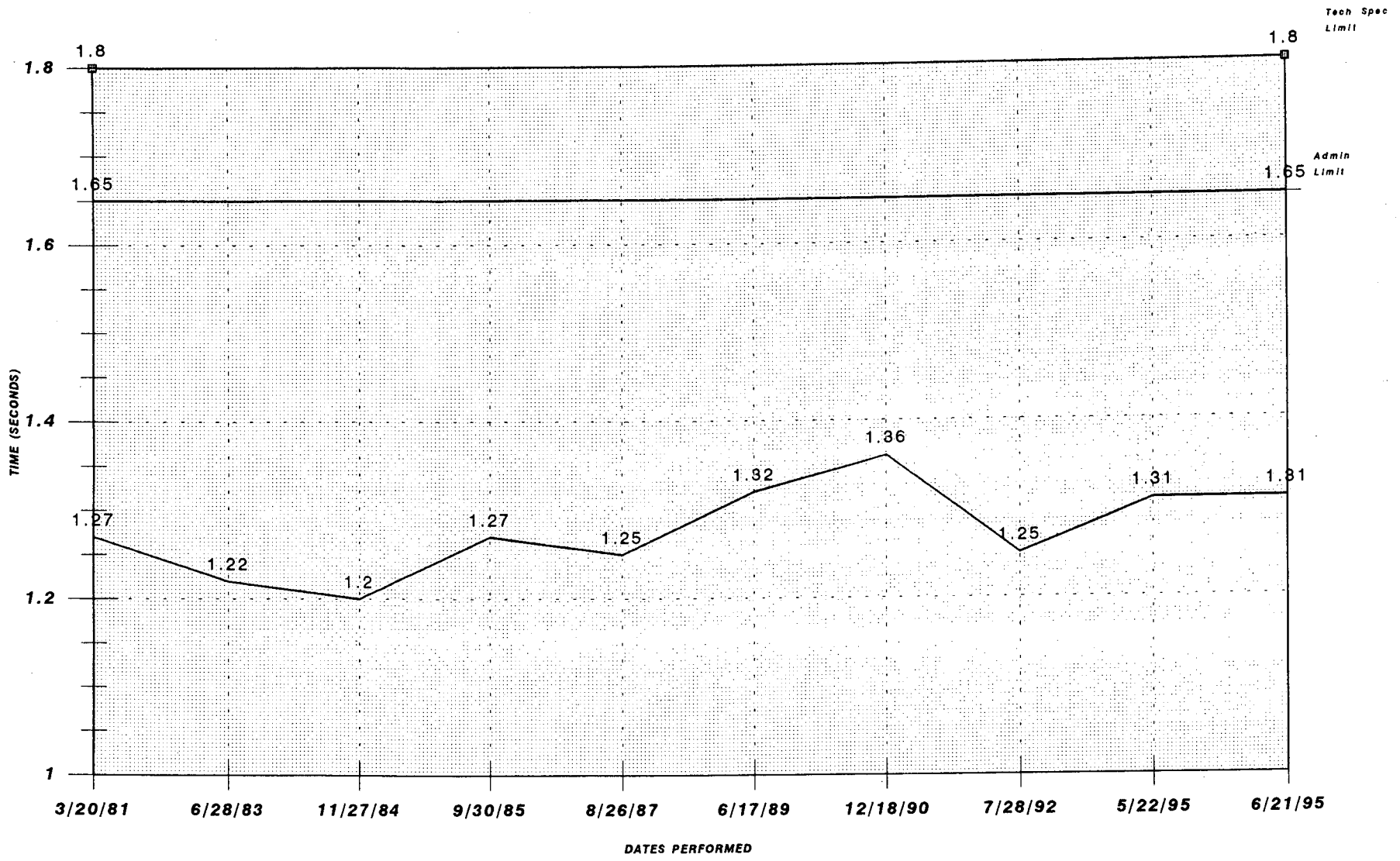
FULL LENGTH ROD DROP TIME TESTS



Attachment 2.6

ROD N-11

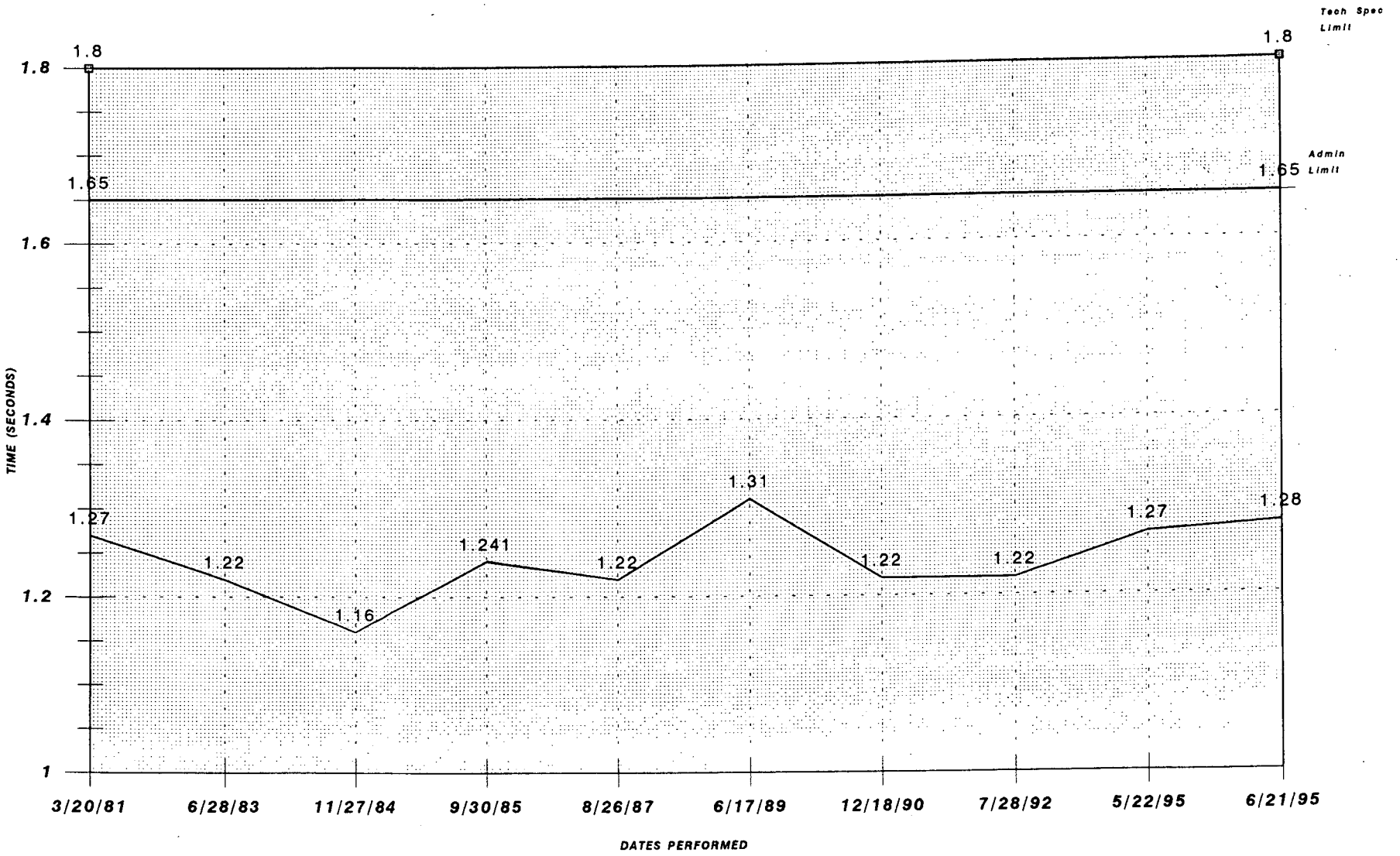
FULL LENGTH ROD DROP TIME TESTS



Attachment 2.7

ROD L-3

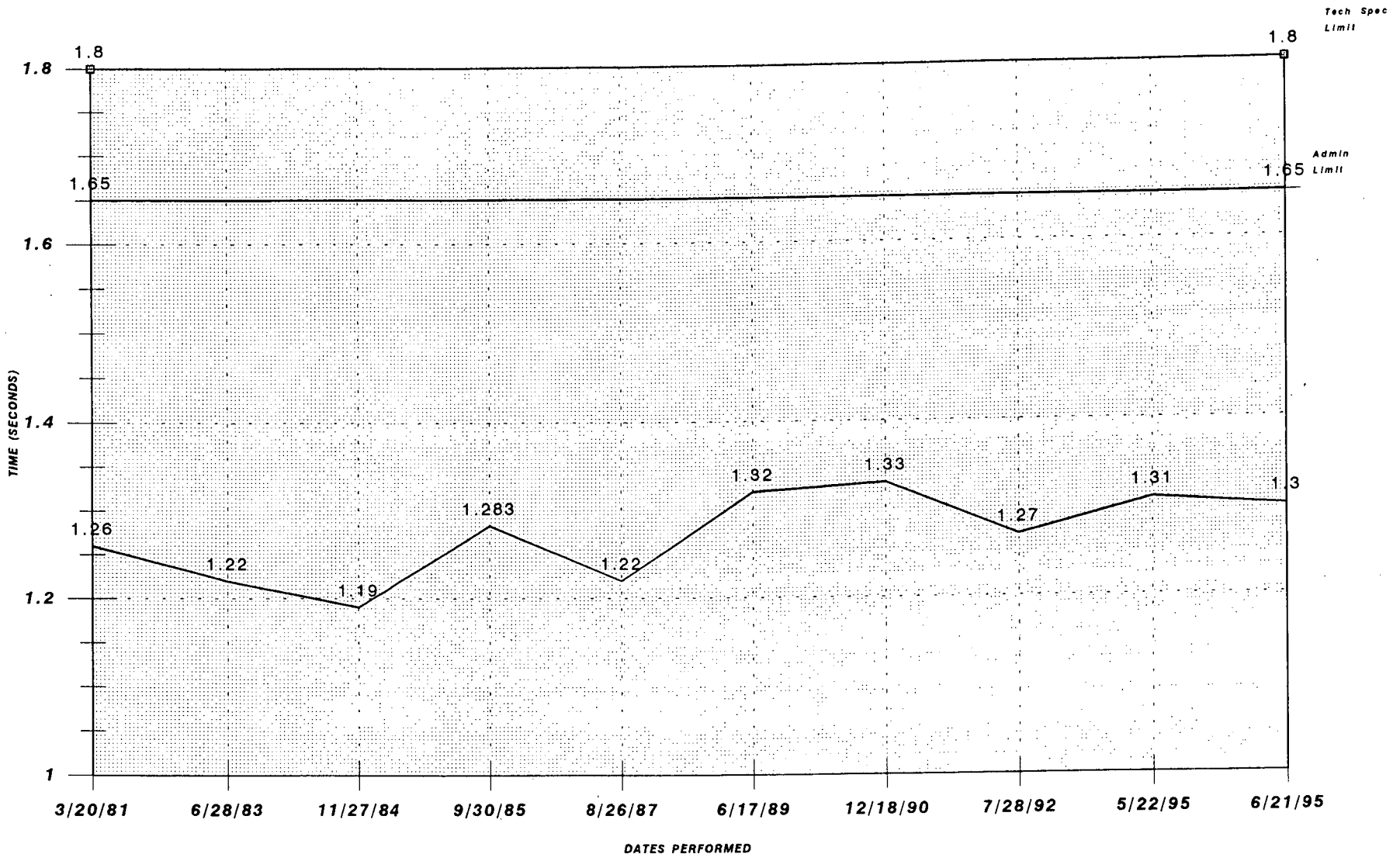
FULL LENGTH ROD DROP TIME TESTS



Attachment 2.8

ROD D-8

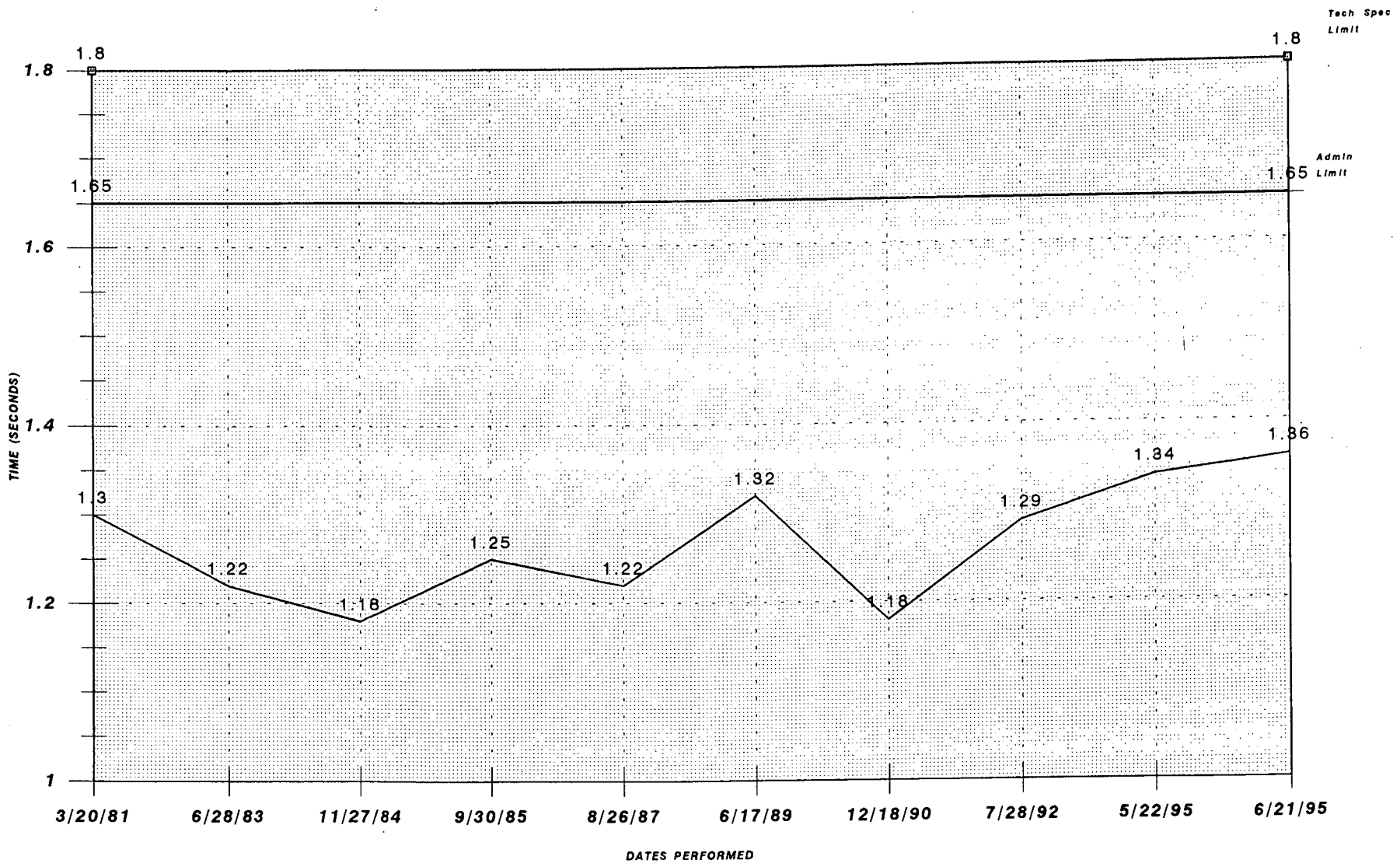
FULL LENGTH ROD DROP TIME TESTS



Attachment 2.9

ROD M-8

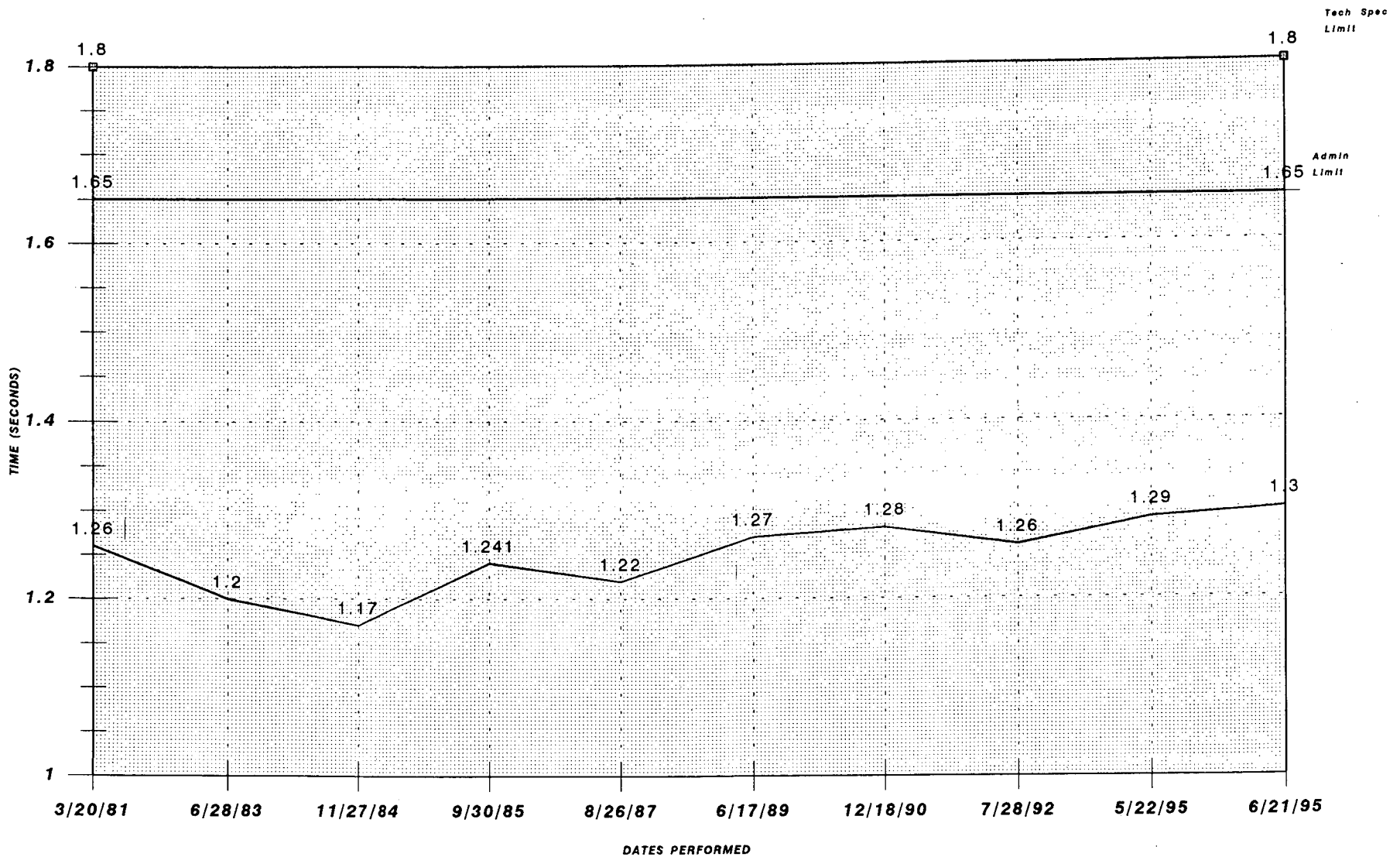
FULL LENGTH ROD DROP TIME TESTS



Attachment 2.10

ROD H-4

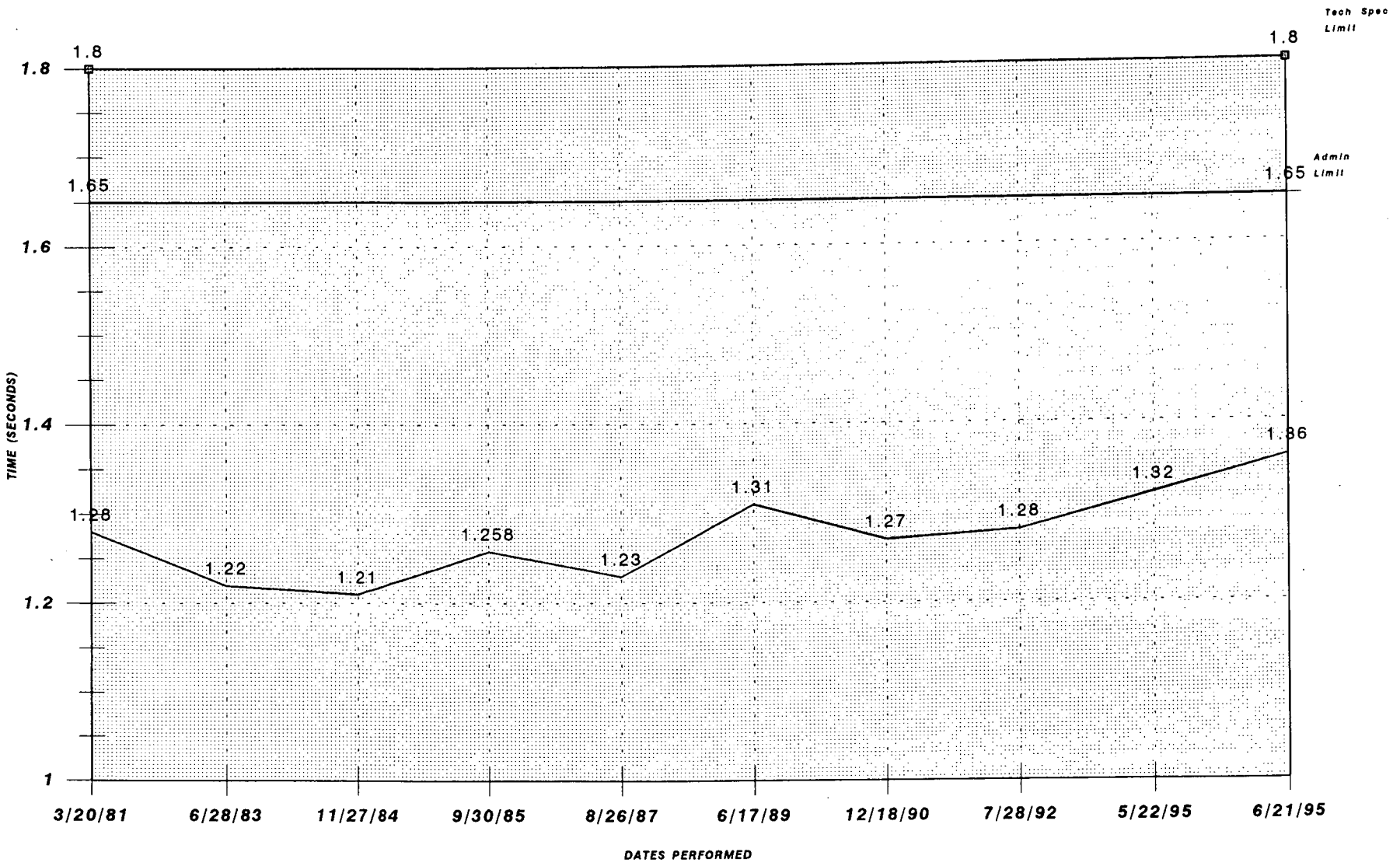
FULL LENGTH ROD DROP TIME TESTS



Attachment 2.11

ROD H-12

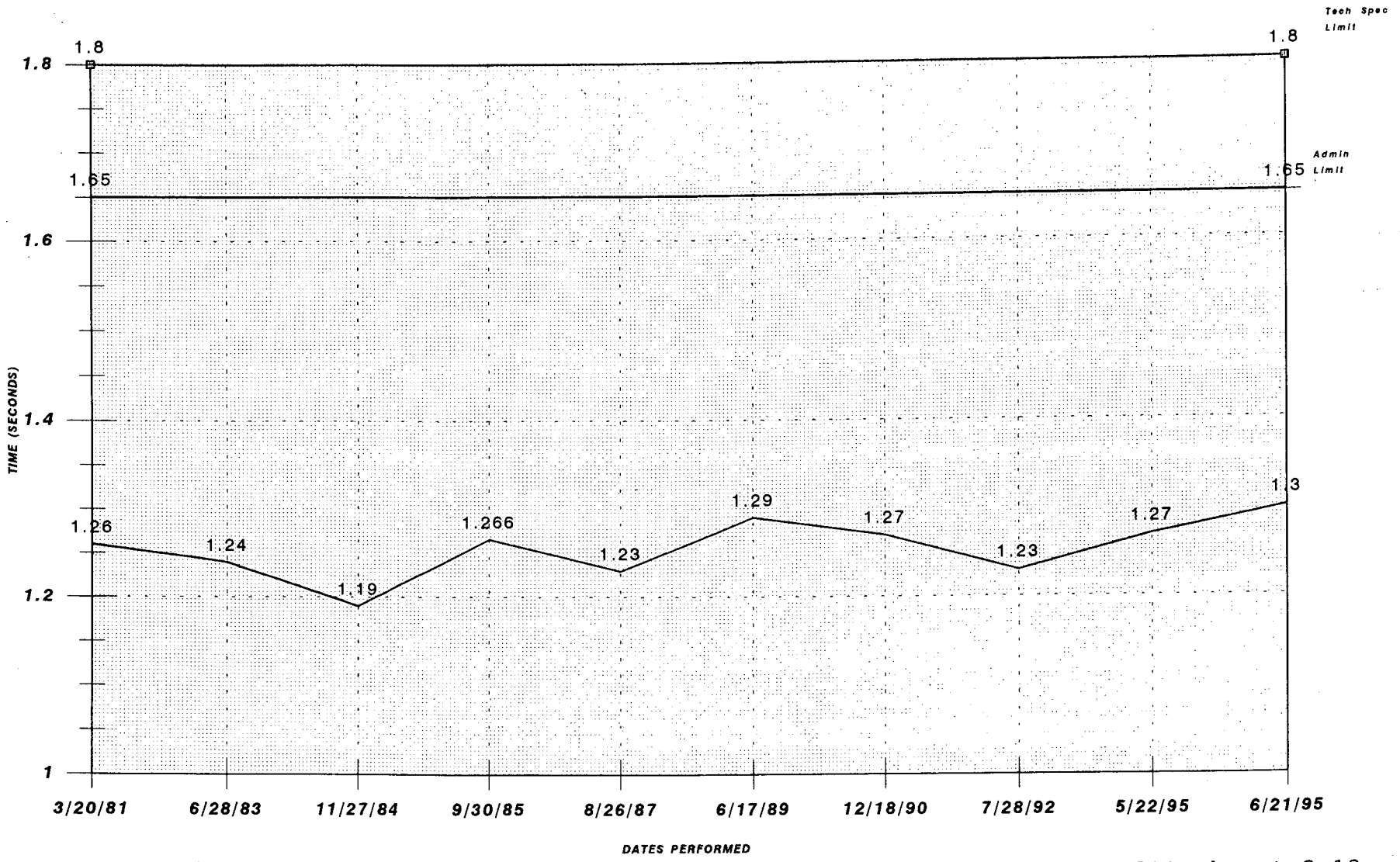
FULL LENGTH ROD DROP TIME TESTS



Attachment 2.12

ROD C-3

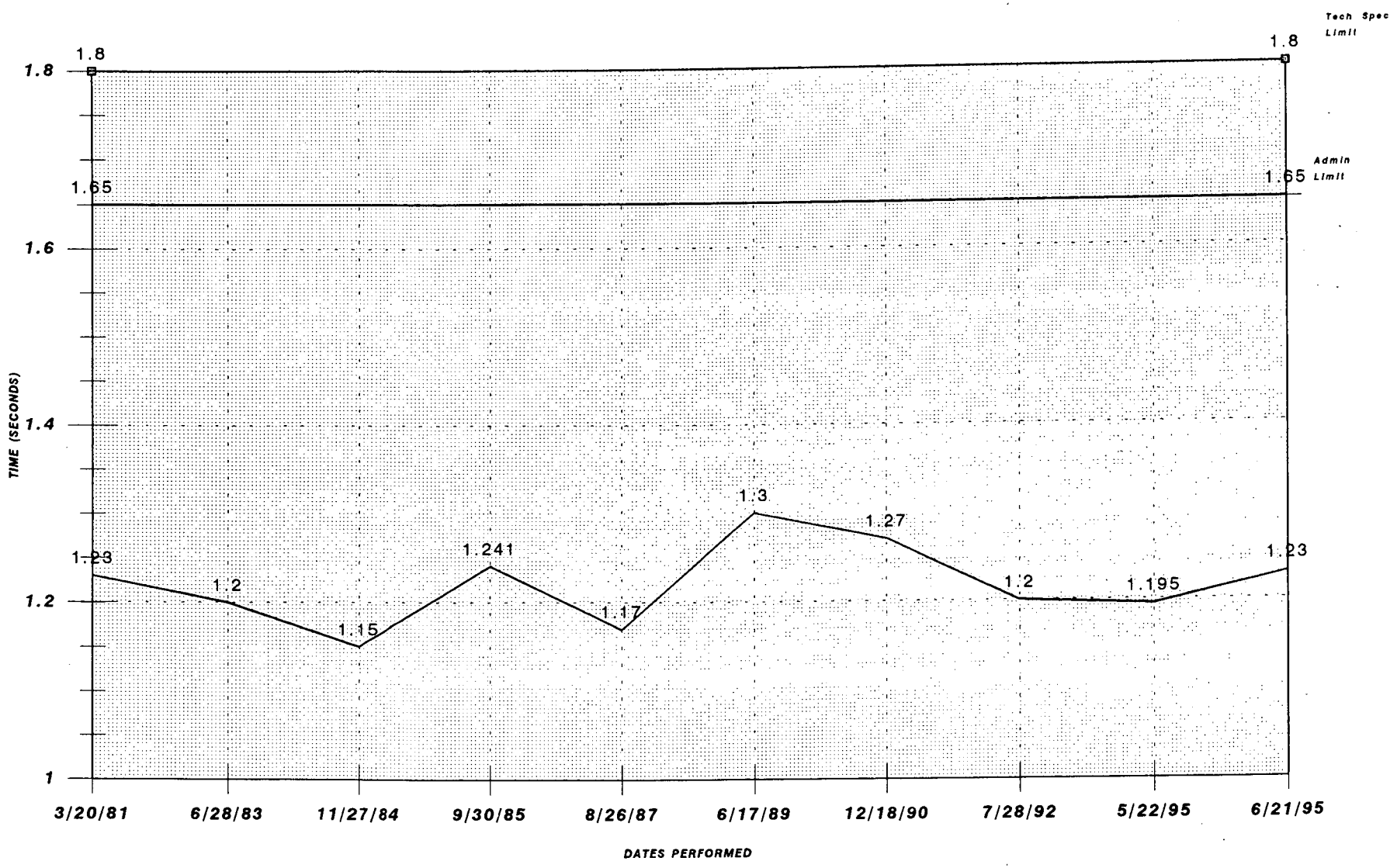
FULL LENGTH ROD DROP TIME TESTS



Attachment 2.13

ROD C-13

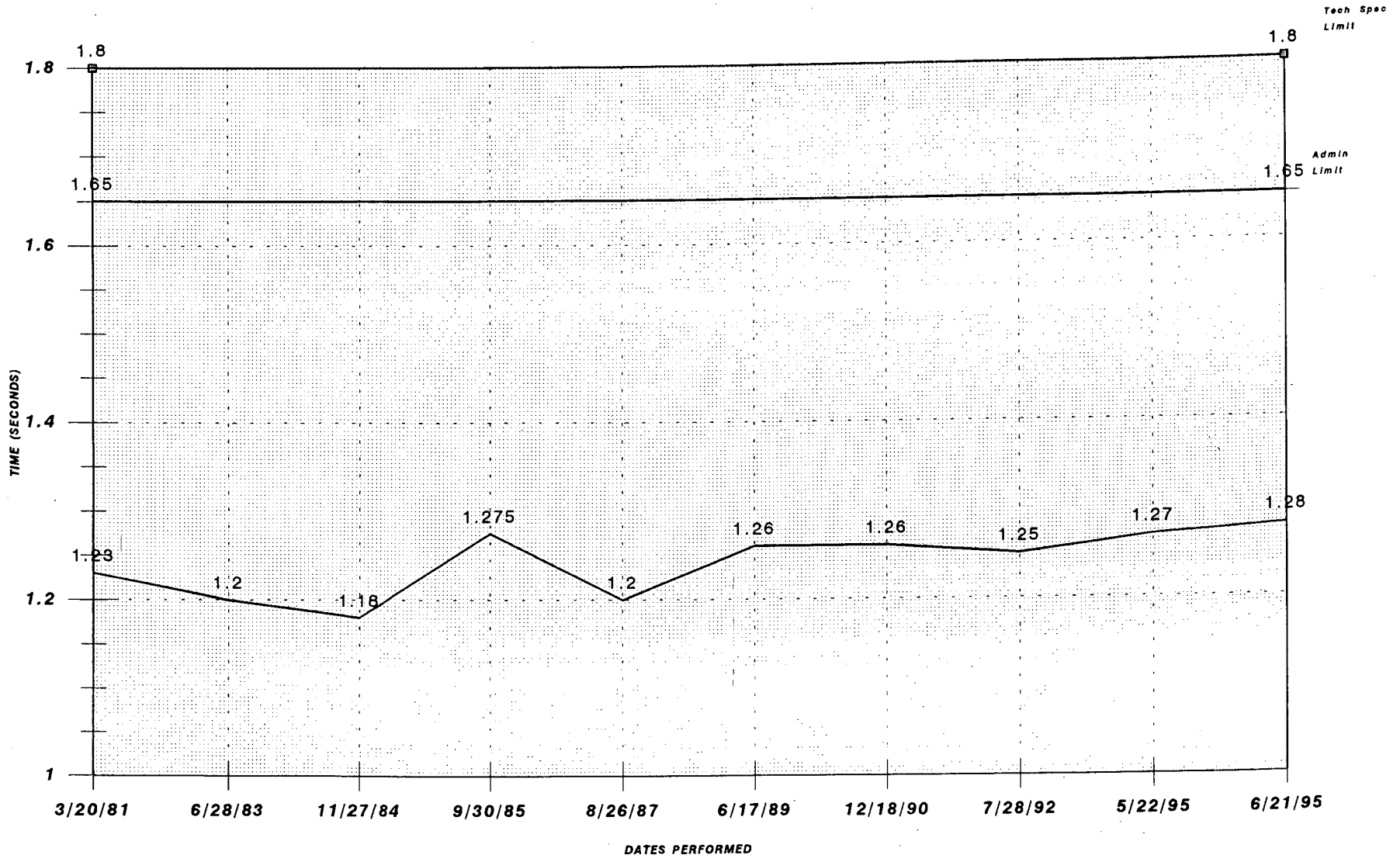
FULL LENGTH ROD DROP TIME TESTS



Attachment 2.14

ROD N-13

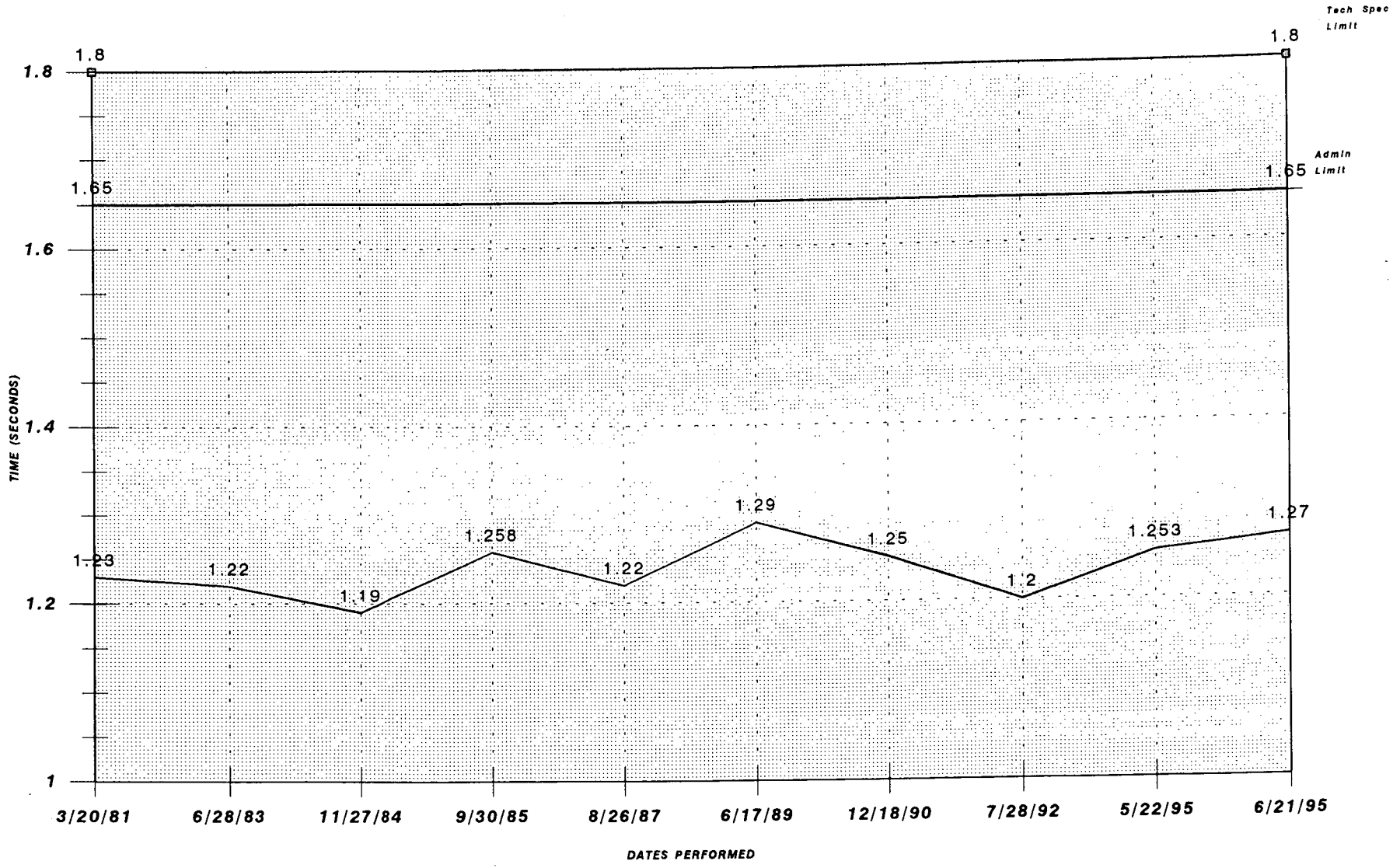
FULL LENGTH ROD DROP TIME TESTS



Attachment 2.15

ROD N-3

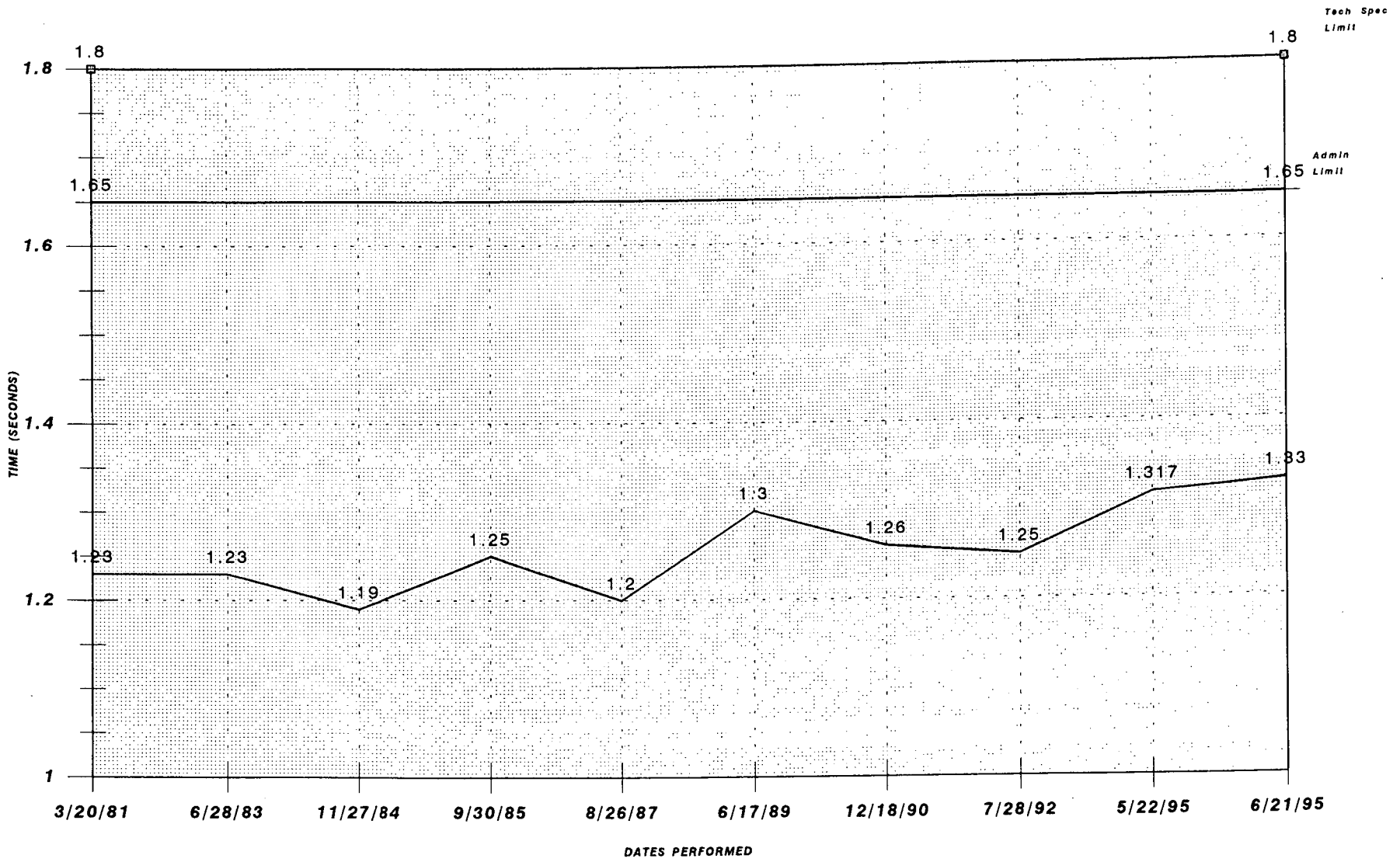
FULL LENGTH ROD DROP TIME TESTS



Attachment 2.16

ROD H-6

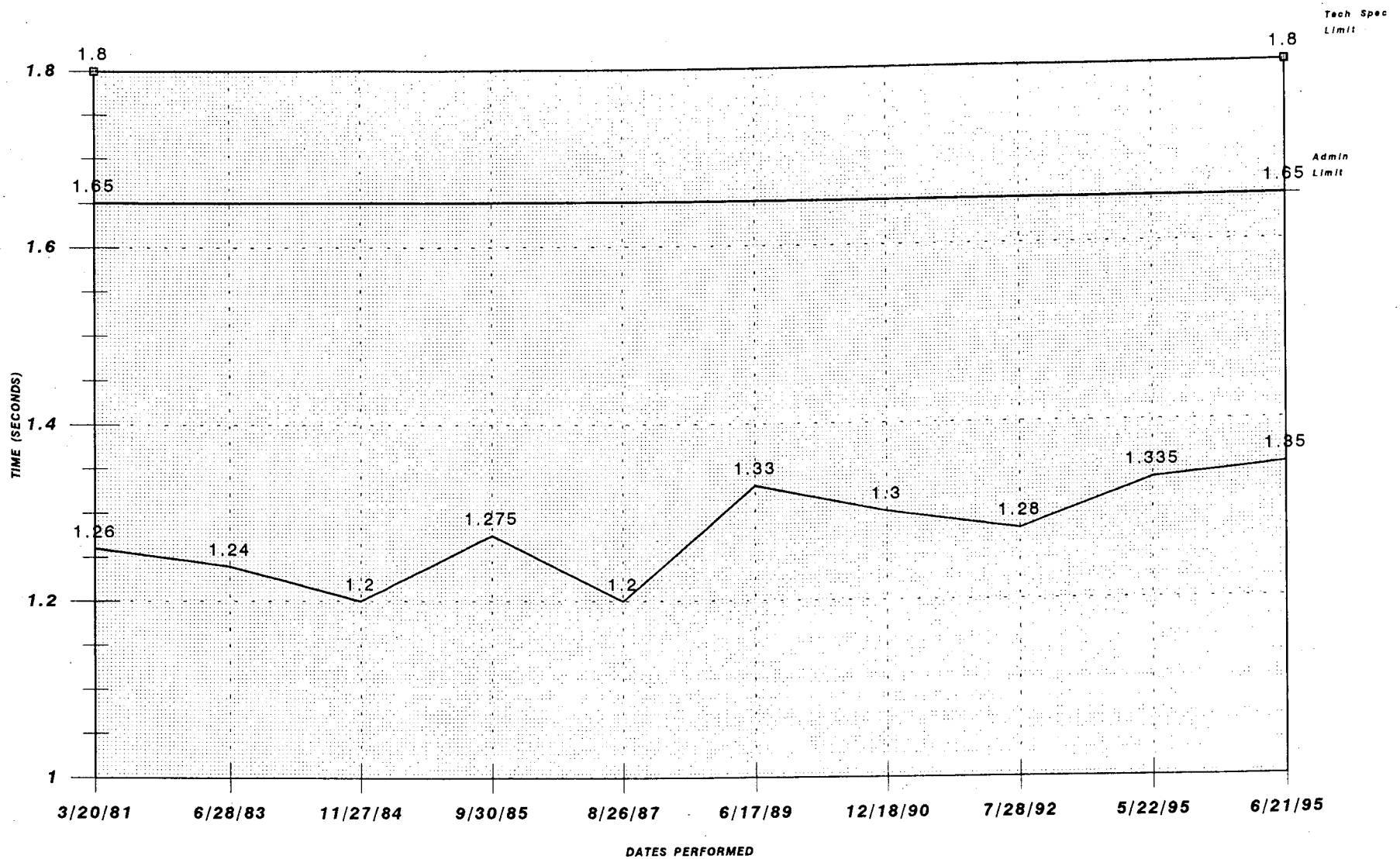
FULL LENGTH ROD DROP TIME TESTS



Attachment 2.17

ROD F-8

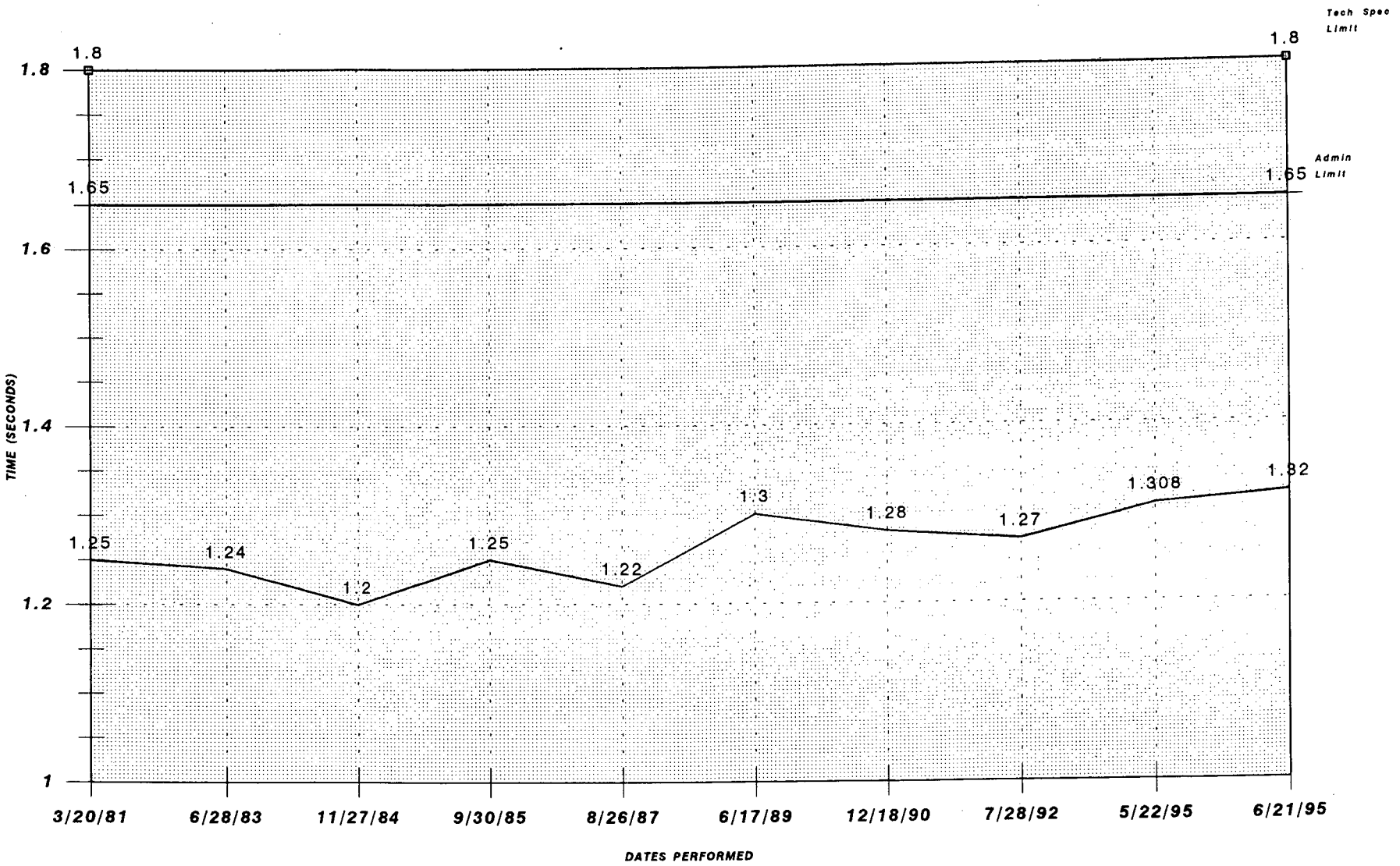
FULL LENGTH ROD DROP TIME TESTS



Attachment 2.18

ROD H-10

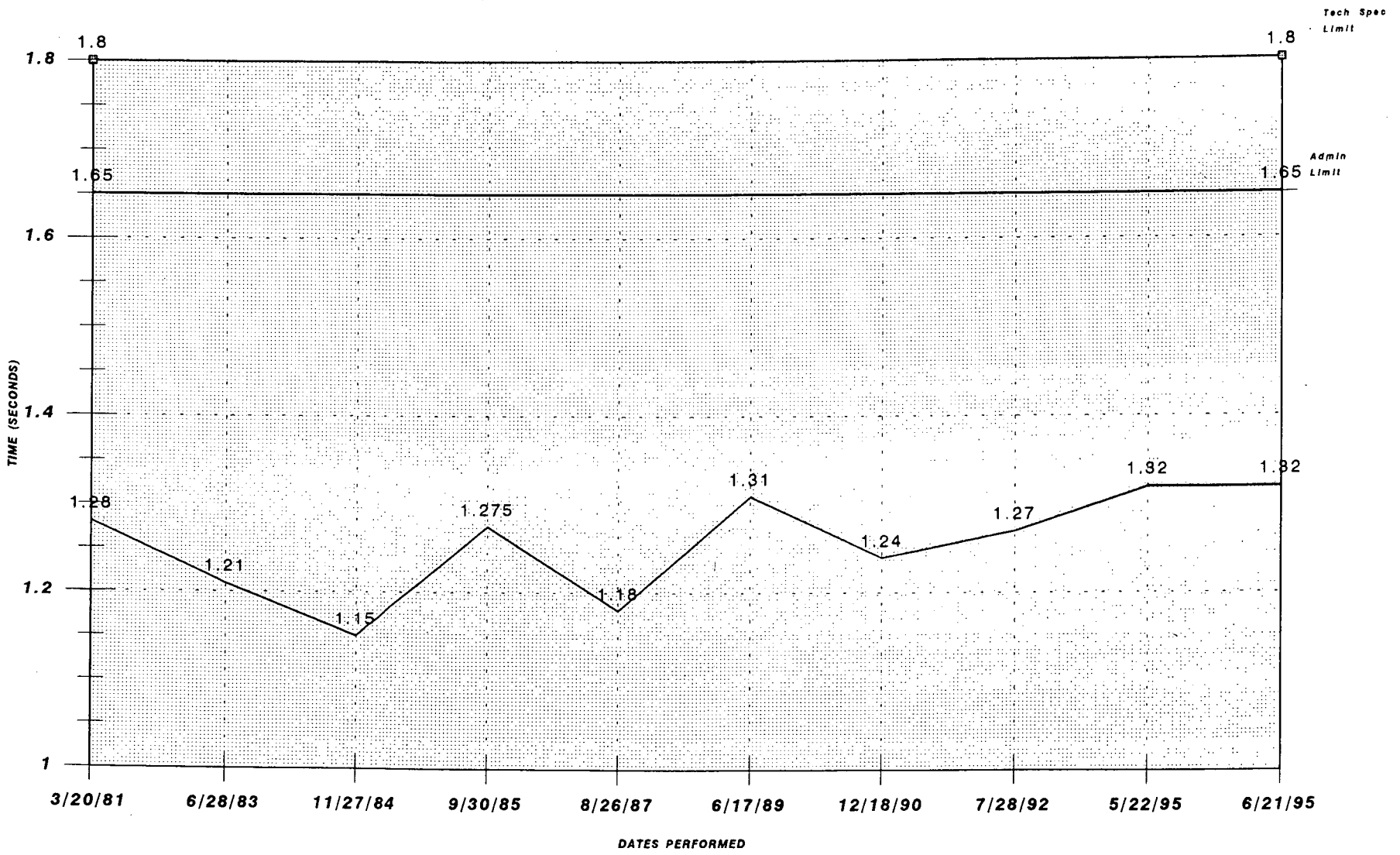
FULL LENGTH ROD DROP TIME TESTS



Attachment 2.19

ROD K-8

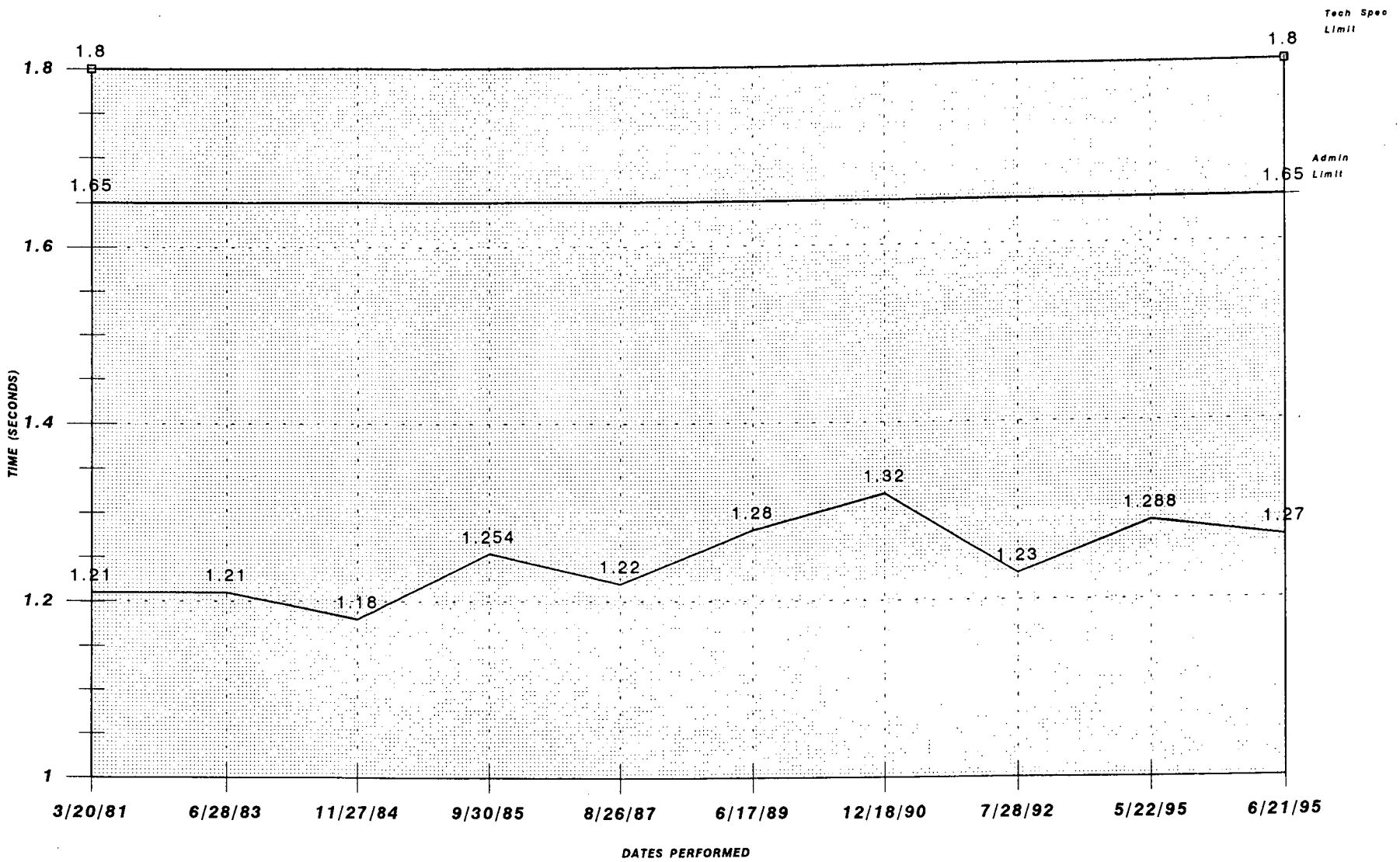
FULL LENGTH ROD DROP TIME TESTS



Attachment 2.20

ROD F-2

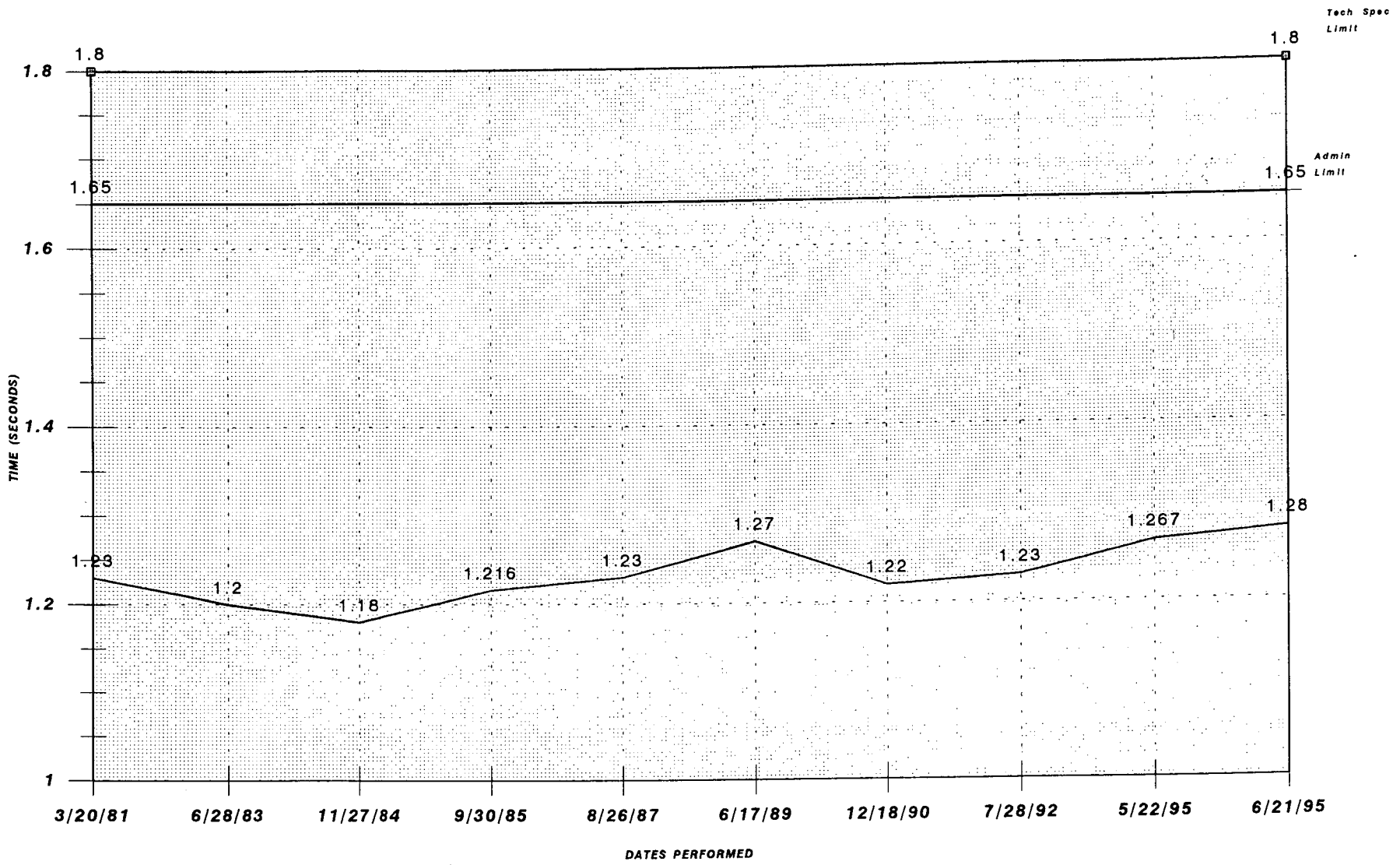
FULL LENGTH ROD DROP TIME TESTS



Attachment 2.21

ROD B-10

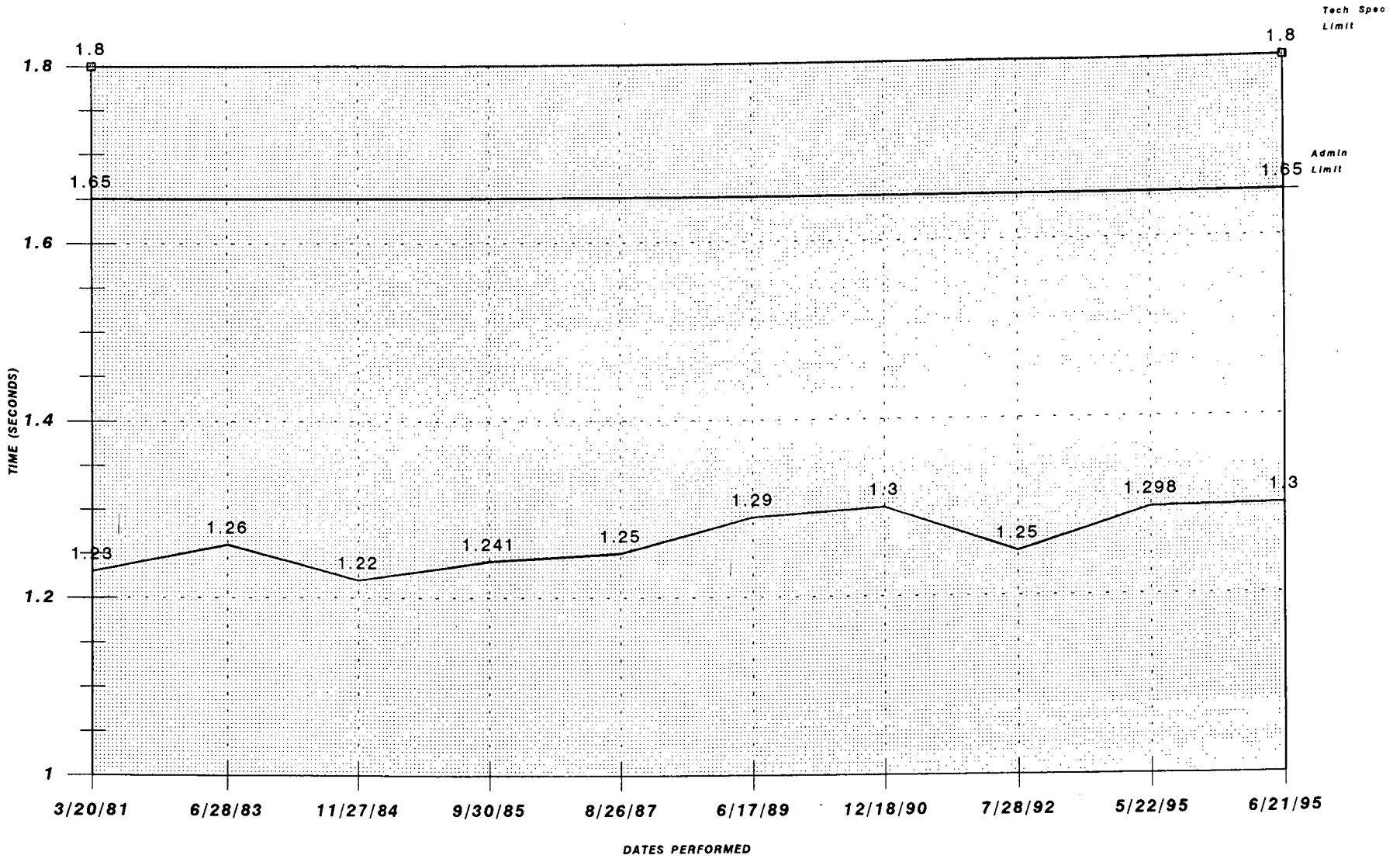
FULL LENGTH ROD DROP TIME TESTS



Attachment 2.22

ROD K-14

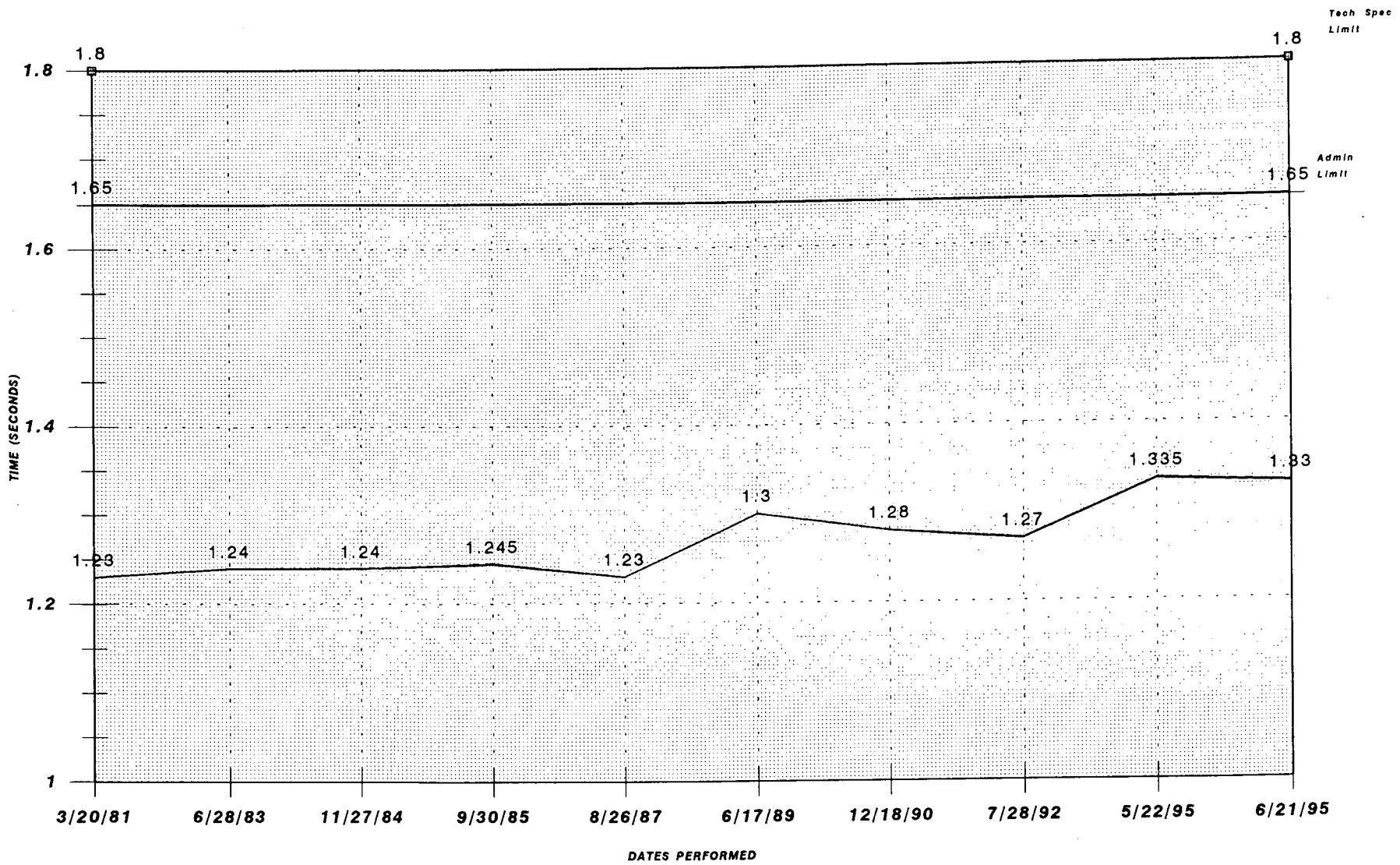
FULL LENGTH ROD DROP TIME TESTS



Attachment 2.23

ROD P-6

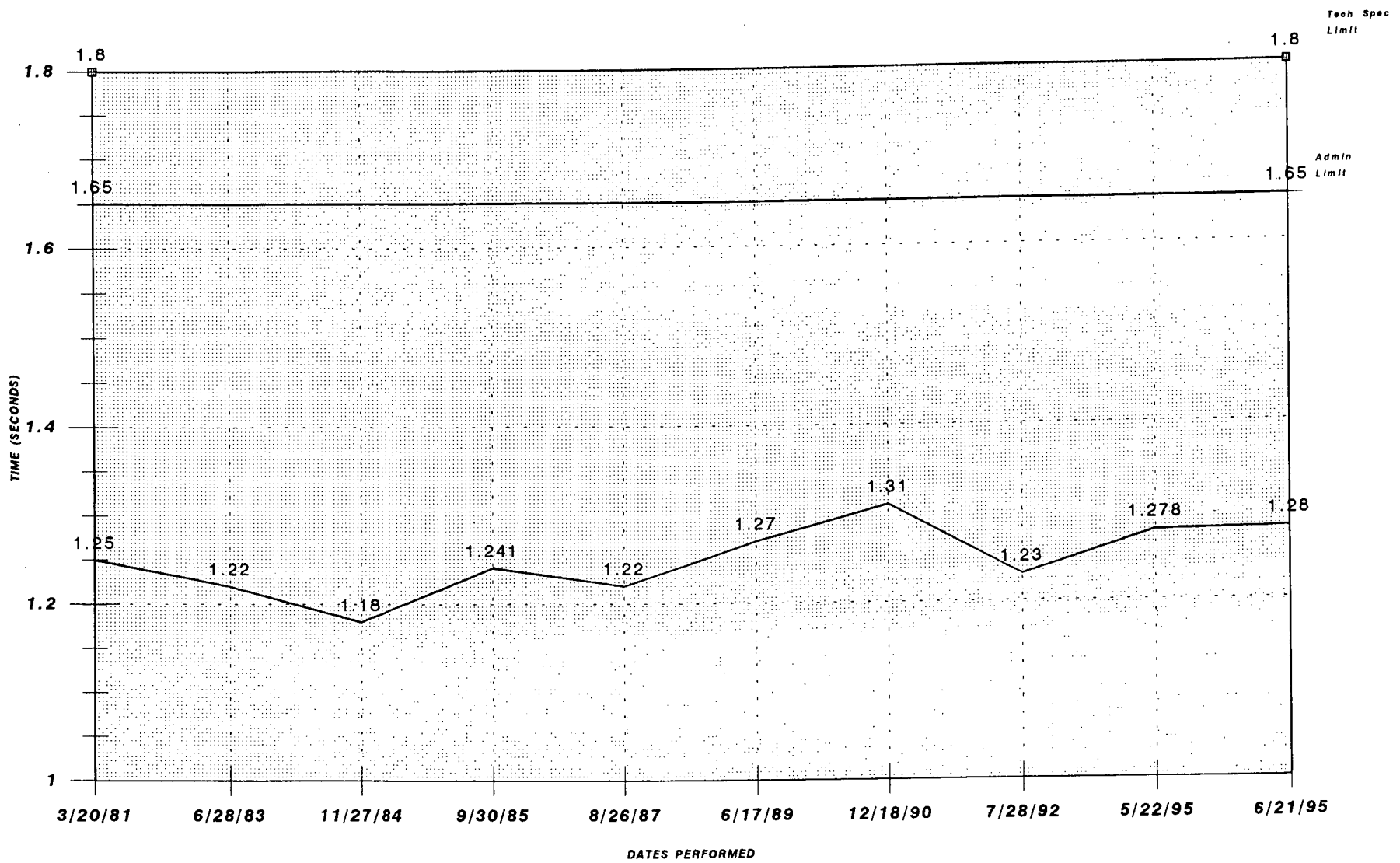
FULL LENGTH ROD DROP TIME TESTS



Attachment 2.24

ROD B-6

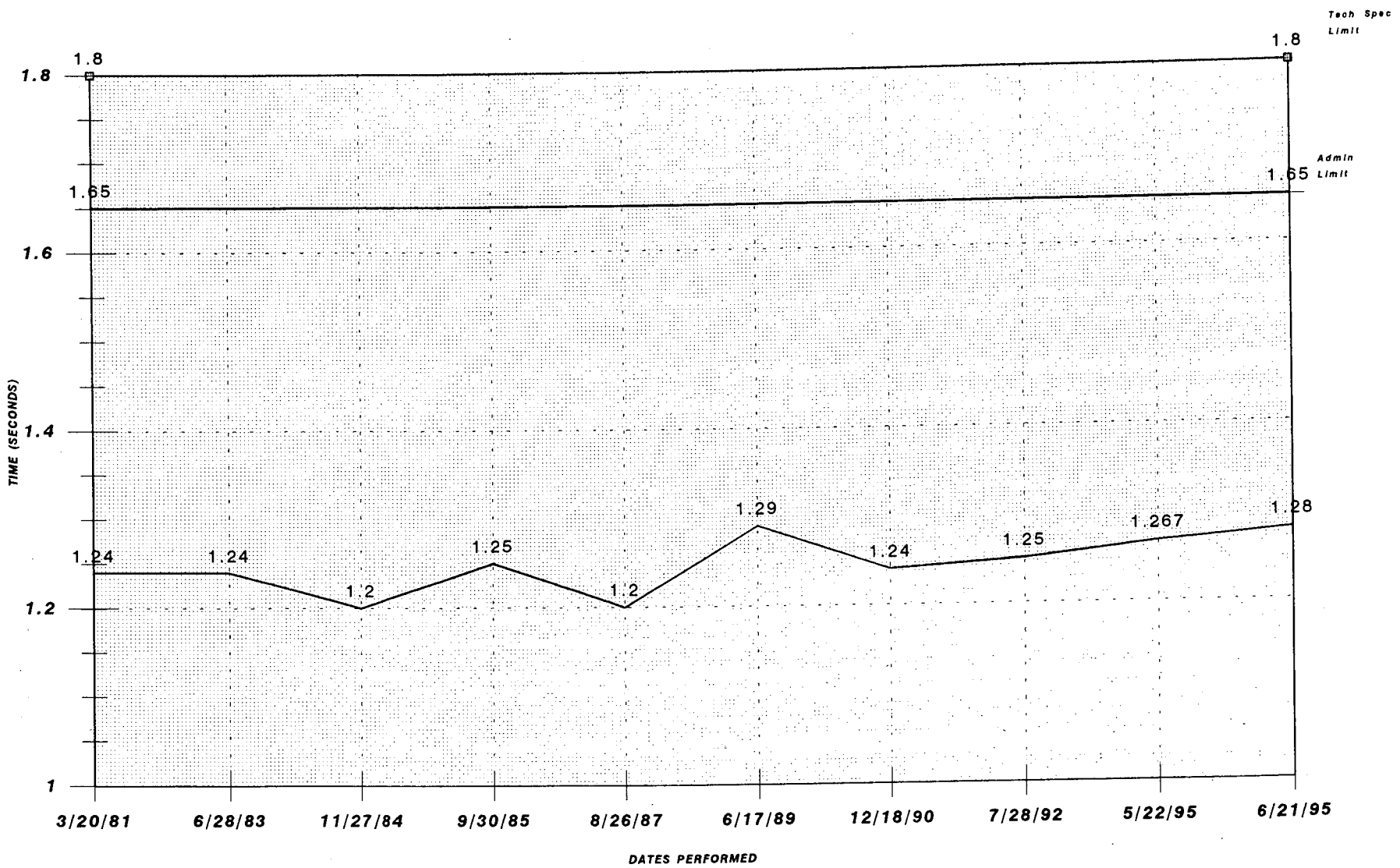
FULL LENGTH ROD DROP TIME TESTS



Attachment 2.25

ROD F-14

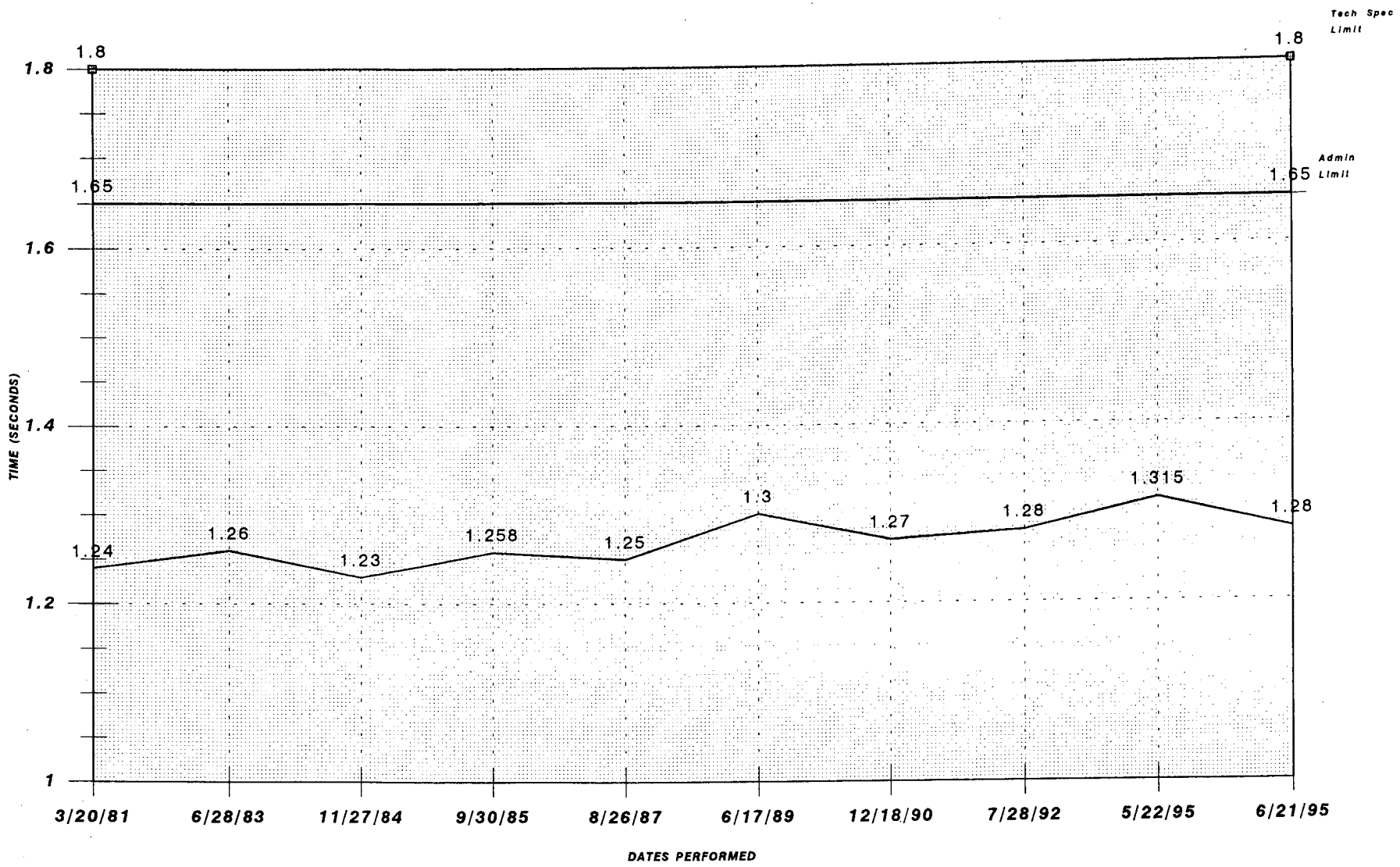
FULL LENGTH ROD DROP TIME TESTS



Attachment 2.26

ROD P-10

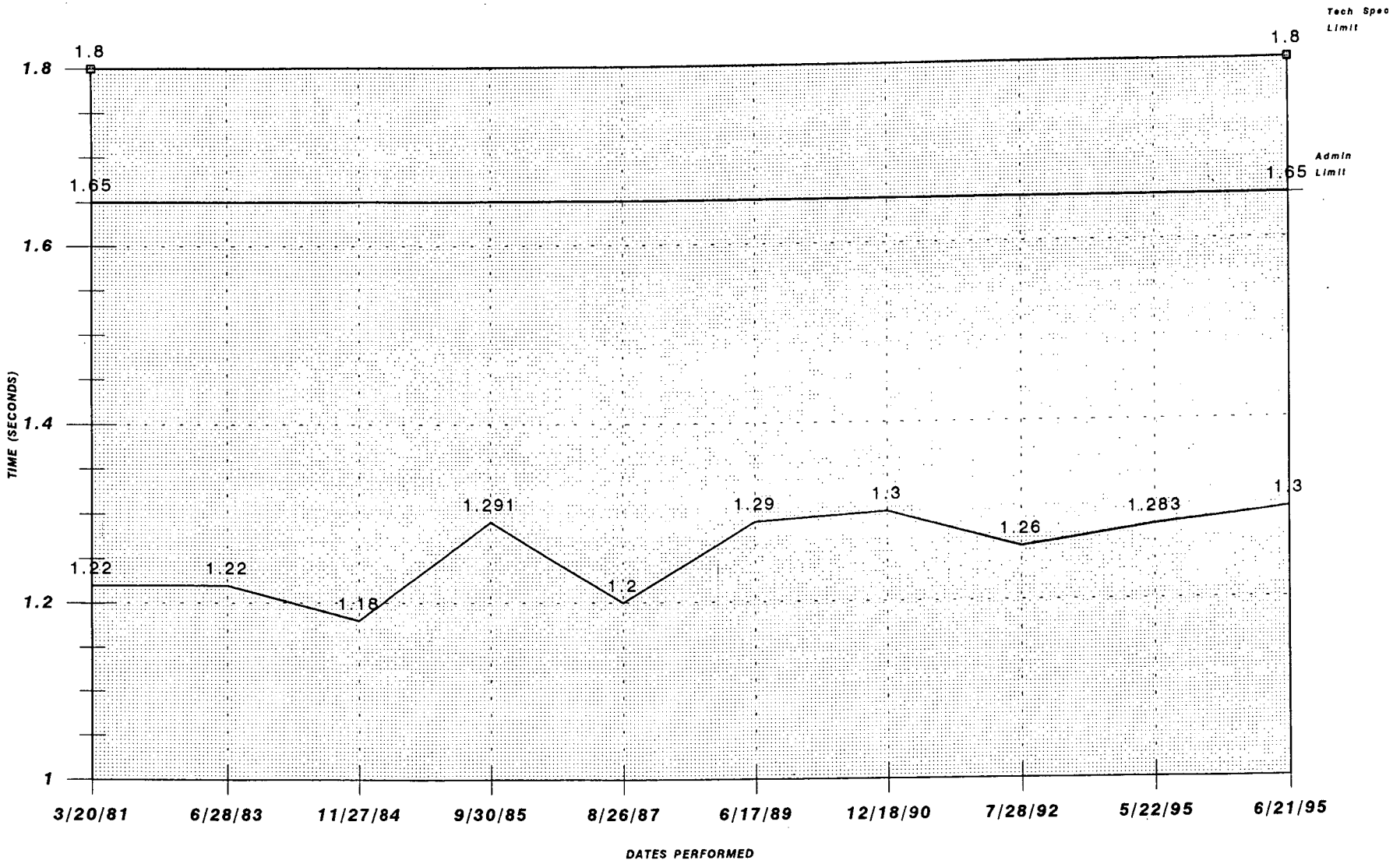
FULL LENGTH ROD DROP TIME TESTS



Attachment 2.27

ROD K-2

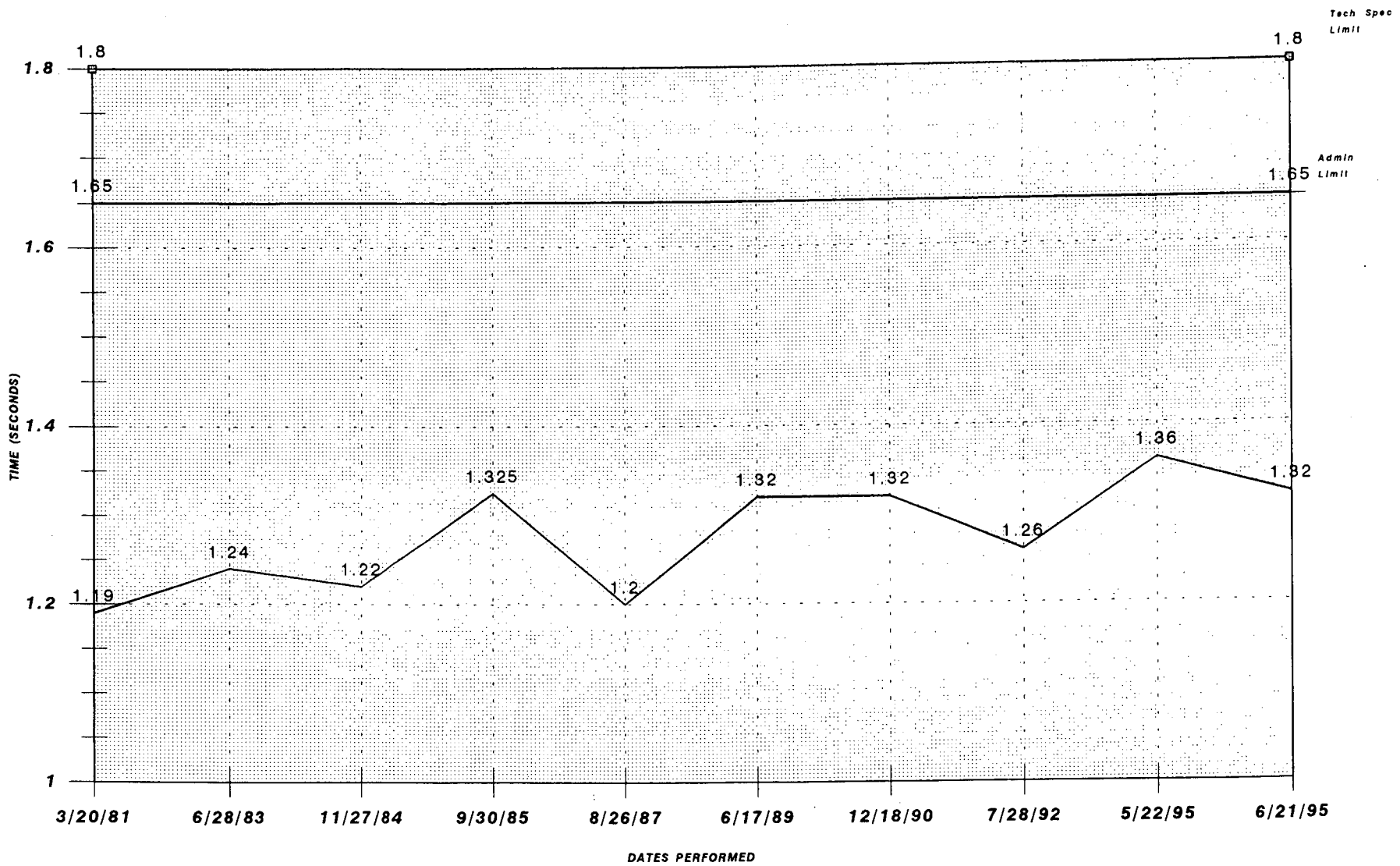
FULL LENGTH ROD DROP TIME TESTS



Attachment 2.28

ROD H-8

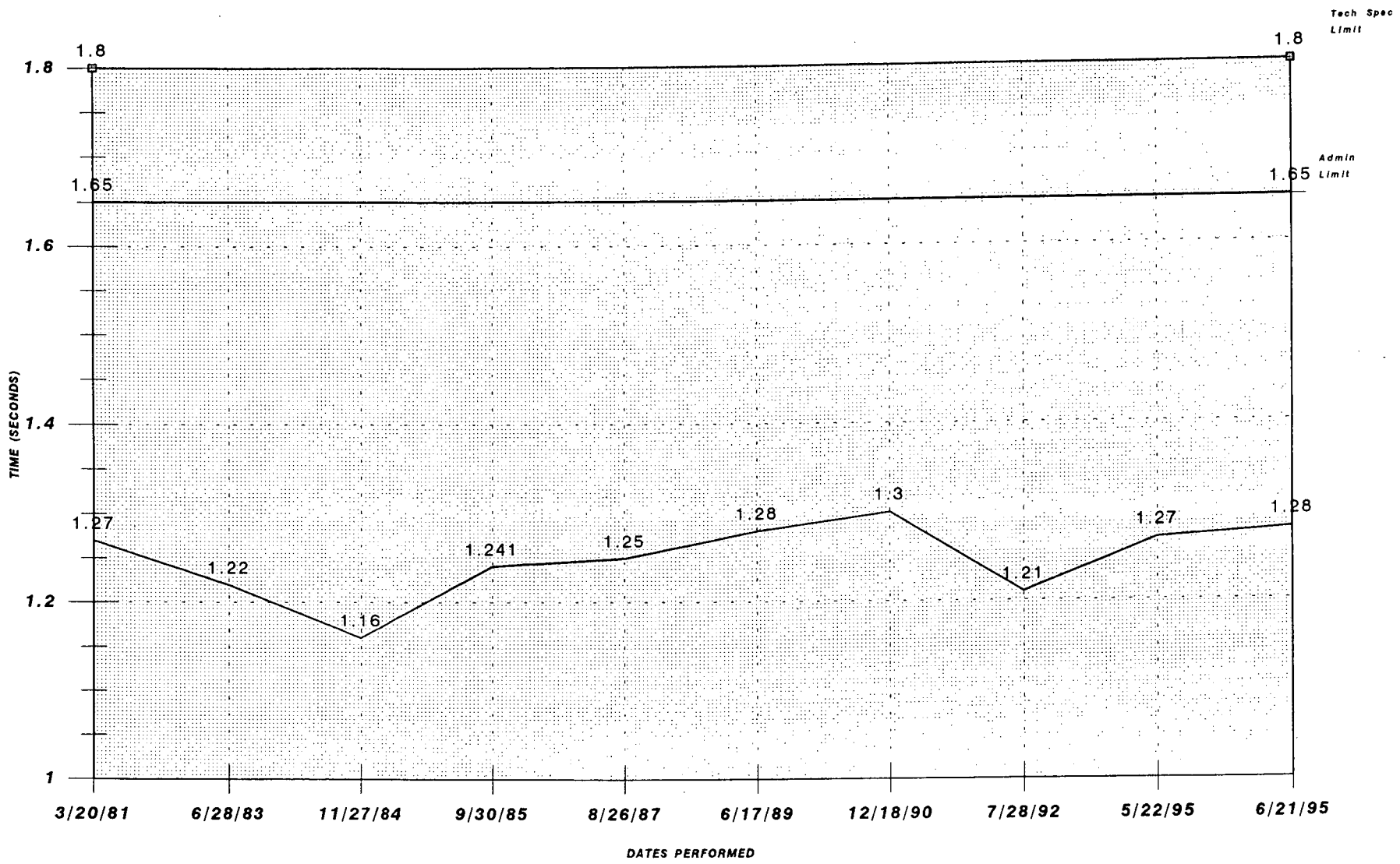
FULL LENGTH ROD DROP TIME TESTS



Attachment 2.29

ROD D-4

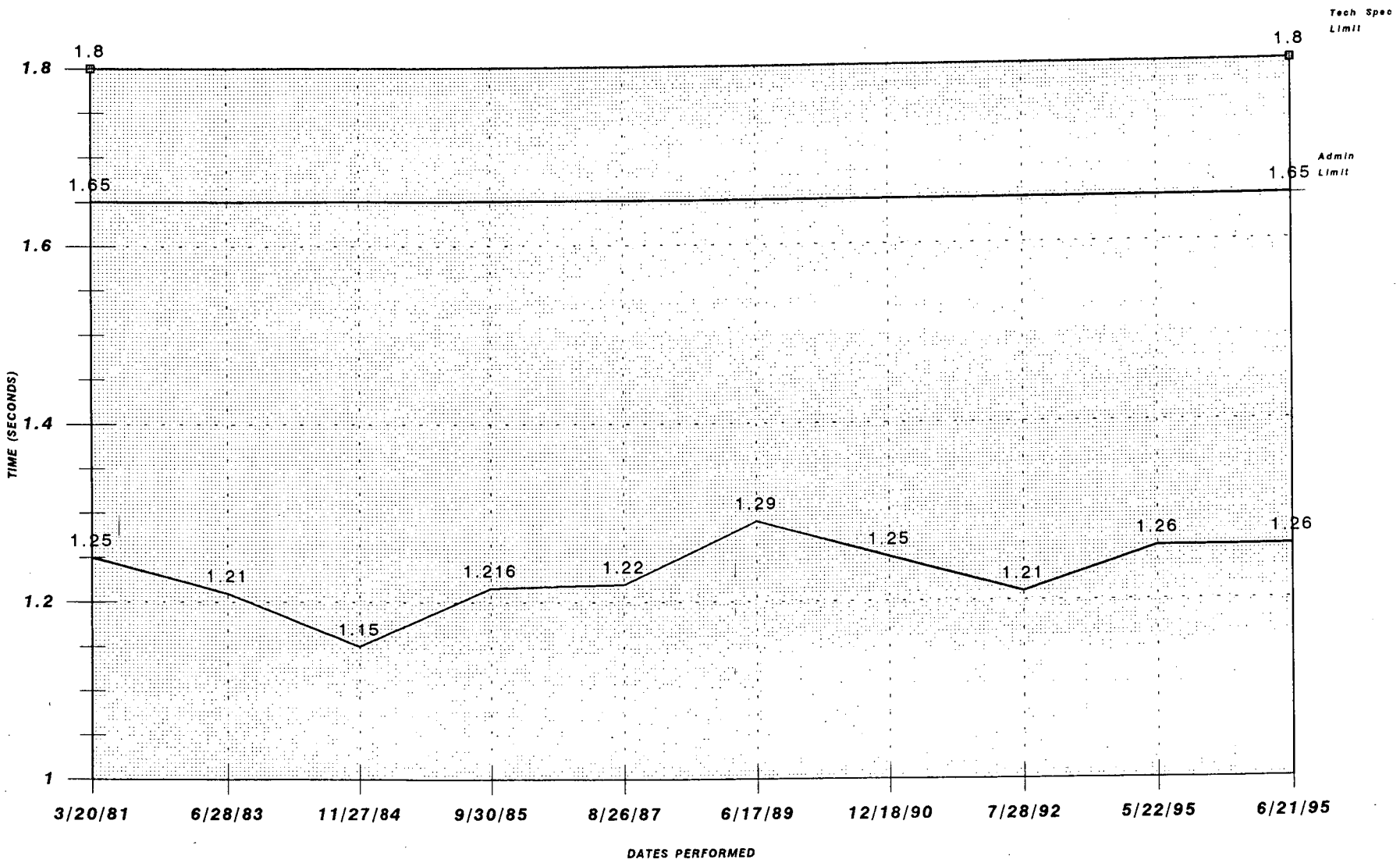
FULL LENGTH ROD DROP TIME TESTS



Attachment 2.30

ROD D-12

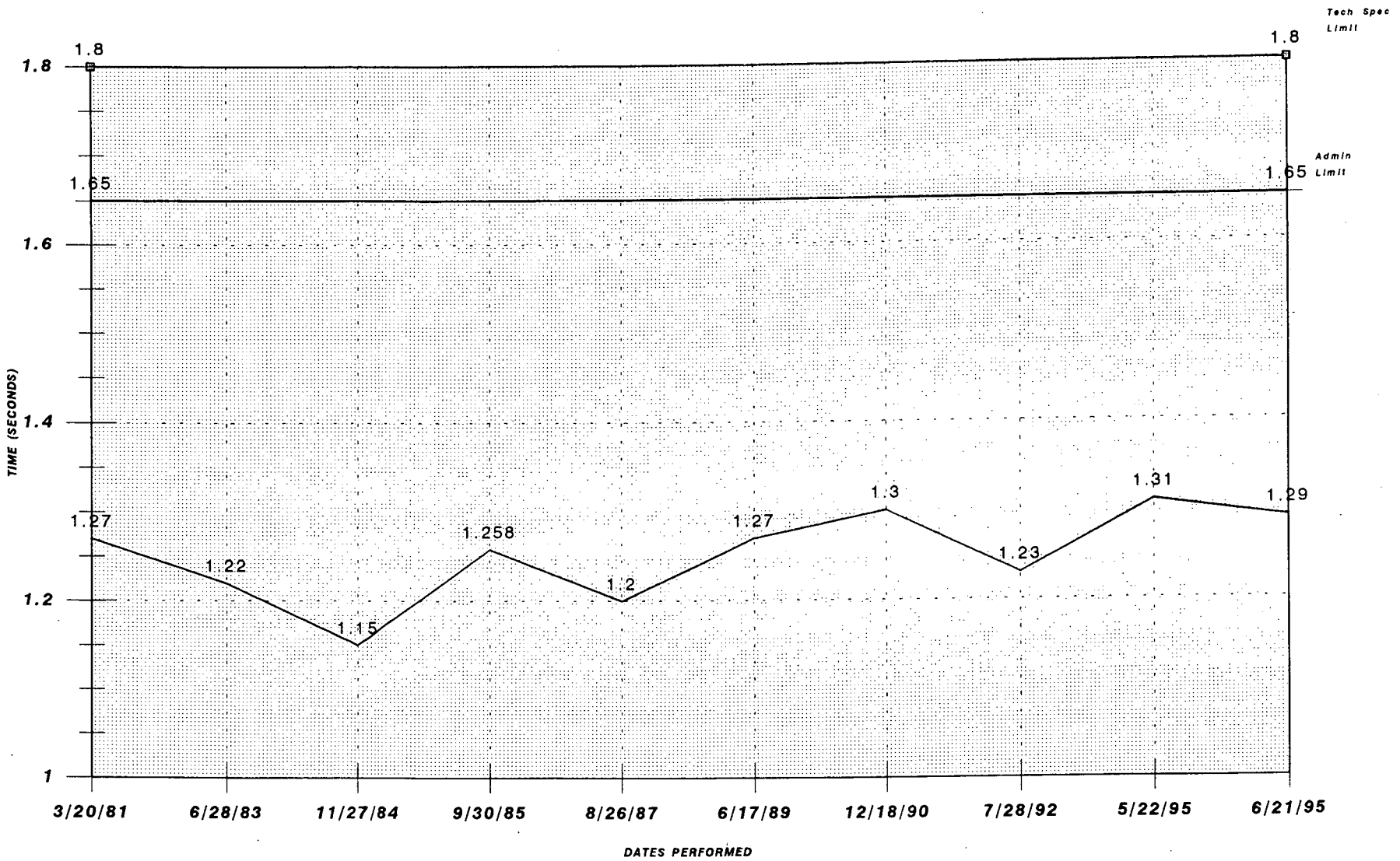
FULL LENGTH ROD DROP TIME TESTS



Attachment 2.31

ROD M-12

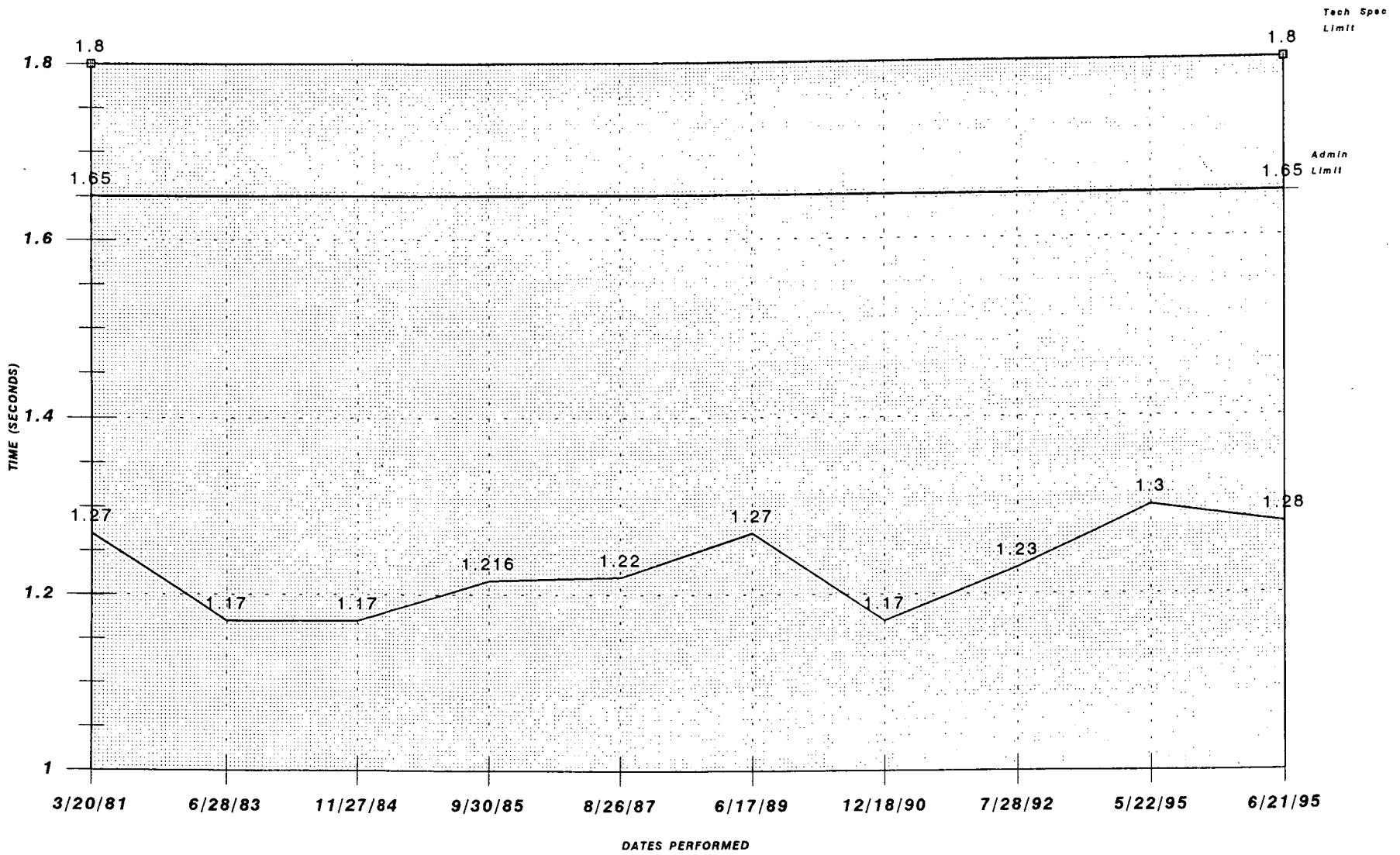
FULL LENGTH ROD DROP TIME TESTS



Attachment 2.32

ROD M-4

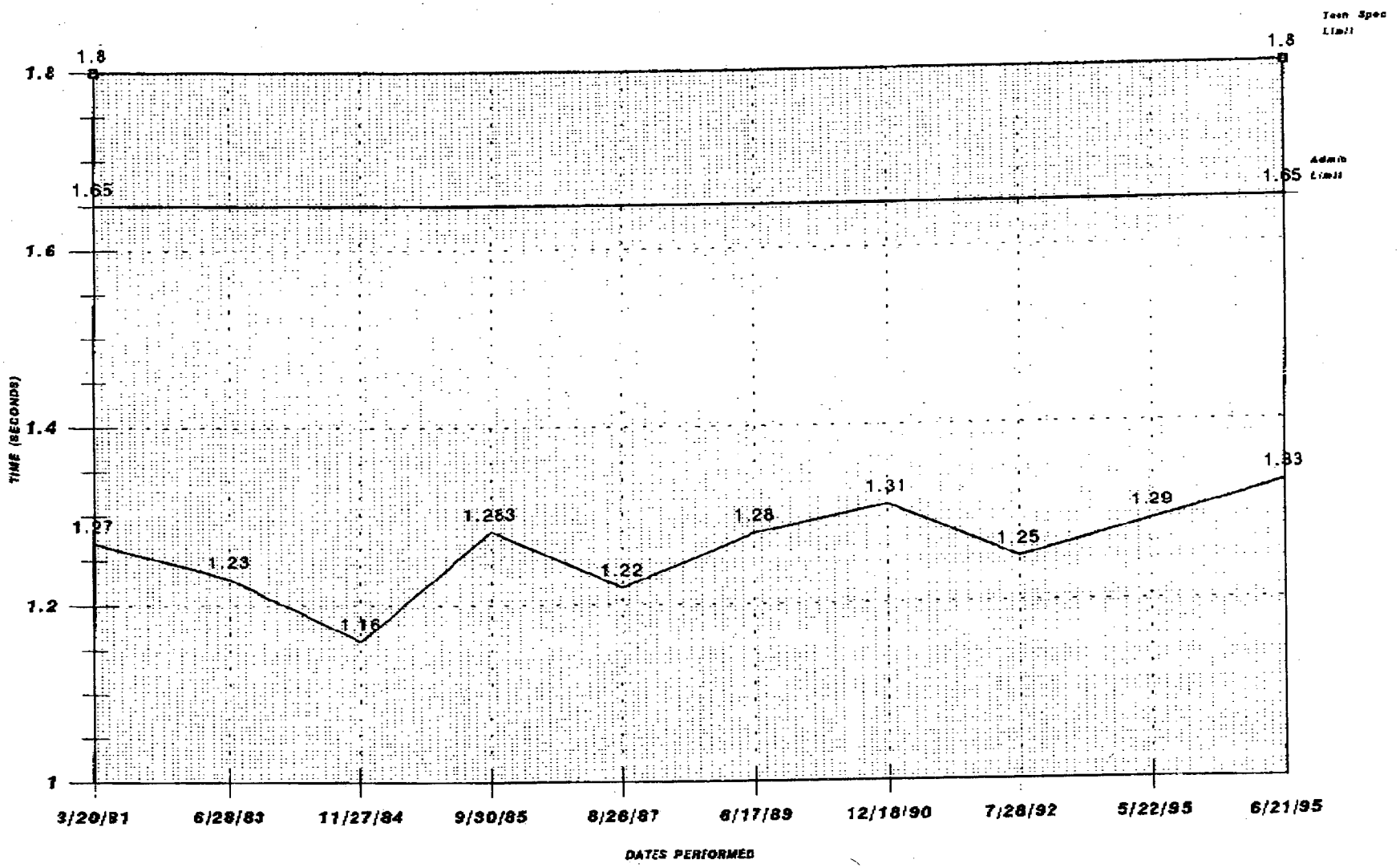
FULL LENGTH ROD DROP TIME TESTS



Attachment 2.33

ROD G-5

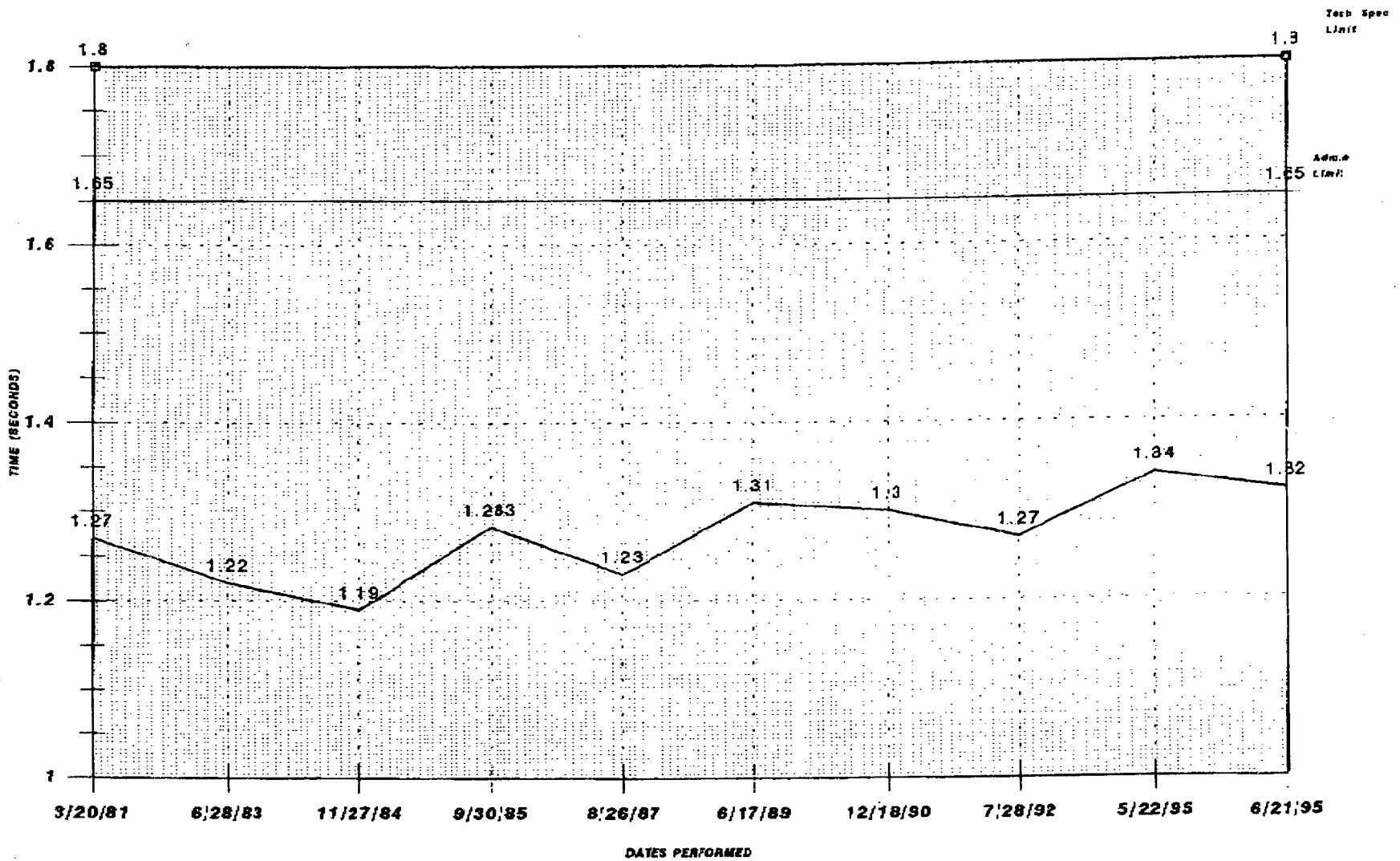
FULL LENGTH ROD DROP TIME TESTS



Attachment 2.34

ROD E-9

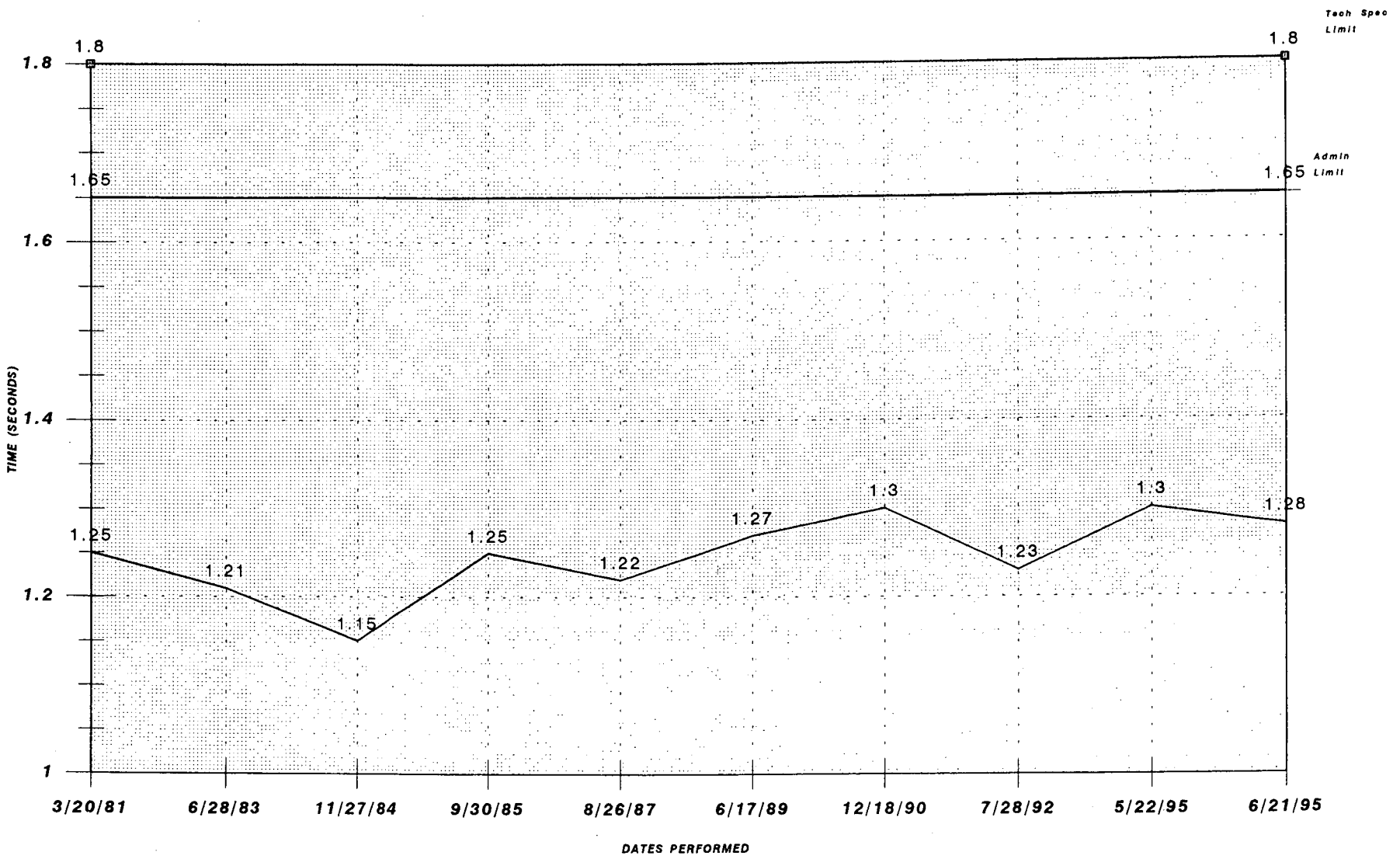
FULL LENGTH ROD DROP TIME TESTS



Attachment 2.35

ROD J-11

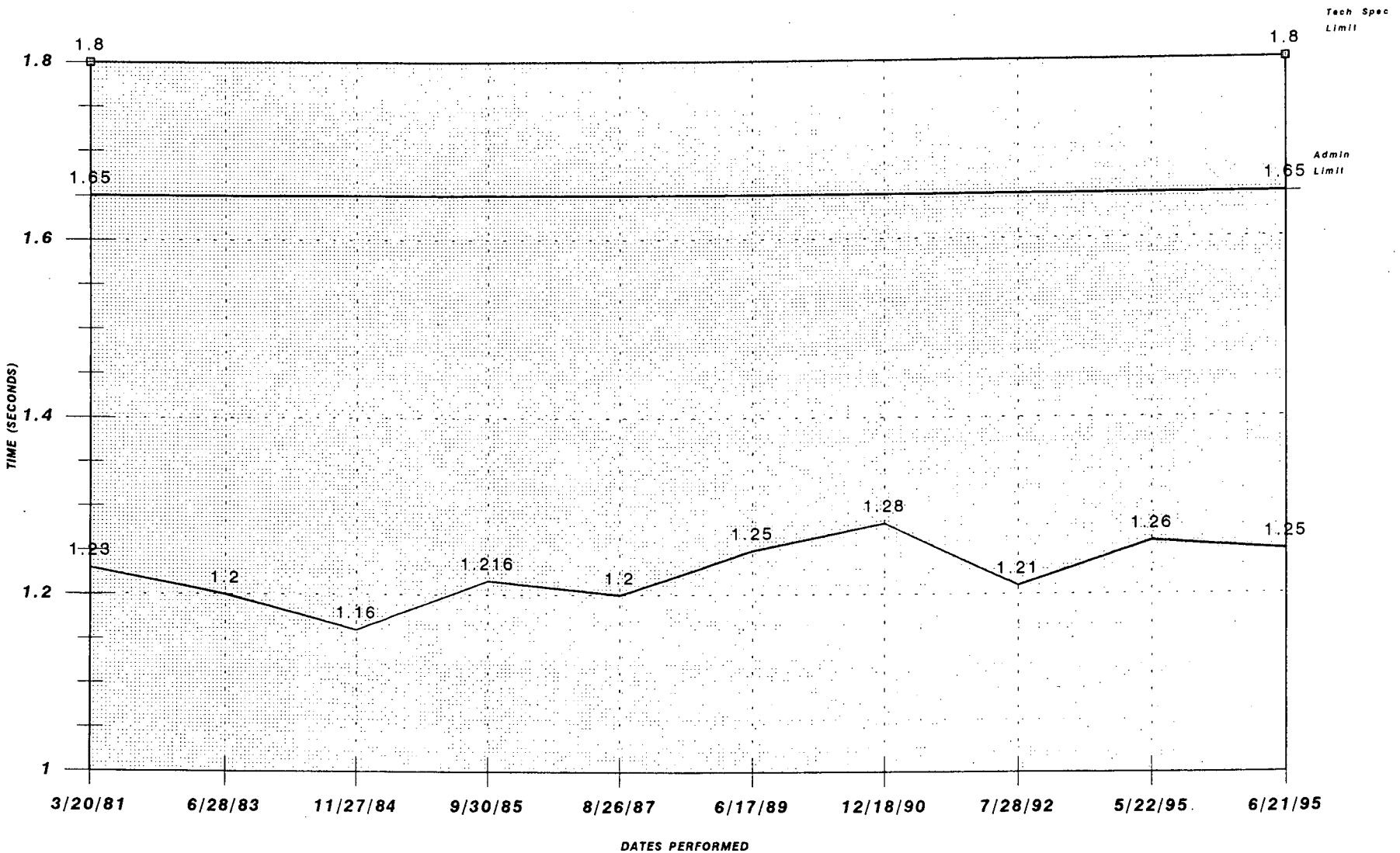
FULL LENGTH ROD DROP TIME TESTS



Attachment 2.36

ROD G-3

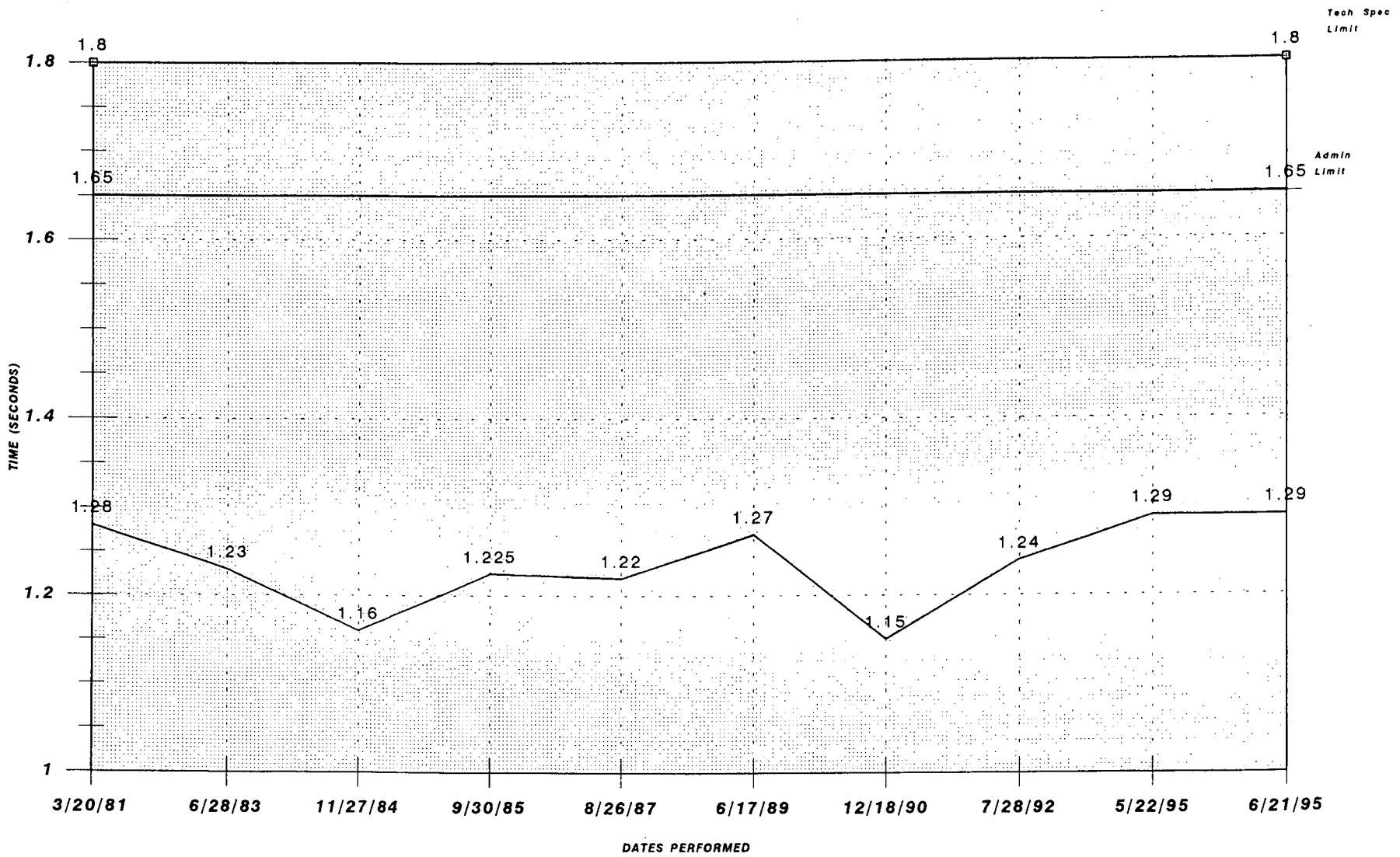
FULL LENGTH ROD DROP TIME TESTS



Attachment 2.37

ROD C-9

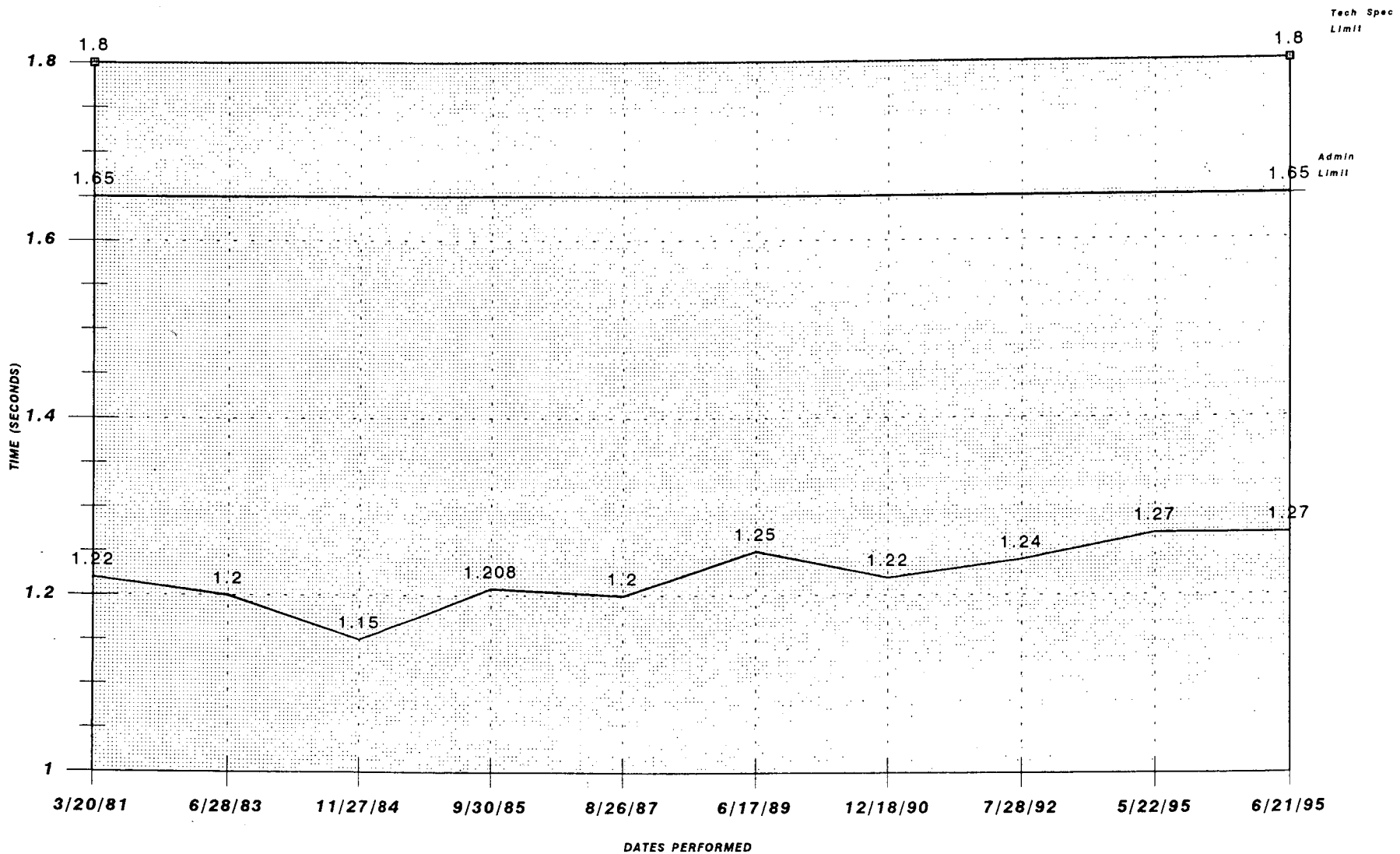
FULL LENGTH ROD DROP TIME TESTS



Attachment 2.38

ROD J-13

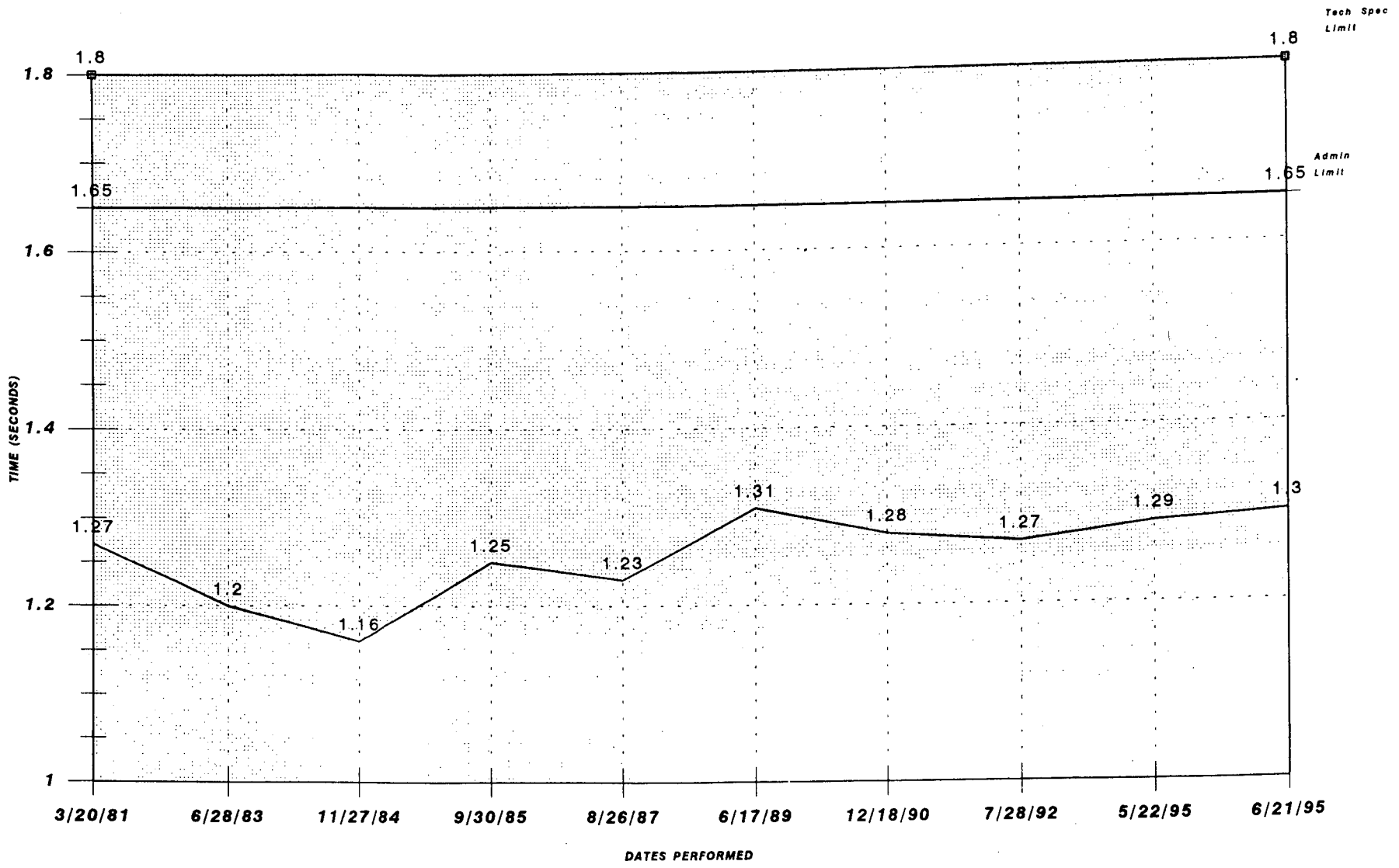
FULL LENGTH ROD DROP TIME TESTS



Attachment 2.39

ROD N-7

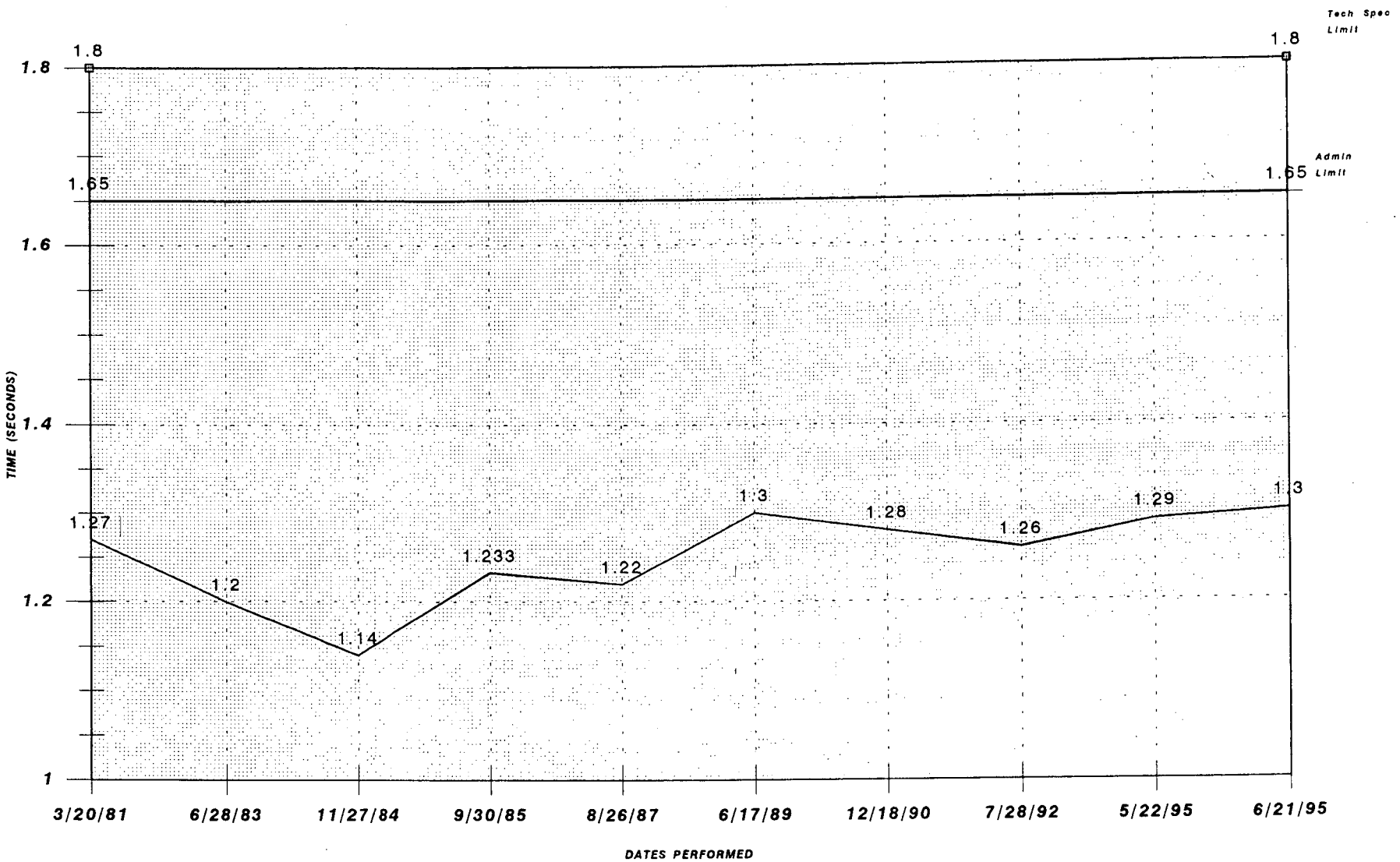
FULL LENGTH ROD DROP TIME TESTS



Attachment 2.40

ROD C-7

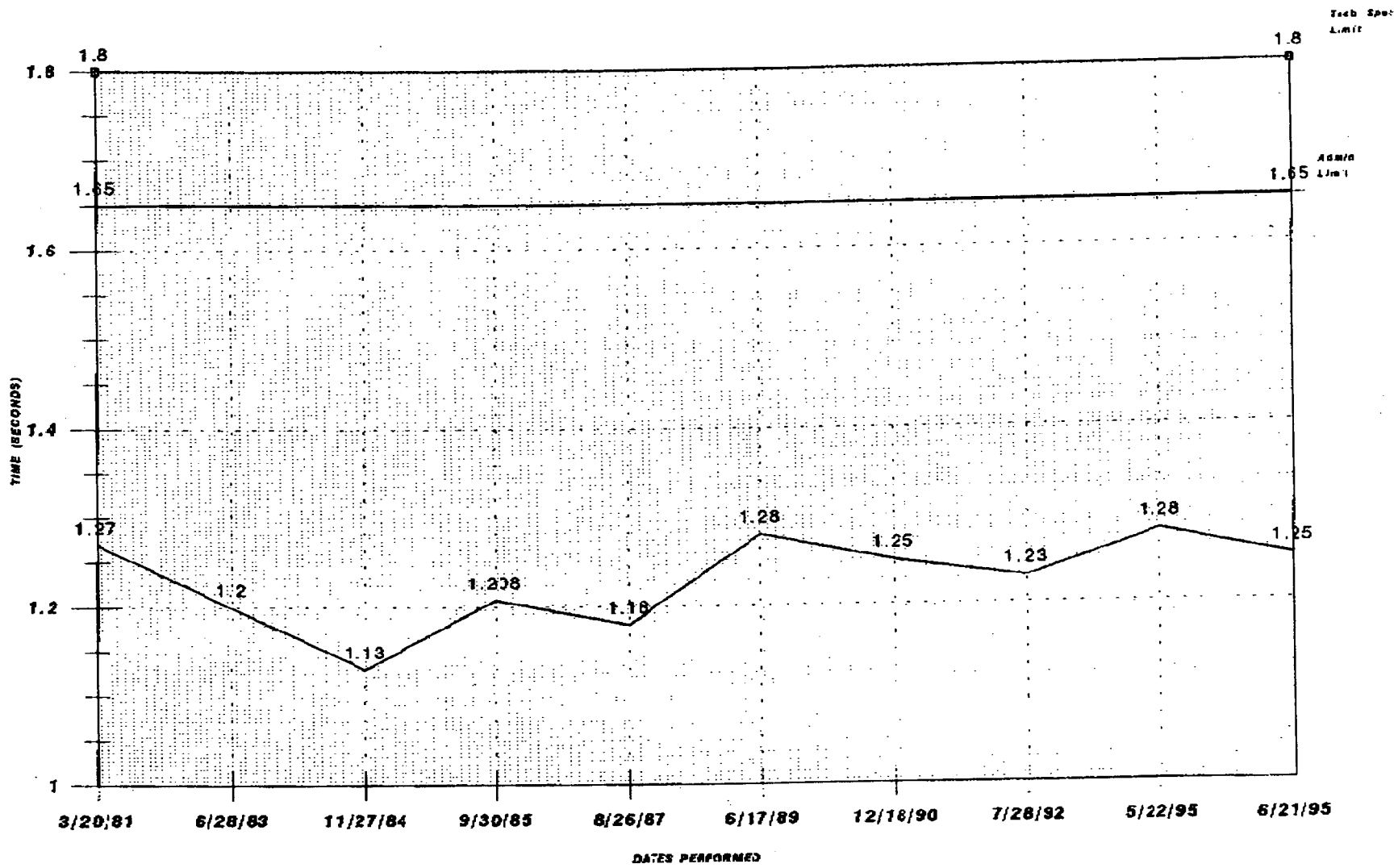
FULL LENGTH ROD DROP TIME TESTS



Attachment 2.41

ROD G-13

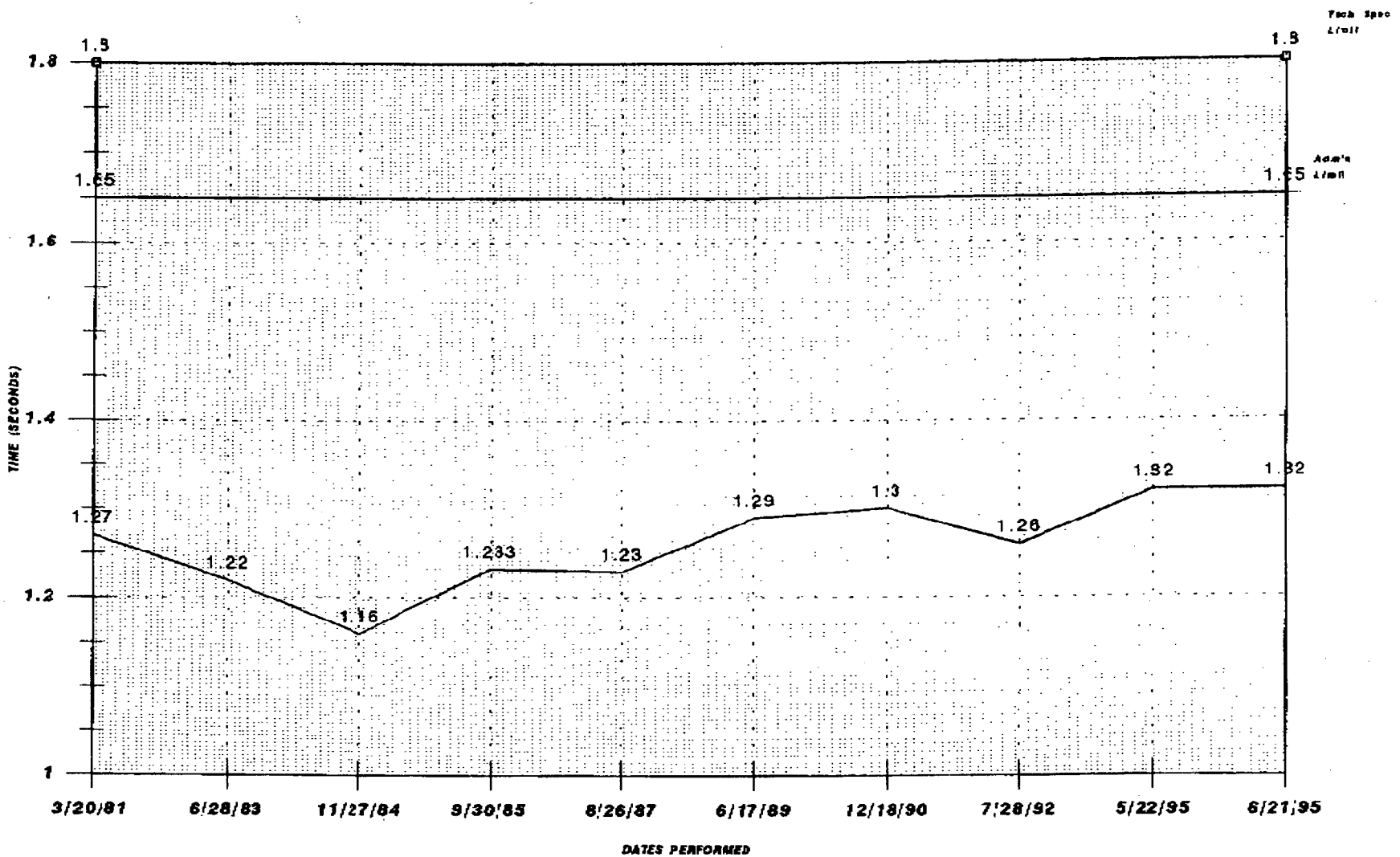
FULL LENGTH ROD DROP TIME TESTS



Attachment 2.42

ROD N-9

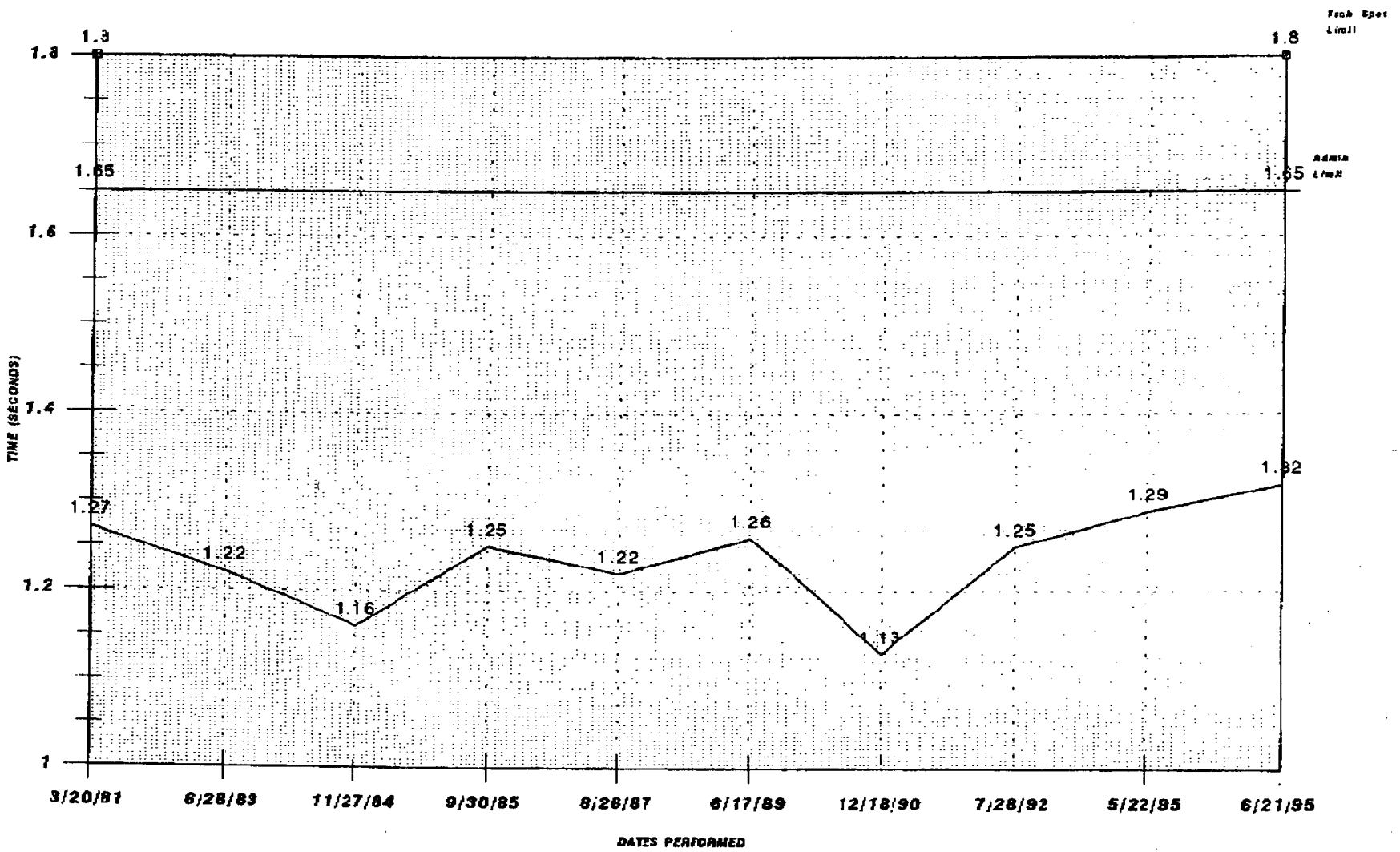
FULL LENGTH ROD DROP TIME TESTS



Attachment 2.43

ROD J-3

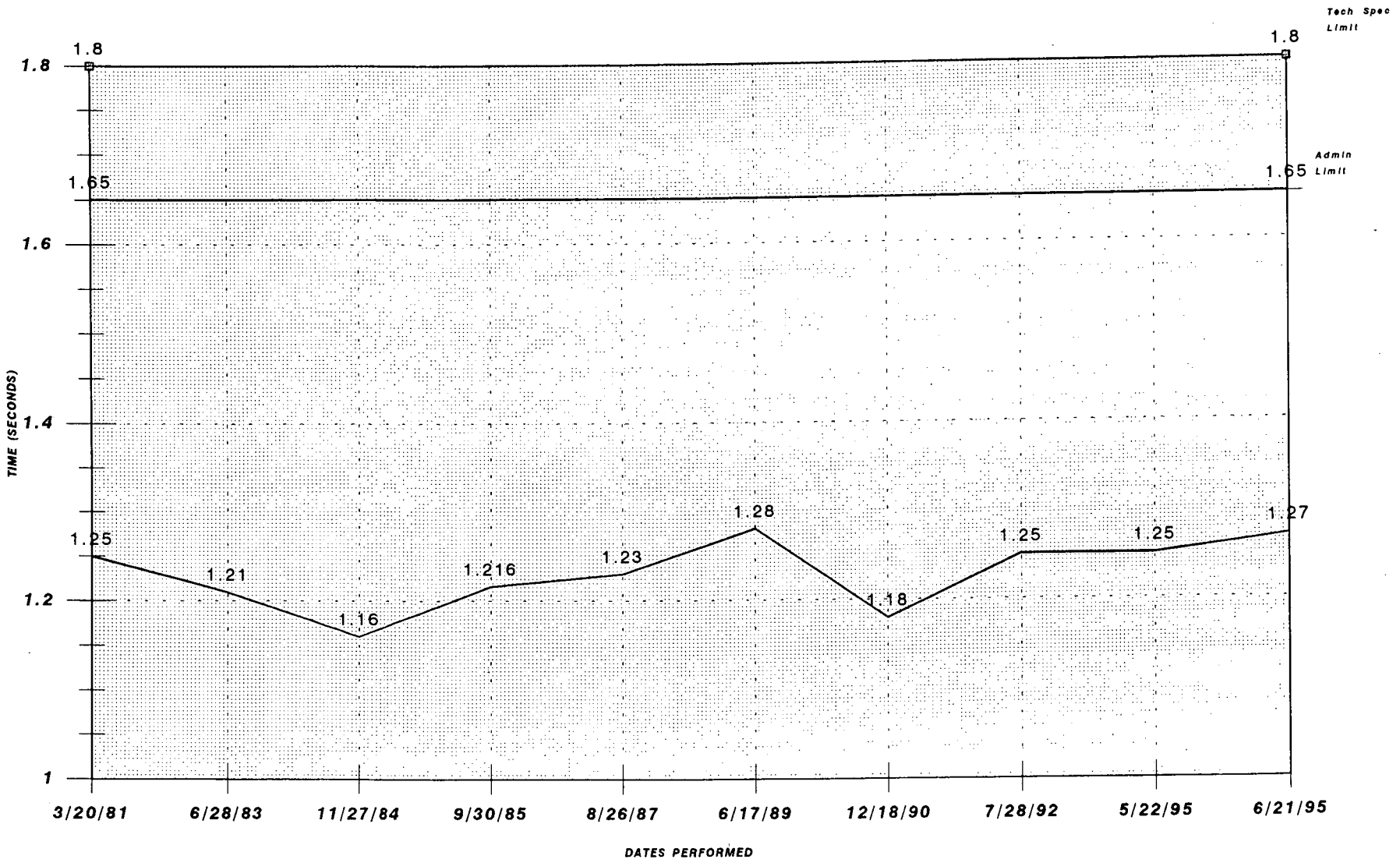
FULL LENGTH ROD DROP TIME TESTS



Attachment 2.44

ROD H-2

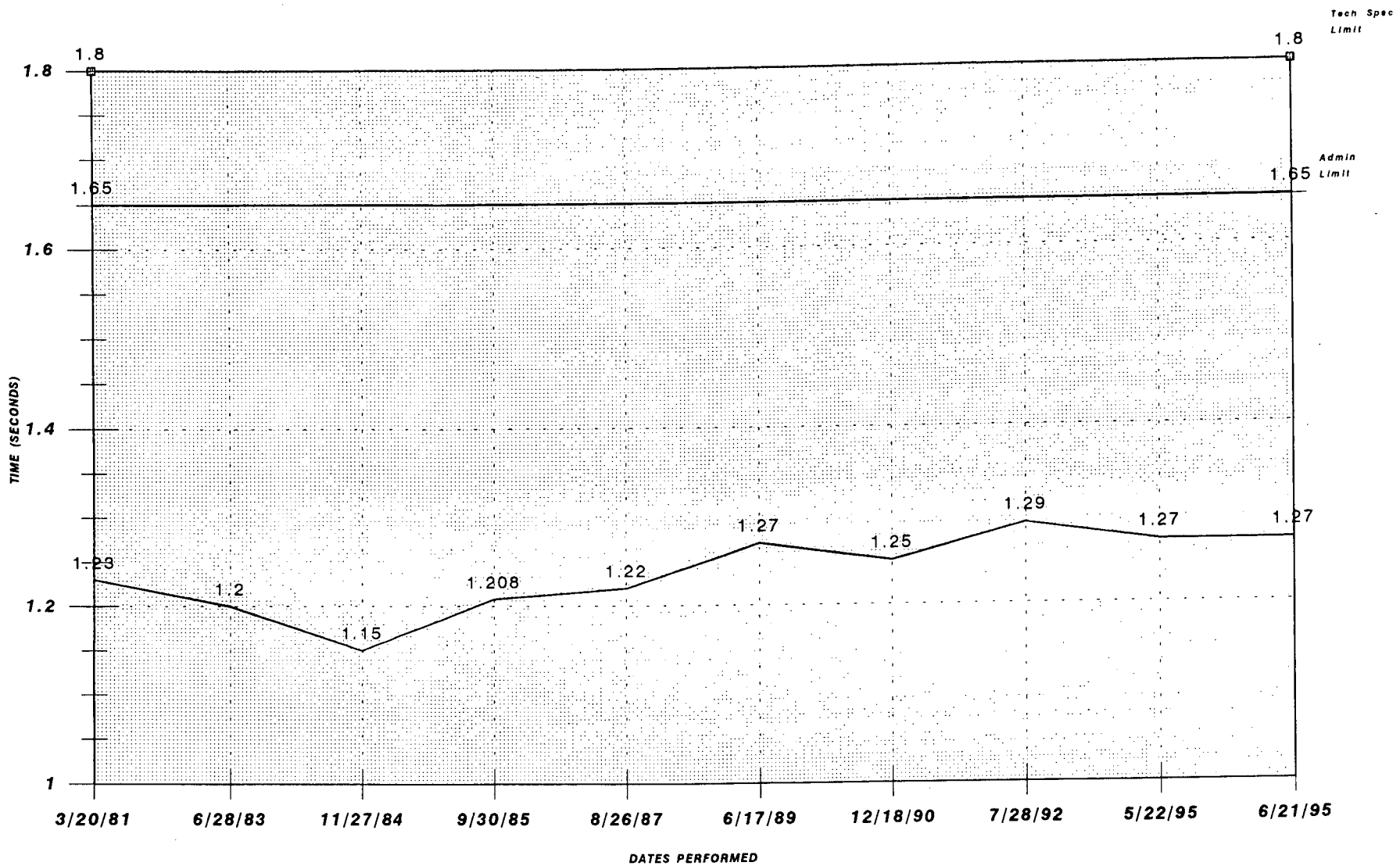
FULL LENGTH ROD DROP TIME TESTS



Attachment 2.45

ROD B-8

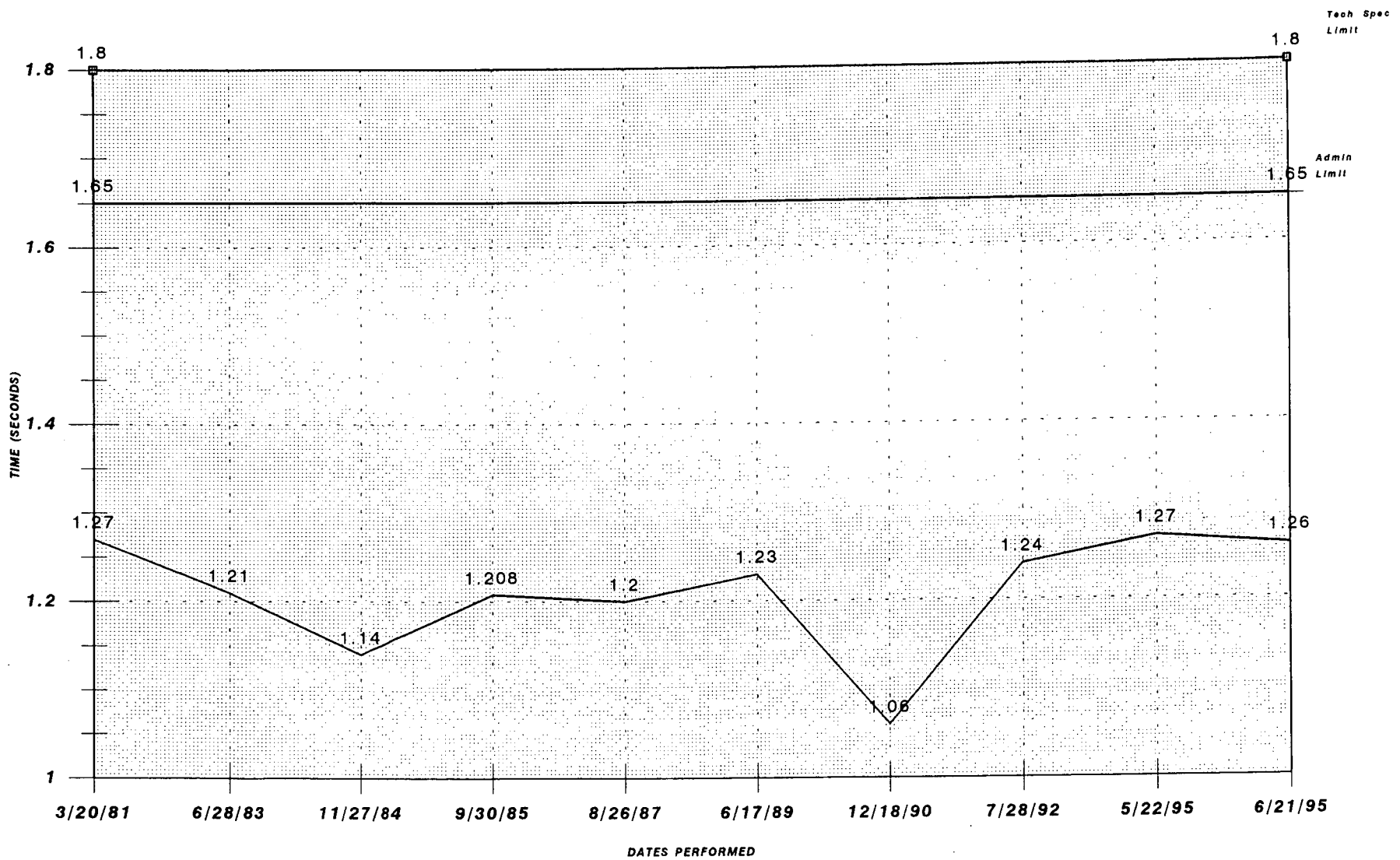
FULL LENGTH ROD DROP TIME TESTS



Attachment 2.46

ROD H-14

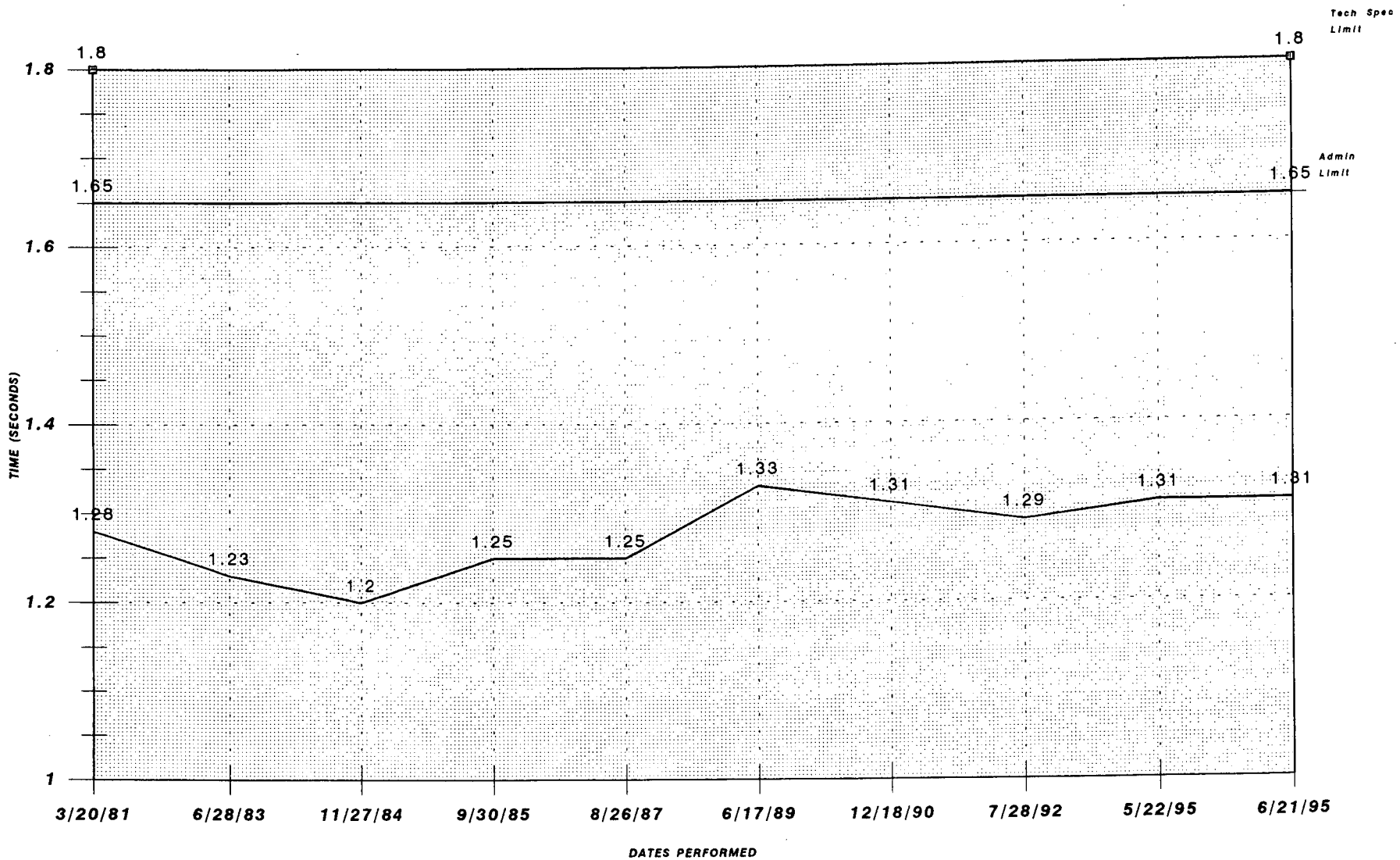
FULL LENGTH ROD DROP TIME TESTS



Attachment 2.47

ROD P-8

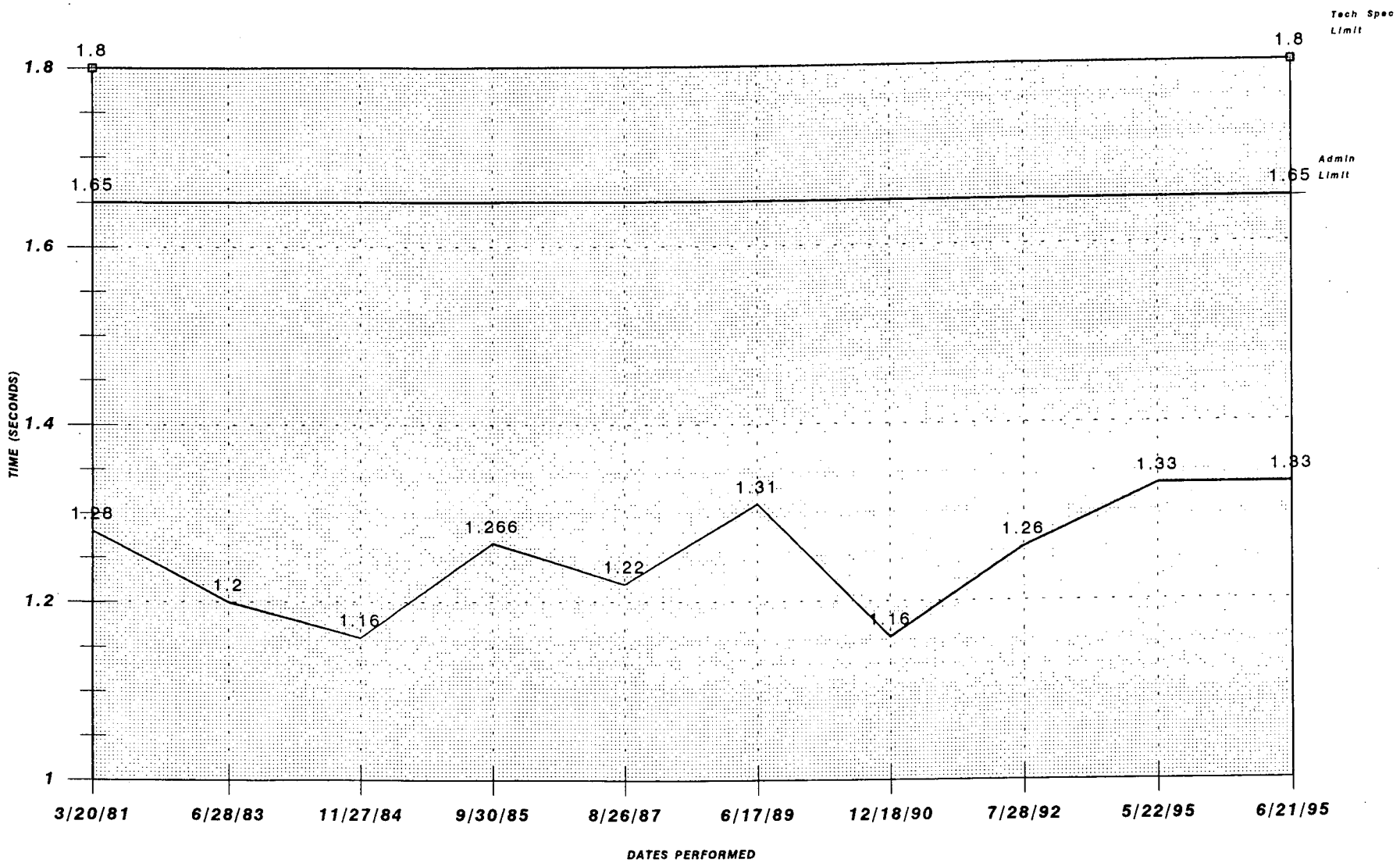
FULL LENGTH ROD DROP TIME TESTS



Attachment 2.48

ROD F-6

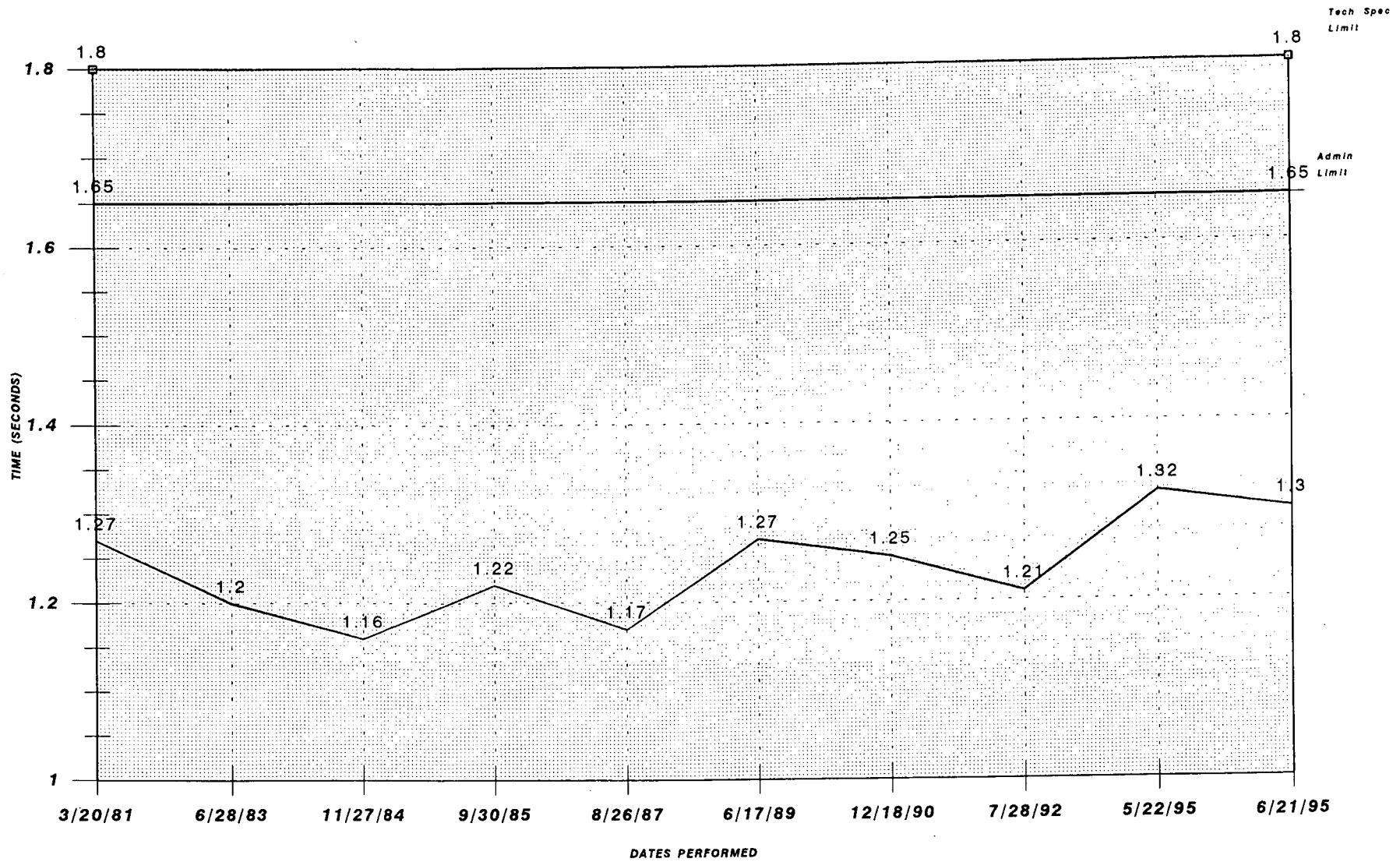
FULL LENGTH ROD DROP TIME TESTS



Attachment 2.49

ROD F-10

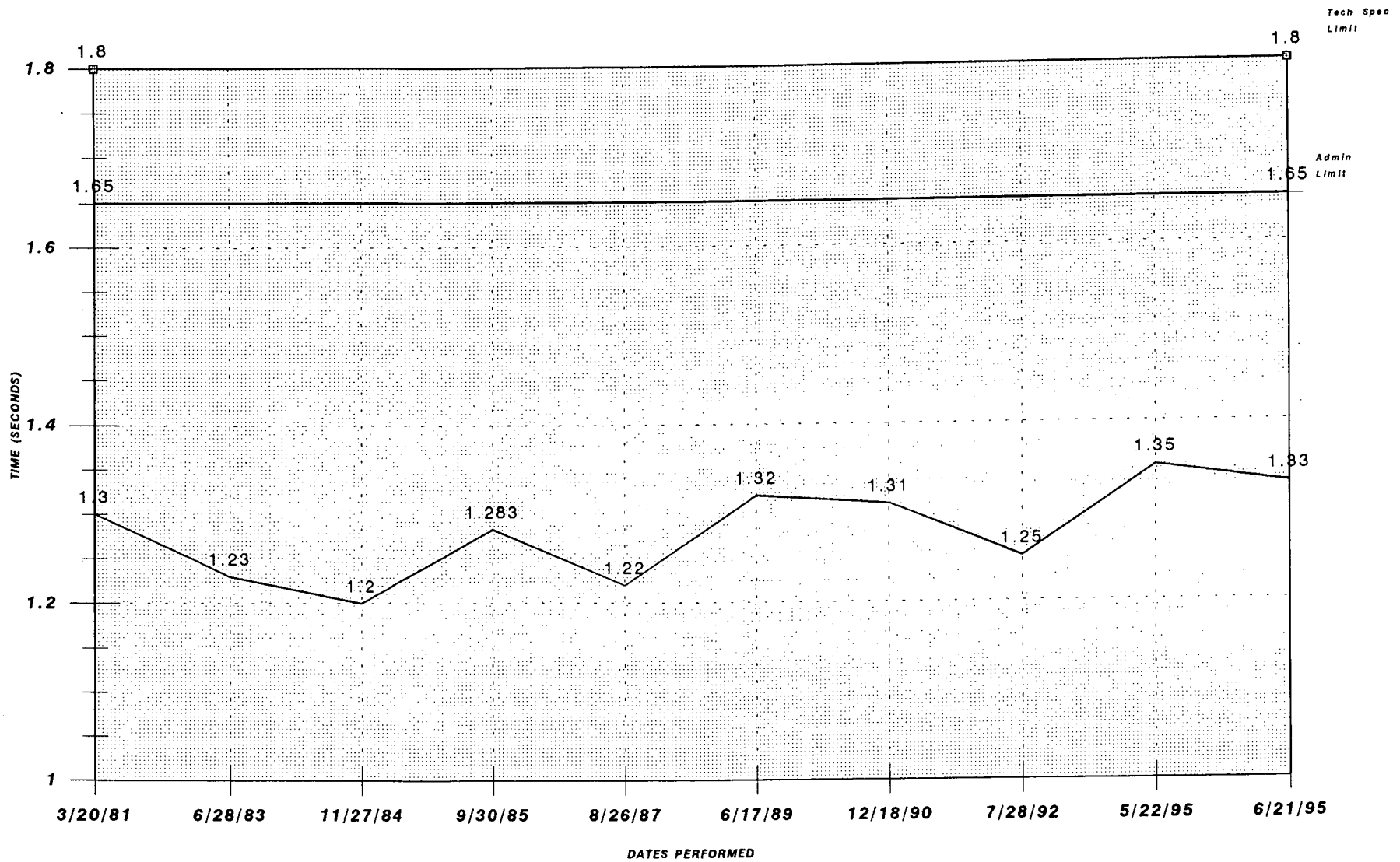
FULL LENGTH ROD DROP TIME TESTS



Attachment 2.50

ROD K-10

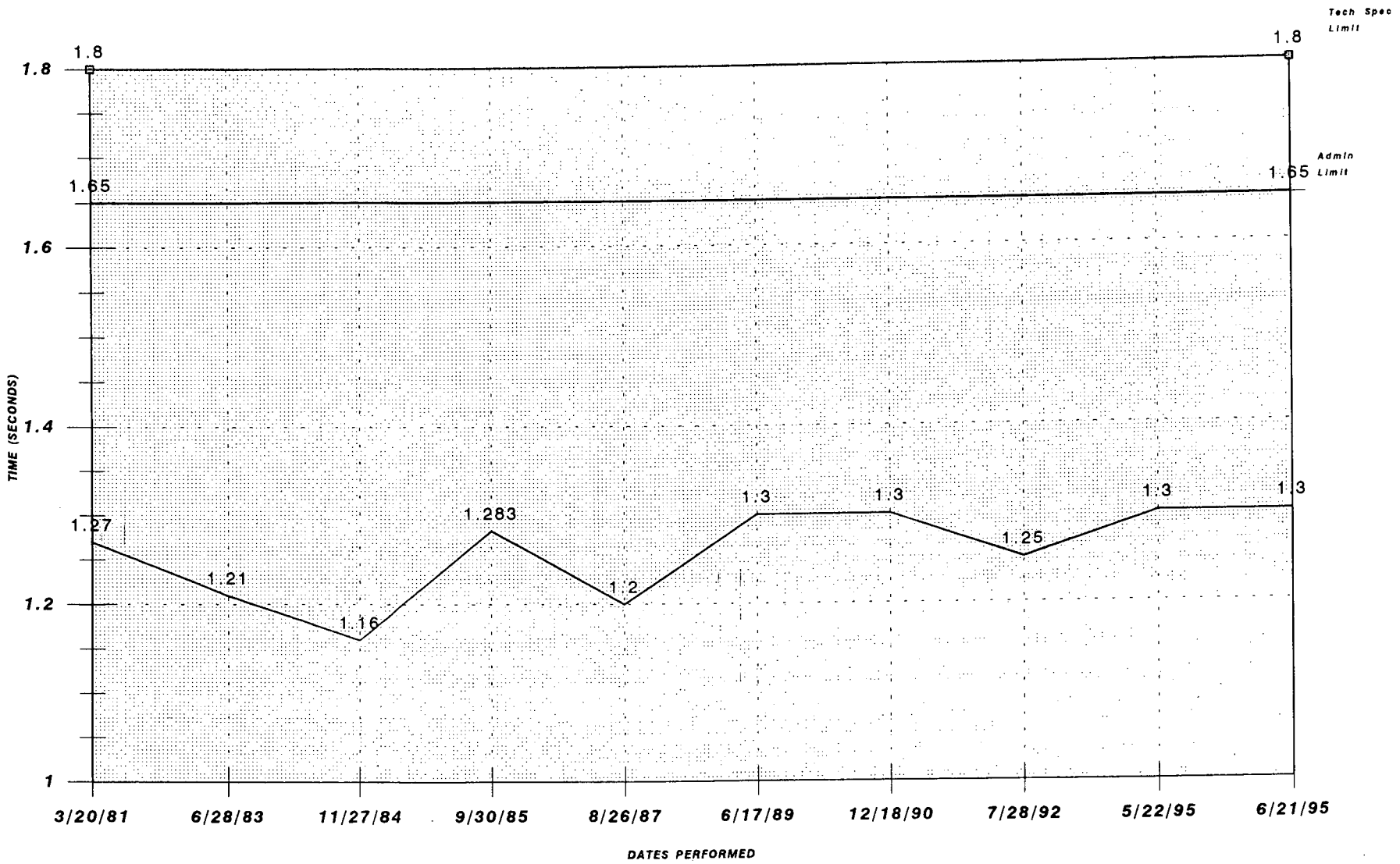
FULL LENGTH ROD DROP TIME TESTS



Attachment 2.51

ROD K-6

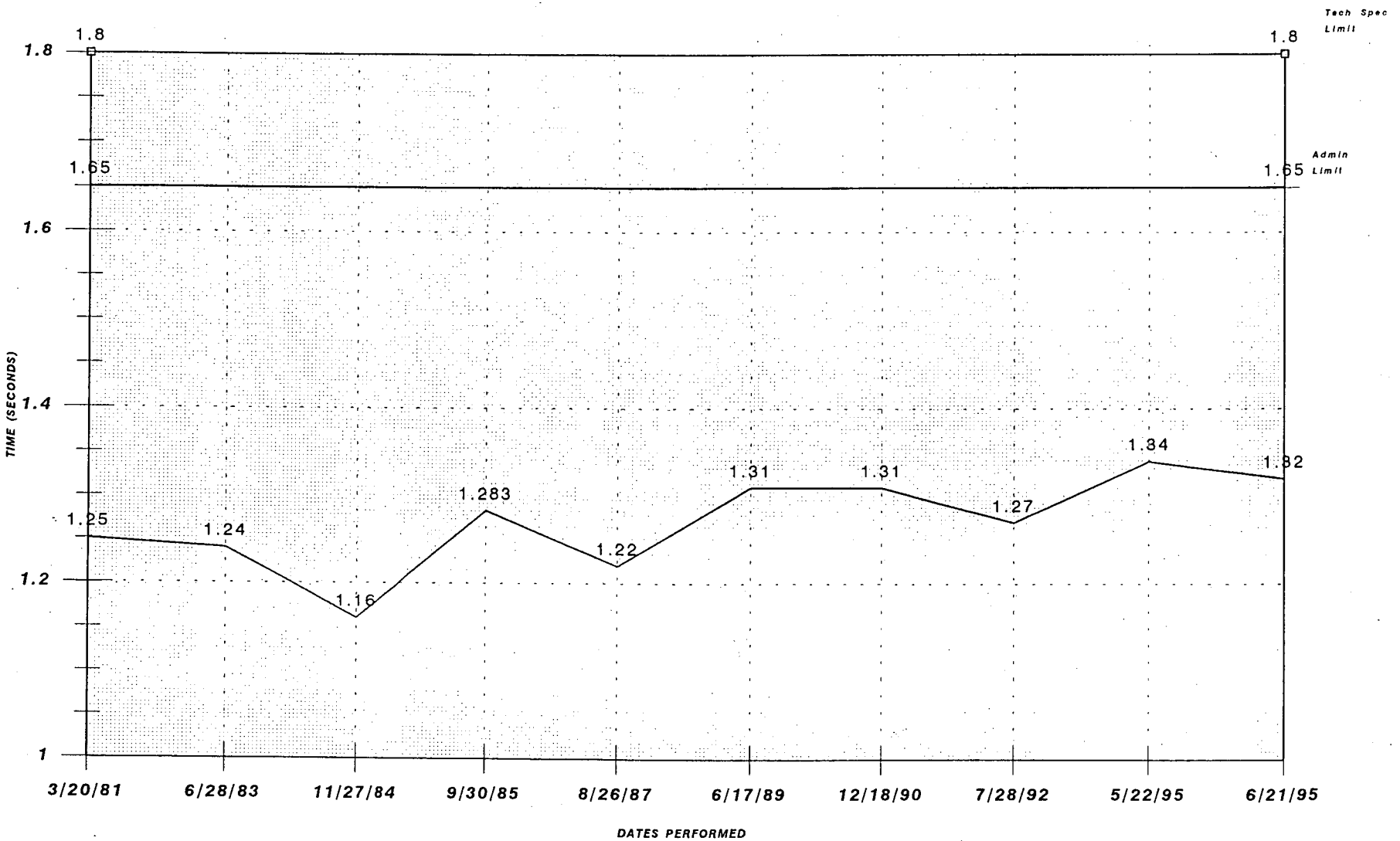
FULL LENGTH ROD DROP TIME TESTS



Attachment 2.52

ROD L-7

FULL LENGTH ROD DROP TIME TESTS



Attachment 2.53