Appendix 14.1 Financial and Economic Analysis

Appendix 14.1

Table 14.1-1 - Construction Costs				
No.	Item	¥ (000)	¥/$	$ (000)
1	EMU Finishing Shop	144720	120	1206.0
2	Electrical Apparatus Shop	28800	120	240.0
3	EMU Repair Shop	115200	120	960.0
4	Carbody Painting Shop	77760	120	648.0
5	Carbody Cleaning Shop	16200	120	135.0
6	Electric Loco Finishing Shop	17280	120	144.0
	Sub-Total:	399960	120	3333.0
7	Pavement etc.	45750	120	381.3
8	Rails	19120	120	159.3
9	Sleepers	5310	120	44.3
10	Pointwork	15360	120	128.0
11	Trackbed	7200	120	60.0
12	Inspection Pit	17880	120	149.0
13	Steel for Pit	4420	120	36.8
14	Pavement for Rail Crossing	4800	120	40.0
15	Transformer for EMU	16340	120	136.2
16	Electric Loco Catenary	450	120	3.8
17	EMU Catenary	1350	120	11.3
	Sub-Total:	137980	120	1149.8
18	Adjustment 14/3 +10,000	10000	120	83.3
	Total for Jack Method:	547940	120	4566.2
19	Additional Cost for Crane Method	57600	120	480.0
	Total for Crane Method:	605540	120	5046.2

Table 14.1-2 - Facilities Costs

No.	Item	¥ (000) (Foreign)	¥ (000) (Local)	¥ (000) (Total)	Y/$	$ (000)
1	Carbody Cleaning Shop	115000	4900	119900	120	999.2
2	Carbody Painting Shop	750400	21100	771500	120	6429.2
3	EMU Finishing Shop	135100	6000	141100	120	1175.8
4	Electric Loco Finishing Shop	88850	3850	92700	120	772.5
5	EMU Repair Shop	330190	17460	347650	120	2897.1
5a	*(Of which, Replacement of Old Equipment)*	*8600*	*990*	*9590*	120	*79.9*
6	Electric Loco Repair Shop	478040	7790	485830	120	4048.6
6a	*(Of which, Replacement of Old Equipment)*	*338940*	*6470*	*345410*	120	*2878.4*
7	Bogie Shop	442860	18750	461610	120	3846.8
7a	*(Of which, Replacement of Old Equipment)*	*308800*	*13080*	*321880*	120	*2682.3*
8	Wheelset Shop	1081300	44330	1125630	120	9380.3
8a	*(Of which, Replacement of Old Equipment)*	*1030300*	*42480*	*1072780*	120	*8939.8*
9	Electric Rotating Machine Shop	817360	26570	843930	120	7032.8
9a	*(Of which, Replacement of Old Equipment)*	*514110*	*17820*	*531930*	120	*4432.8*
10	Electric Apparatus Shop	475410	9610	485020	120	4041.8
10a	*(Of which, Replacement of Old Equipment)*	*36960*	*640*	*37600*	120	*313.3*
11	Transport/Power Supply Shops	417130	38550	455680	120	3797.3
11a	*(Of which, Replacement of Old Equipment)*	*136000*	*1900*	*137900*	120	*1149.2*
12	Adjustment 14/3 -10,000	-10000		-10000	120	-83.3
	Total for Jack Method:	5121640	198910	5320550	120	44337.9
	(Of which, Replacement of Old Equipment)	***2373710***	***83380***	***2457090***	120	***20475.8***
	Total for Jack Method, Excluding Replacement:	2747930	115530	2863460	120	23862.2
13	Additional Cost for Crane Method	2900	4600	7500	120	62.5
	Total for Crane Method:	5124540	203510	5328050	120	44400.4
	(Of which, Replacement of Old Equipment)	***2373710***	***83380***	***2457090***	120	***20475.8***
	Total for Crane Method, Excluding Replacement:	2750830	120130	2870960	120	23924.7

Table 14.1-3 - Uzzheldorremmash - Fuel/Energy Costs 1996									
			Unit	Volume	Unit Price	Total Sum (000)			
Electricity	Lighting	Industrial	kWH (000)	625	2.61	1631			
		Non-Industrial	kWH (000)	647	2.61	1689			
		Total	kWH (000)	1272	2.61	3320			
	Ovens		kWH (000)	4800	2.61	12528			
	Equipment		kWH (000)	13418	2.61	35021			
	Grand Total		kWH (000)	19490	2.61	50869	50869		
Steam	Industrial		2 Kal	41595	583.36	24265			
	Heating	Industrial	2 Kal	10000	583.36	5834			
		Non-Industrial	2 Kal	1198	583.36	699			
	Other		2 Kal	12530	583.36	7310			
	Grand Total		2 Kal	65323	583.36	38107	38107		
Water Heating	Industrial		2 Kal	25470	583.36	14858			
	Non-Industrial		2 Kal	2010	583.36	1173			
	Grand Total		2 Kal	27480	583.36	16031	16031		
Compressed Air	Industrial		Cu. M (000)	55564	301	16725			
	DL and Coaches		Cu. M (000)	618.8	301	186			
	Non-Industrial		Cu. M (000)	264	301	79			
	Grand Total		Cu. M (000)	56446.8	301	16990	16990		
Natural Gas	Industrial		Cu. M (000)	16804	2.22	37305			
	DL and Coaches		Cu. M (000)	190.8	2.22	424			
	Non-Industrial		Cu. M (000)	127	2.22	282			
	Grand Total		Cu. M (000)	17121.8	2.22	38010	38010		
Water	Social Needs		Cu. M (000)	195.4	6.4	1251			
	Technical Needs		Cu. M (000)	538.5	6.4	3446			
	Grand Total		Cu. M (000)	733.9	6.4	4697	4697		
Black Oil			Tonnes	1800	1.739	3130	3130		
Diesel Fuel	Locomotives		Tonnes	712	9.268	6599			
	Other		Tonnes	132	9.268	1223			
	Grand Total		Tonnes	844	9.268	7822	7822		
Coke	DL and Coach Repair		Tonnes	17.3	3.5	61			
	Shoe Manufacture		Tonnes	721	3.5	2524			
	Grand Total		Tonnes	738.3	3.5	2584	2584		
Oxygen	Industrial		Cu. M	318984	0.01	3190			
	Non-Industrial		Cu. M	12406	0.01	124			
	Grand Total		Cu. M	331390	0.01	3314	3314		
							Sum (000)	Sum/$	$ (000)
Grand Total							181555	100	1816
					Total less Diesel:		173733	100	1737
					New Workshop at 5%:		8687	100	87

Table 14.1-4 - Incremental Staffing Costs (Large Locomotive Fleet)

Year		Number of EL Sections	Number of EMU Cars	No of EL Overhauls in Uzb. (6-year cycle)	No of EMU (1M-1T) Overhauls in Uzb. (6-year cycle)	Staff per EL Overhaul (Assumed)	Staff per EMU Overhaul (Assumed)	Total Extra Staff Required	Average Monthly Wage(Sum)	Exchange Rate Sum/$	Average Monthly Wage ($)	Annual Wage Increment ($000)	Excluding Income Tax ($000)
													37.00%
1997	1	138	66	0	0	0	0	0	5732	100	57	0.0	0.0
1998	2	175	78	0	0	0	0	0	5732	100	57	0.0	0.0
1999	3	212	90	0	0	0	0	0	5732	100	57	0.0	0.0
2000	4	249	102	0	0	0	0	0	5732	100	57	0.0	0.0
2001	5	286	113	0	0	0	0	0	5732	100	57	0.0	0.0
2002	6	323	125	54	10	9	9	579	5732	100	57	398.3	250.9
2003	7	360	137	60	11	9	9	644	5732	100	57	442.6	278.9
2004	8	398	149	66	12	9	9	708	5732	100	57	487.0	306.8
2005	9	435	161	72	13	9	9	773	5732	100	57	531.4	334.8
2006	10	472	173	79	14	9	9	837	5732	100	57	575.7	362.7
2007	11	509	184	85	15	9	9	902	5732	100	57	620.1	390.7
2008	12	546	196	91	16	9	9	966	5732	100	57	664.5	418.6
2009	13	583	208	97	17	9	9	1031	5732	100	57	708.8	446.6
2010	14	620	220	103	18	9	9	1095	5732	100	57	753.2	474.5
2011	15	620	220	103	18	9	9	1095	5732	100	57	753.2	474.5
2012	16	620	220	103	18	9	9	1095	5732	100	57	753.2	474.5
2013	17	620	220	103	18	9	9	1095	5732	100	57	753.2	474.5
2014	18	620	220	103	18	9	9	1095	5732	100	57	753.2	474.5
2015	19	620	220	103	18	9	9	1095	5732	100	57	753.2	474.5
2016	20	620	220	103	18	9	9	1095	5732	100	57	753.2	474.5
2017	21	620	220	103	18	9	9	1095	5732	100	57	753.2	474.5
2018	22	620	220	103	18	9	9	1095	5732	100	57	753.2	474.5
2019	23	620	220	103	18	9	9	1095	5732	100	57	753.2	474.5
2020	24	620	220	103	18	9	9	1095	5732	100	57	753.2	474.5
2021	25	620	220	103	18	9	9	1095	5732	100	57	753.2	474.5
2022	26	620	220	103	18	9	9	1095	5732	100	57	753.2	474.5
2023	27	620	220	103	18	9	9	1095	5732	100	57	753.2	474.5
2024	28	620	220	103	18	9	9	1095	5732	100	57	753.2	474.5
2025	29	620	220	103	18	9	9	1095	5732	100	57	753.2	474.5
2026	30	620	220	103	18	9	9	1095	5732	100	57	753.2	474.5
											Total:	17232.5	10856.4

Table 14.1-4a - Incremental Staffing Costs (Medium Locomotive Fleet)

Year		Number of EL Sections	Number of EMU Cars	No of EL Overhauls in Uzb. (6-year cycle)	No of EMU (1M+1T) Overhauls in Uzb. (6-year cycle)	Staff per EL Overhaul (Assumed)	Staff per EMU Overhaul (Assumed)	Total Extra Staff Required	Average Monthly Wage(Sum)	Exchange Rate Sum/$	Average Monthly Wage ($)	Annual Wage Increment ($000)	Excluding Income Tax ($000)
													37.00%
1997	1	138	66	0	0	0	0	0	5732	100	57	0.0	0.0
1998	2	158	78	0	0	0	0	0	5732	100	57	0.0	0.0
1999	3	178	90	0	0	0	0	0	5732	100	57	0.0	0.0
2000	4	198	102	0	0	0	0	0	5732	100	57	0.0	0.0
2001	5	219	113	0	0	0	0	0	5732	100	57	0.0	0.0
2002	6	239	125	40	10	9	9	452	5732	100	57	311.0	195.9
2003	7	259	137	43	11	9	9	491	5732	100	57	337.9	212.9
2004	8	279	149	47	12	9	9	530	5732	100	57	364.8	229.8
2005	9	299	161	50	13	9	9	569	5732	100	57	391.7	246.8
2006	10	319	173	53	14	9	9	609	5732	100	57	418.6	263.7
2007	11	340	184	57	15	9	9	648	5732	100	57	445.5	280.7
2008	12	360	196	60	16	9	9	687	5732	100	57	472.4	297.6
2009	13	380	208	63	17	9	9	726	5732	100	57	499.3	314.6
2010	14	400	220	67	18	9	9	765	5732	100	57	526.2	331.5
2011	15	400	220	67	18	9	9	765	5732	100	57	526.2	331.5
2012	16	400	220	67	18	9	9	765	5732	100	57	526.2	331.5
2013	17	400	220	67	18	9	9	765	5732	100	57	526.2	331.5
2014	18	400	220	67	18	9	9	765	5732	100	57	526.2	331.5
2015	19	400	220	67	18	9	9	765	5732	100	57	526.2	331.5
2016	20	400	220	67	18	9	9	765	5732	100	57	526.2	331.5
2017	21	400	220	67	18	9	9	765	5732	100	57	526.2	331.5
2018	22	400	220	67	18	9	9	765	5732	100	57	526.2	331.5
2019	23	400	220	67	18	9	9	765	5732	100	57	526.2	331.5
2020	24	400	220	67	18	9	9	765	5732	100	57	526.2	331.5
2021	25	400	220	67	18	9	9	765	5732	100	57	526.2	331.5
2022	26	400	220	67	18	9	9	765	5732	100	57	526.2	331.5
2023	27	400	220	67	18	9	9	765	5732	100	57	526.2	331.5
2024	28	400	220	67	18	9	9	765	5732	100	57	526.2	331.5
2025	29	400	220	67	18	9	9	765	5732	100	57	526.2	331.5
2026	30	400	220	67	18	9	9	765	5732	100	57	526.2	331.5
											Total:	12186.4	7677.4

Table 14.1-5 - Maintenance Savings (Large Locomotive Fleet)

Year		Number of EL Sections	Number of EMU Cars	No of EL Overhauls in Uzb. (6-year cycle)	Of which KP1	Of which KP2	Cost of Foreign EL KP1 ($000)	Cost of Uzbek EL KP1 ($000)	Saving per EL KP1 ($000)	Total Savings EL KP1 ($000)	Cost of Foreign EL KP2 ($000)	Cost of Uzbek EL KP2 ($000)	Saving per EL KP2 ($000)	Total Savings EL KP2 ($000)	Total Savings EL KP1 and KP2 ($000)
1997	1	138	66	0	0	0	140	80	60	0	156	92	64	0	0
1998	2	175	78	0	0	0	140	80	60	0	156	92	64	0	0
1999	3	212	90	0	0	0	140	80	60	0	156	92	64	0	0
2000	4	249	102	0	0	0	140	80	60	0	156	92	64	0	0
2001	5	286	113	0	0	0	140	80	60	0	156	92	64	0	0
2002	6	323	125	54	27	27	140	80	60	1617	156	92	64	1725	3342
2003	7	360	137	60	30	30	140	80	60	1802	156	92	64	1922	3725
2004	8	398	149	66	33	33	140	80	60	1988	156	92	64	2120	4108
2005	9	435	161	72	36	36	140	80	60	2173	156	92	64	2318	4491
2006	10	472	173	79	39	39	140	80	60	2358	156	92	64	2516	4874
2007	11	509	184	85	42	42	140	80	60	2544	156	92	64	2713	5257
2008	12	546	196	91	45	45	140	80	60	2729	156	92	64	2911	5640
2009	13	580	208	97	49	49	140	80	60	2915	156	92	64	3109	6024
2010	14	620	220	103	52	52	140	80	60	3100	156	92	64	3307	6407
2011	15	620	220	103	52	52	140	80	60	3100	156	92	64	3307	6407
2012	16	620	220	103	52	52	140	80	60	3100	156	92	64	3307	6407
2013	17	620	220	103	52	52	140	80	60	3100	156	92	64	3307	6407
2014	18	620	220	103	52	52	140	80	60	3100	156	92	64	3307	6407
2015	19	620	220	103	52	52	140	80	60	3100	156	92	64	3307	6407
2016	20	620	220	103	52	52	140	80	60	3100	156	92	64	3307	6407
2017	21	620	220	103	52	52	140	80	60	3100	156	92	64	3307	6407
2018	22	620	220	103	52	52	140	80	60	3100	156	92	64	3307	6407
2019	23	620	220	103	52	52	140	80	60	3100	156	92	64	3307	6407
2020	24	620	220	103	52	52	140	80	60	3100	156	92	64	3307	6407
2021	25	620	220	103	52	52	140	80	60	3100	156	92	64	3307	6407
2022	26	620	220	103	52	52	140	80	60	3100	156	92	64	3307	6407
2023	27	620	220	103	52	52	140	80	60	3100	156	92	64	3307	6407
2024	28	620	220	103	52	52	140	80	60	3100	156	92	64	3307	6407
2025	29	620	220	103	52	52	140	80	60	3100	156	92	64	3307	6407
2026	30	620	220	103	52	52	140	80	60	3100	156	92	64	3307	6407

Table 14.1-5 (Continued) - Maintenance Savings (Large Locomotive Fleet)

Year	No of EMU (1M+1T): Overhauls in Um. (6-year cycle)	Of which KP1	Of which KP2	Cost of Foreign EMU KP1 ($000)	Cost of Ustek EMU KP1 ($000)	Saving per EMU KP1 ($000)	Total Savings EMU KP1 ($000)	Cost of Foreign EMU KP2 ($000)	Cost of Ustek EMU KP2 ($000)	Saving per EMU KP2 ($000)	Total Savings EMU KP2 ($000)	Total Savings EMU KP1 and KP2 ($000)	Add Back Staff Costs (Table 14.1-4)	Add Back Spares Costs	Total Savings EL/EMU KP1/KP2 ($000)
1997	0	0	0	109	68	41	0	118	76	42	0	0	0		0
1998	0	0	0	109	68	41	0	118	76	42	0	0	0		0
1999	0	0	0	109	68	41	0	118	76	42	0	0	0		0
2000	0	0	0	109	68	41	0	118	76	42	0	0	0		0
2001	0	0	0	109	68	41	0	118	76	42	0	0	0	7992	7992
2002	10	5	5	109	68	41	214	118	76	42	219	433	251		4026
2003	11	6	6	109	68	41	234	118	76	42	240	474	279		4478
2004	12	6	6	109	68	41	254	118	76	42	261	515	307		4930
2005	13	7	7	109	68	41	275	118	76	42	281	556	335		5382
2006	14	7	7	109	68	41	295	118	76	42	302	597	363		5834
2007	15	8	8	109	68	41	315	118	76	42	323	638	391		6286
2008	16	8	8	109	68	41	335	118	76	42	344	679	419		6738
2009	17	9	9	109	68	41	356	118	76	42	364	720	447		7190
2010	18	9	9	109	68	41	376	118	76	42	385	761	475		7642
2011	18	9	9	109	68	41	376	118	76	42	385	761	475		7642
2012	18	9	9	109	68	41	376	118	76	42	385	761	475		7642
2013	18	9	9	109	68	41	376	118	76	42	385	761	475		7642
2014	18	9	9	109	68	41	376	118	76	42	385	761	475		7642
2015	18	9	9	109	68	41	376	118	76	42	385	761	475		7642
2016	18	9	9	109	68	41	376	118	76	42	385	761	475		7642
2017	18	9	9	109	68	41	376	118	76	42	385	761	475		7642
2018	18	9	9	109	68	41	376	118	76	42	385	761	475		7642
2019	18	9	9	109	68	41	376	118	76	42	385	761	475		7642
2020	18	9	9	109	68	41	376	118	76	42	385	761	475		7642
2021	18	9	9	109	68	41	376	118	76	42	385	761	475		7642
2022	18	9	9	109	68	41	376	118	76	42	385	761	475		7642
2023	18	9	9	109	68	41	376	118	76	42	385	761	475		7642
2024	18	9	9	109	68	41	376	118	76	42	385	761	475		7642
2025	18	9	9	109	68	41	376	118	76	42	385	761	475		7642
2026	18	9	9	109	68	41	376	118	76	42	385	761	475		7642
													Total:		182760

Table 14.1-5a - Maintenance Savings (Medium Locomotive Fleet)

Year		Number of EL Sections	Number of EMU Cars	No of EL Overhauls in Urb. (6-year cycle)	Of which KP1	Of which KP2	Cost of Foreign EL KP1 ($000)	Cost of Urban EL KP1 ($000)	Saving per EL KP1 ($000)	Total Savings EL KP1 ($000)	Cost of Foreign EL KP2 ($000)	Cost of Urban EL KP2 ($000)	Saving per EL KP2 ($000)	Total Savings EL KP2 ($000)	Total Savings EL KP1 and KP2 ($000)
1997	1	138	66	0	0	0	140	80	60	0	156	92	64	0	0
1998	2	158	78	0	0	0	140	80	60	0	156	92	64	0	0
1999	3	178	90	0	0	0	140	80	60	0	156	92	64	0	0
2000	4	198	102	0	0	0	140	80	60	0	156	92	64	0	0
2001	5	219	113	0	0	0	140	80	60	0	156	92	64	0	0
2002	6	239	125	40	20	20	140	80	60	1194	156	92	64	1273	2467
2003	7	259	137	43	22	22	140	80	60	1295	156	92	64	1381	2676
2004	8	279	149	47	23	23	140	80	60	1395	156	92	64	1488	2884
2005	9	299	161	50	25	25	140	80	60	1496	156	92	64	1596	3092
2006	10	319	173	53	27	27	140	80	60	1597	156	92	64	1703	3300
2007	11	340	184	57	28	28	140	80	60	1698	156	92	64	1811	3509
2008	12	360	196	60	30	30	140	80	60	1798	156	92	64	1918	3717
2009	13	380	208	63	32	32	140	80	60	1899	156	92	64	2026	3925
2010	14	400	220	67	33	33	140	80	60	2000	156	92	64	2133	4133
2011	15	400	220	67	33	33	140	80	60	2000	156	92	64	2133	4133
2012	16	400	220	67	33	33	140	80	60	2000	156	92	64	2133	4133
2013	17	400	220	67	33	33	140	80	60	2000	156	92	64	2133	4133
2014	18	400	220	67	33	33	140	80	60	2000	156	92	64	2133	4133
2015	19	400	220	67	33	33	140	80	60	2000	156	92	64	2133	4133
2016	20	400	220	67	33	33	140	80	60	2000	156	92	64	2133	4133
2017	21	400	220	67	33	33	140	80	60	2000	156	92	64	2133	4133
2018	22	400	220	67	33	33	140	80	60	2000	156	92	64	2133	4133
2019	23	400	220	67	33	33	140	80	60	2000	156	92	64	2133	4133
2020	24	400	220	67	33	33	140	80	60	2000	156	92	64	2133	4133
2021	25	400	220	67	33	33	140	80	60	2000	156	92	64	2133	4133
2022	26	400	220	67	33	33	140	80	60	2000	156	92	64	2133	4133
2023	27	400	220	67	33	33	140	80	60	2000	156	92	64	2133	4133
2024	28	400	220	67	33	33	140	80	60	2000	156	92	64	2133	4133
2025	29	400	220	67	33	33	140	80	60	2000	156	92	64	2133	4133
2026	30	400	220	67	33	33	140	80	60	2000	156	92	64	2133	4133

Table 14.2-5a (Continued) - Maintenance Savings (Medium Locomotive Fleet)

Year	No of EMU (1M+1T) Overhauls in Urb. (6-year cycle)	Of which KP1	Of which KP2	Cost of Foreign EMU KP1 ($000)	Cost of Uzbek EMU KP1 ($000)	Saving per EMU KP1 ($000)	Total Savings EMU KP1 ($000)	Cost of Foreign EMU KP2 ($000)	Cost of Uzbek EMU KP2 ($000)	Saving per EMU KP2 ($000)	Total Savings EMU KP2 ($000)	Total Savings EMU KP1 and KP2 ($000)	Add Back Staff Costs (Table 14.2-4a)	Add Back Startup Costs	Total Savings EL/EMU KP1/KP2 ($000)
1997	0	0	0	109	68	41	0	118	76	42	0	0	0		0
1998	0	0	0	109	68	41	0	118	76	42	0	0	0		0
1999	0	0	0	109	68	41	0	118	76	42	0	0	0		0
2000	0	0	0	109	68	41	0	118	76	42	0	0	0		0
2001	0	0	0	109	68	41	0	118	76	42	0	0	0	7992	7992
2002	10	5	5	109	68	41	214	118	76	42	219	433	196		3096
2003	11	6	6	109	68	41	234	118	76	42	240	474	213		3362
2004	12	6	6	109	68	41	254	118	76	42	261	515	230		3629
2005	13	7	7	109	68	41	275	118	76	42	281	556	247		3895
2006	14	7	7	109	68	41	295	118	76	42	303	597	264		4161
2007	15	8	8	109	68	41	315	118	76	42	323	638	281		4427
2008	16	8	8	109	68	41	335	118	76	42	344	679	298		4693
2009	17	9	9	109	68	41	356	118	76	42	364	720	315		4959
2010	18	9	9	109	68	41	376	118	76	42	385	761	332		5226
2011	18	9	9	109	68	41	376	118	76	42	385	761	332		5226
2012	18	9	9	109	68	41	376	118	76	42	385	761	332		5226
2013	18	9	9	109	68	41	376	118	76	42	385	761	332		5226
2014	18	9	9	109	68	41	376	118	76	42	385	761	332		5226
2015	18	9	9	109	68	41	376	118	76	42	385	761	332		5226
2016	18	9	9	109	68	41	376	118	76	42	385	761	332		5226
2017	18	9	9	109	68	41	376	118	76	42	385	761	332		5226
2018	18	9	9	109	68	41	376	118	76	42	385	761	332		5226
2019	18	9	9	109	68	41	376	118	76	42	385	761	332		5226
2020	18	9	9	109	68	41	376	118	76	42	385	761	332		5226
2021	18	9	9	109	68	41	376	118	76	42	385	761	332		5226
2022	18	9	9	109	68	41	376	118	76	42	385	761	332		5226
2023	18	9	9	109	68	41	376	118	76	42	385	761	332		5226
2024	18	9	9	109	68	41	376	118	76	42	385	761	332		5226
2025	18	9	9	109	68	41	376	118	76	42	385	761	332		5226
2026	18	9	9	109	68	41	376	118	76	42	385	761	332		5226
													Total:		129843

Table 14.1-6 - Locomotive Savings (Large Locomotive Fleet)

Year		EL Sections	No of EL Overhauls in Urb. (6-year cycle)	Of which KP1	Of which KP2	Days Lost Per Foreign Overhaul	Total Days Lost	Additional EL Sections Needed (Total)	No of New EL Sections Needed (Per Annum)	(1) Cost of New EL Section ($000)	Total EL Savings ($000)	Savings In Extra KP1 ($000)	Savings In Extra KP2 ($000)
1997	1	138	23	12	12	44	1012	2.8	2.8	1875	5198.6	32.3	36.0
1998	2	175	29	15	15	44	1284	3.5	0.7	1875	1396.7	41.0	45.7
1999	3	212	35	18	18	44	1556	4.3	0.7	1875	1396.7	49.7	55.4
2000	4	249	42	21	21	44	1828	5.0	0.7	1875	1396.7	58.4	65.1
2001	5	286	48	24	24	44	2100	5.8	0.7	1875	1396.7	67.1	74.8
2002	6	323	54	27	27	44	2371	6.5	0.7	1875	1396.7	75.8	84.5
2003	7	360	60	30	30	44	2643	7.2	0.7	1875	1396.7	84.5	94.1
2004	8	398	66	33	33	44	2915	8.0	0.7	1875	1396.7	93.2	103.8
2005	9	435	72	36	36	44	3187	8.7	0.7	1875	1396.7	101.9	113.5
2006	10	472	79	39	39	44	3459	9.5	0.7	1875	1396.7	110.6	123.2
2007	11	509	85	42	42	44	3731	10.2	0.7	1875	1396.7	119.3	132.9
2008	12	546	91	45	45	44	4003	11.0	0.7	1875	1396.7	127.9	142.6
2009	13	583	97	49	49	44	4275	11.7	0.7	1875	1396.7	136.6	152.3
2010	14	620	103	52	52	44	4547	12.5	0.7	1875	1396.7	145.3	161.9
2011	15	620	103	52	52	44	4547	12.5	0.0	1875	0.0	145.3	161.9
2012	16	620	103	52	52	44	4547	12.5	0.0	1875	0.0	145.3	161.9
2013	17	620	103	52	52	44	4547	12.5	0.0	1875	0.0	145.3	161.9
2014	18	620	103	52	52	44	4547	12.5	0.0	1875	0.0	145.3	161.9
2015	19	620	103	52	52	44	4547	12.5	0.0	1875	0.0	145.3	161.9
2016	20	620	103	52	52	44	4547	12.5	0.0	1875	0.0	145.3	161.9
2017	21	620	103	52	52	44	4547	12.5	0.0	1875	0.0	145.3	161.9
2018	22	620	103	52	52	44	4547	12.5	0.0	1875	0.0	145.3	161.9
2019	23	620	103	52	52	44	4547	12.5	0.0	1875	0.0	145.3	161.9
2020	24	620	103	52	52	44	4547	12.5	0.0	1875	0.0	145.3	161.9
2021	25	620	103	52	52	44	4547	12.5	0.0	1875	0.0	145.3	161.9
2022	26	620	103	52	52	44	4547	12.5	0.0	1875	0.0	145.3	161.9
2023	27	620	103	52	52	44	4547	12.5	0.0	1875	0.0	145.3	161.9
2024	28	620	103	52	52	44	4547	12.5	0.0	1875	0.0	145.3	161.9
2025	29	620	103	52	52	44	4547	12.5	0.0	1875	0.0	145.3	161.9
2026	30	620	103	52	52	44	4547	12.5	0.0	1875	0.0	145.3	161.9

(1) Calculated as (70% x $2300/2) + (30% x $2400)

Table 14.1-6 (Continued) - Locomotive Savings (Large Locomotive Fleet)													
		No of EMU (1M+1T)			Days Lost		Additional EMU	No of New EMU	Cost of New	Total	Savings In	Savings In		Total
		Overhauls in Urb.			Per Foreign	Total	(1M+1T) Needed	(1M+1T) Needed	EMU (1M+1T)	EMU Savings	Extra KP1	Extra KP2		EL and EMU
Year	EMU Cars	(6-year cycle)	Of which KP1	Of which KP2	Overhaul	Days Lost	(Total)	(Per Annum)	($000)	($000)	($000)	($000)		Savings
1997	66	6	3	3	44	242	0.66	0.66	900	596.7	6.0	6.5		5876.3
1998	78	6	3	3	44	285	0.78	0.12	900	107.1	7.1	7.7		1605.4
1999	90	7	4	4	44	329	0.90	0.12	900	107.1	8.2	8.9		1626.0
2000	102	8	4	4	44	372	1.02	0.12	900	107.1	9.3	10.0		1646.6
2001	113	9	5	5	44	416	1.14	0.12	900	107.1	10.3	11.2		1667.3
2002	125	10	5	5	44	459	1.26	0.12	900	107.1	11.4	12.4		1687.9
2003	137	11	6	6	44	503	1.38	0.12	900	107.1	12.5	13.5		1708.5
2004	149	12	6	6	44	546	1.50	0.12	900	107.1	13.6	14.7		1729.2
2005	161	13	7	7	44	589	1.62	0.12	900	107.1	14.7	15.9		1749.8
2006	173	14	7	7	44	633	1.73	0.12	900	107.1	15.8	17.1		1770.4
2007	184	15	8	8	44	676	1.85	0.12	900	107.1	16.8	18.2		1791.0
2008	196	16	8	8	44	720	1.97	0.12	900	107.1	17.9	19.4		1811.7
2009	208	17	9	9	44	763	2.09	0.12	900	107.1	19.0	20.6		1832.3
2010	220	18	9	9	44	807	2.21	0.12	900	107.1	20.1	21.7		1852.9
2011	220	18	9	9	44	807	2.21	0.00	900	0.0	20.1	21.7		349.1
2012	220	18	9	9	44	807	2.21	0.00	900	0.0	20.1	21.7		349.1
2013	220	18	9	9	44	807	2.21	0.00	900	0.0	20.1	21.7		349.1
2014	220	18	9	9	44	807	2.21	0.00	900	0.0	20.1	21.7		349.1
2015	220	18	9	9	44	807	2.21	0.00	900	0.0	20.1	21.7		349.1
2016	220	18	9	9	44	807	2.21	0.00	900	0.0	20.1	21.7		349.1
2017	220	18	9	9	44	807	2.21	0.00	900	0.0	20.1	21.7		349.1
2018	220	18	9	9	44	807	2.21	0.00	900	0.0	20.1	21.7		349.1
2019	220	18	9	9	44	807	2.21	0.00	900	0.0	20.1	21.7		349.1
2020	220	18	9	9	44	807	2.21	0.00	900	0.0	20.1	21.7		349.1
2021	220	18	9	9	44	807	2.21	0.00	900	0.0	20.1	21.7		349.1
2022	220	18	9	9	44	807	2.21	0.00	900	0.0	20.1	21.7		349.1
2023	220	18	9	9	44	807	2.21	0.00	900	0.0	20.1	21.7		349.1
2024	220	18	9	9	44	807	2.21	0.00	900	0.0	20.1	21.7		349.1
2025	220	18	9	9	44	807	2.21	0.00	900	0.0	20.1	21.7		349.1
2026	220	18	9	9	44	807	2.21	0.00	900	0.0	20.1	21.7		349.1
													Total:	33940.3

<u>Appendix 14.1</u>

Table 14.1-6a - Locomotive Savings (Medium Locomotive Fleet)

Year		EL Sections	No of EL Overheuls in Ukb. (6-year cycle)	Of which KP1	Of which KP2	Days Lost Per Foreign Overhaul	Total Days Lost	Additional EL Sections Needed (Total)	No of New EL Sections Needed (Per Annum)	(1) Cost of New EL Section ($000)	Total EL Savings ($000)	Savings In Extra KP1 ($000)	Savings In Extra KP2 ($000)
1997	1	138	23	12	12	44	1012	2.8	2.8	1875	5198.6	32.3	36.0
1998	2	158	26	13	13	44	1160	3.2	0.4	1875	759.2	37.1	41.3
1999	3	178	30	15	15	44	1308	3.6	0.4	1875	759.2	41.8	46.6
2000	4	198	33	17	17	44	1455	4.0	0.4	1875	759.2	46.5	51.8
2001	5	219	36	18	18	44	1603	4.4	0.4	1875	759.2	51.2	57.1
2002	6	239	40	20	20	44	1751	4.8	0.4	1875	759.2	56.0	62.4
2003	7	259	43	22	22	44	1899	5.2	0.4	1875	759.2	60.7	67.6
2004	8	279	47	23	23	44	2047	5.6	0.4	1875	759.2	65.4	72.9
2005	9	299	50	25	25	44	2194	6.0	0.4	1875	759.2	70.1	78.2
2006	10	319	53	27	27	44	2342	6.4	0.4	1875	759.2	74.9	83.4
2007	11	340	57	28	28	44	2490	6.8	0.4	1875	759.2	79.6	88.7
2008	12	360	60	30	30	44	2638	7.2	0.4	1875	759.2	84.3	93.9
2009	13	380	63	32	32	44	2786	7.6	0.4	1875	759.2	89.0	99.2
2010	14	400	67	33	33	44	2933	8.0	0.4	1875	759.2	93.8	104.5
2011	15	400	67	33	33	44	2933	8.0	0.0	1875	0.0	93.8	104.5
2012	16	400	67	33	33	44	2933	8.0	0.0	1875	0.0	93.8	104.5
2013	17	400	67	33	33	44	2933	8.0	0.0	1875	0.0	93.8	104.5
2014	18	400	67	33	33	44	2933	8.0	0.0	1875	0.0	93.8	104.5
2015	19	400	67	33	33	44	2933	8.0	0.0	1875	0.0	93.8	104.5
2016	20	400	67	33	33	44	2933	8.0	0.0	1875	0.0	93.8	104.5
2017	21	400	67	33	33	44	2933	8.0	0.0	1875	0.0	93.8	104.5
2018	22	400	67	33	33	44	2933	8.0	0.0	1875	0.0	93.8	104.5
2019	23	400	67	33	33	44	2933	8.0	0.0	1875	0.0	93.8	104.5
2020	24	400	67	33	33	44	2933	8.0	0.0	1875	0.0	93.8	104.5
2021	25	400	67	33	33	44	2933	8.0	0.0	1875	0.0	93.8	104.5
2022	26	400	67	33	33	44	2933	8.0	0.0	1875	0.0	93.8	104.5
2023	27	400	67	33	33	44	2933	8.0	0.0	1875	0.0	93.8	104.5
2024	28	400	67	33	33	44	2933	8.0	0.0	1875	0.0	93.8	104.5
2025	29	400	67	33	33	44	2933	8.0	0.0	1875	0.0	93.8	104.5
2026	30	400	67	33	33	44	2933	8.0	0.0	1875	0.0	93.8	104.5

(1) Calculated as (70% x $3300/2) + (30% x $2400)

Table 14.1-6a (Continued) - Locomotive Savings (Medium Locomotive Fleet)

Year	EMU Cars	No of EMU (1M+1T) Overhauls in Urb. (6-year cycle)	Of which KP1	Of which KP2	Days Lost Per Foreign Overhaul	Total Days Lost	Additional EMU (1M+1T) Needed (Total)	No of New EMU (1M+1T) Needed (Per Annum)	Cost of New EMU (1M+1T) ($000)	Total EMU Savings ($000)	Savings In Extra KP1 ($000)	Savings In Extra KP2 ($000)		Total EL and EMU Savings
1997	66	6	3	3	44	242	0.66	0.66	900	596.7	6.0	6.5		5876.3
1998	78	6	3	3	44	285	0.78	0.12	900	107.1	7.1	7.7		959.5
1999	90	7	4	4	44	329	0.90	0.12	900	107.1	8.2	8.9		972.7
2000	102	8	4	4	44	372	1.02	0.12	900	107.1	9.3	10.0		984.0
2001	113	9	5	5	44	416	1.14	0.12	900	107.1	10.3	11.2		996.2
2002	125	10	5	5	44	459	1.26	0.12	900	107.1	11.4	12.4		1008.5
2003	137	11	6	6	44	503	1.38	0.12	900	107.1	12.5	13.5		1020.7
2004	149	12	6	6	44	546	1.50	0.12	900	107.1	13.6	14.7		1032.9
2005	161	13	7	7	44	589	1.62	0.12	900	107.1	14.7	15.9		1045.2
2006	173	14	7	7	44	633	1.73	0.12	900	107.1	15.8	17.1		1057.4
2007	184	15	8	8	44	676	1.85	0.12	900	107.1	16.8	18.2		1069.6
2008	196	16	8	8	44	720	1.97	0.12	900	107.1	17.9	19.4		1081.9
2009	208	17	9	9	44	763	2.09	0.12	900	107.1	19.0	20.6		1094.1
2010	220	18	9	9	44	807	2.21	0.12	900	107.1	20.1	21.7		1106.4
2011	220	18	9	9	44	807	2.21	0.00	900	0.0	20.1	21.7		240.0
2012	220	18	9	9	44	807	2.21	0.00	900	0.0	20.1	21.7		240.0
2013	220	18	9	9	44	807	2.21	0.00	900	0.0	20.1	21.7		240.0
2014	220	18	9	9	44	807	2.21	0.00	900	0.0	20.1	21.7		240.0
2015	220	18	9	9	44	807	2.21	0.00	900	0.0	20.1	21.7		240.0
2016	220	18	9	9	44	807	2.21	0.00	900	0.0	20.1	21.7		240.0
2017	220	18	9	9	44	807	2.21	0.00	900	0.0	20.1	21.7		240.0
2018	220	18	9	9	44	807	2.21	0.00	900	0.0	20.1	21.7		240.0
2019	220	18	9	9	44	807	2.21	0.00	900	0.0	20.1	21.7		240.0
2020	220	18	9	9	44	807	2.21	0.00	900	0.0	20.1	21.7		240.0
2021	220	18	9	9	44	807	2.21	0.00	900	0.0	20.1	21.7		240.0
2022	220	18	9	9	44	807	2.21	0.00	900	0.0	20.1	21.7		240.0
2023	220	18	9	9	44	807	2.21	0.00	900	0.0	20.1	21.7		240.0
2024	220	18	9	9	44	807	2.21	0.00	900	0.0	20.1	21.7		240.0
2025	220	18	9	9	44	807	2.21	0.00	900	0.0	20.1	21.7		240.0
2026	220	18	9	9	44	807	2.21	0.00	900	0.0	20.1	21.7		240.0
													Total:	23145.0

Table 14.1-7 - Maintenance Savings (Large Locomotive Fleet)

Year		Number of EL Sections	Number of EMU Cars	No of EL overhauls in Uzb. (6-year cycle)	Of which KP1	Of which KP2	Cost of Foreign EL KP1 ($000)	Cost of Uzbek EL KP1 ($000)	Saving per EL KP1 ($000)	Total Savings EL KP1 ($000)	Cost of Foreign EL KP2 ($000)	Cost of Uzbek EL KP2 ($000)	Saving per EL KP2 ($000)	Total Savings EL KP2 ($000)	Total Savings EL KP1 and KP2 ($000)
1997	1	138	66	0	0	0	140	112	28	0	156	125	31	0	0
1998	2	175	78	0	0	0	140	112	28	0	156	125	31	0	0
1999	3	212	90	0	0	0	140	112	28	0	156	125	31	0	0
2000	4	249	102	0	0	0	140	112	28	0	156	125	31	0	0
2001	5	286	113	0	0	0	140	112	28	0	156	125	31	0	0
2002	6	323	125	54	27	27	140	112	28	755	156	125	31	835	1590
2003	7	360	137	60	30	30	140	112	28	841	156	125	31	931	1772
2004	8	398	149	66	33	33	140	112	28	928	156	125	31	1027	1955
2005	9	435	161	72	36	36	140	112	28	1014	156	125	31	1123	2137
2006	10	472	173	79	39	39	140	112	28	1101	156	125	31	1219	2319
2007	11	509	184	85	42	42	140	112	28	1187	156	125	31	1314	2501
2008	12	546	196	91	45	45	140	112	28	1274	156	125	31	1410	2684
2009	13	583	208	97	49	49	140	112	28	1360	156	125	31	1506	2866
2010	14	620	220	103	52	52	140	112	28	1447	156	125	31	1602	3048
2011	15	620	220	103	52	52	140	112	28	1447	156	125	31	1602	3048
2012	16	620	220	103	52	52	140	112	28	1447	156	125	31	1602	3048
2013	17	620	220	103	52	52	140	112	28	1447	156	125	31	1602	3048
2014	18	620	220	103	52	52	140	112	28	1447	156	125	31	1602	3048
2015	19	620	220	103	52	52	140	112	28	1447	156	125	31	1602	3048
2016	20	620	220	103	52	52	140	112	28	1447	156	125	31	1602	3048
2017	21	620	220	103	52	52	140	112	28	1447	156	125	31	1602	3048
2018	22	620	220	103	52	52	140	112	28	1447	156	125	31	1602	3048
2019	23	620	220	103	52	52	140	112	28	1447	156	125	31	1602	3048
2020	24	620	220	103	52	52	140	112	28	1447	156	125	31	1602	3048
2021	25	620	220	103	52	52	140	112	28	1447	156	125	31	1602	3048
2022	26	620	220	103	52	52	140	112	28	1447	156	125	31	1602	3048
2023	27	620	220	103	52	52	140	112	28	1447	156	125	31	1602	3048
2024	28	620	220	103	52	52	140	112	28	1447	156	125	31	1602	3048
2025	29	620	220	103	52	52	140	112	28	1447	156	125	31	1602	3048
2026	30	620	220	103	52	52	140	112	28	1447	156	125	31	1602	3048

Table 14.1-7 (Continued) - Maintenance Savings (Large Locomotive Fleet)

Year	No of EMU (1M+1T) Overhauls in Uzb. (6-year cycle)	Of which KP1	Of which KP2	Cost of Foreign EMU KP1 ($000)	Cost of Uzbek EMU KP1 ($000)	Saving per EMU KP1 ($000)	Total Savings EMU KP1 ($000)	Cost of Foreign EMU KP2 ($000)	Cost of Uzbek EMU KP2 ($000)	Saving per EMU KP2 ($000)	Total Savings EMU KP2 ($000)	Total Savings EMU KP1 and KP2 ($000)	Add Back Staff Costs (Table 14.1-4)	Add Back Spares Costs	Total Savings EL/EMU KP1/KP2 ($000)
1997	0	0	0	109	87	22	0	118	94	24	0	0	0		0
1998	0	0	0	109	87	22	0	118	94	24	0	0	0		0
1999	0	0	0	109	87	22	0	118	94	24	0	0	0		0
2000	0	0	0	109	87	22	0	118	94	24	0	0	0		0
2001	0	0	0	109	87	22	0	118	94	24	0	0	0	7992	7992
2002	10	5	5	109	87	22	115	118	94	24	125	240	251		2081
2003	11	6	6	109	87	22	126	118	94	24	137	263	279		2314
2004	12	6	6	109	87	22	137	118	94	24	149	285	307		2547
2005	13	7	7	109	87	22	147	118	94	24	161	308	335		2780
2006	14	7	7	109	87	22	158	118	94	24	173	331	363		3013
2007	15	8	8	109	87	22	169	118	94	24	184	354	391		3246
2008	16	8	8	109	87	22	180	118	94	24	196	376	419		3479
2009	17	9	9	109	87	22	191	118	94	24	208	399	447		3712
2010	18	9	9	109	87	22	202	118	94	24	220	422	475		3945
2011	18	9	9	109	87	22	202	118	94	24	220	422	475		3945
2012	18	9	9	109	87	22	202	118	94	24	220	422	475		3945
2013	18	9	9	109	87	22	202	118	94	24	220	422	475		3945
2014	18	9	9	109	87	22	202	118	94	24	220	422	475		3945
2015	18	9	9	109	87	22	202	118	94	24	220	422	475		3945
2016	18	9	9	109	87	22	202	118	94	24	220	422	475		3945
2017	18	9	9	109	87	22	202	118	94	24	220	422	475		3945
2018	18	9	9	109	87	22	202	118	94	24	220	422	475		3945
2019	18	9	9	109	87	22	202	118	94	24	220	422	475		3945
2020	18	9	9	109	87	22	202	118	94	24	220	422	475		3945
2021	18	9	9	109	87	22	202	118	94	24	220	422	475		3945
2022	18	9	9	109	87	22	202	118	94	24	220	422	475		3945
2023	18	9	9	109	87	22	202	118	94	24	220	422	475		3945
2024	18	9	9	109	87	22	202	118	94	24	220	422	475		3945
2025	18	9	9	109	87	22	202	118	94	24	220	422	475		3945
2026	18	9	9	109	87	22	202	118	94	24	220	422	475		3945
													Total:		98218

Table 14.1-7a - Maintenance Savings (Medium Locomotive Fleet)

Year		Number of EL Sections	Number of EMU Cars	No of EL Overhauls in Uzb. (Average/yr)	Of which KP1	Of which KP2	Cost of Foreign EL KP1 ($000)	Cost of Uzbek EL KP1 ($000)	Saving per EL KP1 ($000)	Total Savings EL KP1 ($000)	Cost of Foreign EL KP2 ($000)	Cost of Uzbek EL KP2 ($000)	Saving per EL KP2 ($000)	Total Savings EL KP2 ($000)	Total Savings EL KP1 and KP2 ($000)
1997	1	138	66	0	0	0	140	112	28	0	156	125	31	0	0
1998	2	158	78	0	0	0	140	112	28	0	156	125	31	0	0
1999	3	178	90	0	0	0	140	112	28	0	156	125	31	0	0
2000	4	198	102	0	0	0	140	112	28	0	156	125	31	0	0
2001	5	219	113	0	0	0	140	112	28	0	156	125	31	0	0
2002	6	239	125	40	20	20	140	112	28	557	156	125	31	617	1174
2003	7	259	137	43	22	22	140	112	28	604	156	125	31	669	1273
2004	8	279	149	47	23	23	140	112	28	651	156	125	31	721	1372
2005	9	299	161	50	25	25	140	112	28	698	156	125	31	773	1471
2006	10	319	173	53	27	27	140	112	28	745	156	125	31	825	1570
2007	11	340	184	57	28	28	140	112	28	792	156	125	31	877	1669
2008	12	360	196	60	30	30	140	112	28	839	156	125	31	929	1768
2009	13	380	208	63	32	32	140	112	28	886	156	125	31	981	1868
2010	14	400	220	67	33	33	140	112	28	933	156	125	31	1033	1967
2011	15	400	220	67	33	33	140	112	28	933	156	125	31	1033	1967
2012	16	400	220	67	33	33	140	112	28	933	156	125	31	1033	1967
2013	17	400	220	67	33	33	140	112	28	933	156	125	31	1033	1967
2014	18	400	220	67	33	33	140	112	28	933	156	125	31	1033	1967
2015	19	400	220	67	33	33	140	112	28	933	156	125	31	1033	1967
2016	20	400	220	67	33	33	140	112	28	933	156	125	31	1033	1967
2017	21	400	220	67	33	33	140	112	28	933	156	125	31	1033	1967
2018	22	400	220	67	33	33	140	112	28	933	156	125	31	1033	1967
2019	23	400	220	67	33	33	140	112	28	933	156	125	31	1033	1967
2020	24	400	220	67	33	33	140	112	28	933	156	125	31	1033	1967
2021	25	400	220	67	33	33	140	112	28	933	156	125	31	1033	1967
2022	26	400	220	67	33	33	140	112	28	933	156	125	31	1033	1967
2023	27	400	220	67	33	33	140	112	28	933	156	125	31	1033	1967
2024	28	400	220	67	33	33	140	112	28	933	156	125	31	1033	1967
2025	29	400	220	67	33	33	140	112	28	933	156	125	31	1033	1967
2026	30	400	220	67	33	33	140	112	28	933	156	125	31	1033	1967
14.1-7a		20	72												

Table 14.1-7a (Continued) - Maintenance Savings (Medium Locomotive Fleet)

Year	No of EMU (1M+1T) Overhauls in Uzb. (6-year cycle)	Of which KP1	Of which KP2	Cost of Foreign EMU KP1 ($000)	Cost of Uzbek EMU KP1 ($000)	Saving per EMU KP1 ($000)	Total Savings EMU KP1 ($000)	Cost of Foreign EMU KP2 ($000)	Cost of Uzbek EMU KP2 ($000)	Saving per EMU KP2 ($000)	Total Savings EMU KP2 ($000)	Total Savings EMU KP1 and KP2 ($000)	Add Back Staff Costs (Table 14.1-4a)	Add Back Source Costs	Total Savings EL/EMU KP1/KP2 ($000)
1997	0	0	0	109	87	22	0	118	94	24	0	0	0		0
1998	0	0	0	109	87	22	0	118	94	24	0	0	0		0
1999	0	0	0	109	87	22	0	118	94	24	0	0	0		0
2000	0	0	0	109	87	22	0	118	94	24	0	0	0		0
2001	0	0	0	109	87	22	0	118	94	24	0	0	0	7992	7992
2002	10	5	5	109	87	22	115	118	94	24	125	240	196		1610
2003	11	6	6	109	87	22	126	118	94	24	137	263	213		1749
2004	12	6	6	109	87	22	137	118	94	24	149	285	230		1887
2005	13	7	7	109	87	22	147	118	94	24	161	308	247		2026
2006	14	7	7	109	87	22	158	118	94	24	173	331	264		2165
2007	15	8	8	109	87	22	169	118	94	24	184	354	281		2304
2008	16	8	8	109	87	22	180	118	94	24	196	376	298		2442
2009	17	9	9	109	87	22	191	118	94	24	208	399	315		2581
2010	18	9	9	109	87	22	202	118	94	24	220	422	332		2720
2011	18	9	9	109	87	22	202	118	94	24	220	422	332		2720
2012	18	9	9	109	87	22	202	118	94	24	220	422	332		2720
2013	18	9	9	109	87	22	202	118	94	24	220	422	332		2720
2014	18	9	9	109	87	22	202	118	94	24	220	422	332		2720
2015	18	9	9	109	87	22	202	118	94	24	220	422	332		2720
2016	18	9	9	109	87	22	202	118	94	24	220	422	332		2720
2017	18	9	9	109	87	22	202	118	94	24	220	422	332		2720
2018	18	9	9	109	87	22	202	118	94	24	220	422	332		2720
2019	18	9	9	109	87	22	202	118	94	24	220	422	332		2720
2020	18	9	9	109	87	22	202	118	94	24	220	422	332		2720
2021	18	9	9	109	87	22	202	118	94	24	220	422	332		2720
2022	18	9	9	109	87	22	202	118	94	24	220	422	332		2720
2023	18	9	9	109	87	22	202	118	94	24	220	422	332		2720
2024	18	9	9	109	87	22	202	118	94	24	220	422	332		2720
2025	18	9	9	109	87	22	202	118	94	24	220	422	332		2720
2026	18	9	9	109	87	22	202	118	94	24	220	422	332		2720
													Total:		70993

Table 14.1-8 - Case 1: Full Equipment Renewal With Jack Method (Large Locomotive Fleet) - $000

Year	Construction	Facilities	Professional Fees	Contingency	Initial Spare Parts	Staff	Shop Maintenance	Running Costs	Total	Total (PV) 12.00%	Total (PV) (Cumulative)
			10.00%	5.00%			5.00%				
1997						0			0.0	0.0	0.0
1998						0			0.0	0.0	0.0
1999						0			0.0	0.0	0.0
2000	2283.1	22169.0	2445.2	1344.9		0			28242.1	20102.2	20102.2
2001	2283.1	22169.0	2445.2	1344.9	7992.0	0			36234.1	23027.4	43129.6
2002			0.0	0.0		250.9	2216.9	87	2554.7	1449.6	44579.2
2003			0.0	0.0		278.9	2216.9	87	2582.6	1308.4	45887.6
2004			0.0	0.0		306.8	2216.9	87	2610.6	1180.9	47068.5
2005			0.0	0.0		334.8	2216.9	87	2638.5	1065.7	48134.2
2006			0.0	0.0		362.7	2216.9	87	2666.5	961.6	49095.7
2007			0.0	0.0		390.7	2216.9	87	2694.4	867.5	49963.3
2008			0.0	0.0		418.6	2216.9	87	2722.4	782.6	50745.9
2009			0.0	0.0		446.6	2216.9	87	2750.3	705.9	51451.8
2010			0.0	0.0		474.5	2216.9	87	2778.3	636.7	52088.5
2011			0.0	0.0		474.5	2216.9	87	2778.3	568.5	52657.0
2012			0.0	0.0		474.5	2216.9	87	2778.3	507.6	53164.6
2013			0.0	0.0		474.5	2216.9	87	2778.3	453.2	53617.8
2014			0.0	0.0		474.5	2216.9	87	2778.3	404.6	54022.4
2015			0.0	0.0		474.5	2216.9	87	2778.3	361.3	54383.7
2016			0.0	0.0		474.5	2216.9	87	2778.3	322.6	54706.3
2017			0.0	0.0		474.5	2216.9	87	2778.3	288.0	54994.3
2018			0.0	0.0		474.5	2216.9	87	2778.3	257.2	55251.4
2019			0.0	0.0		474.5	2216.9	87	2778.3	229.6	55481.0
2020			0.0	0.0		474.5	2216.9	87	2778.3	205.0	55686.1
2021			0.0	0.0		474.5	2216.9	87	2778.3	183.0	55869.1
2022			0.0	0.0		474.5	2216.9	87	2778.3	163.4	56032.5
2023			0.0	0.0		474.5	2216.9	87	2778.3	145.9	56178.4
2024			0.0	0.0		474.5	2216.9	87	2778.3	130.3	56308.7
2025			0.0	0.0		474.5	2216.9	87	2778.3	116.3	56425.0
2026			0.0	0.0		474.5	2216.9	87	2778.3	103.9	56528.9
Total:	4566.2	44337.9	4890.4	2689.7	7992.0	10856.4	55422.4	2171.7	132926.7	56528.9	56528.9
Source Table:	14.1-1	14.1-2				14.1-4		14.1-3			

Appendix 14.1

Table 14.1-8 (Continued) - Case 1: Full Equipment Renewal With Jack Method (Large Locomotive Fleet) - $000

Year	Maintenance Savings	EL and EC Savings	Total	Total (PV) 12.00%	Total (PV) (Cumulative)	Total NPV	Total NPV (Cumulative)
1997	0.0	5876.3	5876.3	5876.3	5876.3	5876.3	5876.3
1998	0.0	1605.4	1605.4	1433.4	7309.7	1433.4	7309.7
1999	0.0	1626.0	1626.0	1296.3	8605.9	1296.3	8605.9
2000	0.0	1646.6	1646.6	1172.1	9778.0	-18930.1	-10324.2
2001	7992.0	1667.3	9659.3	6138.6	15916.6	-16888.8	-27213.0
2002	4025.6	1687.9	5713.5	3242.0	19158.6	1792.4	-25420.6
2003	4477.7	1708.5	6186.2	3134.1	22292.7	1825.7	-23594.9
2004	4929.7	1729.2	6658.9	3012.1	25304.9	1831.3	-21763.6
2005	5381.8	1749.8	7131.5	2880.3	28185.2	1814.7	-19949.0
2006	5833.8	1770.4	7604.2	2742.2	30927.4	1780.6	-18168.4
2007	6285.9	1791.0	8076.9	2600.5	33527.9	1733.0	-16435.4
2008	6737.9	1811.7	8549.6	2457.8	35985.7	1675.2	-14760.2
2009	7190.0	1832.3	9022.2	2315.8	38301.5	1609.8	-13150.3
2010	7642.0	1852.9	9494.9	2176.0	40477.5	1539.3	-11611.0
2011	7642.0	349.1	7991.1	1635.1	42112.6	1066.6	-10544.4
2012	7642.0	349.1	7991.1	1459.9	43572.5	952.4	-9592.0
2013	7642.0	349.1	7991.1	1303.5	44876.1	850.3	-8741.7
2014	7642.0	349.1	7991.1	1163.9	46039.9	759.2	-7982.5
2015	7642.0	349.1	7991.1	1039.2	47079.1	677.9	-7304.6
2016	7642.0	349.1	7991.1	927.8	48006.9	605.2	-6699.4
2017	7642.0	349.1	7991.1	828.4	48835.3	540.4	-6159.0
2018	7642.0	349.1	7991.1	739.7	49574.9	482.5	-5676.5
2019	7642.0	349.1	7991.1	660.4	50235.3	430.8	-5245.7
2020	7642.0	349.1	7991.1	589.6	50825.0	384.6	-4861.1
2021	7642.0	349.1	7991.1	526.5	51351.5	343.4	-4517.6
2022	7642.0	349.1	7991.1	470.1	51821.5	306.6	-4211.0
2023	7642.0	349.1	7991.1	419.7	52241.2	273.8	-3937.2
2024	7642.0	349.1	7991.1	374.7	52616.0	244.4	-3692.8
2025	7642.0	349.1	7991.1	334.6	52950.5	218.3	-3474.5
2026	7642.0	349.1	7991.1	298.7	53249.3	194.9	-3279.6
	182768.5	33940.3	216708.8	53249.3	53249.3	-3279.6	-3279.6
Source Table:	14.1-5	14.1-6					

Table 14.1-8a - Case 1a: Full Equipment Renewal With Jack Method (Medium Locomotive Fleet) - $000

Year	Construction	Facilities	Professional Fees	Contingency	Initial Spare Parts	Staff	Shop Maintenance	Running Costs	Total	Total (PV) 12.00%	Total (PV) (Cumulative)
			10.00%	5.00%			5.00%				
1997						0			0.0	0.0	0.0
1998						0			0.0	0.0	0.0
1999						0			0.0	0.0	0.0
2000	2283.1	22169.0	2445.2	1344.9		0			28242.1	20102.2	20102.2
2001	2283.1	22169.0	2445.2	1344.9	7992.0	0			36234.1	23027.4	43129.6
2002			0.0	0.0		195.9	2216.9	87	2499.7	1418.4	44548.0
2003			0.0	0.0		212.9	2216.9	87	2516.6	1275.0	45823.0
2004			0.0	0.0		229.8	2216.9	87	2533.6	1146.1	46969.0
2005			0.0	0.0		246.8	2216.9	87	2550.5	1030.1	47999.1
2006			0.0	0.0		263.7	2216.9	87	2567.5	925.9	48925.0
2007			0.0	0.0		280.7	2216.9	87	2584.4	832.1	49757.1
2008			0.0	0.0		297.6	2216.9	87	2601.4	747.8	50504.9
2009			0.0	0.0		314.6	2216.9	87	2618.3	672.1	51177.0
2010			0.0	0.0		331.5	2216.9	87	2635.3	603.9	51780.9
2011			0.0	0.0		331.5	2216.9	87	2635.3	539.2	52320.2
2012			0.0	0.0		331.5	2216.9	87	2635.3	481.5	52801.6
2013			0.0	0.0		331.5	2216.9	87	2635.3	429.9	53231.5
2014			0.0	0.0		331.5	2216.9	87	2635.3	383.8	53615.3
2015			0.0	0.0		331.5	2216.9	87	2635.3	342.7	53958.0
2016			0.0	0.0		331.5	2216.9	87	2635.3	306.0	54264.0
2017			0.0	0.0		331.5	2216.9	87	2635.3	273.2	54537.1
2018			0.0	0.0		331.5	2216.9	87	2635.3	243.9	54781.1
2019			0.0	0.0		331.5	2216.9	87	2635.3	217.8	54998.9
2020			0.0	0.0		331.5	2216.9	87	2635.3	194.5	55193.3
2021			0.0	0.0		331.5	2216.9	87	2635.3	173.6	55366.9
2022			0.0	0.0		331.5	2216.9	87	2635.3	155.0	55521.9
2023			0.0	0.0		331.5	2216.9	87	2635.3	138.4	55660.3
2024			0.0	0.0		331.5	2216.9	87	2635.3	123.6	55783.9
2025			0.0	0.0		331.5	2216.9	87	2635.3	110.3	55894.3
2026			0.0	0.0		331.5	2216.9	87	2635.3	98.5	55992.8
Total:	4566.2	44337.9	4890.4	2689.7	7992.0	7677.4	55422.4	2171.7	129747.7	55992.8	55992.8
Source Table:	14.1-1	14.1-2				14.1-4a		14.1-3			

Table 14.1-8a (Continued) - Case 1a: Full Equipment Renewal With Jack Method (Medium Locomotive Fleet) - $000

Year	Maintenance Savings	EL and EC Savings	Total	Total (PV) 12.00%	Total (PV) (Cumulative)	Total NPV	Total NPV (Cumulative)
1997	0.0	5876.3	5876.3	5876.3	5876.3	5876.3	5876.3
1998	0.0	959.5	959.5	856.7	6733.0	856.7	6733.0
1999	0.0	971.7	971.7	774.7	7507.6	774.7	7507.6
2000	0.0	984.0	984.0	700.4	8208.0	-19401.8	-11894.2
2001	7992.0	996.2	8988.2	5712.2	13920.2	-17315.3	-29209.4
2002	3096.3	1008.5	4104.7	2329.1	16249.3	910.8	-28298.7
2003	3362.4	1020.7	4383.1	2220.6	18469.9	945.6	-27353.0
2004	3628.6	1032.9	4661.6	2108.6	20578.6	962.6	-26390.4
2005	3894.8	1045.2	4940.0	1995.2	22573.8	965.1	-25425.4
2006	4161.0	1057.4	5218.4	1881.8	24455.6	955.9	-24469.4
2007	4427.1	1069.6	5496.8	1769.8	26225.4	937.7	-23531.7
2008	4693.3	1081.9	5775.2	1660.2	27885.6	912.4	-22619.3
2009	4959.5	1094.1	6053.6	1553.8	29439.4	881.8	-21737.6
2010	5225.7	1106.4	6332.0	1451.1	30890.6	847.2	-20890.4
2011	5225.7	240.0	5465.7	1118.4	32009.0	579.2	-20311.2
2012	5225.7	240.0	5465.7	998.6	33007.5	517.1	-19794.1
2013	5225.7	240.0	5465.7	891.6	33899.1	461.7	-19332.4
2014	5225.7	240.0	5465.7	796.1	34695.1	412.2	-18920.1
2015	5225.7	240.0	5465.7	710.8	35405.9	368.1	-18552.1
2016	5225.7	240.0	5465.7	634.6	36040.5	328.6	-18223.4
2017	5225.7	240.0	5465.7	566.6	36607.1	293.4	-17930.0
2018	5225.7	240.0	5465.7	505.9	37113.0	262.0	-17668.0
2019	5225.7	240.0	5465.7	451.7	37564.7	233.9	-17434.1
2020	5225.7	240.0	5465.7	403.3	37968.0	208.9	-17225.3
2021	5225.7	240.0	5465.7	360.1	38328.1	186.5	-17038.8
2022	5225.7	240.0	5465.7	321.5	38649.6	166.5	-16872.3
2023	5225.7	240.0	5465.7	287.1	38936.7	148.7	-16723.6
2024	5225.7	240.0	5465.7	256.3	39193.0	132.7	-16590.9
2025	5225.7	240.0	5465.7	228.8	39421.9	118.5	-16472.4
2026	5225.7	240.0	5465.7	204.3	39626.2	105.8	-16366.6
	129051.5	23145.0	152196.5	39626.2	39626.2	-16366.6	-16366.6
Source Table:	14.1-5a	14.1-6a					

Table 14.1- 9 - Case 2: Partial Equipment Renewal With Jack Method (Large Locomotive Fleet) - 5000

Year	Construction	Facilities	Professional Fees	Contingency	Initial Spare Parts	Staff	Shop Maintenance	Running Costs	Total	Total (PV) 12.00%	Total (PV) (Cumulative)
			10.00%	5.00%			5.00%				
1997						0			0.0	0.0	0.0
1998						0			0.0	0.0	0.0
1999						0			0.0	0.0	0.0
2000	2283.1	11931.1	1421.4	781.8		0			16417.4	11685.6	11685.6
2001	2283.1	11931.1	1421.4	781.8	7992.0	0			24409.4	15512.6	27198.1
2002			0.0	0.0		250.9	1193.1	87	1530.9	868.7	28066.8
2003			0.0	0.0		278.9	1193.1	87	1558.8	789.8	28856.6
2004			0.0	0.0		306.8	1193.1	87	1586.8	717.8	29574.3
2005			0.0	0.0		334.8	1193.1	87	1614.7	652.2	30226.5
2006			0.0	0.0		362.7	1193.1	87	1642.7	592.4	30818.9
2007			0.0	0.0		390.7	1193.1	87	1670.6	537.9	31356.8
2008			0.0	0.0		418.6	1193.1	87	1698.6	488.3	31845.1
2009			0.0	0.0		446.6	1193.1	87	1726.5	443.2	32288.2
2010			0.0	0.0		474.5	1193.1	87	1754.5	402.1	32690.3
2011			0.0	0.0		474.5	1193.1	87	1754.5	359.0	33049.3
2012			0.0	0.0		474.5	1193.1	87	1754.5	320.5	33369.8
2013			0.0	0.0		474.5	1193.1	87	1754.5	286.2	33656.0
2014			0.0	0.0		474.5	1193.1	87	1754.5	255.5	33911.6
2015			0.0	0.0		474.5	1193.1	87	1754.5	228.2	34139.7
2016			0.0	0.0		474.5	1193.1	87	1754.5	203.7	34343.4
2017			0.0	0.0		474.5	1193.1	87	1754.5	181.9	34525.3
2018			0.0	0.0		474.5	1193.1	87	1754.5	162.4	34687.7
2019			0.0	0.0		474.5	1193.1	87	1754.5	145.0	34832.7
2020			0.0	0.0		474.5	1193.1	87	1754.5	129.5	34962.2
2021			0.0	0.0		474.5	1193.1	87	1754.5	115.6	35077.7
2022			0.0	0.0		474.5	1193.1	87	1754.5	103.2	35180.9
2023			0.0	0.0		474.5	1193.1	87	1754.5	92.1	35273.1
2024			0.0	0.0		474.5	1193.1	87	1754.5	82.3	35355.4
2025			0.0	0.0		474.5	1193.1	87	1754.5	73.5	35428.8
2026			0.0	0.0		474.5	1193.1	87	1754.5	65.6	35494.4
Total:	4566.2	23862.2	2842.8	1563.6	7992.0	10856.4	29827.7	2171.7	83682.5	35494.4	35494.4
Source Table:	14.1-1	14.1-2				14.1-4		14.1-3			

Table 14.1- 9 (Continued) - Case 2: Partial Equipment Renewal With Jack Method (Large Locomotive Fleet) - $000

Year	Maintenance Savings	EL and EC Savings	Total	Total (PV) 12.00%	Total (PV) (Cumulative)	Total NPV	Total NPV (Cumulative)
1997	0.0	5876.3	5876.3	5876.3	5876.3	5876.3	5876.3
1998	0.0	1605.4	1605.4	1433.4	7309.7	1433.4	7309.7
1999	0.0	1626.0	1626.0	1296.3	8605.9	1296.3	8605.9
2000	0.0	1646.6	1646.6	1172.1	9778.0	-10513.5	-1907.6
2001	7992.0	1667.3	9659.3	6138.6	15916.6	-9373.9	-11281.5
2002	2080.9	1687.9	3768.8	2138.5	18055.1	1269.9	-10011.7
2003	2313.9	1708.5	4022.4	2037.9	20093.0	1248.1	-8763.6
2004	2546.8	1729.2	4276.0	1934.2	22027.2	1216.4	-7547.1
2005	2779.8	1749.8	4529.5	1829.4	23856.6	1177.2	-6369.9
2006	3012.7	1770.4	4783.1	1724.8	25581.5	1132.5	-5237.4
2007	3245.7	1791.0	5036.7	1621.7	27203.1	1083.8	-4153.6
2008	3478.6	1811.7	5290.3	1520.8	28724.0	1032.5	-3121.1
2009	3711.6	1832.3	5543.8	1423.0	30146.9	979.8	-2141.3
2010	3944.5	1852.9	5797.4	1328.6	31475.5	926.5	-1214.8
2011	3944.5	349.1	4293.6	878.6	32354.1	519.5	-695.2
2012	3944.5	349.1	4293.6	784.4	33138.5	463.9	-231.3
2013	3944.5	349.1	4293.6	700.4	33838.9	414.2	182.8
2014	3944.5	349.1	4293.6	625.3	34464.2	369.8	552.7
2015	3944.5	349.1	4293.6	558.3	35022.6	330.2	882.8
2016	3944.5	349.1	4293.6	498.5	35521.1	294.8	1177.6
2017	3944.5	349.1	4293.6	445.1	35966.2	263.2	1440.9
2018	3944.5	349.1	4293.6	397.4	36363.6	235.0	1675.9
2019	3944.5	349.1	4293.6	354.8	36718.4	209.8	1885.7
2020	3944.5	349.1	4293.6	316.8	37035.2	187.4	2073.1
2021	3944.5	349.1	4293.6	282.9	37318.1	167.3	2240.3
2022	3944.5	349.1	4293.6	252.6	37570.7	149.4	2389.7
2023	3944.5	349.1	4293.6	225.5	37796.2	133.4	2523.1
2024	3944.5	349.1	4293.6	201.3	37997.5	119.1	2642.1
2025	3944.5	349.1	4293.6	179.8	38177.3	106.3	2748.4
2026	3944.5	349.1	4293.6	160.5	38337.8	94.9	2843.4
	98218.4	33940.3	132158.8	38337.8	38337.8	2843.4	2843.4
Source Table	14.1-7	14.1-6					

Table 14.1-9a - Case 2a: Partial Equipment Renewal With Jack Method (Medium Locomotive Fleet) - $000

Year	Construction	Facilities	Professional Fees	Contingency	Initial Spare Parts	Staff	Shop Maintenance	Running Costs	Total	Total (PV) 12.00%	Total (PV) (Cumulative)
			10.00%	5.00%			5.00%				
1997						0			0.0	0.0	0.0
1998						0			0.0	0.0	0.0
1999						0			0.0	0.0	0.0
2000	2283.1	11931.1	1421.4	781.8		0			16417.4	11685.6	11685.6
2001	2283.1	11931.1	1421.4	781.8	7992.0	0			24409.4	15512.6	27198.1
2002			0.0	0.0		195.9	1193.1	87	1475.9	837.5	28035.6
2003			0.0	0.0		212.9	1193.1	87	1492.8	756.3	28791.9
2004			0.0	0.0		229.8	1193.1	87	1509.8	682.9	29474.9
2005			0.0	0.0		246.8	1193.1	87	1526.7	616.6	30091.5
2006			0.0	0.0		263.7	1193.1	87	1543.7	556.7	30648.1
2007			0.0	0.0		280.7	1193.1	87	1560.6	502.5	31150.6
2008			0.0	0.0		297.6	1193.1	87	1577.6	453.5	31604.1
2009			0.0	0.0		314.6	1193.1	87	1594.5	409.3	32013.4
2010			0.0	0.0		331.5	1193.1	87	1611.5	369.3	32382.7
2011			0.0	0.0		331.5	1193.1	87	1611.5	329.7	32712.5
2012			0.0	0.0		331.5	1193.1	87	1611.5	294.4	33006.9
2013			0.0	0.0		331.5	1193.1	87	1611.5	262.9	33269.7
2014			0.0	0.0		331.5	1193.1	87	1611.5	234.7	33504.4
2015			0.0	0.0		331.5	1193.1	87	1611.5	209.6	33714.0
2016			0.0	0.0		331.5	1193.1	87	1611.5	187.1	33901.1
2017			0.0	0.0		331.5	1193.1	87	1611.5	167.1	34068.2
2018			0.0	0.0		331.5	1193.1	87	1611.5	149.2	34217.3
2019			0.0	0.0		331.5	1193.1	87	1611.5	133.2	34350.5
2020			0.0	0.0		331.5	1193.1	87	1611.5	118.9	34469.4
2021			0.0	0.0		331.5	1193.1	87	1611.5	106.2	34575.6
2022			0.0	0.0		331.5	1193.1	87	1611.5	94.8	34670.4
2023			0.0	0.0		331.5	1193.1	87	1611.5	84.6	34755.0
2024			0.0	0.0		331.5	1193.1	87	1611.5	75.6	34830.6
2025			0.0	0.0		331.5	1193.1	87	1611.5	67.5	34898.0
2026			0.0	0.0		331.5	1193.1	87	1611.5	60.2	34958.3
Total:	4566.2	23862.2	2842.8	1563.6	7992.0	7677.4	29827.7	2171.7	80503.5	34958.3	34958.3
Source Table:	14.1-1	14.1-2				14.1-4a		14.1-3			

Table 14.1-9a (Continued) - Case 2a: Partial Equipment Renewal With Jack Method (Medium Locomotive Fleet) - $000

Year	Maintenance Savings	EL and EC Savings	Total	Total (PV) 12.00%	Total (PV) (Cumulative)	Total NPV	Total NPV (Cumulative)
1997	0.0	5876.3	5876.3	5876.3	5876.3	5876.3	5876.3
1998	0.0	959.5	959.5	856.7	6733.0	856.7	6733.0
1999	0.0	971.7	971.7	774.7	7507.6	774.7	7507.6
2000	0.0	984.0	984.0	700.4	8208.0	-10985.2	-3477.6
2001	7992.0	996.2	8988.2	5712.2	13920.2	-9800.4	-13278.0
2002	1609.9	1008.5	2618.3	1485.7	15405.9	648.3	-12629.7
2003	1748.6	1020.7	2769.3	1403.0	16808.9	646.7	-11983.0
2004	1887.4	1032.9	2920.3	1321.0	18129.9	638.0	-11345.0
2005	2026.1	1045.2	3071.3	1240.4	19370.3	623.8	-10721.1
2006	2164.9	1057.4	3222.3	1162.0	20532.3	605.3	-10115.8
2007	2303.6	1069.6	3373.2	1086.1	21618.4	583.6	-9532.2
2008	2442.3	1081.9	3524.2	1013.1	22631.5	559.6	-8972.6
2009	2581.1	1094.1	3675.2	943.3	23574.9	534.1	-8438.5
2010	2719.8	1106.4	3826.2	876.9	24451.7	507.6	-7931.0
2011	2719.8	240.0	2959.9	605.6	25057.4	275.9	-7655.1
2012	2719.8	240.0	2959.9	540.8	25598.2	246.3	-7408.7
2013	2719.8	240.0	2959.9	482.8	26081.0	220.0	-7188.8
2014	2719.8	240.0	2959.9	431.1	26512.1	196.4	-6992.4
2015	2719.8	240.0	2959.9	384.9	26897.0	175.3	-6817.0
2016	2719.8	240.0	2959.9	343.7	27240.6	156.6	-6660.5
2017	2719.8	240.0	2959.9	306.8	27547.5	139.8	-6520.7
2018	2719.8	240.0	2959.9	274.0	27821.4	124.8	-6395.9
2019	2719.8	240.0	2959.9	244.6	28066.0	111.4	-6284.5
2020	2719.8	240.0	2959.9	218.4	28284.4	99.5	-6185.0
2021	2719.8	240.0	2959.9	195.0	28479.5	88.8	-6096.1
2022	2719.8	240.0	2959.9	174.1	28653.6	79.3	-6016.8
2023	2719.8	240.0	2959.9	155.5	28809.0	70.8	-5946.0
2024	2719.8	240.0	2959.9	138.8	28947.8	63.2	-5882.8
2025	2719.8	240.0	2959.9	123.9	29071.7	56.5	-5826.3
2026	2719.8	240.0	2959.9	110.6	29182.4	50.4	-5775.9
	70993.1	23145.0	94138.1	29182.4	29182.4	-5775.9	-5775.9
Source Ta	14.1-5a	14.1-6a					

Appendix 14.1

Table 14.1-10 - Sensitivity Analysis ($000 E)						
	Discount Rate	ENPV Base	Benefit to Cost Ratio	ENPV Costs + 10%	ENPV Benefits - 10%	ENPV Costs + 10% Benefits - 10%
Case 1	12.00%	-3279.6	0.94	-8932.5	-8604.6	-14257.5
Case 1a	12.00%	-166366.6	0.71	-21965.9	-20329.2	-25928.5
Case 2	12.00%	2843.4	1.08	-706.1	-990.4	-4539.9
Case 2a	12.00%	-5775.9	0.83	-9271.7	-8694.1	-12190.0

Table 14.1-11 - Sensitivity Analysis ($000 F)						
	Discount Rate	FNPV Base	Benefit to Cost Ratio	FNPV Costs + 10%	FNPV Benefits - 10%	FNPV Costs + 10% Benefits - 10%
Case 1	12.00%	-4405.1	0.92	-10170.5	-9730.0	-15495.4
Case 1a	12.00%	-17177.2	0.70	-22857.5	-21139.8	-26820.1
Case 2	12.00%	1717.9	1.05	-1944.1	-2115.9	-577.8
Case 2a	12.00%	-6586.5	0.82	-10163.3	-9504.7	-13081.6

Appendix 14.2-1 Atomospheric Dispersion

Appendix 14.2-1 Atmospheric Dispersion

1. Factors Affecting Dispersion of Air Pollutants

The factors that affect the transport, dilution, and dispersion of air pollutants can generally be categorized in terms of the emission point characteristics, the nature of the pollutant material, meteorological conditions, and effects of terrain and anthropogenic structures.

1.1 Source characteristics

Most industrial effluents are discharged vertically into the open air through a stack or duct. As the contaminated gas stream leaves the discharge point, the plume tends to expand and mix with the ambient air. Horizontal air movement will tend to bend the discharge plume toward the downwind direction. At some point between 300 and 3,000 m downwind, the effluent plume will level off. While the effluent plume is rising, bending, and beginning to move in a horizontal direction, the gaseous effluents are being diluted by larger and larger volumes of ambient air, they are eventually dispersed toward the ground.

The plume rise is affected by both the upward inertia of the discharge gas stream and by its buoyancy. The vertical inertia is related the exit gas velocity and mass. The plume's buoyancy is related to the exit gas mass relative to the surrounding air mass. Increasing the exit velocity or the exit gas temperature will generally increase the plume rise. The plume rise, together with the physical stack height, is called the effective stack height.

The additional rise of the plume above the discharge point as the plume bends and levels off is a factor in the resultant downwind ground level concentrations. The higher the plume rises initially, the greater distance there is for diluting the contaminated gases as they expand and mix downward.

For a specific discharge height and a specific set of plume dilution conditions, the ground level concentration is proportional to the amount of contaminant materials discharged from the stack outlet for a specific period of time. Thus, when all other conditions are constant, an increase in the pollutant discharge rate will cause a proportional increase in the downwind ground level concentrations.

1.2 Downwind distance

The greater the distance between the point of discharge and a ground level receptor downwind, the greater will be the volume of air available for diluting the contaminant discharge before it reaches the receptor.

1.3 Wind speed and direction

The wind direction determines the direction in which the contaminated gas stream will move across local terrain. Wind speed affects the plume rise and the rate of mixing or dilution of the contaminated gases as they leave the discharge point. An increase in wind speed will decrease the plume rise by bending the plume over more rapidly. The decrease in plume rise tends to increase the pollutant's ground level concentration. On the other hand, an increase in wind speed will increase the rate of dilution of the effluent plume, tending to lower the downwind concentrations. Under different conditions, one or the other of the two wind speed affects becomes the predominant effect. These effects, in turn, affect the distance downwind of the source at which the maximum ground level concentration will occur.

1.4 Stability

The turbulence of the atmosphere follows no other factor in power of dilution. The more unstable the atmosphere, the greater the diluting power. Inversions that are not ground based, but begin at some height above the stack exit, act as a lid to restrict vertical dilution.

2. Dispersion Modeling

2.1 General considerations and use of models

A dispersion model is a mathematical description of the meteorological transport and dispersion process that is quantified in terms of source and meteorological parameters during a particular time. The resultant numerical calculations yield estimates of concentrations of the particular pollutant for specific locations and times.

2.2 Basic point source Gaussian dispersion model.

The basic Gaussian diffusion equation assumes that atmospheric stability is uniform throughout the layer into which the contaminated gas stream is discharged.

The model assumes that turbulent diffusion is a random activity and hence the dilution of contaminated gas stream in both the horizontal and vertical direction can be described by the Gaussian or normal equation.

The model further assumes that the contaminated gas stream is released into the atmosphere at a distance above ground level that is equal to the physical stack height plus the plume rise. The model assumes that the contaminated gas stream is released into the atmosphere at a distance above ground level that is equal to the physical stack height plus the plume rise.

The model assumes that the degree of dilution of the effluent plume is inversely proportional to the wind speed (u).

The model also assumes that pollutant material that reaches ground level is totally reflected back into the atmosphere like a beam of light striking a mirror at an angle. Mathematically, this ground reflection is accounted for by assuming a virtual or imaginary source located at a distance of -H with respect to ground level, and emitting an imaginary plume with the same source strength as the real source being modeled. The same general idea can be used to establish other boundary layer conditions for the equations, such as limiting horizontal or vertical mixing.

2.3 The model

The model equation in the form presented by D.B. Turner is selected. It gives the ground level concentration (χ) of pollutant at a point (coordinates x and y) downwind from a stack with an effective height (H). The standard deviation of the plume in the horizontal and vertical directions is designated by s_y and s_z, respectively. The standard deviations are function of the downward distance from the source and the stability of the atmosphere. The equation is as follows:

$$\chi(x, y, 0, H) = [Q/(\pi s_y s_z u)]\{\exp[-0.5(y/s_y)^2]\}\{\exp[-0.5(H/s_z)^2]\} \quad (2\text{-}1)$$

where

$\chi(x, y, 0, H)$: downwind concentration at ground level, g/m^3

Q: emission rate of pollutants, g/s

s_y and s_z : plume standard deviation, m

u: wind speed, m/s

x, y, z, and H : distances, m

exp : exponential e such that terms in brackets immediately following are powers of e, where e = 2.7182

The value for the effective stack height is the sum of the physical stack height (h) and the plume rise ΔH:

$$H = h + \Delta H \quad (2\text{-}2)$$

ΔH may be computed from Holland's formula as follows:

$$\Delta H = (v_s d/u)[1.5 + (2.68x10^{-2}(P)(T_s - T_a)d/T_s)] \quad (2\text{-}3)$$

where

v_s : stack velocity, m/s
d : stack diameter
u : wind speed, m/s
P : pressure
T_s : stack temperature, K
T_a : air temperature, K

The values of s_y and s_z depend upon the turbulent structure or stability of the atmosphere. Figure 1 and Figure 2 of Appendix 14.2-1 provide graphical relationships between the downwind distance x in kilometers and values of s_y and s_z in meters. The curves on the two figures are labeled "A" through "F" . The label "A" refers to very unstable atmospheric conditions, "B" to unstable atmospheric conditions, "C" to slightly unstable to neutral condition, "D" to stable conditions, "E" to stable atmospheric conditions, and "F" to very stable atmospheric conditions. Each of these stability parameters represents an averaging time of approximately 3 to 15 min.

Other averaging times may be approximated by multiplying by empirical constants, for example, 0.36 for 24 hours. Turner presented a table and discussion that allows an estimate of stability based on wind speed and the conditions of solar radiation. This is given in the following Table.

Table 1 Key to stability categories

Surface Wind speed (at 10 m) (m/s)	Day Incoming solar radiation Strong	Moderate	Slight	Night Thinly overcast or >=4/8 Low cloud	<=3/8 cloud
<2	A	A-B	B		
2-3	A-B	B	C	E	F
3-5	B	B-C	C	D	E
5-6	C	C-D	D	D	D
>6	C	D	D	D	D

3. Example

Using the Eq. 2-1, the ground level concentration is calculated for the cupola and the section of cutting metals (in Table 8.7 of Appendix 5-1). The results are shown in Tables 2 to 7 of Appendix 14.2-1 for the cupola and in Tables 8 to 13 of Appendix 14.2-1 for the section of cutting metals.

4. Standards

WHO Air Quality Guidelines, U.S. National Ambient Air Quality Standards and German Ambient Air Quality Standards and Smog Alarm Values are shown in Table 14, Table 15 and Table 16 of Appendix 14.2-1, respectively.

Reference

1. M.L.Davis, D.C. Cornwell, "Introduction to Environmental Engineering", 1991, McGraw-Hill International Edition
2. D.B. Turner, "Workbook of Atmospheric Dispersion Estimation", 1967, U.S. Department of Health, Education and Welfare, Public Health Service, National Center for Air Pollution Control, Publication No. 999-AP-26
3. G. Baumbach, "Air Quality Control", 1996, Springer

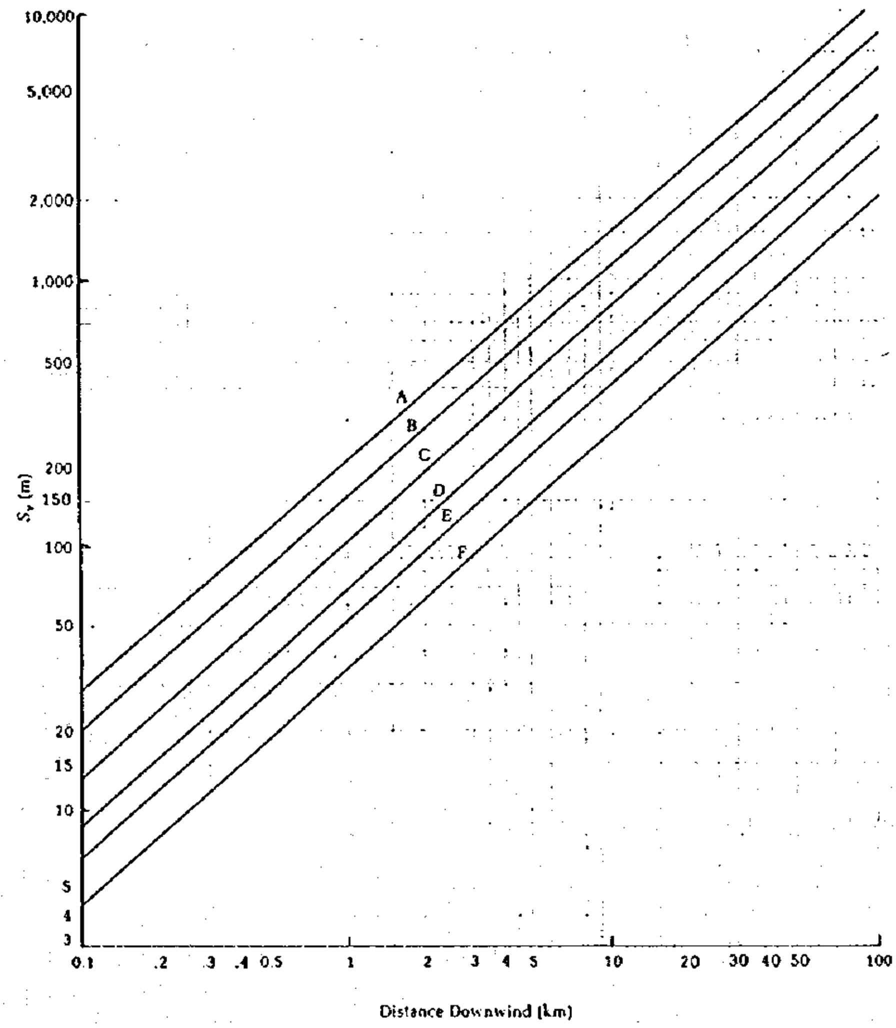

Fig. 1 Horizontal dispersion coefficient
(Source: Turner, Workbook of Atmospheric Dispersion Estimates)

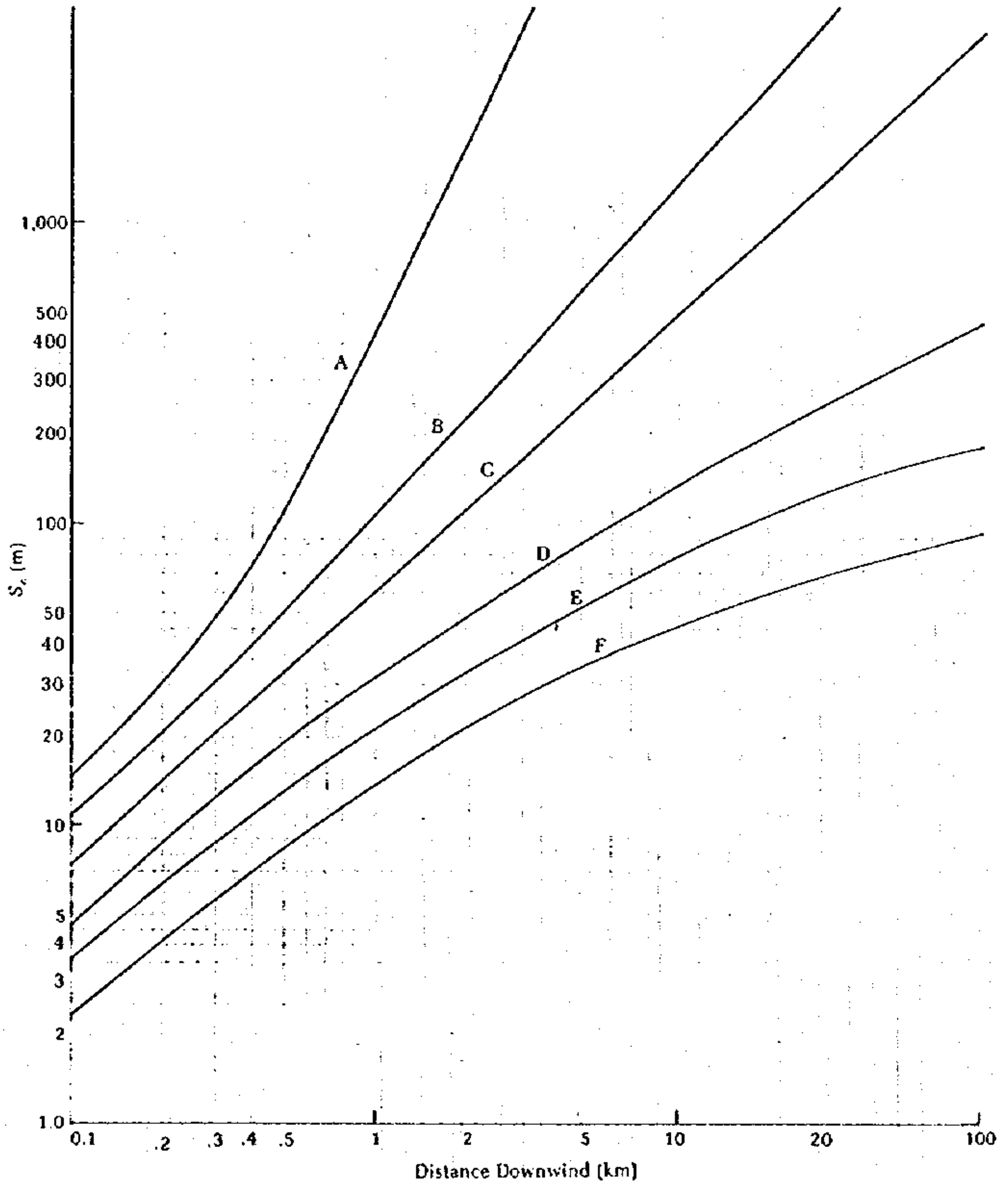

Fig. 2 Vertical dispersion coefficient
(Source: Turner, Workbook of Atmospheric Dispersion Estimates)

Table 2 Ground Level Concentration of Carbon Monoxide (mg/m^3) from a Cupola

		x(wind direction), m								
		100	150	200	250	300	350	400	450	500
y, m	0	0.0000	0.0000	0.0001	0.0020	0.0185	0.0404	0.0761	0.1205	0.1424
	50	0.0000	0.0000	0.0001	0.0011	0.0118	0.0288	0.0585	0.0976	0.1193
	100	0.0000	0.0000	0.0000	0.0002	0.0031	0.0105	0.0266	0.0518	0.0701
	150	0.0000	0.0000	0.0000	0.0000	0.0003	0.0020	0.0072	0.0181	0.0289
	200	0.0000	0.0000	0.0000	0.0000	0.0000	0.0002	0.0011	0.0041	0.0084
	250	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0006	0.0017
	300	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0002
	350	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	400	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	450	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	500	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

stack parameter
height 18 m
diameter 3.5 m
emission rate 6.04 g/s
stack velocity 1.4 m/s
temperature 973 ° K

atmosphere parameter
pressure 100 kPa
wind speed 0.5 m/s
temperature 298 ° K
stability category B
y: horizontal perpendicular direction to wind direction

Table 3 Ground Level Concentration of Carbon monoxide (mg/m^3) from a Cupola

		x(wind direction), m								
		100	150	200	250	300	350	400	450	500
y, m	0	0.0294	0.1307	0.2488	0.2696	0.2803	0.2528	0.2239	0.1944	0.1726
	50	0.0013	0.0296	0.0998	0.1493	0.1796	0.1807	0.1722	0.1574	0.1445
	100	0.0000	0.0003	0.0065	0.0254	0.0473	0.0660	0.0783	0.0836	0.0850
	150	0.0000	0.0000	0.0001	0.0013	0.0051	0.0123	0.0211	0.0291	0.0350
	200	0.0000	0.0000	0.0000	0.0000	0.0002	0.0012	0.0034	0.0067	0.0101
	250	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0003	0.0010	0.0021
	300	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0003
	350	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	400	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	450	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	500	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

stack parameter
height 18 m
diameter 3.5 m
emission rate 6.04 g/s
stack velocity 1.4 m/s
temperature 973 ° K

atmosphere parameter
pressure 100 kPa
wind speed 2 m/s
temperature 298 ° K
stability category B
y: horizontal perpendicular direction to wind direction

Table 4 Ground Level Concentration of Carbon Monoxide (mg/m^3) from a Cupola

		x(wind direction), m								
		100	150	200	250	300	350	400	450	500
y, m	0	0.1576	0.2249	0.2321	0.1960	0.1654	0.1372	0.1131	0.0928	0.0801
	50	0.0069	0.0509	0.0932	0.1086	0.1060	0.0980	0.0870	0.0751	0.0671
	100	0.0000	0.0006	0.0060	0.0185	0.0279	0.0358	0.0396	0.0399	0.0395
	150	0.0000	0.0000	0.0001	0.0010	0.0030	0.0067	0.0106	0.0139	0.0163
	200	0.0000	0.0000	0.0000	0.0000	0.0001	0.0006	0.0017	0.0032	0.0047
	250	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0002	0.0005	0.0010
	300	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001
	350	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	400	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	450	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	500	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

stack parameter
height 18 m
diameter 3.5 m
emission rate 6.04 g/s
stack velocity 1.4 m/s
temperature 973 ° K

atmosphere parameter
pressure 100 kPa
wind speed 5 m/s
temperature 298 ° K
stability category B
y: horizontal perpendicular direction to wind direction

Table 5 Ground Level Concentration of Carbon Monoxide (mg/m^3) from a Cupola

		x(wind direction), m								
		100	150	200	250	300	350	400	450	500
y, m	0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	50	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	100	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	150	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	200	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	250	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	300	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	350	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	400	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	450	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	500	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

stack parameter
height 18 m
diameter 3.5 m
emission rate 6.04 g/s
stack velocity 1.4 m/s
temperature 973 ° K

atmosphere parameter
pressure 100 kPa
wind speed 0.5 m/s
temperature 298 ° K
stability category D
y: horizontal perpendicular direction to wind direction

Table 6 Ground Level Concentration of Carbon Monoxide (mg/m^3) from a Cupola

		x(wind direction), m								
		100	150	200	250	300	350	400	450	500
y, m	0	0.0000	0.0000	0.0008	0.0126	0.0489	0.0701	0.1088	0.1482	0.1927
	50	0.0000	0.0000	0.0000	0.0006	0.0046	0.0118	0.0271	0.0470	0.0773
	100	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0004	0.0015	0.0050
	150	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001
	200	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	250	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	300	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	350	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	400	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	450	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	500	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

stack parameter
height 18 m
diameter 3.5 m
emission rate 6.04 g/s
stack velocity 1.4 m/s
temperature 973 ° K

atmosphere parameter
pressure 100 kPa
wind speed 2 m/s
temperature 298 ° K
stability category D
y: horizontal perpendicular direction to wind direction

Table 7 Ground Level Concentration of Carbon Monoxide (mg/m^3) from a Cupola

		x(wind direction), m								
		100	150	200	250	300	350	400	450	500
y, m	0	0.0000	0.0046	0.0375	0.1106	0.1783	0.1886	0.2060	0.2159	0.2169
	50	0.0000	0.0000	0.0005	0.0049	0.0168	0.0318	0.0514	0.0685	0.0871
	100	0.0000	0.0000	0.0000	0.0000	0.0000	0.0002	0.0008	0.0022	0.0056
	150	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001
	200	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	250	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	300	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	350	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	400	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	450	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	500	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

stack parameter

height	18 m
diameter	3.5 m
emission rate	6.04 g/s
stack velocity	1.4 m/s
temperature	973 ° K

atmosphere parameter

pressure	100 kPa
wind speed	5 m/s
temperature	298 ° K
stability category	D

y: horizontal perpendicular direction to wind direction

Table 8 Ground Level Concentration of Carbon Monoxide (mg/m^3) from a Section of Cutting Metals

		x(wind direction), m								
		100	150	200	250	300	350	400	450	500
y, m	0	0.0218	0.0142	0.0096	0.0069	0.0050	0.0039	0.0031	0.0024	0.0021
	50	0.0010	0.0032	0.0039	0.0038	0.0032	0.0028	0.0024	0.0020	0.0017
	100	0.0000	0.0000	0.0002	0.0006	0.0008	0.0010	0.0011	0.0010	0.0010
	150	0.0000	0.0000	0.0000	0.0000	0.0001	0.0002	0.0003	0.0004	0.0004
	200	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0001
	250	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	300	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	350	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	400	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	450	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	500	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

stack parameter
height 4 m
diameter 5.6 m
emission rate 0.014 g/s
stack velocity 0.5 m/s
temperature 298 ° K

atmosphere parameter
pressure 100 kPa
wind speed 0.5 m/s
temperature 298 ° K
stability category B
y: horizontal perpendicular direction to wind direction

Table 9 Ground Level Concentration of Carbon Monoxide (mg/m^3) from a Section of Cutting Metals

		x(wind direction), m								
		100	150	200	250	300	350	400	450	500
y.	0	0.0082	0.0045	0.0028	0.0019	0.0013	0.0010	0.0008	0.0006	0.0005
m	50	0.0004	0.0010	0.0011	0.0010	0.0009	0.0007	0.0006	0.0005	0.0004
	100	0.0000	0.0000	0.0001	0.0002	0.0002	0.0003	0.0003	0.0003	0.0003
	150	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0001	0.0001	0.0001
	200	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	250	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	300	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	350	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	400	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	450	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	500	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

stack parameter

height	4 m
diameter	5.6 m
emission rate	0.014 g/s
stack velocity	0.5 m/s
temperature	298 ° K

atmosphere parameter

pressure	100 kPa
wind speed	2 m/s
temperature	298 ° K
stability category	B

y: horizontal perpendicular direction to wind direction

Table 10 Ground Level Concentration of Carbon Monoxide (mg/m^3) from a Section of Cutting Metals

		x(wind direction), m								
		100	150	200	250	300	350	400	450	500
y. m	0	0.0034	0.0018	0.0011	0.0008	0.0005	0.0004	0.0003	0.0003	0.0002
	50	0.0002	0.0004	0.0004	0.0004	0.0003	0.0003	0.0002	0.0002	0.0002
	100	0.0000	0.0000	0.0000	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
	150	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	200	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	250	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	300	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	350	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	400	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	450	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	500	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

stack parameter
height 4 m
diameter 5.6 m
emission rate 0.014 g/s
stack velocity 0.5 m/s
temperature 298 ° K

atmosphere parameter
pressure 100 kPa
wind speed 5 m/s
temperature 298 ° K
stability category B
y: horizontal perpendicular direction to wind direction

Table 11 Ground Level Concentration of Carbon Monoxide (mg/m^3) from a Section of Cutting Metals

		x(wind direction) . m								
		100	150	200	250	300	350	400	450	500
y, m	0	0.0065	0.0204	0.0223	0.0215	0.0189	0.0162	0.0139	0.0122	0.0103
	50	0.0000	0.0000	0.0003	0.0009	0.0018	0.0027	0.0035	0.0039	0.0041
	100	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0001	0.0003
	150	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	200	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	250	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	300	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	350	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	400	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	450	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	500	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

stack parameter	
height	4 m
diameter	5.6 m
emission rate	0.014 g/s
stack velocity	0.5 m/s
temperature	298 ° K

atmosphere parameter	
pressure	100 kPa
wind speed	0.5 m/s
temperature	298 ° K
stability category	D

y: horizontal perpendicular direction to wind direction

Table 12 Ground Level Concentration of Carbon Monoxide (mg/m^3) from a Section of Cutting Metals

		x(wind direction), m								
		100	150	200	250	300	350	400	450	500
y, m	0	0.0227	0.0168	0.0116	0.0087	0.0067	0.0055	0.0044	0.0037	0.0030
	50	0.0000	0.0000	0.0002	0.0004	0.0006	0.0009	0.0011	0.0012	0.0012
	100	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001
	150	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	200	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	250	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	300	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	350	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	400	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	450	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	500	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

stack parameter		atmosphere parameter	
height	4 m	pressure	100 kPa
diameter	5.6 m	wind speed	2 m/s
emission rate	0.014 g/s	temperature	298 ° K
stack velocity	0.5 m/s	stability category	D
temperature	298 ° K		

y: horizontal perpendicular direction to wind direction

Table 13 Ground Level Concentration of Carbon Monoxide (mg/m^3) from a Section of Cutting metals

		x(wind direction) . m								
		100	150	200	250	300	350	400	450	500
y, m	0	0.0124	0.0077	0.0051	0.0037	0.0028	0.0023	0.0018	0.0015	0.0012
	50	0.0000	0.0000	0.0001	0.0002	0.0003	0.0004	0.0005	0.0005	0.0005
	100	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	150	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	200	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	250	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	300	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	350	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	400	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	450	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	500	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

stack parameter		atmosphere parameter	
height	4 m	pressure	100 kPa
diameter	5.6 m	wind speed	5 m/s
emission rate	0.014 g/s	temperature	298 ° K
stack velocity	0.5 m/s	stability category	D
temperature	298 ° K		

y: horizontal perpendicular direction to wind direction

Table 14 List of WHO Air Quality Guidelines for Individual Substances

Substance	Time-weighted average	Averaging time[1]	Carcinogenic risk	Site of tumor
Arsenic			4×10^{-3}	lung
Benzene			4×10^{-6}	blood, leukemia
Asbestos			10^{-6}–10^{-5} [2] 10^{-3}–10^{-4} [2]	lung cancer [3] mesothelioma
Cadmium	1–5 ng/m^3 10–20 ng/m^3	1year (rural area)		
Carbon disulfide	100 μg/m^3	24 h		
Carbon monoxide	100 mg/m^3 60 mg/m^3 30 mg/m^3 10 mg/m^3	15 min [4] 30 min [4] 1h [4] 8h [4]		
Chromium			4×10^{-2}	lung
Formaldehyde	100 μg/m^3	30 min		
Hydrogen sulfide	150 μg/m^3	24 h		
Lead	0.5–1.0 μg/m^3	1 year		
Mercury	1 μg/m^3 [5]	1 year		
Nitrogen dioxide	400 μg/m^3 150 μg/m^3	1 h 24 h		
Ozone	150–200 μg/m^3 100–120 μg/m^3	1 h 8 h		
Polynuclear aromatic hydrocarbons			9×10^{-2}	lung
Sulfur dioxide	500 μg/m^3 350 μg/m^3	10 min 1 h		
Toluene	8 mg/m^3	24 h		
Vinyl chloride			1×10^{-6}	liver and other sites

(Source: Air quality guidelines for Europe. Copenhagen: World Health Organization, Regional Office for Europe. WHO regional publications, European series No.23, ISBN 92-890-1114-9)

1) Cancer risk estimates for lifetime exposure to a concentration of 1μg/m^3

2) Cancer risk estimates for lifetime exposure to a fiber concentration of 500 fibers/m^3 (fiber measured by optical methods)

3) Lung cancer in a population with 30% smokers

4) Exposure at these concentrations should be for no longer than the indicated times and should not repeated within 8 hours

5) The guideline value is given only for indoor air pollution; no guidance is given on outdoor concentration (via deposition and entry into the food chain) that might be of indirect relevance

Table 15 U.S. National Ambient Air Quality Standards*

Substance	Concentration	Averaging time
Carbon monoxide	40 mg/m^3	1 h
	10 mg/m^3	8 h
Lead	1.5 $\mu g/m^3$	1 year
Nitrogen dioxide	100 $\mu g/m^3$	1 year
Ozone	235 $\mu g/m^3$	1 h (daily max.)[1)]
Particulate matter	150 $\mu g/m^3$	24 h [1)]
	50 $\mu g/m^3$	1 year
Sulfur dioxide	1300 $\mu g/m^3$	3 h [1)]
	365 $\mu g/m^3$	24 h [1)]
	80 $\mu g/m^3$	1 year

(Source: Measuring Air Quality, The Pollutant Standards Index, EPA-451/K-94-001, U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC, 1994)
Belonging to the 189 hazardous air pollutants (HAPs) identified in the U.S. Clean Air Act Amendments of 1990 (vol. 42 sec. 7412(b) (2), 1990) with several effects
1) Not to be exceeded more than once per year

Table 16 German Ambient Air Quality Standards and Smog alarm Values

Substance	Ambient air quality standards		Smog alarm values	
	Concentration	Averaging time	Concentration	Averaging time
Benzene	10 μg/m³	1 year		
Carbon monoxide			30 mg/m³ 1) 45 mg/m³ 2) 60 mg/m³ 3)	3 h 3 h 3 h
Nitrogen dioxide	200 μg/m³	98% of all 1 h values over 1 year	0.6 mg/m³ 1) 1.0 mg/m³ 2) 1.4 mg/m³ 3)	3 h 3 h 3 h
Ozone	110 μg/m³	8 h	180 μg/m³ 1) 240 μg/m³ 2)	1 h 1 h
Total suspended particulate matter (TSM)	300 μg/m³ 150 μg/m³	95% of all 24 h values over 1 year 1year aver. of 24 h values		
Sulfur dioxide	80 μg/m³ 4) 120 μg/m³ 5) 130 μg/m³ 6) 180 μg/m³ 7) 250 μg/m³ 8) 350 μg/m³ 9)	1 year aver. of 24 h values winter aver. of 24 h values 98% of all 24 values of 1 year	0.6 mg/m³ 1) 1.2 mg/m³ 2) 1.8 mg/m³ 3)	3 h 3 h 3 h
Sum of SO_2 + 2xTSM			1.1 mg/m³ 1) 1.4 mg/m³ 2)	24 h 24 h

(Source: G. Baumbach, Air Quality Control (1996), Springer)

1) Early warning 2) First alarm degree 3) Second degree

4) with >150 μg/m³ TSM, (average of 24 h values of 1 year)

5) with ≦150 μg/m³ TSM, (average of 24 h values of 1 year)

6) with >200 μg/m³ TSM, (average of 24 h values in winter)

7) with >200 μg/m³ TSM, (average of 24 h values in winter)

8) with >350 μg/m³ TSM, (98% of all 24 h values over 1 year)

9) with >350 μg/m³ TSM, (98% of 24 h values over 1 year)

Appendix 14.2-2 Construction Noise

Appendix 14.2-2 Construction Noise

1. Construction Noise

The range of noise levels found for 19 common types of construction equipment is shown in Table 1 of Appendix 14.2-2(source: Report to the President and Congress on Noise, 1972).

It is difficult, at best, to quantify the annoyance that results from construction noise. The following generalizations appear to hold:

1) Single house construction in suburban communities will generate sporadic complaints if the boundary line eight-hour L_{eq} exceeds 70 dBA.
2) Major excavation and construction in a normal suburban community will generate threats of legal action if the boundary line eight-hour L_{eq} exceeds 85 dBA.

2. Transmission of Noise Outdoors

2.1 Inverse Square Law

If a sphere of radius δ vibrates with a uniform radial expansion and contraction, sound waves radiate uniformly from its surface. If the sphere is placed such that no sound waves are reflected back in the direction of the source, and if the product κδ, where κ is the wave number, is much less than 1, then the noise intensity at any radial distance r from the sphere is inversely proportional to the square of at any radial distance r from the sphere is inversely proportional to the square of distance, that is;

$$I = W/(4\pi r^2) \qquad (2\text{-}1)$$

where

I : noise intensity, watts/m^2
W: noise power of source, watts

This is the inverse square law. It explains that portion of the reduction of noise intensity with distance that is due to wave divergence. If we measure noise power level (Lw, re: 10^{-12}W) rather than noise power, we can rewrite Eq. 2-1 in terms of noise pressure level;

$$L_P \fallingdotseq L_w - 20 \log r - 11 \qquad (2\text{-}2)$$

where

L_P : noise pressure level, dB re: 20 μPa
L_W : noise power level, dB re: 10^{-12}W
r : distance between source and receiver, m
11: decibel transform ≒ 10 log(4π) = 10.99

For a source located on or near a hard, flat surface, Eq.2-2 is:

$$L_P \fallingdotseq L_w - 20 \log r - 8 - A_e \qquad (2\text{-}3)$$

The 3 dB addition is made because the measurement is made over a hemisphere instead of a sphere. With the exception of the last term (A_e), it is the modified inverse square law. The A_e term is the excess attenuation beyond wave divergence. It is caused by environmental conditions and has units of dB.

The A_e term may be further divided into six terms as follows:

A_{e1} : effect of the difference in value of ρc from 400 mks rayls when the ambient temperature and barometric pressure differ appreciably from values that make ρc = 400, for example, 38.9°C and 101.325 kPa. Units are dB.
A_{e2} : attenuation by absorption in the air, dB
A_{e3} : attenuation by rain, sleet, snow, or fog, dB
A_{e4} : attenuation by barriers, dB
A_{e5} : attenuation by grass, shrubbery, and tree, dB
A_{e6} : attenuation and fluctuation owing to wind and temperature gradients, to atmospheric turbulence, and to the characteristics of the ground, dB

The effect of the difference in ρc from 400 mks rayls can be calculated by first computing the change in density (ρ) due to temperature and pressure changes. The effect of temperature changes on the speed of noise (c) can be calculated using the following equation:

$$c = 20.05\,(T)^{0.5}$$

$$\rho = PM/(RT)$$

where

P: absolute pressure, kPa
M: molecular mass (gram moles)
T: absolute temperature, K

R: universal gas constant, 8.3143 J/K • mole

The total attenuation, A_{e1}, is then computed as follows:

$$A_{e1} = 10 \log (\rho c/400) \qquad (2\text{-}4)$$

Results of laboratory tests of the effects of temperature and humidity on attenuation of noise, A_{e2}, in the frequency range of 125 to 12,500 Hz, for temperature between -10 and 30°C, and for relative humidity between 10 and 90 percent have been published by the Society of Automotive Engineers. For a temperature of 20°C, the following formula may be used:

$$A_{e2} = 7.4 \times 10^{-8} f^2 r/\phi \qquad (2\text{-}5)$$

where

f: geometric mean frequency of band, Hz

r : distance between source and receiver, m

ϕ : relative humidity, %

For other temperature (20 ± 10°C), an approximate solution may be used:

$$A'_{e2} = A_{e2} / (1+(\beta)(\Delta T)(f)) \qquad (2\text{-}6)$$

where

A_{e2} : attenuation at 20°C and ϕ = 50 percent from Eq. 5-8, dB

β : 4×10^{-6} for T in °C

ΔT : T-20 °C

T : temperature, °C

The excess attenuation due to rain, mist, fog, hail, sleet, and snow have not been studies extensively, A_{e3} is on the order of 0.5 dB/1,000 m in fog and generally is taken to be zero for conservative estimates.

The attenuation due to barriers (A_{e4}) is a complex function of the path length and the wavelength of the noise.

The absorption data for grass, shrubbery, and trees (A_{e5}) are not easy to generalize. Attenuation ranges from 0 to 30 dB/100 m.

The effects of wind and stability (A_{e5}) are treated separately for upwind and downwind receptors

2.2 Noise power level unknown

Data on the noise power level (L_w) of many noise sources are not readily available. On the other hand, data on the noise pressure level (L_{p0}) at some given distance and angle frequently are available.

An alternative equation to Eq. 2-3 makes use of existing measurements. It is given as follows;

$$L_{p2} = L_{p1} - 20 \log (r_2 / r_1) - A_e \qquad (2\text{-}7)$$

L_{p1} : the measured SPL at angle 0 and distance r_1 from source, dB
L_{p2} : the desired SPL at angle 0 and distance r_2 from source, dB
r_1, r_2 : distance from source to measurement L_{p1} and L_{p2}, respectively
A_e : attenuation for the distance $r_2 - r_1$, dB

Using Eq.2-7 and $A_e = 0$, noise levels from various types of construction equipment at different distance are calculated as shown in Table 1 of Appendix 14.2-2.

Reference

M.L Davis, and D.A. Cornwell, Introduction to Environmental Engineering 2nd ed., 1991, McGraw-Hill

Table 1 Range of Noise Level from Various Type of Construction Equipment at Different Distances

Equipment	Noise level (dBA) at 15m		Noise level (dBA) at 30m		Noise level (dBA) at 50m		Noise level (dBA) at 100m	
	minimum	maximum	minimum	maximum	minimum	maximum	minimum	maximum
Compactors	72	74	66	68	62	64	56	58
Front loaders	72	84	66	78	62	74	56	68
Backhoes	72	93	66	87	62	83	56	77
Tractors	77	96	71	90	67	86	61	80
Scrapers	80	93	74	87	70	83	64	77
Pavers	87	88.5	81	82	77	78	71	72
Trucks	82	93	76	87	72	83	66	77
Concrete mixers	75	87	69	81	65	77	59	71
Concrete pumps	80	83	74	77	70	73	64	67
Crane (movable)	76	87	70	81	66	77	60	71
Crane (Derrick)	87	89	81	83	77	79	71	73
Pumps	69	71	63	65	59	61	53	55
Generators	72	82	66	76	62	72	56	66
Compressors	75	87	69	81	65	77	59	71
Pneumatic wrenches	83	89	77	83	73	79	67	73
Jackhammer and Rock Drills	81	98	75	92	71	88	65	82
Impact pile drivers	95	106	89	100	85	96	79	90

Appendix 14.2-3 Traffic Noise

Appendix 14.2-3 Traffic Noise

1. Traffic Noise Model

The US National Cooperative Highway Research Program has developed a series of documents (NCHRP 117, NCHRP 144, and NCHRP 174) that provide design guidance for the prediction and control of highway noise. These documents have been used widely because of their simplicity and relatively high success in making accurate noise predictions. The NCHRP 174 procedure is the last revision in the series. It contains a four-step procedure for the prediction and control of highway noise. The objective of the "short method" is to obtain a quick and gross (always overpredicting) prediction of the expected noise levels.

During the construction of electric locomotive repair workshop the most perturbed place by the construction traffic is indicated in Fig.1 of Appendix 14.2-3, the street between the main gate of the Tashkent Repair Workshop and a main road. In this case, the following prediction may be permitted:

a) The street is straight;
b) The main traffic is trucks which this construction need.
c) Noise is supposed to be unshield.

In this case, the "short method" can be further simplified.

2. Methodology

The initial step in using the short method consists of defining an infinite straight-line approximation to this street..
Once the approximate roadway has been chosen, the following parameters must be computed or estimated:
(a) the traffic parameters, which include the speed and volume of each class of vehicles;
(b) the propagation characteristics, which describe the location of the receiver relative to the roadway;

These parameters are used in two operations. First, the traffic and propagation parameters are combined in the L_{10} nomograph (Figure 2 of Appendix 14.2-3) to determine, for each type of source, the observer unshielded L_{10} level at the observer.

3. Procedure

The step-by-step procedures necessary to calculate noise levels by the short method are presented in the following numbered paragraphs.

(1) Observer identification: On a route map of convenient scale, identify all observer locations at which analysis is desired.

(2) Roadway approximation: Approximate the roadway alignment by a straight, infinite line. The procedure is as follows: Determine and measure the nearest perpendicular distance, D_C, between the roadway centerline and observer.

(3) Traffic parameters: Determine the vehicle operating conditions by using the traffic parameters at the roadway point nearest the observer (if these parameters vary along the roadway). The procedure is as follows:

a. Determine the automobile volume (vph) and average speed (km/h).

b. Determine the medium truck volume (vph) and average speed (km/h).

c. Determine the heavy truck volume (vph) and average speed (km/h).

d. If the automobile and medium truck speeds are the same, multiply the medium truck volume by ten and add to the automobile volume.

(4) Unshielded L_{10} level at observer location: Determine the unshielded L_{10} level at the observer location for all three traffic sources (automobiles, medium trucks, and heavy trucks) using the L_{10} nomograph (Figure 2 of Appendix 14.2-3). Note that if the automobile and medium truck speeds are equal, these two sources may be evaluated together using the combined volume, V_C, and average speed, S_A or S_M.

a. Automobiles (and medium trucks): Using the vehicle volume, V_A (this corresponds to V_C, the combined auto and medium truck volumes, when the speeds of these two populations are equal), and the average speed, S_A (or S_M), enter the L_{10} nomograph and determine the unshielded L_{10} noise level at the observer as follows;

- Draw a straight line from the left pivot point through an average speed point on the automobile speed scale. Extend the straight line to turn line A. The intersection is marked A1.
- Draw a second straight line from the intersection point A1 to an automobile volume point on the volume scale on the far right of the figure. The intersection of this straight line with turn line B is marked B1.

- Draw a third straight line from point B1 to the point on the Dc scale. The intersection of this third line with the L_{10} scale gives the predicted A-weighted L_{10} level at the observer in Fig.2 of Appendix 14.2-3.

b. Medium trucks: Using the vehicle volume, V_M, multiplied by 10, and the average speed, S_M, enter the L_{10} nomograph and determine the unshielded L_{10} noise level at the observer.

c. Heavy trucks: Using the vehicle volume, V_T , and the average speed, S_T , enter the L_{10} nomograph and determine the unshielded L_{10} noise level at the observer.

(5) Total L_{10} level at observer: Determine the total L_{10} noise level at the observer. This is done by logarithmically adding (decibel addition) the contributions from automobiles, medium trucks, and heavy trucks.

If the main traffic is heavy truck (Table 1 of Appendix 14.2-3) or medium truck (Table2 of Appendix 14.2-3) under various conditions, the unshielded L_{10} noise level at the observer is obtained with the nomograph (Fig.2 of Appendix 14.2-3).

Reference

1. M.L Davis, and D.A. Cornwell, "Introduction to Environmental Engineering 2nd ed.", 1991, McGraw-Hill

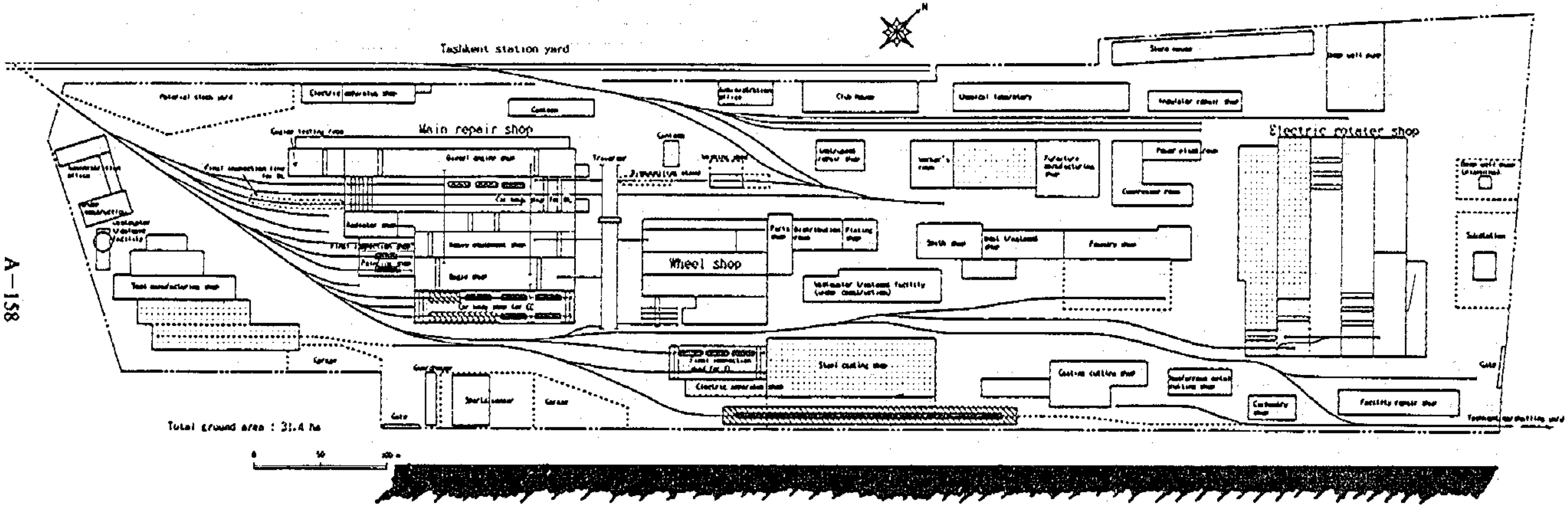

Fig. 1 Area to be Affected by the Construction and Traffic Noise ( )

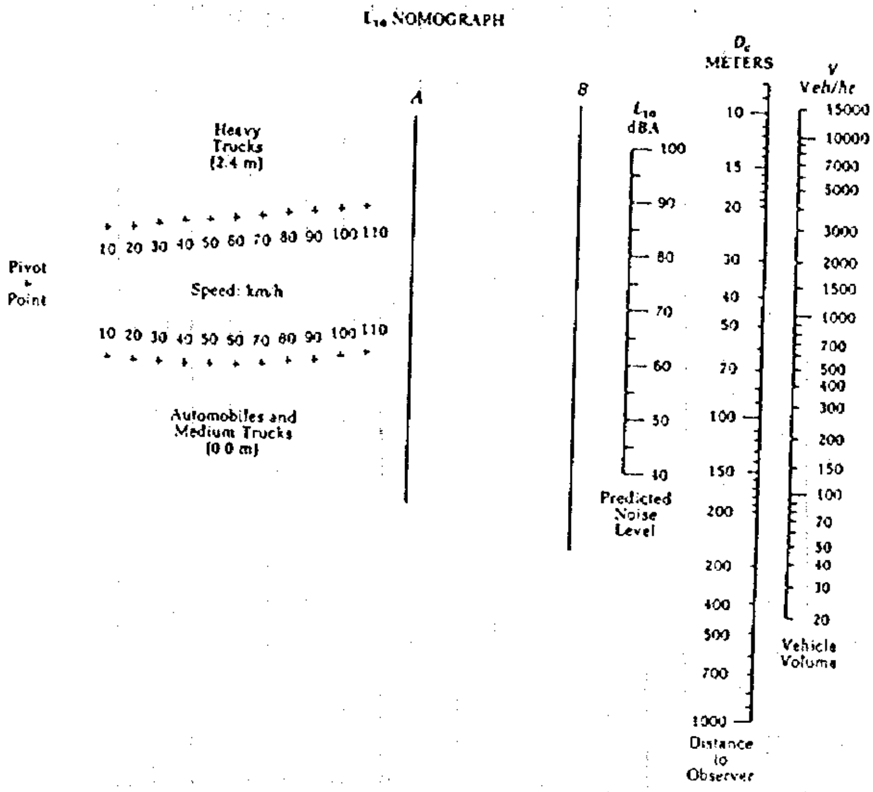

Fig. 2 L_{10} Nomograph (Source: NCHRP 174, 1976)

Table 1 L_{10} Noise Level (dBA) (Heavy Truck)

Heavy Truck		Distance (Dc)						
av. Speed (km/h)	vehicle volume (v/h)	10m	20m	30m	50m	100m	150m	200m
		L_{10} Noise Level (dBA) (Heavy Truck)						
10	10	82	77	75	71	67	65	62
10	20	85	80	77	74	69	67	64
10	30	88	82	80	77	72	70	67
10	50	90	85	82	79	74	72	69
20	10	77	72	68	64	61	58	56
20	20	80	75	72	68	63	61	59
20	30	81	76	74	70	66	63	61
20	50	83	78	76	72	68	65	63
30	10	75	70	66	63	59	57	54
30	20	78	73	71	68	63	60	57
30	30	80	75	72	69	64	62	60
30	50	82	77	74	70	66	64	62
40	10	73	68	65	62	58	55	53
40	20	75	70	68	65	60	58	55
40	30	78	73	70	66	62	59	57
40	50	80	75	72	69	64	62	60

Table 2 L_{10} Noise Level(dBA) (Medium Truck)

Medium Truck		Distance (Dc)						
av. Speed (km/h)	vehicle volume (v/h)	10m	20m	30m	50m	100m	150m	200m
		L_{10} Noise Level(dBA) (Medium Truck)						
10	10	45	41	<40	<40	<40	<40	<40
10	20	50	45	42	<40	<40	<40	<40
10	30	51	46	43	40	<40	<40	<40
10	50	53	48	46	42	<40	<40	<40
10	100	56	51	48	45	40	<40	<40
20	10	52	47	43	40	<40	<40	<40
20	20	55	49	46	43	<40	<40	<40
20	30	56	51	48	45	40	<40	<40
20	50	58	53	50	47	42	40	<40
20	100	61	56	53	50	46	43	41
30	10	55	50	47	43	<40	<40	<40
30	20	58	53	50	47	42	40	<40
30	30	60	55	52	48	43	41	<40
30	50	62	57	55	51	46	43	41
30	100	65	60	57	53	49	46	44
40	10	57	52	49	46	41	<40	<40
40	20	60	55	52	48	43	41	<40
40	30	62	57	55	51	46	43	41
40	50	65	60	57	53	49	46	44
40	100	67	62	59	56	51	48	46