IARJSET ISSN (O) 2393-8021, ISSN (P) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

ISO 3297:2007 Certified ⁜ Impact Factor 8.066 ⁜ Peer-reviewed / Refereed journal ⁜ Vol. 10, Issue 6, June 2023

DOI: 10.17148/IARJSET.2023.10613

Reliability Based Maintenance Scheduling of Public Transport Buses

Krishna Medaraboina

Associate Professor (MED), Matrusri Engineering College, Hyderabad, INDIA.

Abstract: The objective of this paper is to design a suitable maintenance schedule by assessing the condition of the buses using TTT and Weibull's plots and finding out $T_{optimal}$ period of buses. $T_{optimal}$ period helps in fixing the maintenance schedule of each bus. This will help in improving the availability of buses for operation and hence to the productivity improvement of the organization.

Key Words: Reliability, TTT plots, Weibull's plots, $T_{optimal}$, Maintenance schedules

1. INTRODUCTION

TSRTC is the public transport provider with large fleet of buses. To maintain the good condition of the buses, the corporation follows break down as well as Preventive maintenance schedules. When there is failure of buses, they are immediately resolved by sending the service crew and the buses are kept on running condition. And the preventive maintenance are followed in four levels i.e.,

Daily, weekly, monthly (or every 9000 km) and Quarterly (or every 27000 km). Sometimes, the maintenance department also interchange the parts of one bus to the other, to keep the buses moving. But this kind of production orientation would transfer the problems of one bus to the other bus, thus affecting the reliability of the particular bus. Though, every care is taken, the failures are recurring and reliability of some of the buses is coming down. This paper proposes the better maintenance schedules for the good health of the buses.

2. METHODOLOGY

The condition of about forty buses (20 each from two depots) is evaluated in this paper using Total Time on Test (TTT) plots and Weibull's plots. Using this information, a suitable maintenance schedules are developed using $T_{optimal}$ period, which is one of the reliability characteristics.

3. DATA COLLECTION AND PREPARATION OF TABLES FOR TTT AND WEIBULL'S PLOTS

The failure data of 40 buses is collected for six months and presented here, after the required calculations. The same information is used to plot the TTT (MLE method) and Weibull's plots.

[Note: **(a)** x=(n-1) * (O_j-O_i); **(b)** i/n =serial no. of failure/total no. of failures. **(c)** phi=$\sum x_i$/CTBF **(d)** Slope=phi/ [(0.5+(i/n), TBF = Time between failures; CTBF = Cumulative Time between failures; OTBF = Ordered Time between failures].

3.1 The sample Calculations: Sample calculations of bus no.3635 is presented here for reference and the tables 1 and 2 are prepared along with TTT and Weibull's plots (i.e. table1& 2 and fig. 1 & 2). Similarly, for other buses, the values are calculated and the same data is used to plot the TTT graphs and Weibull graphs.

a) x1 = (23-0) * (20-0) = 460 and so on.
b) i/n= Serial no. of failure/total no. of failures =1/23= 0.0435 and so on.
c) Phi_1= 460/1598 = 0.2879 and so on.
d) $Slope_1$ = 0.2879/ [0.5+(1/23)] = 0.5297 and so on.

Preparation of Table I for plotting TTT plot : As described above, the sample table I(of Bus no.3635) is computed and presented below, which is used to plot TTT graph. The data from table I, is also used to prepare table II, which is used for plottting the Weibull's graph.

IARJSET ISSN (O) 2393-8021, ISSN (P) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

ISO 3297:2007 Certified ⁜ Impact Factor 8.066 ⁜ Peer-reviewed / Refereed journal ⁜ Vol. 10, Issue 6, June 2023

DOI: 10.17148/IARJSET.2023.10613

TABLE I: VALUES FOR TTT PLOT (BUS NO.3635)

Failure no.(i)	TBF (Hrs)	CTBF (Hrs)	OTBF (O)	X	∑ (X)	i/n	Phi	Slope
0	0	0	0			0	0	0
1	42	42	20	460	460	0.0435	0.2879	0.5297
2	107	149	20	0	460	0.0870	0.2879	0.4904
3	45	194	20	0	460	0.1304	0.2879	0.4566
4	20	214	22	40	500	0.1739	0.3129	0.4643
5	52	266	27	95	595	0.2174	0.3723	0.5190
6	54	320	40	234	829	0.2609	0.5188	0.6818
7	120	440	42	34	863	0.3043	0.5401	0.6714
8	40	480	42	0	863	0.3478	0.5401	0.6370
9	130	610	45	45	908	0.3913	0.5682	0.6375
10	86	696	52	98	1006	0.4348	0.6295	0.6735
11	20	716	52	0	1006	0.4783	0.6295	0.6435
12	52	768	54	24	1030	0.5217	0.6446	0.6308
13	80	848	64	110	1140	0.5652	0.7134	0.6697
14	20	868	80	160	1300	0.6087	0.8135	0.7338
15	122	990	86	54	1354	0.6522	0.8473	0.7354
16	128	1118	96	80	1434	0.6957	0.8974	0.7505
17	104	1222	104	56	1490	0.7391	0.9324	0.7525
18	125	1347	107	18	1508	0.7826	0.9437	0.7358
19	64	1411	120	65	1573	0.8261	0.9844	0.7423
20	96	1507	122	8	1581	0.8696	0.9894	0.7224
21	42	1549	125	9	1590	0.9130	0.9950	0.7041
22	22	1571	128	6	1596	0.9565	0.9987	0.6857
23	27	1598	130	2	1598	1.0000	1.0000	0.6667
0		0				1	1	
n = 23		1598				-0.5	0	
						0.7391	0.9324	0.7525

3.2 Construction of TTT plots

TTT plot is drawn, by taking *i/n* on x-axis and *phi* on y-axis and the Weibull's plot is constructed by having *ln(t)* on x-axis and *ln (ln (1/(1-i/n)))* on y-axis. These are explained in the following paragraphs with examples.

Sample TTT plotting of Bus no. 3635: From above table I, the following TTT plot (Fig.1) is drawn, by taking *i/n* on x-axis and *phi* on y-axis. The highest point on the slope is 0.7525 and the corresponding values *phi* is 0.9324 and *i/n* is 0.7391.

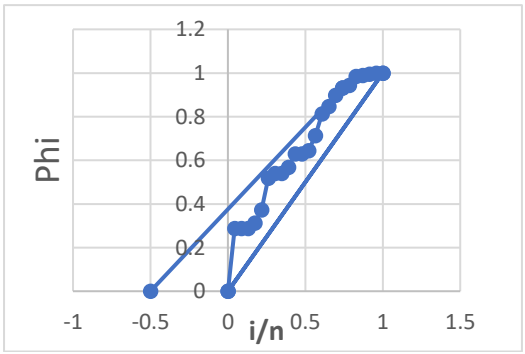

Fig. 1: TTT plot [of bus 3635]

Note: To calculate the optimum maintenance interval, the maximum slope at minimal additional Preventive Maintenance cost i.e., c/(c+k) is used, where c is the maintenance cost due to breakdown and k is the additional cost due

IARJSET ISSN (O) 2393-8021, ISSN (P) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

ISO 3297:2007 Certified ⁜ Impact Factor 8.066 ⁜ Peer-reviewed / Refereed journal ⁜ Vol. 10, Issue 6, June 2023

DOI: 10.17148/IARJSET.2023.10613

to Preventive Maintenance (PM), which is assumed to be 0.5 for all buses. So, the slope value more than 0.67, will give the optimum maintenance interval.

3.3 Table to draw Weibull's plot of Bus no. 3635: Using the values of 'OTBF' and the 'i/n' from the table I, the following is table II is prepared.

TABLE II: VALUES FOR WEIBULL'S PLOT (BUS NO.3635)

OTBF	Ln (OTBF)	i/n	1/(1-i/n)	ln(1/(1-i/n)	ln(Ln(1/(1-i/n)))
0		0	1	0	
20	2.9957	0.0435	1.0455	0.0445	-3.1134
20	2.9957	0.0870	1.0952	0.0910	-2.3972
20	2.9957	0.1304	1.1500	0.1398	-1.9678
22	3.0910	0.1739	1.2105	0.1911	-1.6552
27	3.2958	0.2174	1.2778	0.2451	-1.4060
40	3.6889	0.2609	1.3529	0.3023	-1.1964
42	3.7377	0.3043	1.4375	0.3629	-1.0136
42	3.7377	0.3478	1.5333	0.4274	-0.8499
45	3.8067	0.3913	1.6429	0.4964	-0.7003
52	3.9512	0.4348	1.7692	0.5705	-0.5612
52	3.9512	0.4783	1.9167	0.6506	-0.4299
54	3.9890	0.5217	2.0909	0.7376	-0.3044
64	4.1589	0.5652	2.3000	0.8329	-0.1828
80	4.3820	0.6087	2.5556	0.9383	-0.0637
86	4.4543	0.6522	2.8750	1.0561	0.0545
96	4.5643	0.6957	3.2857	1.1896	0.1736
104	4.6444	0.7391	3.8333	1.3437	0.2955
107	4.6728	0.7826	4.6000	1.5261	0.4227
120	4.7875	0.8261	5.7500	1.7492	0.5592
122	4.8040	0.8696	7.6667	2.0369	0.7114
125	4.8283	0.9130	11.5000	2.4423	0.8930
128	4.8520	0.9565	1.0000		

Weibull's plot of Bus no. 3635: Using the values from Table II, the following graph, Fig.2 is drawn by taking, *ln(t)* on x-axis and *ln (ln (1/(1-i/n)))* on y-axis, and the straight-line equation similar to y = mx+c, (i.e. y = 1.607x - 6.9985) is obtained. From this equation, the values of alpha (α) and beta (β) are found.

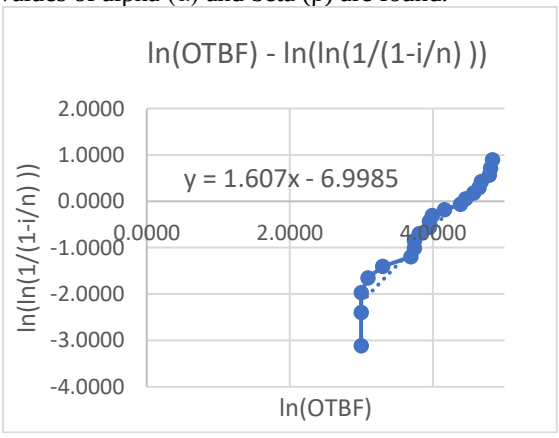

Fig. 2: Weibull's plot [of bus 3635]

4.0 COMPUTATIONS OF 'α' AND 'β' VALUES OF BUS NO. 3635

From fig. 2, the equation obtained is, y = 1.607x - 6.9985, the slope (m)=1.607 which is nothing but 'β' and c (or I) is the Intercept. Further, the value of 'α' is calculated using formula, α = e^(I/β) i.e., α = 77.87. Similarly for all buses the Alpha (α) & Beta (β) values are calculated and presented in table III & IV.

IARJSET ISSN (O) 2393-8021, ISSN (P) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

ISO 3297:2007 Certified ⁜ Impact Factor 8.066 ⁜ Peer-reviewed / Refereed journal ⁜ Vol. 10, Issue 6, June 2023

DOI: 10.17148/IARJSET.2023.10613

TABLE III: ALPHA (A) & BETA (B) VALUES OF DILSUKHNAGAR BUS DEPOT

S.no.	Bus number	β	α
1	3635	1.61	77.87
2	5096	1.62	87.62
3	2194	1.86	74.18
4	7651	1.74	61.29
5	5690	1.99	51.61
6	1944	1.89	76.94
7	3963	1.61	59.48
8	6211	1.33	82.00
9	7142	2.98	91.94
10	6326	2.48	76.32
11	7637	1.88	70.43
12	1943	1.43	63.57
13	7636	1.79	98.10
14	2396	1.65	74.23
15	7262	1.64	73.69
16	5769	1.65	94.00
17	7192	1.54	74.55
18	4022	1.54	72.05
19	3091	1.69	65.76
20	4036	1.73	74.16

TABLE IV: ALPHA (A) & BETA (B) VALUES OF UPPAL BUS DEPOT

S.no.	Bus number	β	α
21	1212	1.42	91.25
22	6123	1.98	77.00
23	6107	2.55	87.34
24	7270	1.99	73.38
25	6783	1.46	93.35
26	9986	1.32	112.84
27	4202	1.46	93.35
28	6772	2.66	98.69
29	7286	1.46	93.35
30	5028	1.83	71.13
31	6773	1.46	93.35
32	1211	2.55	70.13
33	6244	1.46	93.35
34	4543	1.59	83.54
35	6101	1.61	77.24
36	7110	1.71	80.60
37	1157	1.55	52.75
38	6106	1.46	93.35
39	6795	1.65	83.61
40	6791	3.57	85.04

5.0 MAINTENANCE SCHEDULING

From the above, it has been identified that all the beta values are more than 1, which indicates the need to improve the maintenance schedules. So, to arrive at the optimum maintenance schedule, one of the reliability characteristics (i.e. T(mode), (ii) T (median), (iii) T(optimal), (iv) Characteristic life B1 life and (vi) B.1 life), T (Optimal) is chosen for the

IARJSET ISSN (O) 2393-8021, ISSN (P) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

ISO 3297:2007 Certified ⁜ Impact Factor 8.066 ⁜ Peer-reviewed / Refereed journal ⁜ Vol. 10, Issue 6, June 2023

DOI: 10.17148/IARJSET.2023.10613

present study and is found out for each of the buses by using the equation **T(Optimal) =** α * [1/(β-1)] ∧ (1/β). AAll the values are tabulated in the tables (V and VI for Dilsukhnagar and Uppal depots respectively). **Sample Calculation of Bus no.3635:** From table III, the value of β =1.61 and α =77.87 and using the equation, **T(Optimal) =** α * [1/(β-1)] ∧ (1/β) i.e. **T(Optimal) =** 77.87* [1/(1.61-1)] ∧ (1/1.61) =106.24 Hours, or 13 days or 2 weeks (approx.). Similarly, for all the buses, the T(optimal) period is calculated and presented in following tables (V and VI).

TABLE V: T(OPTIMAL) PERIODS OF BUSES OF DILSUKHNAGAR BUS DEPOT

S.no. of Bus	Bus no.	Topt-Hrs	Topt-days	Topt-weeks
1	3635	106.24	13	2
2	5096	117.42	15	2
3	2194	80.52	10	1
4	7651	72.59	9	1
5	5690	51.85	6	1
6	1944	82.06	10	1
7	3963	80.57	10	1
8	6211	188.07	24	3
9	7142	73.13	9	1
10	6326	65.19	8	1
11	7637	75.55	9	1
12	1943	115.51	14	2
13	7636	111.85	14	2
14	2396	96.29	12	2
15	5769	97.03	12	2
16	7262	121.7	15	2
17	7192	111.29	14	2
18	4022	108.07	14	2
19	3901	81.8	10	1
20	4036	89.3	7	1

TABLE VI: T(OPTIMAL) PERIODS OF BUSES OF UPPAL BUS DEPOT

S.no. of Bus	Bus no.	Topt-Hrs	Topt-days	Topt-weeks
21	1212	167.2	21	3
22	6123	77.6	10	1
23	6107	73.6	9	1
24	7270	73.9	9	1
25	6783	159	20	3
26	9986	268	34	5
27	4202	159	20	3
28	6772	81.6	10	1
29	7286	159	20	3
30	5028	79	10	1
31	6773	159	20	3
32	1211	59.1	7	1
33	6244	159	20	3
34	4543	165.6	21	3
35	6101	105	13	2
36	7110	98	12	2
37	1157	77.6	10	1
38	6106	159	20	3
39	6795	108.9	14	2
40	6791	65.3	8	1

IARJSET ISSN (O) 2393-8021, ISSN (P) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

ISO 3297:2007 Certified ⁜ Impact Factor 8.066 ⁜ Peer-reviewed / Refereed journal ⁜ Vol. 10, Issue 6, June 2023

DOI: 10.17148/IARJSET.2023.10613

from the tables: At the corporation, the full maintenance is carried out every quarterly, but the study show that the maintenance of 20 buses (sample lot), has to be taken up as below:

a. For Dilsukhnagar depot

- 10 buses require full maintenance every week
- 9 buses require full maintenance every two weeks and
- 1 bus require full maintenance every 3 weeks.
-

b. For Uppal depot

- 8 buses require full maintenance every week
- 3 buses require full maintenance every two weeks
- 8 bus require full maintenance every 3 weeks and
- 1 bus requires full maintenance every 5 weeks.

6.0 PROPOSED MAINTENANCE SCHEDULE

Using the T optimal period (in Weeks), from the above tables V and VI, a new maintenance schedule is prepared and presented in the following tables VII and VIII, for Dilsukhnagar and Uppal depots respectively.

TABLE VII: PROPOSED MAINTENANCE SCHEDULE OF DILSUKHNAGAR BUS DEPOT

S.no. of Bus	WEEK NUMBER FOR MAINTENANCE											
	1	2	3	4	5	6	7	8	9	10	11	12
1		m		m		m		m		m		m
2		m		m		m		m		m		m
3	m	m	m	m	m	m	m	m	m	m	m	m
4	m	m	m	m	m	m	m	m	m	m	m	m
5	m	m	m	m	m	m	m	m	m	m	m	m
6	m	m	m	m	m	m	m	m	m	m	m	m
7	m	m	m	m	m	m	m	m	m	m	m	m
8			m			m			m			m
9			m			m			m			m
10	m	m	m	m	m	m	m	m	m	m	m	m
11	m	m	m	m	m	m	m	m	m	m	m	m
12		m		m		m		m		m		m
13		m		m		m		m		m		m
14		m		m		m		m		m		m
15		m		m		m		m		m		m
16		m		m		m		m		m		m
17		m		m		m		m		m		m
18		m		m		m		m		m		m
19	m	m	m	m	m	m	m	m	m	m	m	m
20	m	m	m	m	m	m	m	m	m	m	m	m
Buses/ week	**9**	**17**	**11**	**18**	**9**	**20**	**9**	**17**	**11**	**18**	**9**	**20**

IARJSET ISSN (O) 2393-8021, ISSN (P) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

ISO 3297:2007 Certified ⁜ Impact Factor 8.066 ⁜ Peer-reviewed / Refereed journal ⁜ Vol. 10, Issue 6, June 2023

DOI: 10.17148/IARJSET.2023.10613

[Note: m = Full Maintenance (as done in schedule IV of the corporation)]

TABLE VIII: PROPOSED MAINTENANCE SCHEDULE OF UPPAL BUS DEPOT

S.no. of Bus	WEEK NUMBER FOR MAINTENANCE											
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
21			m			m			m			m
22	m	m	m	m	m	m	m	m	m	m	m	m
23	m	m	m	m	m	m	m	m	m	m	m	m
24	m	m	m	m	m	m	m	m	m	m	m	m
25			m			m			m			m
26					m					m		
27			m			m			m			m
28	m	m	m	m	m	m	m	m	m	m	m	m
29			m			m			m			m
30	m	m	m	m	m	m	m	m	m	m	m	m
31			m			m			m			m
32	m	m	m	m	m	m	m	m	m	m	m	m
33			m			m			m			m
34			m			m			m			m
35		m		m		m		m		m		m
36		m		m		m		m		m		m
37	m	m	m	m	m	m	m	m	m	m	m	m
38			m			m			m			m
39		m		m		m		m		m		m
40	m	m	m	m	m	m	m	m	m	m	m	m
Buses/ week	**8**	**11**	**16**	**11**	**9**	**19**	**8**	**11**	**16**	**12**	**12**	**19**

7.0 SMOOTHED MAINTENANCE SCHEDULE

From the above tables VII & VIII, it is observed that the maintenance cycle is getting repeated every 6 weeks and weekly load is not equally distributed. So, to have balanced load and proper utilization of manpower, the schedules are balanced (smoothed) by allocating the cells which have lesser load, from the adjoining cells and presented in the following tables IX and X.

7.1 Smoothed Maintenance schedule for Dilsukhnagar Bus Depot

TABLE IX: BALANCED MAINTENANCE SCHEDULE, [NOTE: M=SMOOTHED SCHEDULE]

S.no. of Bus	Sche -duled week	WEEK NUMBER FOR MAINTENANCE											
		1	2	3	4	5	6	7	8	9	10	11	12
1	2		m		m		m		m		m		m
2	2		m		m		m		m		m		m
3	1	m	m	m	m	m	m	m	m	m	m	m	m
4	1	m	m	m	m	m	m	m	m	m	m	m	m
5	1	m	m	m	m	m	m	m	m	m	m	m	m
6	1	m	m	m	m	m	m	m	m	m	m	m	m
7	1	m	m	m	m	m	m	m	m	m	m	m	m

IARJSET ISSN (O) 2393-8021, ISSN (P) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

ISO 3297:2007 Certified ⁜ Impact Factor 8.066 ⁜ Peer-reviewed / Refereed journal ⁜ Vol. 10, Issue 6, June 2023

DOI: 10.17148/IARJSET.2023.10613

8	3			m			m			m			m
9	1	m	m	m	m	m	m	m	m	m	m	m	m
10	1	m	m	m	m	m	m	m	m	m	m	m	m
11	1	m	m	m	m	m	m	m	m	m	m	m	m
12	2		m		m		m		m		m		m
13	2		m		m		m		m		m		m
14	2	***M***		***M***		***M***		***M***		***M***		***M***	
15	2	***M***		***M***		***M***		***M***		***M***		***M***	
16	2	***M***		***M***		***M***		***M***		***M***		***M***	
17	2	***M***		***M***		***M***		***M***		***M***		***M***	
18	2		***M***		***M***		***M***		***M***		***M***		***M***
19	1	m	m	m	m	m	m	m	m	m	m	m	m
20	1	m	m	m	m	m	m	m	m	m	m	m	m
No. of buses/week		**14**	**15**	**15**	**15**	**14**	**16**	**14**	**15**	**15**	**15**	**14**	**16**

Explanation: For example, from above table, take Bus no 1 (i.e. Bus no.3635), which is to be scheduled every 2nd week for full maintenance activities and so on for all other buses. Further, one can understand from the above table, that there is an average load of 15 buses per week which will go for maintenance and hence, the manpower is to be planned and adjusted accordingly.

Similarly, for the buses of Uppal depot, a smoothed maintenance schedule is presented in table X.

7.2 Smoothed Maintenance schedule for Uppal Bus depot

TABLE X: BALANCED MAINTENANCE SCHEDULE [NOTE: **M=SMOOTHED SCHEDULE**]

S.no. of	Sche-duled Week	WEEK NUMBER FOR MAINTENANCE											
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
21	3		M			M			M			M	
22	1	m	m	m	m	m	m	m	m	m	m	m	m
23	1	m	m	m	m	m	m	m	m	m	m	m	m
24	1	m	m	m	m	m	m	m	m	m	m	m	m
25	3			**M**			**M**			**M**			**M**
26	5					**M**					**M**		
27	3	**M**			**M**			**M**			**M**		
28	1	m	m	m	m	m	m	m	m	m	m	m	m
29	3			m			m			m			m
30	1	m	m	m	m	m	m	m	m	m	m	m	m
31	3			m			m			m			m
32	1	m	m	m	m	m	m	m	m	m	m	m	m
33	3		**M**			**M**			**M**			**M**	
34	3	**M**			**M**			**M**			**M**		
35	2			**M**		**M**		**M**		**M**		**M**	
36	2	**M**		**M**		**M**		**M**		**M**		**M**	
37	1	m	m	m	m	m	m	m	m	m	m	m	m

IARJSET ISSN (O) 2393-8021, ISSN (P) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

ISO 3297:2007 Certified ⁜ Impact Factor 8.066 ⁜ Peer-reviewed / Refereed journal ⁜ Vol. 10, Issue 6, June 2023

DOI: 10.17148/IARJSET.2023.10613

38	3	**M**			**M**			**M**			**M**		
39	2		**M**		**M**		**M**		**M**		**M**		
40	1	m	m	m	m	m	m	m	m	m	m	m	m
Buses/ week		**12**	**12**	**13**	**12**	**14**	**12**	**12**	**12**	**13**	**12**	**14**	**12**

Explanation: Take Bus s.no. 21 (i.e. Bus no.1212), it is to be scheduled every 3rd week for full maintenance activities and so on for other buses. There is an average load of 12 buses per week which will go for maintenance and accordingly, the manpower is to be adjusted. It can be noted that (from table X) the bus s.no.26 is operating better among the other buses.

8.0 CONCLUSIONS ON PROPOSED MAINTENANCE SCHEDULE

The new maintenance schedules to be followed by Dilsukhnagar bus depot is given in table IX, which shows that every week there is a load of about 15 buses and for Uppal bus depot the load is about 12 buses (refer table X). These are to be followed in addition to the daily and weekly maintenance schedules. Manpower requirements to be planned/adjusted accordingly. It can be noted that out of these two depots, the Uppal bus depot buses are performing better though the maintenance practices are same at two depots. This indicates the study of driving habits of drivers and performance of repair staff.

REFERENCES

[1]. Dr. N.V.S. Raju, "*Plant maintenance and Reliability engineering*", Cengage Learning-2011.
[2]. Dr. M. Krishna, "*Reliability analysis of group of buses- A case study at TSRTC"*, International journal of Current Engineering and scientific research 2017, Vol. 5, 110
[3]. Dr. M. Krishna, *"Reliability evaluation and characterization of public transport buses using TTT and Weibull's plots"*, 3rd International Conference on Manufacturing, Material Science & Engineering, at CMRIT, Hyderabad.
[4]. Wayne Nelson, *"Graphical Analysis of System Repair Data*", Journal of Quality Technology, USA, Vol.20, No.1, pp 24-35, January 1988.
[5]. Dr. M. Krishna, *"Estimation of failure rate of Public Transport Buses Using Trend Tests and TTT plots",* International Journal of Research and Analytical Reviews. 2019 Volume 6 pp.506- 517.
[6]. E.E. Lewis, "*Introduction to Reliability Engineering*", John Wiley,1989.