TP 13945E

INFLUENCE OF DUTY CYCLES AND FLEET PROFILE ON EMISSIONS FROM LOCOMOTIVES IN CANADA

Prepared for
Transportation Development Centre
Transport Canada

by

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NOTICES

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Since the report references the North American railway sector as a whole, units of measure are a mixture of imperial and metric units (as per current Canadian railway convention) and American units (as per current railway convention in the U.S.A.).

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Un sommaire français se trouve avant la table des matières.

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16. Abstract

This report contains analyses of the factors influencing exhaust emissions from locomotives in Canadian railway operations. Emissions factors and annual tonnage were calculated based on duty cycles and fleet profile as existed in 2001. There has been a significant change in the locomotive fleet as the Canadian Class 1 railways replace the 1970s' era SD-40 type 3000 HP locomotives with modern fuel-efficient 4300 to 6000 HP locomotives. The new locomotives being introduced, or re-manufactured after January 1, 2000, meet Tier 0 emissions standards of the U.S. Environmental Protection Agency. It was found that locomotive technology used in the fleet significantly influenced emissions factors, while locomotive duty cycles had a lesser influence. The analyses provide a database from which trends and scenarios can be examined vis-à-vis the voluntary cap of 115,000 tonnes per year of oxides of nitrogen agreed for the period 1990 to 2005 by the Railway Association of Canada in its Memorandum of Understanding with Environment Canada regarding railway locomotive emissions.

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16. Résumé

Ce rapport rend compte d'analyses des facteurs influant sur les émissions d'échappement des locomotives de chemin de fer utilisées au Canada. Les facteurs d'émissions et le tonnage annuel ont été calculés à partir des données de 2001 relatives aux cycles d'utilisation des locomotives et à la composition du parc canadien de locomotives. Or, ce parc a connu une profonde transformation depuis, les chemins de fer canadiens de catégorie 1 ayant remplacé leurs locomotives SD-40 de 3 000 hp, datant des années 1970, par des locomotives modernes et économes en carburant, d'une puissance de 4 300 à 6 000 hp. Ces nouvelles locomotives, ou les locomotives remises à neuf depuis le 1er janvier 2000, respectent les normes d'émissions du palier 0 de la réglementation de l'Environmental Protection Agency des États-Unis. L'étude a révélé que la technologie des locomotives dont est composé le parc canadien influe de façon importante sur les facteurs d'émissions, et que les cycles d'utilisation des locomotives ont aussi une influence, mais moindre. Les analyses ont permis de constituer une base de données dont on peut extrapoler des tendances et des scénarios concernant la limitation des émissions d'oxydes d'azote fixée à 115 000 tonnes par année pour la période de 1990 à 2005, limitation volontairement acceptée par l'Association des chemins de fer du Canada dans le protocole d'entente sur les émissions des locomotives qu'elle a conclu avec Environnement Canada.

17. Mots clés Chemin de fer, locomotive, moteur diesel, composition du parc, cycle d'utilisation, émissions d'échappement, facteurs d'émissions, normes d'émissions, ACFC, EPA	18. Diffusion Le Centre de développement des transports dispose d'un nombre limité d'exemplaires.

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EXECUTIVE SUMMARY

The project was initiated by the Transportation Development Centre of Transport Canada to determine the influence of locomotive duty cycles and fleet make-up on locomotive emissions in Canada. The volume of emissions from railway operations in Canada is influenced primarily by fleet make-up, locomotive duty cycles, locomotive technology, railway annual fuel consumption, and traffic volume. The make-up of the locomotive fleet in Canada is changing continuously, as are duty cycles, reflecting the introduction of modern locomotives with more fuel-efficient, higher horsepower diesel engines. This report contains data and analyses based on locomotive fleet profiles and corresponding exhaust emissions as of the end of 2001. The results of the analyses can be used as benchmarks to monitor the emissions level from Canadian railway operations or to examine scenarios of the impact on emissions levels as a result of the envisaged changes in the fleet profile, operating strategies and traffic forecasts of emissions levels.

Measures to limit diesel locomotive emissions harmful to human health – in particular, oxides of nitrogen (NOx) and particulate matter (PM) – are for Canada, contained in the 1995 Memorandum of Understanding between Environment Canada and the Railway Association of Canada regarding railway locomotive emissions and, for the United States, included in regulations promulgated in 1998 by the Environmental Protection Agency (EPA). The Canadian measures set an annual voluntary cap of 115,000 tonnes of NOx from all Canadian railway operations for the period 1990 to 2005, whereas starting in 2000 the U.S. EPA has designated emissions limits that must be met by new or remanufactured individual locomotives. Recent amendments to the Canadian Railway Safety Act have empowered Transport Canada with the authority to regulate emissions from railway locomotives operating in Canada.

Data was obtained on locomotive duty cycles from Canadian National Railway, Canadian Pacific Railway and GO Transit. Locomotive fleet profiles were obtained from the members of the Railway Association of Canada. Emissions factors and annual tonnage were then calculated based on this fleet data and test measurements conducted by the Southwest Research Institute for the U.S. EPA on emissions from locomotives having technology representative of most of the Canadian fleet. It was found that the NOx emissions factor of 248 grams per imperial gallon as calculated in 1990 has increased to 269.2 in 2001. For the volume of fuel consumed, this equates to 119,200 tonnes of NOx produced in 2001 compared to 113,500 tonnes in 1990.

It was concluded that locomotive technology used in the fleet significantly influences emissions factors, while locomotive duty cycles have a lesser influence. There has been some change in duty cycles since 1990 but the change has had little influence on overall quantity of emissions produced. Of note is that since 1997, Canadian railways have transported 10 percent more tonnage with 15 percent less horsepower, consuming 10 percent less diesel fuel.

It was recommended that emissions factors be calculated annually to reflect the fleet make-up for that year, that developments worldwide relating to reducing fuel consumption and emissions be monitored to help Canadian railways introduce the technology necessary to lower emissions, and that steps be taken to obtain the test data for those locomotives for which data are not currently available.

SOMMAIRE

Le projet, lancé par le Centre de développement des transports de Transports Canada, visait à mesurer l'influence des cycles d'utilisation des locomotives et de la composition du parc de locomotives sur les émissions des locomotives au Canada. Le niveau des émissions attribuables aux opérations ferroviaires canadiennes est surtout fonction de la composition du parc de locomotives, des cycles d'utilisation des locomotives, de la technologie des locomotives, de la consommation annuelle de carburant par les chemin de fer et du volume du trafic. Au Canada, la composition du parc de locomotives, tout comme les cycles d'utilisation, évoluent constamment, à mesure que des locomotives modernes, plus économes en carburant et dotées de moteurs diesel plus puissants, sont mises en service. Le rapport présente des données et des analyses fondées sur un parc de locomotives, et les émissions d'échappement correspondantes, datant de la fin de 2001. Les résultats de ces analyses peuvent servir de points de repère pour surveiller les niveaux d'émissions dus aux opérations ferroviaires canadiennes ou pour étudier les scénarios des répercussions sur les niveaux d'émissions des changements éventuels à la composition des parcs, aux stratégies d'exploitation et aux prévisions du trafic.

Au Canada, les mesures prises pour limiter les émissions nocives pour la santé des humains – en particulier les oxydes d'azote (NO_x) et les particules en suspension – produites par les locomotives diesel sont contenues dans un protocole d'entente conclu en 1995 entre Environnement Canada et l'Association des chemins de fer du Canada. Aux États-Unis, ces mesures prennent la forme de règles promulguées en 1998 par l'Environmental Protection Agency (EPA). Le protocole d'entente canadien établit une limite volontaire des émissions de NO_x, fixée à 115 000 tonnes par année pour la période de 1990 à 2005, qui s'applique à l'ensemble des chemins de fer canadiens, tandis qu'aux États-Unis, l'EPA a commencé en 2000 à fixer des limites d'émissions pour chaque locomotive neuve ou remise à neuf. Les dernières modifications apportées à la *Loi sur la sécurité ferroviaire* du Canada ont doté Transports Canada des pouvoirs de réglementer les émission des locomotives de chemin de fer qui circulent au Canada.

Des données ont été colligées sur les cycles d'utilisation des locomotives du Canadien National, du Canadien Pacifique et de GO Transit. L'information sur la composition du parc de locomotives a été communiquée par les membres de l'Association des chemins de fer du Canada. Les facteurs d'émissions et le tonnage annuel ont alors été calculés à partir de ces données sur le parc de locomotives et des résultats d'essais menés par le Southwest Research Institute pour le compte de l'EPA sur les émissions produites par les locomotives les plus représentatives, sur le plan de la technologie, du parc canadien de locomotives. Ces travaux ont révélé que le facteur d'émissions de NO_x, qui avait été établi à 248 grammes par gallon impérial en 1990, était de 269,2 en 2001. Compte tenu du carburant consommé, on obtient des émissions de 119 200 tonnes de NO_x en 2001, comparativement à 113 500 tonnes en 1990.

L’étude permet de conclure que la technologie des locomotives qui composent le parc a une influence marquante sur les facteurs d’émissions, plus que les cycles d’utilisation des locomotives, dont l’influence est moindre. En effet, les cycles d’utilisation ont changé depuis 1990, mais sans produire d’effet sensible sur la quantité globale des émissions. Il convient de noter que depuis 1997, les chemins de fer canadiens ont augmenté leur efficacité, transportant 10 p. 100 de plus de tonnage en développant une puissance de 15 p. 100 inférieure, et consommant 10 p. 100 de moins de carburant diesel.

Les chercheurs recommandent de reprendre chaque année le calcul des facteurs d’émissions de façon à tenir compte de l’évolution de la composition du parc de locomotives d’une année à l’autre; de surveiller les progrès réalisés partout dans le monde en ce qui a trait à la réduction de la consommation de carburant et des émissions, afin d’aider les chemins de fer canadiens à choisir la meilleure technologie; et de prendre les mesures nécessaires pour soumettre à des essais les locomotives pour lesquelles on ne dispose pas de données.

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Terminology of Diesel Locomotive Emissions and Related Technology

The medium-speed diesel engine provides the predominant motive power for locomotives in operation on Canadian and American railways. It has found its niche as a result of its fuel efficiency, ruggedness, reliability and installation flexibility. Combustion takes place in a diesel engine by compressing air and then injecting diesel fuel near top dead centre where auto-ignition occurs (compression ignition, as compared to using a spark plug). The high temperatures typical of combustion in the cylinder of a diesel engine cause oxygen and nitrogen from the intake air to combine as oxides of nitrogen (NOx). NOx is an invisible, toxic gas that can form fine aerosol particles of salts that contribute to acidic precipitation (commonly known as acid rain, snow or fog). If the combustion temperature is decreased to reduce NOx, this tends to increase the amount of non-combusted fuel that may be emitted as particulate matter (PM) or gaseous hydrocarbons (HC). HC reacts with NOx and other pollutants to form ground-level ozone (smog). Ozone and PM are associated with many adverse health and welfare effects, including respiratory illness, environmental damage and visibility problems.

Like all processes where combustion takes place, the combustion products emitted by diesel engines are a negative reality that has to be taken into account. This reality is currently being addressed by environmental and health regulators. The terminology pertaining to emissions is listed below.

Emissions Factors: The emissions factors of a locomotive are calculations based on data from test measurements of specific emissions, its operational duty cycle and the specific fuel consumption of its engine. The units are grams of a specific emission per imperial gallon of diesel fuel consumed (g/IG).

NOx (Oxides of Nitrogen): These are the products of nitrogen and oxygen that result from high combustion temperature. NOx has implications for the health of humans, animals and the ecology. NOx reacts with hydrocarbons to form ozone in the presence of sunlight. The NOx emission level can be lowered by reducing combustion temperatures; one way is to retard injection timing and another is exhaust gas recirculation (but both result in higher fuel consumption and lower total power from the engine).

HC (Hydrocarbons): These are the result of incomplete combustion and the lubrication oil that is not oxidized during the combustion process. It is caused by partial combustion caused by short combustion time and low combustion temperatures (which are sometimes caused by excessive idling and operating engines at low power levels)

PM (Particulate Matter): This is residue of combustion consisting of unburned fuel and lubrication oil. It is known as primary PM. Increasing the combustion temperatures and duration can lower PM. It should be noted here that there is no NOx - PM trade-off under the laws of physics. Technologies that control NOx (such as retarding injection timing) result in higher PM emissions. Conversely, technologies that control PM often result in increased NOx emissions. However, reducing NOx emissions will yield reductions in ambient concentrations of secondary PM. For example, it is estimated that about 4 tonnes of nitrate particulate are formed from every 100 tonnes of NOx emitted.

CO (Carbon Monoxide): This gas is a by-product of the combustion of fossil fuels. Relative to other prime movers, it is low in diesel engines. CO is considered a "greenhouse gas" and its accumulation in the atmosphere contributes to global warming.

SOx (Oxides of Sulfur): These are the result of burning diesel fuels that contain sulfur compounds. These emissions can be reduced by using diesel fuel with a lower sulfur content.

O_3 (Ozone): This is a gas formed from the combination of NO_X, hydrocarbons and sunlight.

CO_2 (Carbon Dioxide): This gas is by far the largest by-product of combustion emitted from engines and is the principal greenhouse gas which, because of its accumulation in the atmosphere, is considered to be the principal contributor to global warming. CO_2 and water vapour are normal by-products of the combustion of fossil fuels. The only way to reduce CO_2 emissions is to reduce the consumption of fossil fuels. For transportation applications, this means using more fuel-efficient engines, using more fuel-efficient modes for the transport of passengers, goods and bulk commodities, or reducing mobility.

Operational Aspects of the Emissions Issue and Development Trends

Not to be overlooked in the quest to reduce emissions are the operational aspects of railway transportation. Any operational tactic that reduces the fuel consumed or diverts utilization from energy-intensive modes to the railways has merit. The Canadian railways have been able to reduce their fuel consumption by 10 percent between 1997 and 2001 by using such tactics as:

Duty Cycle Improvements: The duty cycle for a locomotive refers to the percentage of time the locomotive is operated at different power settings. Locomotives have eight power settings or "notches" plus low idle, idle and dynamic braking settings. The object is to aim for operating strategies that permit a higher percentage of time at the higher power levels.

Higher-power, Higher-adhesion Locomotives: This strategy permits fewer locomotives to pull the same train length, resulting in better matching of power and, hence, economies in fuel consumption. Adhesion improvements include opting for microprocessor-controlled A.C. (versus D.C.) traction motors, air blast cleaning of the railhead and attention to wheel tread profiles.

Low-idle and Engine Shut-down Options: Outfitting locomotive engines with a low-idle option and, when in standby use, outfitting them with mechanisms for automatic engine shutdown and restart (to avoid water coolant freezing) will lead to reduced overall locomotive fuel consumption and emissions.

Dynamic Braking: A term characterizing a train-operating mode in which the traction motors of a locomotive are controlled to function as generators and, hence, retard the motion of the train. Dynamic braking requires an application of engine power equivalent to Notch 1 or 2 throttle setting. Dynamic braking reduces fuel consumption and, hence, exhaust emissions in two ways:

a) it eliminates braking under power (to keep the train stretched out); and

b) electrical power recovered in this operating mode can be diverted to the train supply system. Excess electrical power is dissipated in on-board air-cooled resistance coils.

ABBREVIATIONS, ACRONYMS AND SYMBOLS

Organizations, Societies and Agreements

AAR	Association of American Railroads
EC	Environment Canada
EMD	Electro-Motive Division of General Motors
GE	General Electric Transportation Division
ISO	International Organization for Standardization
MLW	Montreal Locomotive Works
MOU	Memorandum of Understanding
OEM	Original Equipment Manufacturer
RAC	Railway Association of Canada
SwRI	Southwest Research Institute
U.S. EPA	United States Environmental Protection Agency

Emissions-Related Abbreviations

bhp-hr	brake horsepower hour
bsfc	brake specific fuel consumption
CO	Carbon Monoxide
CO_2	Carbon Dioxide
DB	Dynamic Brake
g	gram
HC	Hydrocarbons
HP	Horsepower
IG	Imperial Gallon
kg	kilogram
L	litre
LEM	Locomotive Emissions Monitoring
lb.	pound
N	Notch
PM	Particulate Matter
tonne	metric tonne (1000 kg)

IMPERIAL - METRIC CONVERSIONS

1 lb. = 454 g
1 IG = 4.54 L
1 g/IG = 0.22 g/L
1 tonne = 2200 lb.

1.0 INTRODUCTION

The rising concern, in general, about pollutants emitted into the atmosphere that are affecting human health, harming ecosystems and contributing to global warming and climate change is cause for the Canadian railway sector to ensure that it has data at hand that accurately reflects the atmospheric loading from diesel locomotive emissions. The volume of emissions from railway operations in Canada is influenced primarily by the fleet profile, the locomotive duty cycles, locomotive and diesel engine technology, diesel fuel quality, and traffic volume. The make-up of the locomotive fleet in Canada is changing continuously, as are duty cycles, reflecting the introduction of modern locomotives with more fuel-efficient, high-horsepower diesel engines. This report contains data and analyses based on locomotive fleet profiles and corresponding exhaust emissions as of the end of 2001. The results of the analyses can be used as benchmarks to monitor the emissions level from Canadian railway operations or to examine scenarios of the impact on emissions levels due to envisaged changes in the fleet profile, operating strategies and traffic forecasts.

2.0 BACKGROUND AND CONTEXT

The Railway Association of Canada (RAC) monitors locomotive emissions in Canada on a voluntary basis. In 1995, within the framework of a Memorandum of Understanding (MOU), the RAC entered into a voluntary monitoring action with Environment Canada (EC) to strive to cap locomotive emissions at 1989 annual levels through 2005 [1]. The MOU, shown in Appendix A, sets a cap of 115,000 tonnes per year for oxides of nitrogen (NOx). Based on total fuel consumed and emissions factors established for the locomotive types and mix in the Canadian fleet, the RAC reports annually to EC the calculated volume of NOx emitted and, for information purposes, other emissions such as hydrocarbons (HC), carbon monoxide (CO), particulate matter (PM), carbon dioxide (CO_2) and sulfur dioxide. The factors used for the calculation of emissions from the Canadian locomotive fleet were developed from fuel consumption and emissions data published in 1988 from a comprehensive testing program conducted by the Association of American Railroads (AAR) on several locomotives [2]. The Electro-Motive Division (EMD) of General Motors manufactured the most popular locomotive in the Canadian fleet at that time – the EMD SD-40. The characteristics of its 645E3 engine strongly influenced the establishment of the emissions factors values used in the RAC reporting. The duty cycles used for freight and switcher operations were developed by the RAC to reflect Canadian railway operations as they existed in the 1980s.

The annual RAC reporting quantifies the NOx emissions relative to Gross Ton Miles and Net Ton Miles for freight services and per passenger mile for passenger services. In addition to reporting on emissions Canada-wide, the MOU requires RAC to report the emissions in the three densely populated Tropospheric Ozone Management Areas where NOx emissions, and hence ground-level ozone, are more critical and of more concern [3]. These are the Quebec-Windsor corridor, the Lower Fraser Valley of British Columbia and the Southern Atlantic Region. The reporting takes into consideration seasonal variations in railway traffic in these designated areas.

Another factor affecting the review is the introduction by the U.S. Environmental Protection Agency (EPA) during the last decade of more stringent emissions standards for all modes of transportation vehicles [4, 5]. The equipment and operating context for the Canadian transportation sector is highly integrated with that of its American counterparts, reflecting the reality that the Canadian and American economies are increasingly intertwined. Standards put in place in the U.S., in general, also have an impact on those Canadian entities interacting with the U.S. This is because the vast majority of railway transportation equipment, particularly the engines, is designed and manufactured by the two dominant U.S. original equipment manufacturers (OEMs): EMD and General Electric (GE) Transportation Systems. When in April 1998 the EPA promulgated its rulemaking concerning emissions standards for locomotives and locomotive engines operating in the U.S., it raised the question as to its impact on the Canadian railway sector, particularly for the Class 1 railways having cross-border operations [6-8]. The RAC negotiated an exemption with the EPA for Canadian locomotives as the situation of Canadian locomotives running into the U.S. was considered incidental to its principal operations. However, in the absence of any Canadian standards, the EPA rulemaking has recently become the technical regulation of reference for all newly manufactured locomotives being purchased by Canadian railways from the two U.S.-based OEMs.

Since the MOU was entered into, there has been considerable change in the Canadian locomotive fleet, particularly with the introduction of modern higher powered, more fuel-efficient locomotives replacing the older units on a two-for-three basis. Despite consuming less fuel for the power produced, the newer diesel engines produce more emissions per unit of fuel consumed [9] Similarly, older SD-40 locomotives are being taken out of service. This suggested that, for this new fleet profile with more demanding duty cycles, revised emissions factors should be used for the calculation of the estimated emissions levels reported annually to EC. Another change since the MOU came into force is the amendment to the Railway Safety Act empowering Transport Canada with the authority to regulate emissions from railway equipment in Canada.

3.0 FLEET PROFILE

The make-up of the locomotive fleet in Canada, shown in Appendix B, is continuously changing. Since the mid-1990s the Canadian Class 1 railways have been replacing locomotives with modern, fuel-efficient, high-horsepower models. For example, in the years 1998 to 2001, 184 new locomotives (net) have been added to the Canadian fleet. At the same time, as exhibited in Table 1, 676 locomotives built in the 1960s, 1970s and 1980s have been retired from service. Of note is that locomotives purchased by Canadian railways that were manufactured since 2000 meet the U.S. EPA Tier 0 emissions standards. Table 2 shows declining horsepower (HP) possessed by the railways.

In terms of horsepower, the railways have reduced their available horsepower by 15 percent since 1997. Table 2 shows that the fleet replacement has not kept pace with the amount of horsepower that has been retired.

Table 1: Fleet Profile for the Year 2001 – Locomotives

Model	Engine	HP	Age	1997	1998	1999	2000	2001	Change since 1997
MLW	251		pre-1990	86	41	61	31	31	- 55
EMD SD-40	645	3000	pre-1990	1567	1238	1130	1044	944	- 623
EMD SD-50	645	3600	pre-1990	66	66	66	64	64	- 2
EMD SD-60	710	3800	pre-1990	69	63	63	63	63	- 6
GE	7FDL	2250	pre-1990	3	0	3	3	3	0
GE	7FDL	3000	pre-1990	0	10	0	0	0	0
GE	7FDL	3200	pre-1990	0	0	15	15	15	15
GE	7FDL	3600	pre-1990	16	5	6	12	12	- 4
Caterpillar	3516	3100	pre-1990	1	0	0	0	0	- 1
EMD SD-70	710	4000	post-1990	26	76	26	0	12	- 14
EMD SD-70	710	3000	post-1990	50	45	45	52	52	2
EMD SD-75	710	4300	post-1990	139	167	241	240	240	101
EMD SD-90	710	6000	post-1990	0	0	4	4	4	4
GE Dash 8	7FDL	4000	post-1990	109	61	87	84	84	- 25
GE Dash 9	7FDL	4400	post-1990	291	317	302	352	408	117
Caterpillar	3608	2075	post-1990	4	3	0	3	3	- 1
			Total	2427	2092	2049	1967	1935	- 492

Table 2: Fleet Profile for the Year 2001 – Horsepower

Model	Engine	HP	Age	1997	1998	1999	2000	2001	Change since 1997
MLW	251		pre-1990	258,000	123,000	183,000	93,000	93,000	-165,000
EMD SD-40	645	3000	pre-1990	4,701,000	3,714,000	3,390,000	3,132,000	2,832,000	-1,869,000
EMD SD-50	645	3600	pre-1990	237,600	237,600	237,600	230,400	230,400	-7,200
EMD SD-60	710	3800	pre-1990	262,200	239,400	239,400	239,400	239,400	-22,800
GE	7FDL	2250	pre-1990	6,750	0	6,750	6,750	6,750	0
GE	7FDL	3000	pre-1990	0	30,000	0	0	0	0
GE	7FDL	3200	pre-1990	0	0	48,000	48,000	48,000	48,000
GE	7FDL	3600	pre-1990	57,600	18,000	21,600	43,200	43,200	-14,400
Caterpillar	3516	3100	pre-1990	3,100	0	0	0	0	-3,100
EMD SD-70	710	4000	post-1990	104,000	304,000	104,000	0	48,000	-56,000
EMD SD-70	710	3000	post-1990	150,000	135,000	135,000	156,000	156,000	6,000
EMD SD-75	710	4300	post-1990	597,700	718,100	1,036,300	1,032,000	1,032,000	434,300
EMD SD-90	710	6000	post-1990	0	0	24,000	24,000	24,000	24,000
GE Dash 8	7FDL	4000	post-1990	436,000	244,000	348,000	336,000	336,000	-100,000
GE Dash 9	7FDL	4400	post-1990	1,280,400	1,394,800	1,328,800	1,548,800	1,795,200	514,800
Caterpillar	3608	2075	post-1990	8,300	6,225	0	6,225	6,225	-2,075
			Total	8,102,650	7,164,125	7,102,450	6,895,775	6,890,175	-1,212,475

4.0 FUEL CONSUMPTION

According to Statistics Canada, annual fuel consumption has been declining at a rate of approximately 2.5 percent per year since fleet replacement started in the early 1990s [10]. Since 1997, the decline has been 10 percent. This can be attributed to replacement of the older locomotives, but also includes such features such as dynamic braking and electronic fuel injection, longer trains and other train-handling operations.

Table 3: Canadian Railway Annual Fuel Consumption Comparison

	IG x 10^6 / year	Litres x 10^9 / year
1997	487	2.210
1998	455	2.060
1999	429	1.950
2000	438	1.999

The net result is that the Canadian railways have been able to transport up to 10 percent more tonnage over the last four years with approximately 15 percent less horsepower and consuming 10 percent less diesel fuel.

5.0 DUTY CYCLES

The railways establish duty cycles for their locomotives by downloading operational data from the locomotives' event recorders. Table 4 shows a comparison of the duty cycles by locomotive type taken from data downloaded from event recorders from both pre-1990 and post-1990 manufactured models. Data in the table also shows a weighted average duty cycle comprising all models, which is referred to in Table 4 as Combined Freight. As a reference, Table 4 also shows the duty cycle used by the RAC in its annual reports to EC [11-13]. The Canadian duty cycles for the locomotive models operating in Canada in 2001 are shown in Appendix C.

There are several observations. The most striking is the amount of time spent by freight locomotives in dynamic brake (DB) mode. There are several dynamic brake settings (DB 1, DB 2, etc.). depending on speed, but the engine's fuel consumption in these settings is similar to that of idle. The purpose of the dynamic brake feature is to apply an accurate, computer-controlled braking application. This is a more fuel-efficient method of braking than the old method of applying the air brakes and powering up the locomotive to keep the train stretched.

The other noticeable observation is that the newer locomotives (post-1990) have a more demanding duty cycle than the older locomotives; that is, spending approximately 26 percent more time in Notch 8 (N 8) than the older locomotives (pre-1990). These changes in duty cycle have evolved slowly over time as railways replaced their fleets and made their operating practices more efficient.

Table 4: Duty Cycle Comparison by Locomotive Type

Locomotive Type	Idle	N1	N2	N3	N4	N5	N6	N7	N8	DB
Freight pre-1990	61.1%	3.8%	4.7%	4.1%	3.5%	3.1%	2.8%	1.5%	10.9%	4.5%
Freight post-1990	53.6%	4.1%	5.6%	4.7%	3.9%	3.4%	3.2%	1.6%	13.8%	6.0%
Combined Freight	58.1%	3.9%	5.0%	4.4%	3.7%	3.3%	3.0%	1.5%	12.0%	5.1%
Passenger	69.6%	0.0%	4.8%	2.1%	1.4%	1.2%	0.8%	0.2%	19.5%	0.0%
Switcher	83.0%	4.1%	4.0%	3.6%	2.0%	1.0%	0.5%	0.3%	1.5%	0.0%
RAC Duty Cycle 1990	60.0%	4.0%	4.0%	4.0%	4.0%	4.0%	4.0%	4.0%	12.0%	0.0%

6.0 TRAFFIC GROWTH

Railway traffic has been growing by approximately 2.5 percent per year since the early 1990s [14]. It is unlikely this growth rate will be sustained in the near future. It is predicted that the rate will more likely be 1.2 percent. There are many factors that affect railway traffic growth, such as Canadian versus U.S. economic growth rates, modal shifts, political decisions such as affect softwood lumber exports, and unforeseen events such as happened on September 11, 2001.

7.0 EMISSIONS DATA

The emissions data used in the analyses in this report were measurements taken during actual locomotive testing performed for various organizations at the Southwest Research Institute (SwRI) in San Antonio, Texas [2, 15-20]. These data include horsepower generated for each notch setting, fuel consumption, brake specific fuel consumption, and measurement of exhaust gas content of NOx, CO, HC and PM. The data were extracted from SwRI reports and are summarized in Appendix D. Appendix E shows the detailed calculations for locomotives in Canadian operations using duty cycles as described in Section 5.0.

A summary of emissions factors calculated for the locomotive models operating in Canada in 2001 are shown in Tables 5 and 6. The tables show the significant differences in emissions factors between models. Also shown is the effect of U.S. EPA Tier 0 levels on emissions factors.

Table 5: Emissions Factors of Canadian Freight Locomotives

			Emissions Factors			
			NOx	**CO**	**HC**	**PM**
Model	**Engine**	**HP**	**g/IG**	**g/IG**	**g/IG**	**g/IG**
Other	MLW & Caterpillar		247.5	52.7	12.9	4.7
SD-40	645	3000	247.5	52.7	12.9	4.7
SD-50	645	3600	247.5	52.7	12.9	4.7
SD-60	710	3800	340.1	22.1	9.0	7.2
SD 70	710	3000	324.1	22.4	8.7	7.4
SD 70	710	4000	338.8	21.9	8.6	7.2
SD-75	710	4300	339.5	22.2	9.1	7.3
SD 90	710	6000	473.1	30.9	12.0	10.0
Dash 8	7FDL	4000	241.5	126.7	12.9	7.0
Dash 9	7FDL	4400	310.7	20.4	7.4	2.7
Dash 9	Tier 0	new or rebuilt	204.6	20.4	7.4	2.7
	Factor: Freight Locomotives		**269.2**	**53.8**	**10.8**	**5.6**

Table 6: Emissions Factors of Passenger and Switcher Locomotives

			Emissions Factors			
			NOx	CO	HC	PM
Model	Engine	HP	g/IG	g/IG	g/IG	g/IG
Passenger Locomotives						
MLW	251	3700	247.2	55.2	12.2	6.3
SD-40	645	3000	247.2	55.2	12.2	6.3
F59PH	710	3000	324.1	22.4	8.7	7.4
Factor: Passenger Locomotives			**275.8**	**43.0**	**10.9**	**6.7**
Switcher Locomotives						
SD-40	645		261.8	73.4	23.4	6.9
other	567 & MLW		245.6	72.8	22.0	8.8
Factor: Switcher Locomotives			**257.8**	**73.3**	**23.1**	**7.4**

8.0 EMISSIONS FACTORS INFLUENCES

8.1 Duty Cycle Influence

As shown in Appendix F, emissions factors were calculated for three locomotive models (EMD SD-40, EMD SD-75 and GE Dash 9) to determine the influence of duty cycle on emissions factors. The duty cycles shown in Table 7 as well as the freight duty cycles determined in Section 5.0 were used for the calculations.

Table 7: Duty Cycles Used to Calculate Emissions Factors

	DB	Idle	N1	N2	N3	N4	N5	N6	N7	N8
Freight pre-1990 Locomotives	4.5%	61.1%	3.8%	4.7%	4.1%	3.5%	3.1%	2.8%	1.5%	10.9%
Freight post-1990 Locomotives	6.0%	53.6%	4.1%	5.6%	4.7%	3.9%	3.4%	3.2%	1.6%	13.8%
Freight Combined	5.1%	58.1%	3.9%	5.0%	4.4%	3.7%	3.3%	3.0%	1.5%	12.0%
RAC 1990	0.0%	60.0%	4.0%	4.0%	4.0%	4.0%	4.0%	4.0%	4.0%	12.0%
California Mixed Freight	12.0%	49.0%	4.0%	4.0%	4.0%	4.5%	4.5%	4.0%	3.0%	12.0%
California Intermodal	10.0%	55.0%	3.0%	3.0%	4.0%	4.0%	4.0%	4.0%	3.0%	10.0%
GE Line Haul	4.0%	50.0%	5.0%	5.0%	3.0%	4.0%	4.0%	3.0%	3.0%	14.0%
EMD Road Duty	9.0%	46.0%	4.0%	4.0%	4.0%	4.0%	4.0%	4.0%	4.0%	17.0%
ISO Europe	0.0%	60.0%	0.0%	0.0%	0.0%	15.0%	0.0%	0.0%	0.0%	25.0%
RAC Branch & Yard	0.0%	81.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	5.0%
California Yard	0.0%	82.0%	4.0%	4.0%	3.0%	3.0%	1.0%	0.0%	0.0%	2.0%
California Local	4.0%	47.0%	9.0%	8.0%	8.0%	7.0%	4.0%	3.0%	3.0%	7.0%

A summary of the emissions factors calculations is shown for each locomotive model in Tables 8, 9 and 10. The 2001 fleet emissions factors were determined by proportioning the emissions factors according to fuel consumption.

Table 8: Summary of Emissions Factors – EMD SD-40

EMD SD-40 3000 HP	Emissions Factors			
	NOx	CO	HC	PM
	g/IG	g/IG	g/IG	g/IG
Mainline & Branchline	247.7	53.2	13.1	4.8
1990 RAC Freight	246.0	51.8	11.9	4.2
California Mixed Freight	245.4	49.8	11.9	3.9
California Intermodal	245.7	51.2	12.4	4.0
GE Line Haul	246.1	50.8	11.7	4.4
EMD Road Duty	244.9	49.9	11.1	4.2
ISO Europe	244.4	49.4	11.0	5.0
1990 RAC Branch Yard	250.9	63.3	16.6	5.6
California Yard	261.4	71.8	23.0	7.1
California Local	245.7	40.6	10.1	2.3

Table 9: Summary of Emissions Factors – EMD SD-75

EMD SD-75 4300 HP	Emissions Factors			
	NOx	CO	HC	PM
	g/IG	g/IG	g/IG	g/IG
Mainline & Branchline	339.5	22.2	9.1	7.3
1990 RAC Freight	348.2	22.3	8.4	7.2
California Mixed Freight	346.2	22.1	8.5	7.2
California Intermodal	348.3	22.5	8.8	7.2
GE Line Haul	342.3	21.9	8.3	7.2
EMD Road Duty	343.1	22.2	8.1	7.2
ISO Europe	332.2	20.6	8.0	7.2
1990 RAC Branch Yard	346.5	24.2	11.0	7.6
California Yard	330.9	22.3	14.9	7.9
California Local	353.3	19.3	7.4	6.8

Table 10: Summary of Emissions Factors – GE Dash 9

GE Dash 9 - 4400 HP	Emissions Factors			
	NOx	CO	HC	PM
	g/IG	g/IG	g/IG	g/IG
Mainline & Branchline	310.4	20.4	7.5	2.7
1990 RAC Freight	314.5	20.1	6.9	2.6
California Mixed Freight	313.9	20.6	6.9	2.6
California Intermodal	314.6	21.3	7.3	2.7
GE Line Haul	312.5	19.2	6.6	2.5
EMD Road Duty	313.6	18.9	6.4	2.4
ISO Europe	314.9	17.1	6.0	2.3
1990 RAC Branch Yard	311.2	23.9	9.8	3.0
California Yard	294.2	28.2	14.2	4.3
California Local	311.9	20.0	5.8	2.8

8.2 Fleet Profile Influence

Emissions factors and annual tonnage of emissions were determined for all the reporting years of the RAC-EC Locomotive Emissions Monitoring (LEM) [11-13]. The emissions were calculated specifically for a locomotive fleet as it was shown in the annual RAC EC LEM reports and the details are shown in Appendix G. Table 11 is a summary of the influence of the road locomotive fleet profile on emissions factors.

Table 11: Road Fleet Profile Influence on Emissions Factors

	NOx	CO	HC	PM
	g/IG	g/IG	g/IG	g/IG
1990	250.8	81.9	12.8	4.9
1997	257.8	73.2	23.0	7.3
1998	273.8	49.0	11.3	4.9
1999	275.4	52.3	11.3	4.9
2000	272.1	56.2	11.1	5.2
2001	269.2	53.8	10.8	5.6

Table 12 shows the influence of total fleet profile on annual tonnage of NOx for the reporting years 1997–2001, with 1990 shown as a baseline. Figure 1 shows the influence on tonnage graphically.

Table 12: Fleet Profile Influence on Annual Tonnage of NOx

	Annual Tonnage of NOx (x 1000)					
Factor	**1990**	**1997**	**1998**	**1999**	**2000**	**2001**
Fleet Specific	115.2	130.3	124.9	119.0	120.1	119.2
Baseline of 248 g/IG	113.5	120.8	113.6	107.1	109.1	109.3

Table 12 clearly shows that the emissions factor for NOx of 248 g/IG, established in the early 1990s, was accurate for the fleet as it existed in 1990, but underestimates the NOx tonnage by 8 to 11 percent in the years 1997 to 2001. This underestimation of NOx developed slowly as railways replaced their fleets with modern, high-horsepower locomotives. This is because the new locomotives, introduced into the Canadian fleet in the mid 1990s, have higher emissions factors than the older locomotives. This is demonstrated by comparing Tables 8, 9 and 10.

CO, HC and PM have all decreased with fuel consumption reduction because the new locomotives have emissions factors similar to the older locomotives for these pollutants. CO_2, a greenhouse gas, has been reduced by approximately 4 percent as a result of fuel consumption improvements.

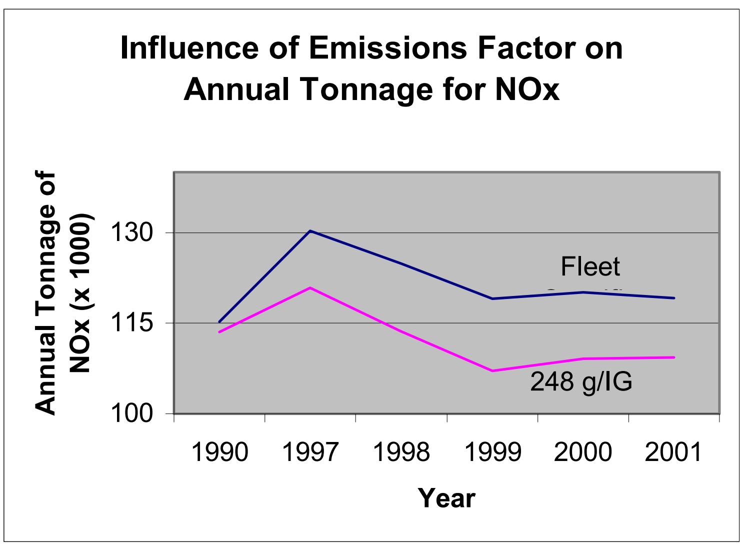

Figure 1: Fleet Profile Influence on Annual Tonnage of NOx

9.0 FUTURE FLEET TRENDS AND EMISSIONS FACTORS

Purchases of new locomotives, retirement of old locomotives, rebuilding of locomotives to U.S. EPA Tier 0 and traffic growth all contribute to the complex decision-making formula that will determine the future Canadian fleet and the emissions factors.

Three scenarios having differing locomotive replacement targets were evaluated to establish emissions factors for the next five years. The scenarios were calculated by determining how many locomotives would be required for traffic growth, in terms of horsepower, with the balance of the new locomotives replacing retired locomotives on an equivalent horsepower basis. For example, assuming a 2.5 percent traffic growth and a purchase of 100 new locomotives, 33 4500 HP locomotives would be required for traffic growth, assuming the current horsepower available is in exact balance with what is required, and the balance of 67 could then be used to replace 90 3000 HP locomotives (two for three). It was also assumed, for the purpose of this evaluation, that an equal number of EMD and GE locomotives would be rebuilt.

9.1 Fast Track Scenario

Fleet replacement	100	locomotives per year
Rebuilds	100	locomotives per year
SD 40 retirements	90	locomotives per year
Traffic growth	2.5	percent per year

9.2 Medium Track Scenario

Fleet replacement	50	locomotives per year
Rebuilds	50	locomotives per year
SD 40 retirements	30	locomotives per year
Traffic growth	2.0	percent per year

9.3 Slow Track Scenario

Fleet replacement	25	locomotives per year
Rebuilds	25	locomotives per year
SD 40 retirements	18	locomotives per year
Traffic growth	1.0	percent per year

The above scenarios have been developed to provide an indication of how fleet changes influence annual NOx tonnages. It does not necessarily follow that all the elements listed above change in relation with each other. Appendix H shows the detailed calculations for the three scenarios. Table 13 shows the effect on annual tonnage of NOx.

Table 13: Summary of NOx Emissions Trends

	2001 kilotonnes	2002 kilotonnes	2006 kilotonnes
Scenario 1	119.2	114.3	98.8
Scenario 2	119.2	116.8	112.4
Scenario 3	119.2	117.6	115.2

Figure 2 demonstrates the effect on NOx annual tonnage graphically.

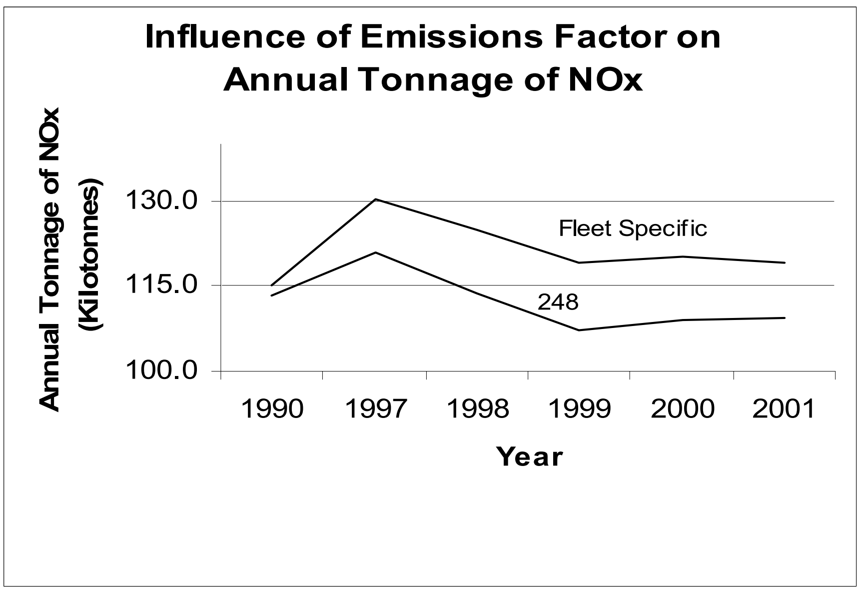

Figure 2: Forecast of NOx Emissions

10.0 FUTURE DUTY CYCLES

Most of the operational changes introduced by the Canadian railways have now been implemented across the system. The move toward longer trains, for example, is unlikely to be extended to even longer trains because of siding length restrictions and the difficulty of handling mile-long trains, particularly in urban centres where the possibility of blocking crossings for extended periods exists. Similarly, the wider use of dynamic braking is unlikely to increase significantly because this feature is currently used effectively. Heavier car loadings are unlikely because of the axle weight limitations.

It is foreseen that duty cycles will not change significantly in the near future.

11.0 CONCLUSIONS

The gathering of data for the duty cycles of locomotives operating in Canadian railways plus analyses using data from emissions measurements exposed that:

a) Engine technology has a significant influence on a locomotive's emissions factors, while duty cycle has a lesser influence.

b) Since 1997, as a result of the rapid introduction of modern high-horsepower locomotives, the calculated overall emissions factor for the Canadian locomotive fleet has increased from 248 g/IG to 269.2 g/IG because of new locomotive purchases and rebuilding or retirement of older locomotives.

c) Since 1997, the deployment of modern, more fuel-efficient, higher horsepower locomotives by Canadian railways has resulted in a 10 percent reduction in overall fuel consumption despite a 10 percent increase in tonnage hauled. During this period, the railways reduced the available horsepower by 15 percent.

12.0 RECOMMENDATIONS

Based on the findings of the work reported herein, it is recommended that:

a) Emissions factors used to calculate emissions levels of NOx, CO, HC and PM for future LEM reports of the RAC - EC MOU be calculated annually to reflect the fleet make-up for that year.

b) Emphasis be placed on monitoring and identifying technological developments worldwide relating to reducing fuel consumption and emissions from medium-speed diesel engines and railway operations to help Canadian railways to introduce:

    i) new, more fuel-efficient, lower NOx-producing operating procedures and/or technology in rail operations; and

    ii) any emissions control systems, hardware or techniques installed or implemented during an engine rebuild program that would reduce NOx emissions.

c) Steps be taken to obtain measured test data for the higher horsepower locomotives (EMD SD-50, SD-60 and SD-90) for which data are not currently available in the public domain.

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APPENDIX A

MEMORANDUM OF UNDERSTANDING

BETWEEN

ENVIRONMENT CANADA

AND

THE RAILWAY ASSOCIATION OF CANADA

MEMORANDUM OF UNDERSTANDING
between
ENVIRONMENT CANADA and THE RAILWAY ASSOCIATION OF CANADA

PART 1 - INTRODUCTION

The purpose of this document is to set out the principles of the basic agreements reached among The Railway Association of Canada (RAC), The Canadian Council of Ministers of the Environment (CCME) and Environment Canada (EC) with respect to the control of emissions of oxides of nitrogen (NOx) produced by locomotives during all rail operations in Canada.

The Memorandum of Understanding (MOU) has been developed from the recommendations contained in the joint Environment Canada / Railway Association of Canada (EC/RAC) report entitled "Recommended Reporting Requirements for the Locomotive Emissions Monitoring (LEM) Program".

PART 2 - BACKGROUND

The Railway Association of Canada, being an association of environmentally concerned corporations doing business in Canada, proposed to the Canadian Council of Ministers of the Environment (CCME), a voluntary cap on the total emissions of oxides of nitrogen from locomotive engines in Canada of 115 kilotonnes per year. The RAC proposal for a voluntary cap on NOx emissions has been included in the CCME NOx/VOC Management Plan and is officially validated by this MOU.

PART 3 - THE PROGRAM

Between January 1, 1990 and December 31, 2005 the RAC will endeavour to collect all data necessary to calculate the total amount of emissions of oxides of nitrogen (NOx) produced during all rail operations in Canada and, if necessary, take whatever action is necessary to avoid exceeding the agreed maximum NOx emissions of 115 kilotonnes per year.

The RAC will make every effort to report once per year to Environment Canada in the manner described below. The data collected should represent the activity of all RAC members and the RAC will endeavour to encourage Associate members of the RAC and non-members to participate in the data reporting.

The RAC also agrees to monitor developments in railway operations technology and encourage member railways to implement new cost-effective technologies that will reduce the NOx emissions from their new equipment.

PART 4 - REPORTS

As outlined in the joint EC/RAC report entitled "Recommended Reporting Requirements for the Locomotive Emissions Monitoring (LEM) Program", the RAC will make every effort to submit to Environment Canada annual reports containing the following information;

1) A list of the Gross Ton Miles (GTM), Net Ton Miles (NTM) and total fuel consumption data for railway operations plus estimates of the emissions of oxides of nitrogen (NOx), hydrocarbons (HC), oxides of sulphur (SOx), particulate matter (PM), carbon monoxide (CO) and carbon dioxide (CO_2) using the RAC emissions factors as corrected in Table 9 of the Report referenced above. All fuel consumption and emissions data will be listed separated with respect to passenger, freight and yard switching services. These data will be submitted for the reporting year and will include revised projections for years 1995, 2000 and 2005;

2) In addition to the national aggregate figures, fuel consumption and emissions should be provided for each Tropospheric Ozone Management Area (TOMA) as geographically defined in the NOx/VOCs Management Plan (CCME, 1990);
3) The emissions data for the TOMAs should be further separated into two additional categories: the Winter Months and the Critical Ground Level Ozone Forming Months of May, June, July, August and September;
4) Updated information should be provided about the composition of the locomotive fleet by year of manufacture, horsepower, engine model, duty type and railway company;
5) A brief written update should be provided on the progress of the railway industry in introducing new, more NOx-efficient operating procedures and/or technology on rail operations;
6) Companies should submit a report on any emissions control systems, hardware or techniques installed or implemented during an engine rebuild program that would effect NOx emissions;
7) A report should be provided on new emissions performance data and new emissions factors for locomotives operated by railways obtained from the AAR, the manufacturers or other agencies;
8) Information should be provided about changes in the properties of diesel fuels used when the properties significantly depart from those specified in the Canadian General Standards Board Specifications CAN/CGSB-3-18-92, entitled Diesel Fuel for Locomotive Type Medium Speed Diesel Engines. Data should be reported from any tests on the sensitivity of emissions from various locomotive engines to fuel quality or to alternative fuels; and
9) A brief report should be provided on the progress and success of any other emissions reduction initiatives or changes in operational procedure, as well as any major changes in the type of duty cycles or service that would significantly affect emissions and their relative percentage of the overall railway operation.

The RAC will make every effort to submit an annual report containing all of the information indicated above by June 30th of the year following the report year. The first report covered by the MOU will be for the year 1990 and last report under this MOU will be for the year 2005.

PART 5 - GENERAL

The baseline of 115 kilotonnes per year for locomotive NOx emissions is based upon the best technical information that was available by the end of 1989 and on projections for traffic increases. It is understood that, if new emissions factors significantly departing from those used to determine the baseline are developed as a result of advanced research on engine emissions or if the rail traffic growth rate is significantly impacted by a shift of traffic from or to another mode of transport, a new environmental review will be initiated.

Although both of the parties hereto have indicated by their signature, acceptance of the principles set out herein, this MOU is not intended to create a legally binding agreement and shall not be construed as creating enforceable contractual obligations among the parties hereto.

DATED at this day of 1995

MINISTER OF THE ENVIRONMENT	THE RAILWAY ASSOCIATION OF CANADA
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Sheila Copps	R. H. Ballantyne

APPENDIX B

CANADIAN LOCOMOTIVE

FLEET PROFILE

Appendix B: Canadian Locomotive Fleet Profile

References:	1990 Data	Environment Canada - Recommended Reporting Requirements for the Locomotive Monitoring Program
	1997 Data	Eggleton / TDC - Impact of EPA Locomotive Emissions Standards on Canadian Railway Sector
	1998 Data	Environment Canada - Locomotive Emissions Monitoring Program 1998
	1999 Data	Environment Canada - Locomotive Emissions Monitoring Program 1999 & 2000
	2000 Data	Environment Canada - Locomotive Emissions Monitoring Program 1999 & 2000
	2001 Data	Private Survey Class 1 Railways only; other railways assumed no change from 2000

Mainline Locomotives

				End of Year Fleet Make-up Trend (number of units)								
Model	Engine	HP	Age	1990	1997	1998	1999	2000	2001	Change since 1997	HP 1997	HP 2001
EMD												
Class 1												
SD-38	645	2000	1975	0	0	0	0	0	4	4	0	8,000
SD-40 (all types)	645	2250	63-66	25	20	2	0	0	0	-20	45,000	0
SD-40 (all types)	645	3000	75-90	1220	1374	1092	987	884	780	-594	4,122,000	2,340,000
SD-50	645	3600	85-87	60	60	60	60	60	60	0	216,000	216,000
SD-60	710	3800	85-89	64	69	63	63	63	63	-6	262,200	239,400
SD-70	710	4000	1995	0	26	26	26	0	12	-14	104,000	48,000
SD-75	710	4300	96-99	0	139	167	235	234	234	95	597,700	1,006,200
SD-90	"H"	6000	1999	0	0	0	4	4	4	4	0	24,000
				1369	1688	1410	1375	1245	1157	**-531**	5,346,900	3,881,600
										Change in HP	**-1,465,300**	
Short Line												
SD-40 (all types)	645	2250	64-66	0	30	16	5	16	16	-14	67500	36000
SD-40 (all types)	645	3000	75-90	89	78	64	75	79	79	1	234000	237000
SD 40 (20V)	645	3600	75-90	0	6	6	6	11	11	5	21600	39600
SD-50	645	3600	85-87	0	6	6	6	4	4	-2	21600	14400
SD-70 (12V)	710	3000	88-95	0	5	0	0	7	7	2	15000	21000
SD-70 (12 cyl)	710	4000	1995	0	0	50	0	0	0	0	0	0
SD-75	710	4300	96-99	0	0	0	6	6	6	6	0	25800
				89	125	142	98	123	123	**-2**	359700	373800
										Change in HP	**14,100**	
Passenger												
SD-40 (all types)	645	3000	75-90	77	59	58	57	54	54	-5	177000	162000
F59PH (12V)	710	3000	1995	42	45	45	45	45	45	0	135000	135000
				119	104	103	102	99	99	**-5**	312000	297000
										Change in HP	**-15,000**	
									Summary EMD	**-538**	**-1,466,200**	
GE												
Class 1												
Dash 8-40CM	7FDL	4000	90-92	30	80	55	55	55	55	-25	320000	220000
Dash 9-44CM	7FDL	4400	94-98	0	287	287	287	327	383	96	1262800	1685200
				30	367	342	342	382	438	**71**	1582800	1905200
										Change in HP	**322,400**	
Short Line												
	7FDL	2250	89-90	0	3	0	3	3	3	0	6750	6750
	7FDL	3000	1979	0	0	10	0	0	0	0		
	7FDL	3200		0	0	0	15	15	15	15	0	48000
	7FDL	3600	1980	0	16	5	6	12	12	-4	57600	43200
Dash 8-40CM	7FDL	4000	90-92	22	29	6	32	29	29	0	116000	116000
Dash 9-44CM	7FDL	4400	94-98	0	4	30	15	25	25	21	17600	110000
				22	52	51	71	84	84	**32**	197950	323950
										Change in HP	**126,000**	
									Summary GE	**103**	**1,780,750**	
MLW												
Class 1												
16V	251	2400	69-82	51	16	1	2	0	0	-16	38400	0
16V	251	3000	63-66	171	6	0	1	0	0	-6	18000	0
18V	251	4000	69-70	1	0	0	24	0	0	0	0	0
				223	22	1	27	0	0	**-22**	56400	0
										Change in HP	**-56,400**	
Short Line												
	251	2400	63-66	9	8	0	2	0	0	-8	19200	0
	251	3000	69-82	0	27	9	1	1	1	-26	81000	3000
	251	3600	69-70	24	0	24	24	23	23	23	0	82800
				33	35	33	27	24	24	**-11**	100200	85800
										Change in HP	**-14,400**	
Passenger												
16V	251	3700	70-84	8	29	7	7	7	7	**-22**	87000	25900
										Change in HP	**-61,100**	
									Summary MLW	**-55**	**243600**	**111700**

Continued on next page

Appendix B: Canadian Locomotive Fleet Profile

				End of Year Fleet Make-up Trend (number of units)								
Model	Engine	HP	Age	1990	1997	1998	1999	2000	2001	Change since 1997	HP 1997	HP 2001
Caterpiller												
Class 1												
3516		2075	1994	0	1	0	0	0	0	-1	2075	0
3608		3100	1988	1	1	0	0	0	0	-1	3100	0
				1	2	0	0	0	0	-2	5175	0
										Change in HP	**-5,175**	0
Short Line												
3516		2075	1994	0	3	3	0	3	3	0	6225	6225
								Summary Caterpiller		**-2**	**-5,175**	
				1894	**2427**	**2092**	**2049**	**1967**	**1935**	**-492**		
								Net decrease of old locos (pre 1990)		**-676**		
								Net Increase of new locos (post 1990)		**184**		
										Total HP	**8,054,350**	**6,899,475**
										Change in HP	**-1,154,875**	
						Fleet Replacement Ratio			**new : old**	**184 : 676**	**or**	**1: 3.7**

Switcher Locomotives

				End of Year Fleet Make-up Trend (number of units)								
Model	Engine	HP	Age	1990	1997	1998	1999	2000	2001	Change since 1997	HP 1997	HP 2001
EMD												
Class 1												
8V	567	800		2	0	0	0	0	0	0	0	0
8V	567	900		7	3	1	1	2	2	-1	2700	1800
12V	567	1200	55-60	172	103	94	57	52	49	-54	123600	58800
	567	1500	51-78	2	1	0	0	17	19	18	1500	28500
	567	1750	51-63	88	1	3	3	197	196	195	1750	343000
12V	645	1200	81-85	128	88	24	64	58	81	-7	105600	97200
12V	645	1350	87-89	8	8	117	8	0	0	-8	10800	0
	645	1500	81-84	12	11	10	16	0	0	-11	16500	0
	645	750/180	54-81	356	450	364	399	188	184	-266	810000	331200
	645	2000	70-86	248	257	239	239	239	208	-49	514000	416000
	645	3000	75-90	0	0	0	0	0	20	20	0	60000
				1023	922	852	787	753	759	**-163**	1586450	1336500
										Change in HP	**-249,950**	
Short Line												
8V	567	800		2	4	1	1	0	0	-4	3200	0
8V	567	900		12	15	12	12	12	12	-3	13500	10800
12V	567	1200	55-60	0	18	9	12	10	10	-8	21600	12000
	567	1500	51-78	0	16	9	12	13	13	-3	24000	19500
	567	1750	51-63	16	81	56	80	62	62	-19	141750	108500
12V	645	1350	87-89	0	0	0	0	3	3	3	0	4050
	645	1500	81-84	3	13	4	10	11	11	-2	19500	16500
	645	1750	75-81	0	0	0	0	5	5	5	0	8750
	645	1800	54-81	20	6	6	4	4	4	-2	10800	7200
	645	2000	70-86	33	44	49	53	56	56	12	88000	112000
				86	197	146	184	176	176	**-21**	322350	299300
										Change in HP	**-23,050**	
Passenger												
16V	645	1800	54-81	21	11	7	7	7	7	-4	19800	12600
12V	645	1200	87-89	3	2	2	2	2	2	0	2400	2400
				24	13	9	9	9	9	**-4**	22200	15000
										Change in HP	**-7,200**	
									Summary EMD	**-188**	**-280,200**	

Continued on next page

Appendix B: Canadian Locomotive Fleet Profile

				End of Year Fleet Make-up Trend (number of units)								
Model	Engine	HP	Age	1990	1997	1998	1999	2000	2001	Change since 1997	HP 1997	HP 2001
MLW												
Class 1												
16V	251	2400	69-82	51	16	1	0	0	0	-16	38400	0
16V	251	3000	63-66	171	6	0	0	0	0	-6	18000	0
18V	251	4000	69-70	1	0	0	0	0	0	0	0	0
				223	22	1	0	0	0	**-22**	56400	0
										Change in HP	**-56,400**	
Short Line												
6l	539	1000	48-58	0	2	0	0	0	0	-2	2000	0
6l	251	1000	59-60	1	35	18	12	34	34	-1	35000	34000
12V	251	1400		0	0	2	0	24	24	24	0	33600
12V	251	1800	1966	48	46	54	52	30	30	-16	82800	54000
12V	251	2000	73-81	29	38	26	29	32	32	-6	76000	64000
				78	121	100	93	120	120	**-1**	195800	185600
										Change in HP	**-10,200**	
Passenger												
16V	251	3700	70-84	8	29	7	0	7	7	**-22**	107300	25900
										Change in HP	**-81,400**	
									Summary MLW	**-45**	**-148,000**	
Caterpiller												
Class 1												
3516		2000	1994		0	6	0	0	0	0	0	0
Short Line												
3516		2000	1994	0	0	27	30	27	27	27	0	54000
										Change in HP	**54,000**	
									Summary Caterpiller	**27**	**54,000**	
				1442	**1304**	**1148**	**1103**	**1092**	**1098**	**-206**		
										Total HP	**2,290,500**	**1,916,300**
										Change in HP	**-374,200**	

APPENDIX C

DUTY CYCLES

OF

CANADIAN LOCOMOTIVES

Appendix C: Duty Cycles of Canadian Locomotives

Model	Engine	HP	Age	No. in Fleet	Idle	N1	N2	N3	N4	N5	N6	N7	N8	DB
Dash 8	7FDL	4000	pre-1990	84	54.1%	3.8%	5.2%	5.2%	4.3%	3.7%	3.3%	1.6%	13.6%	5.4%
SD 40	645	3000	pre-1990	890	62.4%	3.7%	4.6%	3.8%	3.4%	2.9%	2.6%	1.5%	10.8%	4.2%
SD 50	645	3600	pre-1990	64	53.3%	4.0%	4.8%	4.2%	3.5%	3.1%	2.9%	1.5%	16.5%	6.5%
SD 60	710	3800	pre-1990	63	54.6%	4.0%	5.0%	4.5%	3.7%	3.4%	3.3%	1.5%	14.6%	5.4%
Other			pre-1990	57	62.4%	3.7%	4.6%	3.8%	3.4%	2.9%	2.6%	1.5%	10.8%	4.2%
Dash 9	7FDL	4300	post-1990	408	56.6%	3.8%	4.9%	4.6%	3.8%	3.4%	3.0%	1.7%	12.2%	6.0%
SD-70	710	4000	post-1990	19	54.6%	4.0%	5.0%	4.5%	3.7%	3.4%	3.3%	1.5%	14.6%	5.4%
SD 75	710	4300	post-1990	240	50.1%	4.4%	6.4%	5.0%	4.1%	3.4%	3.4%	1.6%	15.1%	6.3%
SD 90	"H"	6000	post-1990	4	54.2%	3.7%	4.5%	4.0%	3.7%	3.2%	3.4%	1.7%	14.0%	7.6%

APPENDIX D

EMISSIONS FIELD DATA

PERFORMED BY

SOUTHWEST RESEARCH INSTITUTE

FOR

LOCOMOTIVES OPERATING IN CANADA

Appendix D: Engine Test Data Performed by SwRI

Ref 1	**Source: AAR Report R-688 (March 1988)**
Ref 2	**Source: SwRI Report No. 08-5374-024 (August 1995)**
Ref 3	**Source: SwRI Report No. 08-02062 (October 2000)**
Ref 4	**Source: SwRI Report No. 03-4171 (October 1994)**

EMD

Manufacturer	EMD
Model	GP-35
Engine	567D3A
Cylinders	16
HP	2250
Air Supply	Turbo
No. Tested	2
Reference	1

	DB	Low Idle	Idle	N1	N2	N3	N4	N5	N6	N7	N8
Fuel Consumption: lb/hr (mean)	102	n/a	42	68	124	194	277	390	524	680	917
Brake Horsepower: bhp	.	.	14	125	268	448	702	997	1348	1759	2365
Brake specific fuel consumption: bsfc	.	.	3.207	0.710	0.474	0.446	0.396	0.391	0.388	0.387	0.387
Engine RPM	598	.	313	312	387	461	545	621	693	777	869
Oxides of Nitrogen: NOx g/hr	2484	.	1433	1763	3161	4790	6768	9299	11870	15275	23841
Carbon Monoxide: CO g/hr	583	.	561	.	302	372	465	904	2230	4811	8860
Hydrocarbons HC g/hr	309	.	189	.	205	249	282	396	482	655	904
Particulates g/hr	.	.	74	.	.	.	.	.	.	.	1272

Manufacturer	EMD
Model	SD-40
Engine	645E3
Cylinders	16
HP	3000
Air Supply	Turbo
No. Tested	15
Reference	1

	DB	Low Idle	Idle	N1	N2	N3	N4	N5	N6	N7	N8
Fuel Consumption: lb/hr (mean)	132	28	42	83	154	281	389	548	714	1020	1202
Brake Horsepower: bhp	.	.	18	106	351	666	992	1440	1934	2766	3267
Brake specific fuel consumption: bsfc	.		2.510	0.790	0.448	0.423	0.391	0.381	0.371	0.370	0.368
Engine RPM	565	250	315	317	383	493	563	650	725	824	899
Oxides of Nitrogen: NOx g/hr	3804	869	1395	3360	4848	8304	10781	15645	19531	28916	34611
Carbon Monoxide: CO g/hr	740	567	672	804	425	587	606	1922	3637	6483	6998
Hydrocarbons HC g/hr	322	206	222	343	224	302	395	524	664	1034	1223
Particulates g/hr	.		75	.	.	.	.	.	.	.	868

Manufacturer	EMD
Model	SD-50
Engine	645F3B
Cylinders	16
HP	3600
Air Supply	Turbo
No. Tested	Extrapolated
Reference	1

	DB	Low Idle	Idle	N1	N2	N3	N4	N5	N6	N7	N8
Fuel Consumption: lb/hr (mean)	150	32	48	95	176	320	443	625	814	1163	1370
Brake Horsepower: bhp	.	.	21	121	400	759	1131	1642	2205	3153	3724
Brake specific fuel consumption: bsfc	.	.	2.510	0.790	0.448	0.423	0.391	0.381	0.371	0.370	0.368
Engine RPM	644	285	359	361	437	562	642	741	827	939	1025
Oxides of Nitrogen: NOx g/hr	4337	991	1590	3830	5527	9467	12290	17835	22265	32964	39457
Carbon Monoxide: CO g/hr	844	646	766	917	485	669	691	2191	4146	7391	7978
Hydrocarbons HC g/hr	367	235	253	391	255	344	450	597	757	1179	1394
Particulates g/hr	.	.	86	.	.	.	.	.	.	.	990

Manufacturer	EMD
Model	SD-60
Engine	710
Cylinders	16
HP	3800
Air Supply	Turbo
No. Tested	Extrapolated
Reference	1

	DB	Low Idle	Idle	N1	N2	N3	N4	N5	N6	N7	N8
Fuel Consumption: lb/hr (mean)	46	25	46	86	163	342	519	667	919	1131	1309
Brake Horsepower: bhp	.	.	18	195	417	930	1444	1885	2739	3470	3994
Brake specific fuel consumption: bsfc	.	.	2.510	0.790	0.448	0.423	0.391	0.381	0.371	0.370	0.368
Engine RPM	326	.	190	256	412	466	540	618	693	779	859
Oxides of Nitrogen: NOx g/hr	1187	814	1187	2188	4108	9493	15165	20150	32590	46398	47681
Carbon Monoxide: CO g/hr	145	67	145	145	241	371	1835	3706	5189	3329	3928
Hydrocarbons HC g/hr	174	95	174	140	184	265	343	411	596	777	975
Particulates g/hr	.	.	45	.	.	.	.	.	.	.	1051

Appendix D: Engine Test Data Performed by SwRI

Manufacturer	EMD
Model	SD-70
Engine	710G3B
Cylinders	16
HP	4000
Air Supply	turbo
No. Tested	4
Reference	3

	DB	Low Idle	Idle	N1	N2	N3	N4	N5	N6	N7	N8
Fuel Consumption: lb/hr (mean)	48	26	48	91	172	360	546	702	967	1190	1378
Brake Horsepower: bhp	19	13	19	205	439	979	1520	1984	2883	3653	4204
Brake specific fuel consumption: bsfc	2.500	1.903	2.500	0.445	0.392	0.368	0.359	0.354	0.335	0.326	0.328
Engine RPM	343	.	200	269	434	490	568	651	729	820	904
Oxides of Nitrogen: NOx g/hr	1249	857	1249	2303	4324	9993	15963	21211	34305	48840	50191
Carbon Monoxide: CO g/hr	153	70	153	153	254	390	1932	3901	5462	3504	4135
Hydrocarbons HC g/hr	183	100	183	147	194	279	361	433	627	818	1026
Particulates g/hr	47	15	47	42	99	266	504	628	776	909	1106

Manufacturer	EMD
Model	SD-75M
Engine	710G3EC
Cylinders	16
HP	4300
Air Supply	turbo
No. Tested	1
Reference	2

	DB	Low Idle	Idle	N1	N2	N3	N4	N5	N6	N7	N8
Fuel Consumption: lb/hr (mean)	34	.	26	108	200	379	529	663	926	1231	1439
Brake Horsepower: bhp	14	.	13	264	537	1062	1531	1944	2767	3824	4431
Brake specific fuel consumption: bsfc	2.38	.	2.079	0.408	0.372	0.357	0.345	0.341	0.335	0.322	0.325
Engine RPM	290	.	200	290	370	490	600	675	760	860	950
Oxides of Nitrogen: NOx g/hr	1020	.	909	3450	7390	15318	24807	29966	43501	58836	54440
Carbon Monoxide: CO g/hr	167	.	141	248	276	453	632	1023	3656	3541	3724
Hydrocarbons HC g/hr	148	.	125	157	221	342	429	535	671	966	1171
Particulates g/hr	35	.	39	64	133	273	402	527	723	1089	1223

Manufacturer	GE
Model	Dash 8
Engine	7FDL
Cylinders	16
HP	4000
Air Supply	turbo
No. Tested	4 (AAR 3 pt)
Reference	4

	DB	Low Idle	Idle	N1	N2	N3	N4	N5	N6	N7	N8
Fuel Consumption: lb/hr (mean)	.	.	21.9	.	.	.	.	770.8	.	.	1427
Brake Horsepower: bhp	.	.	13	.	.	.	.	2045	.	.	4093
Brake specific fuel consumption: bsfc	.	.	1.685	.	.	.	.	0.377	.	.	0.349
Engine RPM	.	.	.	.	.	.	.	.	.	.	.
Oxides of Nitrogen: NOx g/hr	.	.	472	.	.	.	.	22576	.	.	40554
Carbon Monoxide: CO g/hr	.	.	970	.	.	.	.	16165	.	.	15508
Hydrocarbons HC g/hr	.	.	354	.	.	.	.	625	.	.	2077
Particulates g/hr	.	.	.	.	.	.	.	.	.	.	.

Manufacturer	GE
Model	Dash 9
Engine	7FDL
Cylinders	16
HP	4400
Air Supply	turbo
No. Tested	1
Reference	3

	DB	Low Idle	Idle	N1	N2	N3	N4	N5	N6	N7	N8
Fuel Consumption: Lb/hr (mean)	41	20	24	80	191	398	574	803	1020	1251	1564
Brake Horsepower: bhp	22	10	10	194	499	1032	1548	2222	2939	3662	4496
Brake specific fuel consumption: bsfc	1.877	1.950	2.400	0.412	0.383	0.386	0.371	0.361	0.347	0.342	0.348
Engine RPM	576	334	438	438	579	885	885	995	995	995	1047
Oxides of Nitrogen: NOx g/hr	1024	335	637	2166	5821	16361	24093	31869	36589	42567	45669
Carbon Monoxide: CO g/hr	376	208	247	109	291	1437	4935	9282	11669	12285	15485
Hydrocarbons HC g/hr	182	206	152	113	170	354	395	514	679	799	964
Particulates g/hr	35	28	23	38	89	202	264	344	405	448	748

APPENDIX E

EMISSIONS FACTORS

FOR

LOCOMOTIVE MODELS

OPERATING IN CANADA

Mainline Locomotives

Source: AAR Report R-688 (March 1988), page Appendix1-24
EMD 645 E3 16 cylinders 3000 HP

Throttle Position	Fuel Cons. lb/hr	HP	NOx g/hr	CO g/hr	HC g/hr	PM g/hr
DB	132	.	3804	740	322	.
Low Idle	28	.	869	567	206	.
Idle	42	18	1395	672	222	75
1	83	106	3360	804	343	.
2	154	351	4848	425	224	.
3	281	666	8304	587	302	.
4	389	992	10781	606	395	.
5	548	1440	15645	1922	524	.
6	714	1934	19531	3637	664	.
7	1020	2766	28916	6483	1034	.
8	1202	3267	34611	6998	1223	868

Duty Cycle 2002 Mainline and Branchline					Duty Cycle 2002 Mainline and Branchline			Duty Cycle 2002 Mainline and Branchline			Duty Cycle 2002 Mainline and Branchline			Duty Cycle 2002 Mainline and Branchline		
%	HP	Fuel Consumption			NOx			CO			HC			PM		
		duty cycle lb/hr	lb/ bhp-hr	IG/ bhp-hr	g/hr	g/bhp-hr	Factor g/IG	g/hr	g/bhp-hr	Factor g/IG	g/hr	g/bhp-hr	Factor g/IG	g/hr	g/bhp-hr	Factor g/IG
4.5%		5.9			171			33			14					
61.1%	11	25.7			852			410			135			46		
3.8%	4	3.2			128			31			13					
4.7%	16	7.2			228			20			11					
4.1%	27	11.5			340			24			12					
3.5%	35	13.6			377			21			14					
3.1%	45	17.0			485			60			16					
2.8%	54	20.0			547			102			19					
1.5%	41	15.3			434			97			16					
10.9%	356	131.0			3773			763			133			95		
	589.9	250.4	0.4245	0.0502	7335.1	12.4	**247.5**	1561.0	2.6	**52.7**	383.2	0.6	**12.9**	140.2	0.2	**4.7**

Source: Extrapolated from EMD 645 data: 645data*(3600/3000)*0.95
EMD SD - 50 645 E3 16 cylinders 3600 HP

Throttle Position	Fuel Cons. lb/hr	HP	NOx g/hr	CO g/hr	HC g/hr	PM g/hr
DB	150	.	4337	844	367	.
Low Idle	32	.	991	646	235	.
Idle	48	21	1590	766	253	86
1	95	121	3830	917	391	.
2	176	400	5527	485	255	.
3	320	759	9467	669	344	.
4	443	1131	12290	691	450	.
5	625	1642	17835	2191	597	.
6	814	2205	22265	4146	757	.
7	1163	3153	32964	7391	1179	.
8	1370	3724	39457	7978	1394	990

Duty Cycle 2002 Mainline and Branchline					Duty Cycle 2002 Mainline and Branchline			Duty Cycle 2002 Mainline and Branchline			Duty Cycle 2002 Mainline and Branchline			Duty Cycle 2002 Mainline and Branchline		
%	HP	Fuel Consumption			NOx			CO			HC			PM		
		duty cycle lb/hr	lb/ bhp-hr	IG/ bhp-hr	g/hr	g/bhp-hr	Factor g/IG	g/hr	g/bhp-hr	Factor g/IG	g/hr	g/bhp-hr	Factor g/IG	g/hr	g/bhp-hr	Factor g/IG
4.5%		6.8			195			38			17					
61.1%	13	29.3			971			468			155			53		
3.8%	5	3.6			146			35			15					
4.7%	19	8.3			260			23			12					
4.1%	31	13.1			388			27			14					
3.5%	40	15.5			430			24			16					
3.1%	51	19.4			553			68			19					
2.8%	62	22.8			623			116			21					
1.5%	47	17.4			494			111			18					
10.9%	406	149.3			4301			870			152			108		
	672.8	285.5	0.4244	0.0502	8361.8	12.4	**247.5**	1779.7	2.6	**52.7**	437.1	0.6	**12.9**	160.5	0.2	**4.7**

Ref 2 Source: SwRI Report No. 08-5374-024 (August 1995)
EMD SD 60 (710) 3800 HP

Throttle Position	Fuel Cons. lb/hr	HP	NOx g/hr	CO g/hr	HC g/hr	PM g/hr
DB	32	12	946	155	137	32
Low Idle						
Idle	24	11	843	131	116	36
1	100	233	3201	230	146	59
2	186	475	6857	256	205	123
3	352	939	14214	420	317	253
4	491	1353	23019	586	398	373
5	615	1718	27806	949	496	489
6	859	2445	40356	3392	623	671
7	1142	3379	54594	3286	896	1010
8	1335	3916	50515	3456	1087	1135

Duty Cycle 2002 Mainline and Branchline					Duty Cycle 2002 Mainline and Branchline			Duty Cycle 2002 Mainline and Branchline			Duty Cycle 2002 Mainline and Branchline			Duty Cycle 2002 Mainline and Branchline		
%	HP	Fuel Consumption			NOx			CO			HC			PM		
		duty cycle lb/hr	lb/ bhp-hr	IG/ bhp-hr	g/hr	g/bhp-hr	Factor g/IG	g/hr	g/bhp-hr	Factor g/IG	g/hr	g/bhp-hr	Factor g/IG	g/hr	g/bhp-hr	Factor g/IG
4.5%		1.4			43			7			6			1		
61.1%	7	14.7			515			80			71			22		
3.8%	9	3.8			122			9			6			2		
4.7%	22	8.7			322			12			10			6		
4.1%	38	14.4			583			17			13			10		
3.5%	47	17.2			806			21			14			13		
3.1%	53	19.1			862			29			15			15		
2.8%	68	24.1			1130			95			17			19		
1.5%	51	17.1			819			49			13			15		
10.9%	427	145.5			5506			377			118			124		
	723.0	266.0	0.3679	0.0435	10707.0	14.8	**340.1**	695.9	1.0	**22.1**	283.9	0.4	**9.0**	227.7	0.3	**7.2**
3% fuel penalty:		274.0	0.3790	0.0449	Tier 0	**9.5**	**211.8**	Tier 0	1.0	**21.5**		0.3	**6.7**		0.2	**4.5**

Ref 2 Source: SwRI Report No. 08-5374-024 (August 1995); page 45
EMD SD 75 710G3EC 4300 HP

Throttle Position	Fuel Cons. lb/hr	HP	NOx g/hr	CO g/hr	HC g/hr	PM g/hr
DB	34	14	1020	167	148	35
Low Idle						
Idle	26	13	909	141	125	39
1	108	264	3450	248	157	64
2	200	537	7390	276	221	133
3	379	1062	15318	453	342	273
4	529	1531	24807	632	429	402
5	663	1944	29966	1023	535	527
6	926	2767	43501	3656	671	723
7	1231	3824	58836	3541	966	1089
8	1439	4431	54440	3724	1171	1223

Duty Cycle 2002 Mainline and Branchline					Duty Cycle 2002 Mainline and Branchline			Duty Cycle 2002 Mainline and Branchline			Duty Cycle 2002 Mainline and Branchline			Duty Cycle 2002 Mainline and Branchline		
%	HP	Fuel Consumption			NOx			CO			HC			PM		
		duty cycle lb/hr	lb/ bhp-hr	IG/ bhp-hr	g/hr	g/bhp-hr	Factor g/IG	g/hr	g/bhp-hr	Factor g/IG	g/hr	g/bhp-hr	Factor g/IG	g/hr	g/bhp-hr	Factor g/IG
4.2%		1.4			43			7			6			1		
62.4%	8	16.2			567			88			78			24		
3.7%	10	4.0			128			9			6			2		
4.6%	25	9.2			340			13			10			6		
3.8%	40	14.4			582			17			13			10		
3.4%	52	18.0			843			21			15			14		
2.9%	56	19.2			869			30			16			15		
2.6%	72	24.1			1131			95			17			19		
1.5%	57	18.5			883			53			14			16		
10.8%	479	155.4			5880			402			126			132		
	799.2	280.4	0.3509	0.0415	11265.3	14.1	**339.5**	735.6	0.9	**22.2**	301.7	0.4	**9.1**	240.8	0.3	**7.3**
3% fuel penalty:		288.8	0.3614	0.0428	Tier 0	**9.5**	**222.1**	Tier 0	0.9	**21.5**		0.3	**7.0**		0.2	**4.7**
					Tier 1	**7.4**	**173.0**									

Ref 3 Source: SwRI Report No. 08-02062 (October 2000)
GE Dash 9 7FDL17N19 16 cylinders 4400 HP

Throttle Position	Fuel Cons.	HP	NOx	CO	HC	PM
	lb/hr		g/hr	g/hr	g/hr	g/hr
DB	41	23	1085.0	322	155.0	29.0
Low Idle		10	303.0	128	113.0	26.0
Idle	22	10	671.0	186	133.0	23.0
1	82	129	1577.0	153	93.0	38.0
2	188	419	4105.0	315	144.0	105.0
3	394	950	14340.0	902	316.0	240.0
4	570	1400	22890.0	1811	348.0	238.0
5	794	2053	33198.0	2817	605.0	274.0
6	1002	2734	39122.0	3409	680.0	264.0
7	1234	3440	47362.0	2535	708.0	257.0
8	1493	4103	54994.0	2276	823.0	326.0

Duty Cycle 2002 Mainline and Branchline					Duty Cycle 2002 Mainline and Branchline			Duty Cycle 2002 Mainline and Branchline			Duty Cycle 2002 Mainline and Branchline			Duty Cycle 2002 Mainline and Branchline		
%	HP	Fuel Consumption			NOx			CO			HC			PM		
		duty cycle lb/hr	lb/ bhp-hr	IG/ bhp-hr	g/hr	g/bhp-hr	Factor g/IG	g/hr	g/bhp-hr	Factor g/IG	g/hr	g/bhp-hr	Factor g/IG	g/hr	g/bhp-hr	Factor g/IG
4.5%		1.9			48.8			14.5			7.0			1.3		
61.1%	6	13.4			410.0			113.6			81.3			14.1		
3.8%	5	3.1			59.9			5.8			3.5			1.4		
4.7%	20	8.8			192.9			14.8			6.8			4.9		
4.1%	39	16.1			587.9			37.0			13.0			9.8		
3.5%	49	20.0			801.2			63.4			12.2			8.3		
3.1%	64	24.6			1029.1			87.3			18.8			8.5		
2.8%	77	28.1			1095.4			95.5			19.0			7.4		
1.5%	52	18.5			710.4			38.0			10.6			3.9		
10.9%	447	162.7			5994.3			248.1			89.7			35.5		
	757.7	297.2	0.3923	0.0464	10930.1	14.4	**310.7**	718.0	0.9	**20.4**	261.8	0.3	**7.4**	95.2	0.1	**2.7**
		Assume no fuel penalty:			Tier 0	**9.5**	**204.6**	Tier 0	5.0 max	n/c	Tier 0	1.0 Max	n/c	Tier 0	0.6 max	n/c
						7.4	**159.4**									

Ref 2 Source: SwRI Report No. 08-5374-024 (August 1995), page 48
GE Dash 8 7FDL 16 cylinders 4000 HP

Throttle Position	Fuel Cons.	HP	NOx	CO	HC	PM
	lb/hr		g/hr	g/hr	g/hr	g/hr
DB	.	.	.	.	.	.
Low Idle	.	.	.	.	.	.
Idle	22	13	472	970	354	n/a
1	.	.	.	.	.	.
2	.	.	.	.	.	.
3	.	.	.	.	.	.
4	.	.	.	.	.	.
5	771	2045	22576	16165	625	n/a
6	.	.	.	.	.	.
7	.	.	.	.	.	.
8	1427	4093	40554	15508	2077	n/a

Duty Cycle 2002 Mainline and Branchline					Duty Cycle 2002 Mainline and Branchline			Duty Cycle 2002 Mainline and Branchline			Duty Cycle 2002 Mainline and Branchline			Duty Cycle 2002 Mainline and Branchline		
%	HP	Fuel Consumption			NOx			CO			HC			PM		
		duty cycle lb/hr	lb/ bhp-hr	IG/ bhp-hr	g/hr	g/bhp-hr	Factor g/IG	g/hr	g/bhp-hr	Factor g/IG	g/hr	g/bhp-hr	Factor g/IG	g/hr	g/bhp-hr	Factor g/IG
4.5%	.	.			.			.			.			.		
61.1%	6.5	11.0			236.0			485.0			177.0			n/a		
3.8%	.	.			.			.			.			.		
4.7%	.	.			.			.			.			.		
4.1%	.	.			.			.			.			.		
3.5%	.	.			.			.			.			.		
3.1%	511.25	192.8			5644.0			4041.3			156.3			n/a		
2.8%	.	.			.			.			.			.		
1.5%	.	.			.			.			.			.		
10.9%	1023.25	356.8			10138.5			3877.0			519.3			n/a		
	1541.0	560.5	0.3637	0.0430	16018.5	10.4	**241.5**	8403.3	5.5	**126.7**	852.5	0.6	**12.9**	n/a		**n/a**
		Assume no fuel penalty:			Tier 0	**9.5**	**220.7**	Tier 0	5.0 max	n/c	Tier 0	1.0 Max	n/c	Tier 0	0.6 max	n/c

Passenger

Source: AAR Report R-688 (March 1988), page Appendix1-24
EMD 645 E3 16 cylinders 3000 HP

Throttle Position	Fuel Cons. lb/hr	HP	NOx g/hr	CO g/hr	HC g/hr	PM g/hr
DB	132	.	3804	740	322	.
Low Idle	28	.	869	567	206	.
Idle	42	18	1395	672	222	75
1	83	106	3360	804	343	.
2	154	351	4848	425	224	.
3	281	666	8304	587	302	.
4	389	992	10781	606	395	.
5	548	1440	15645	1922	524	.
6	714	1934	19531	3637	664	.
7	1020	2766	28916	6483	1034	.
8	1202	3267	34611	6998	1223	868

Duty Cycle 2002 Passenger					Duty Cycle 2002 Passenger			Duty Cycle 2002 Passenger			Duty Cycle 2002 Passenger			Duty Cycle 2002 Passenger		
%	HP	Fuel Consumption			NOx			CO			HC			PM		
		duty cycle lb/hr	lb/ bhp-hr	IG/ bhp-hr	g/hr	g/bhp-hr	Factor g/IG	g/hr	g/bhp-hr	Factor g/IG	g/hr	g/bhp-hr	Factor g/IG	g/hr	g/bhp-hr	Factor g/IG
0.0%		0.0			0			0			0					
69.6%	13	29.2			971			468			154			52		
0.0%	0	0.0			0			0			0					
4.8%	17	7.4			233			20			11					
2.1%	14	5.9			174			12			6					
1.4%	14	5.4			151			8			6					
1.2%	17	6.6			188			23			6					
0.8%	15	5.7			156			29			5					
0.2%	6	2.0			58			13			2					
19.5%	637	234.4			6749			1365			238			169		
	732.6	296.7	0.4050	0.0479	8679.9	11.8	**247.2**	1938.5	2.6	**55.2**	428.9	0.6	**12.2**	221.1	0.3	**6.3**

Ref 2 Source: SwRI Report No. 08-5374-024 (August 1995); page 45
EMD SD 70 710(12V) 3000 HP

Throttle Position	Fuel Cons. lb/hr	HP	NOx g/hr	CO g/hr	HC g/hr	PM g/hr
DB	23.7	9.8	711.6	116.5	103.3	24.4
Low Idle						
Idle	18.1	9.1	634.2	98.4	87.2	27.2
1	75.3	184.2	2407.0	173.0	109.5	44.7
2	139.5	374.7	5155.8	192.6	154.2	92.8
3	264.4	740.9	10687.0	316.0	238.6	190.5
4	369.1	1068.1	17307.2	440.9	299.3	280.5
5	462.6	1356.3	20906.5	713.7	373.3	367.7
6	646.0	1930.5	30349.5	2550.7	468.1	504.4
7	858.8	2667.9	41048.4	2470.5	674.0	759.8
8	1004.0	3091.4	37981.4	2598.1	817.0	853.3

Duty Cycle 2002 Passenger					Duty Cycle 2002 Passenger			Duty Cycle 2002 Passenger			Duty Cycle 2002 Passenger			Duty Cycle 2002 Passenger		
%	HP	Fuel Consumption			NOx			CO			HC			PM		
		duty cycle lb/hr	lb/ bhp-hr	IG/ bhp-hr	g/hr	g/bhp-hr	Factor g/IG	g/hr	g/bhp-hr	Factor g/IG	g/hr	g/bhp-hr	Factor g/IG	g/hr	g/bhp-hr	Factor g/IG
0.0%		0.0			0			0			0			0		
69.6%	6	12.6			441			68			61			19		
0.0%	0	0.0			0			0			0			0		
4.8%	18	6.7			247			9			7			4		
2.1%	16	5.6			224			7			5			4		
1.4%	15	5.2			242			6			4			4		
1.2%	16	5.6			251			9			4			4		
0.8%	15	5.2			243			20			4			4		
0.2%	5	1.7			82			5			1			2		
19.5%	603	195.8			7406			507			159			166		
	694.7	238.3	0.3430	0.0406	9137.7	13.2	**324.1**	631.1	0.9	**22.4**	246.2	0.4	**8.7**	207.7	0.3	**7.4**
3% fuel penalty:		245.4	0.3532	0.0418	Tier 0	**9.5**	**227.2**	Tier 0	0.9	**21.7**		0.3	**7.2**		0.2	**4.8**

Switcher & Yard Locomotives

Source: AAR Report R-688 (March 1988), page Appendix1-24
EMD 645 E3 16 cylinders 3000 HP

Throttle Position	Fuel Cons. lb/hr	HP	NOx g/hr	CO g/hr	HC g/hr	PM g/hr
DB	132	.	3804	740	322	.
Low Idle	28	.	869	567	206	.
Idle	42	18	1395	672	222	75
1	83	106	3360	804	343	.
2	154	351	4848	425	224	.
3	281	666	8304	587	302	.
4	389	992	10781	606	395	.
5	548	1440	15645	1922	524	.
6	714	1934	19531	3637	664	.
7	1020	2766	28916	6483	1034	.
8	1202	3267	34611	6998	1223	868

Duty Cycle 2002 Yard and Switching					Duty Cycle 2002 Yard and Switching			Duty Cycle 2002 Yard and Switching			Duty Cycle 2002 Yard and Switching			Duty Cycle 2002 Yard and Switching		
%	HP	Fuel Consumption			NOx			CO			HC			PM		
		duty cycle lb/hr	lb/ bhp-hr	IG/ bhp-hr	g/hr	g/bhp-hr	Factor g/IG	g/hr	g/bhp-hr	Factor g/IG	g/hr	g/bhp-hr	Factor g/IG	g/hr	g/bhp-hr	Factor g/IG
0.0%		0.0			0			0			0					
83.0%	15	34.9			1158			558			184			62		
4.1%	4	3.4			138			33			14					
4.0%	14	6.2			194			17			9					
3.6%	24	10.1			299			21			11					
2.0%	20	7.8			216			12			8					
1.0%	14	5.5			156			19			5					
0.5%	10	3.6			98			18			3					
0.3%	8	3.1			87			19			3					
1.5%	49	18.0			519			105			18			13		
	158.5	92.5	0.5833	0.0690	2864.1	18.1	**261.8**	802.6	5.1	**73.4**	255.6	1.6	**23.4**	75.0	0.5	**6.9**

EMD 645 E3 16 cylinders 2000 HP Extrapolated (2000/3000)

Throttle Position	Fuel Cons. lb/hr	HP	NOx g/hr	CO g/hr	HC g/hr	PM g/hr
DB	18.7		579.5	377.7	137.0	
Low Idle	28.0		930.0	447.9	147.7	
Idle	55.3	70.7	2240.0	536.3	228.5	49.8
1	102.7	234.0	3232.0	283.1	149.1	
2	187.3	444.0	5536.0	391.4	201.6	
3	259.3	661.3	7187.3	403.7	263.3	
4	365.3	960.0	10430.0	1281.3	349.5	
5	476.0	1289.3	13020.7	2424.7	442.4	
6	680.0	1844.0	19277.3	4322.0	689.3	
7	801.3	2178.0	23074.0	4665.3	815.3	
8	0.0	0.0	0.0	0.0	0.0	0

Duty Cycle 2002 Yard and Switching					Duty Cycle 2002 Yard and Switching			Duty Cycle 2002 Yard and Switching			Duty Cycle 2002 Yard and Switching			Duty Cycle 2002 Yard and Switching		
%	HP	Fuel Consumption			NOx			CO			HC			PM		
		duty cycle lb/hr	lb/ bhp-hr	IG/ bhp-hr	g/hr	g/bhp-hr	Factor g/IG	g/hr	g/bhp-hr	Factor g/IG	g/hr	g/bhp-hr	Factor g/IG	g/hr	g/bhp-hr	Factor g/IG
0.0%					0			0			0					
83.0%	59	45.9			1859			445			190			41		
4.1%	10	4.2			133			12			6					
4.0%	18	7.5			221			16			8					
3.6%	24	9.3			259			15			9					
2.0%	19	7.3			209			26			7					
1.0%	13	4.8			130			24			4					
0.5%	9	3.4			96			22			3					
0.3%	7	2.4			69			14			2					
1.5%	0	0.0			0			0			0			0		
	157.7	84.8	0.5381	0.0637	2976.3	18.9	**296.5**	572.4	3.6	**57.0**	230.6	1.5	**23.0**	41.3	0.3	**4.1**

EMD 645 E3 16 cylinders 1800 HP Extrapolated (1800/3000)

Throttle Position	Fuel Cons.	HP	NOx	CO	HC	PM
	lb/hr		g/hr	g/hr	g/hr	g/hr
DB	16.8		521.5	340.0	123.3	
Low Idle	25.2		837.0	403.1	132.9	
Idle	49.8	63.6	2016.0	482.6	205.6	44.8
1	92.4	210.6	2908.8	254.8	134.2	
2	168.6	399.6	4982.4	352.3	181.4	
3	233.4	595.2	6468.6	363.3	237.0	
4	328.8	864.0	9387.0	1153.2	314.5	
5	428.4	1160.4	11718.6	2182.2	398.2	
6	612.0	1659.6	17349.6	3889.8	620.4	
7	721.2	1960.2	20766.6	4198.8	733.8	
8	0.0	0.0	0.0	0.0	0.0	0.0

Duty Cycle 2002 Yard and Switching					Duty Cycle 2002 Yard and Switching			Duty Cycle 2002 Yard and Switching			Duty Cycle 2002 Yard and Switching			Duty Cycle 2002 Yard and Switching		
%	HP	Fuel Consumption			NOx			CO			HC			PM		
		duty cycle lb/hr	lb/ bhp-hr	IG/ bhp-hr	g/hr	g/bhp-hr	Factor g/IG	g/hr	g/bhp-hr	Factor g/IG	g/hr	g/bhp-hr	Factor g/IG	g/hr	g/bhp-hr	Factor g/IG
0.0%					0			0			0					
83.0%	53	41.3			1673			401			171			37		
4.1%	9	3.8			119			10			6					
4.0%	16	6.7			199			14			7					
3.6%	21	8.4			233			13			9					
2.0%	17	6.6			188			23			6					
1.0%	12	4.3			117			22			4					
0.5%	8	3.1			87			19			3					
0.3%	6	2.2			62			13			2					
1.5%	0	0.0			0			0			0			0		
	141.9	76.4	0.5381	0.0637	2678.7	18.9	**296.5**	515.1	3.6	**57.0**	207.5	1.5	**23.0**	37.2	0.3	**4.1**

EMD 645 E3 16 cylinders 1200 HP Extrapolated (1200/3000)

Throttle Position	Fuel Cons.	HP	NOx	CO	HC	PM
	lb/hr		g/hr	g/hr	g/hr	g/hr
DB	11.2	.	347.7	226.6	82.2	
Low Idle	16.8	.	558.0	268.7	88.6	
Idle	33.2	42.4	1344.0	321.8	137.1	29.9
1	61.6	140.4	1939.2	169.8	89.4	
2	112.4	266.4	3321.6	234.8	121.0	
3	155.6	396.8	4312.4	242.2	158.0	
4	219.2	576.0	6258.0	768.8	209.7	
5	285.6	773.6	7812.4	1454.8	265.4	
6	408.0	1106.4	11566.4	2593.2	413.6	
7	480.8	1306.8	13844.4	2799.2	489.2	
8	0.0	0.0	0.0	0.0	0.0	0.0

Duty Cycle 2002 Yard and Switching					Duty Cycle 2002 Yard and Switching			Duty Cycle 2002 Yard and Switching			Duty Cycle 2002 Yard and Switching			Duty Cycle 2002 Yard and Switching		
%	HP	Fuel Consumption			NOx			CO			HC			PM		
		duty cycle lb/hr	lb/ bhp-hr	IG/ bhp-hr	g/hr	g/bhp-hr	Factor g/IG	g/hr	g/bhp-hr	Factor g/IG	g/hr	g/bhp-hr	Factor g/IG	g/hr	g/bhp-hr	Factor g/IG
0.0%					0			0			0					
83.0%	35	27.6			1116			267			114			25		
4.1%	6	2.5			80			7			4					
4.0%	11	4.5			133			9			5					
3.6%	14	5.6			155			9			6					
2.0%	12	4.4			125			15			4					
1.0%	8	2.9			78			15			3					
0.5%	6	2.0			58			13			2					
0.3%	4	1.4			42			8			1					
1.5%	0	0.0			0			0			0			0		
	94.6	50.9	0.5381	0.0637	1785.8	18.9	**296.5**	343.4	3.6	**57.0**	138.4	1.5	**23.0**	24.8	0.3	**4.1**

EMD 567 16 cylinders 1750 HP Extrapolated (1750/2250)

Throttle Position	Fuel Cons. lb/hr	HP	NOx g/hr	CO g/hr	HC g/hr	PM g/hr
DB	.	.	.	.	.	.
Low Idle	.	.	.	.	.	.
Idle	32.7	10.9	1114.6	436.3	147.0	57.6
1	52.9	97.2	1371.2	.	.	.
2	96.4	208.4	2458.6	234.9	159.4	.
3	150.9	348.4	3725.6	289.3	193.7	.
4	215.4	546.0	5264.0	361.7	219.3	.
5	303.3	775.4	7232.6	703.1	308.0	.
6	407.6	1048.4	9232.2	1734.4	374.9	.
7	528.9	1368.1	11880.6	3741.9	509.4	.
8	713.2	1839.4	18543.0	6891.1	703.1	989.3

Duty Cycle 2002 Yard and Switching					Duty Cycle 2002 Yard and Switching			Duty Cycle 2002 Yard and Switching			Duty Cycle 2002 Yard and Switching			Duty Cycle 2002 Yard and Switching		
%	HP	Fuel Consumption			NOx			CO			HC			PM		
		duty cycle lb/hr	lb/ bhp-hr	IG/ bhp-hr	g/hr	g/bhp-hr	Factor g/IG	g/hr	g/bhp-hr	Factor g/IG	g/hr	g/bhp-hr	Factor g/IG	g/hr	g/bhp-hr	Factor g/IG
0.0%																
83.0%	9	27.1			925			362			122			48		
4.1%	4	2.2			56											
4.0%	8	3.9			98			9			6					
3.6%	13	5.4			134			10			7					
2.0%	11	4.3			105			7			4					
1.0%	8	3.0			72			7			3					
0.5%	5	2.0			46			9			2					
0.3%	4	1.6			36			11			2					
1.5%	28	10.7			278			103			11			15		
	89.5	60.3	0.6732	0.0797	1751.4	19.6	**245.6**	519.5	5.8	**72.8**	156.8	1.8	**22.0**	62.6	0.7	**8.8**

EMD 567 12 cylinders 1200 HP Extrapolated (1200/2250)

Throttle Position	Fuel Cons. lb/hr	HP	NOx g/hr	CO g/hr	HC g/hr	PM g/hr
DB	.	.	.	.	.	.
Low Idle	.	.	.	.	.	.
Idle	22.4	7.5	764.3	299.2	100.8	39.5
1	36.3	66.7	940.3	.	.	.
2	66.1	142.9	1685.9	161.1	109.3	.
3	103.5	238.9	2554.7	198.4	132.8	.
4	147.7	374.4	3609.6	248.0	150.4	.
5	208.0	531.7	4959.5	482.1	211.2	.
6	279.5	718.9	6330.7	1189.3	257.1	.
7	362.7	938.1	8146.7	2565.9	349.3	.
8	489.1	1261.3	12715.2	4725.3	482.1	678.4

Duty Cycle 2002 Yard and Switching					Duty Cycle 2002 Yard and Switching			Duty Cycle 2002 Yard and Switching			Duty Cycle 2002 Yard and Switching			Duty Cycle 2002 Yard and Switching		
%	HP	Fuel Consumption			NOx			CO			HC			PM		
		duty cycle lb/hr	lb/ bhp-hr	IG/ bhp-hr	g/hr	g/bhp-hr	Factor g/IG	g/hr	g/bhp-hr	Factor g/IG	g/hr	g/bhp-hr	Factor g/IG	g/hr	g/bhp-hr	Factor g/IG
0.0%																
83.0%	6	18.6			634			248			84			33		
4.1%	3	1.5			39											
4.0%	6	2.6			67			6			4					
3.6%	9	3.7			92			7			5					
2.0%	7	3.0			72			5			3					
1.0%	5	2.1			50			5			2					
0.5%	4	1.4			32			6			1					
0.3%	3	1.1			24			8			1					
1.5%	19	7.3			191			71			7			10		
	61.4	41.3	0.6732	0.0797	1200.9	19.6	**245.6**	356.2	5.8	**72.8**	107.5	1.8	**22.0**	43.0	0.7	**8.8**

APPENDIX F

DUTY CYCLE EFFECTS

ON

EMISSIONS FACTORS

Appendix F: Duty Cycle Effects on Emissions Factors

Ref: 1 Source: AAR Report R-688 (March 1988), page Appendix1-24

EMD 645 E3 16 cylinders 3000 HP

1. Duty Cycle: Canadian Freight Pre 1990

Throttle Position	Fuel Cons. lb/hr	HP	NOx g/hr	CO g/hr	HC g/hr	PM g/hr
DB	132	.	3804	740	322	.
Low Idle	28	.	869	567	206	.
Idle	42	18	1395	672	222	75
1	83	106	3360	804	343	.
2	154	351	4848	425	224	.
3	281	666	8304	587	302	.
4	389	992	10781	606	395	.
5	548	1440	15645	1922	524	.
6	714	1934	19531	3637	664	.
7	1020	2766	28916	6483	1034	.
8	1202	3267	34611	6998	1223	868

Duty Cycle: Canadian Freight Pre 1990

DB	Idle	N1	N2	N3	N4	N5	N6	N7	N8
4.5%	61.1%	3.8%	4.7%	4.1%	3.5%	3.1%	2.8%	1.5%	10.9%

EMD SD-40 3000 HP Duty Cycle: Freight Pre 1990					EMD SD-40 3000 HP Duty Cycle: Freight Pre 1990			EMD SD-40 3000 HP Duty Cycle: Freight Pre 1990			EMD SD-40 3000 HP Duty Cycle: Freight Pre 1990			EMD SD-40 3000 HP Duty Cycle: Freight Pre 1990		
%	HP	Fuel Consumption			NOx			CO			HC			PM		
		duty cycle lb/hr	lb/ bhp-hr	IG/ bhp-hr	g/hr	g/bhp-hr	Factor g/IG	g/hr	g/bhp-hr	Factor g/IG	g/hr	g/bhp-hr	Factor g/IG	g/hr	g/bhp-hr	Factor g/IG
4.5%		5.9			171			33			14					
61.1%	11	25.7			852			410			135			46		
3.8%	4	3.2			128			31			13					
4.7%	16	7.2			228			20			11					
4.1%	27	11.5			340			24			12					
3.5%	35	13.6			377			21			14					
3.1%	45	17.0			485			60			16					
2.8%	54	20.0			547			102			19					
1.5%	41	15.3			434			97			16					
10.9%	356	131.0			3773			763			133			95		
	589.9	250.4	0.4245	0.0502	7335.1	12.4	**247.5**	1561.0	2.6	**52.7**	383.2	0.6	**12.9**	140.2	0.2	**4.7**

EMD 645 E3 16 cylinders 3000 HP

2. Duty Cycle: Canadian Freight Post 1990

Throttle Position	Fuel Cons. lb/hr	HP	NOx g/hr	CO g/hr	HC g/hr	PM g/hr
DB	132	.	3804	740	322	.
Low Idle	28	.	869	567	206	.
Idle	42	18	1395	672	222	75
1	83	106	3360	804	343	.
2	154	351	4848	425	224	.
3	281	666	8304	587	302	.
4	389	992	10781	606	395	.
5	548	1440	15645	1922	524	.
6	714	1934	19531	3637	664	.
7	1020	2766	28916	6483	1034	.
8	1202	3267	34611	6998	1223	868

Duty Cycle: Canadian Freight Post 1990

DB	Idle	N1	N2	N3	N4	N5	N6	N7	N8
6.0%	53.6%	4.1%	5.6%	4.7%	3.9%	3.4%	3.2%	1.5%	13.8%

EMD SD-40 3000 HP Duty Cycle: Freight Post 1990					EMD SD-40 3000 HP Duty Cycle: Freight Post 1990			EMD SD-40 3000 HP Duty Cycle: Freight Post 1990			EMD SD-40 3000 HP Duty Cycle: Freight Post 1990			EMD SD-40 3000 HP Duty Cycle: Freight Post 1990		
%	HP	Fuel Consumption			NOx			CO			HC			PM		
		duty cycle lb/hr	lb/ bhp-hr	IG/ bhp-hr	g/hr	g/bhp-hr	Factor g/IG	g/hr	g/bhp-hr	Factor g/IG	g/hr	g/bhp-hr	Factor g/IG	g/hr	g/bhp-hr	Factor g/IG
6.0%		7.9			228			44			19					
53.6%	10	22.5			748			360			119			40		
4.1%	4	3.4			138			33			14					
5.6%	20	8.6			271			24			13					
4.7%	31	13.2			390			28			14					
3.9%	39	15.2			420			24			15					
3.4%	49	18.6			532			65			18					
3.2%	62	22.8			625			116			21					
1.5%	41	15.3			434			97			16					
13.8%	451	165.9			4776			966			169			120		
	706.8	293.5	0.4152	0.0491	8562.9	12.1	**246.5**	1757.2	2.5	**50.6**	417.6	0.6	**12.0**	159.7	0.2	**4.6**

EMD 645 E3 16 cylinders 3000 HP

3. Duty Cycle: Canadian Freight Combined

Throttle Position	Fuel Cons.	HP	NOx	CO	HC	PM
	lb/hr		g/hr	g/hr	g/hr	g/hr
DB	132	.	3804	740	322	.
Low Idle	28	.	869	567	206	.
Idle	42	18	1395	672	222	75
1	83	106	3360	804	343	.
2	154	351	4848	425	224	.
3	281	666	8304	587	302	.
4	389	992	10781	606	395	.
5	548	1440	15645	1922	524	.
6	714	1934	19531	3637	664	.
7	1020	2766	28916	6483	1034	.
8	1202	3267	34611	6998	1223	868

Duty Cycle: Canadian Freight Combined

DB	Idle	N1	N2	N3	N4	N5	N6	N7	N8
5.1%	**58.1%**	**3.9%**	**5.0%**	**4.4%**	**3.7%**	**3.3%**	**3.0%**	**1.5%**	**12.0%**

EMD SD-40 3000 HP Duty Cycle: Freight Combined					EMD SD-40 3000 HP Duty Cycle: Freight Combined			EMD SD-40 3000 HP Duty Cycle: Freight Combined			EMD SD-40 3000 HP Duty Cycle: Freight Combined			EMD SD-40 3000 HP Duty Cycle: Freight Combined		
%	HP	Fuel Consumption			NOx			CO			HC			PM		
		duty cycle lb/hr	lb/ bhp-hr	IG/ bhp-hr	g/hr	g/bhp-hr	Factor g/IG	g/hr	g/bhp-hr	Factor g/IG	g/hr	g/bhp-hr	Factor g/IG	g/hr	g/bhp-hr	Factor g/IG
5.1%		6.7			194			38			16					
58.1%	10	24.4			810			390			129			43		
3.9%	4	3.2			131			31			13					
5.0%	18	7.7			242			21			11					
4.4%	29	12.4			365			26			13					
3.7%	37	14.4			399			22			15					
3.3%	48	18.1			516			63			17					
3.0%	58	21.4			586			109			20					
1.5%	41	15.3			434			97			16					
12.0%	392	144.2			4153			840			147			104		
	637.2	267.9	0.4204	0.0497	7831.5	12.3	**247.0**	1638.4	2.6	**51.7**	397.1	0.6	**12.5**	147.5	0.2	**4.7**

4. Duty Cycle: 1990 RAC

Throttle Position	Fuel Cons.	HP	NOx	CO	HC	PM
	lb/hr		g/hr	g/hr	g/hr	g/hr
DB	132	.	3804	740	322	.
Low Idle	28	.	869	567	206	.
Idle	42	18	1395	672	222	75
1	83	106	3360	804	343	.
2	154	351	4848	425	224	.
3	281	666	8304	587	302	.
4	389	992	10781	606	395	.
5	548	1440	15645	1922	524	.
6	714	1934	19531	3637	664	.
7	1020	2766	28916	6483	1034	.
8	1202	3267	34611	6998	1223	868

Duty Cycle: 1990 RAC

DB	Idle	N1	N2	N3	N4	N5	N6	N7	N8
0.0%	**60.0%**	**4.0%**	**4.0%**	**4.0%**	**4.0%**	**4.0%**	**4.0%**	**4.0%**	**12.0%**

EMD SD-40 3000 HP Duty Cycle: 1990 RAC Freight					EMD SD-40 3000 HP Duty Cycle: 1990 RAC Freight			EMD SD-40 3000 HP Duty Cycle: 1990 RAC Freight			EMD SD-40 3000 HP Duty Cycle: 1990 RAC Freight			EMD SD-40 3000 HP Duty Cycle: 1990 RAC Freight		
%	HP	Fuel Consumption			NOx			CO			HC			PM		
		duty cycle lb/hr	lb/ bhp-hr	IG/ bhp-hr	g/hr	g/bhp-hr	Factor g/IG	g/hr	g/bhp-hr	Factor g/IG	g/hr	g/bhp-hr	Factor g/IG	g/hr	g/bhp-hr	Factor g/IG
0.0%		0.0			0			0			0					
60.0%	11	25.2			837			403			133			45		
4.0%	4	3.3			134			32			14					
4.0%	14	6.2			194			17			9					
4.0%	27	11.2			332			23			12					
4.0%	40	15.6			431			24			16					
4.0%	58	21.9			626			77			21					
4.0%	77	28.6			781			145			27					
4.0%	111	40.8			1157			259			41					
12.0%	392	144.2			4153			840			147			104		
	733.0	297.0	0.4052	0.0479	8645.7	11.8	**246.0**	1821.4	2.5	**51.8**	419.1	0.6	**11.9**	148.9	0.2	**4.2**

5. Duty Cycle: California Mixed Freight

Throttle Position	Fuel Cons. lb/hr	HP	NOx g/hr	CO g/hr	HC g/hr	PM g/hr
DB	132	.	3804	740	322	.
Low Idle	28	.	869	567	206	.
Idle	42	18	1395	672	222	75
1	83	106	3360	804	343	.
2	154	351	4848	425	224	.
3	281	666	8304	587	302	.
4	389	992	10781	606	395	.
5	548	1440	15645	1922	524	.
6	714	1934	19531	3637	664	.
7	1020	2766	28916	6483	1034	.
8	1202	3267	34611	6998	1223	868

Duty Cycle: California Mixed Freight

DB	Idle	N1	N2	N3	N4	N5	N6	N7	N8
12.0%	**49.0%**	**4.0%**	**4.0%**	**4.0%**	**4.5%**	**4.5%**	**4.0%**	**3.0%**	**12.0%**

EMD SD-40 3000 HP Duty Cycle: California Mixed Freight					EMD SD-40 3000 HP Duty Cycle: California Mixed Freight			EMD SD-40 3000 HP Duty Cycle: California Mixed Freight			EMD SD-40 3000 HP Duty Cycle: California Mixed Freight			EMD SD-40 3000 HP Duty Cycle: California Mixed Freight		
%	HP	Fuel Consumption			NOx			CO			HC			PM		
		duty cycle lb/hr	lb/ bhp-hr	IG/ bhp-hr	g/hr	g/bhp-hr	Factor g/IG	g/hr	g/bhp-hr	Factor g/IG	g/hr	g/bhp-hr	Factor g/IG	g/hr	g/bhp-hr	Factor g/IG
12.0%		15.8			456			89			39					
49.0%	9	20.6			684			329			109			37		
4.0%	4	3.3			134			32			14					
4.0%	14	6.2			194			17			9					
4.0%	27	11.2			332			23			12					
4.5%	45	17.5			485			27			18					
4.5%	65	24.7			704			86			24					
4.0%	77	28.6			781			145			27					
3.0%	83	30.6			867			194			31					
12.0%	392	144.2			4153			840			147			104		
	715.6	302.7	0.4230	0.0501	8791.7	12.3	**245.4**	1784.1	2.5	**49.8**	427.6	0.6	**11.9**	140.7	0.2	**3.9**

6. Duty Cycle: California Intermodal

Throttle Position	Fuel Cons. lb/hr	HP	NOx g/hr	CO g/hr	HC g/hr	PM g/hr
DB	132	.	3804	740	322	.
Low Idle	28	.	869	567	206	.
Idle	42	18	1395	672	222	75
1	83	106	3360	804	343	.
2	154	351	4848	425	224	.
3	281	666	8304	587	302	.
4	389	992	10781	606	395	.
5	548	1440	15645	1922	524	.
6	714	1934	19531	3637	664	.
7	1020	2766	28916	6483	1034	.
8	1202	3267	34611	6998	1223	868

Duty Cycle: California Intermodal

DB	Idle	N1	N2	N3	N4	N5	N6	N7	N8
10.0%	**55.0%**	**3.0%**	**3.0%**	**4.0%**	**4.0%**	**4.0%**	**4.0%**	**3.0%**	**10.0%**

EMD SD-40 3000 HP Duty Cycle: California Intermodal					EMD SD-40 3000 HP Duty Cycle: California Intermodal			EMD SD-40 3000 HP Duty Cycle: California Intermodal			EMD SD-40 3000 HP Duty Cycle: California Intermodal			EMD SD-40 3000 HP Duty Cycle: California Intermodal		
%	HP	Fuel Consumption			NOx			CO			HC			PM		
		duty cycle lb/hr	lb/ bhp-hr	IG/ bhp-hr	g/hr	g/bhp-hr	Factor g/IG	g/hr	g/bhp-hr	Factor g/IG	g/hr	g/bhp-hr	Factor g/IG	g/hr	g/bhp-hr	Factor g/IG
10.0%		13.2			380			74			32					
55.0%	10	23.1			767			369			122			41		
3.0%	3	2.5			101			24			10					
3.0%	11	4.6			145			13			7					
4.0%	27	11.2			332			23			12					
4.0%	40	15.6			431			24			16					
4.0%	58	21.9			626			77			21					
4.0%	77	28.6			781			145			27					
3.0%	83	30.6			867			194			31					
10.0%	327	120.2			3461			700			122			87		
	634.6	271.5	0.4278	0.0506	7892.9	12.4	**245.7**	1644.7	2.6	**51.2**	399.7	0.6	**12.4**	127.8	0.2	**4.0**

7. Duty Cycle: GE Line Haul

Throttle Position	Fuel Cons. lb/hr	HP	NOx g/hr	CO g/hr	HC g/hr	PM g/hr
DB	132	.	3804	740	322	.
Low Idle	28	.	869	567	206	.
Idle	42	18	1395	672	222	75
1	83	106	3360	804	343	.
2	154	351	4848	425	224	.
3	281	666	8304	587	302	.
4	389	992	10781	606	395	.
5	548	1440	15645	1922	524	.
6	714	1934	19531	3637	664	.
7	1020	2766	28916	6483	1034	.
8	1202	3267	34611	6998	1223	868

Duty Cycle: GE Line Haul

DB	Idle	N1	N2	N3	N4	N5	N6	N7	N8
4.0%	**50.0%**	**5.0%**	**5.0%**	**3.0%**	**4.0%**	**4.0%**	**3.0%**	**3.0%**	**14.0%**

EMD SD-40 3000 HP Duty Cycle: GE Line Haul					EMD SD-40 3000 HP Duty Cycle: GE Line Haul			EMD SD-40 3000 HP Duty Cycle: GE Line Haul			EMD SD-40 3000 HP Duty Cycle: GE Line Haul			EMD SD-40 3000 HP Duty Cycle: GE Line Haul		
%	HP	Fuel Consumption			NOx			CO			HC			PM		
		duty cycle lb/hr	lb/ bhp-hr	IG/ bhp-hr	g/hr	g/bhp-hr	Factor g/IG	g/hr	g/bhp-hr	Factor g/IG	g/hr	g/bhp-hr	Factor g/IG	g/hr	g/bhp-hr	Factor g/IG
4.0%		5.3			152			30			13					
50.0%	9	21.0			698			336			111			37		
5.0%	5	4.2			168			40			17					
5.0%	18	7.7			242			21			11					
3.0%	20	8.4			249			18			9					
4.0%	40	15.6			431			24			16					
4.0%	58	21.9			626			77			21					
3.0%	58	21.4			586			109			20					
3.0%	83	30.6			867			194			31					
14.0%	457	168.3			4846			980			171			121		
	747.5	304.3	0.4071	0.0482	8865.2	11.9	**246.1**	1829.0	2.4	**50.8**	419.9	0.6	**11.7**	158.8	0.2	**4.4**

8. Duty Cycle: EMD Road Duty

Throttle Position	Fuel Cons. lb/hr	HP	NOx g/hr	CO g/hr	HC g/hr	PM g/hr
DB	132	.	3804	740	322	.
Low Idle	28	.	869	567	206	.
Idle	42	18	1395	672	222	75
1	83	106	3360	804	343	.
2	154	351	4848	425	224	.
3	281	666	8304	587	302	.
4	389	992	10781	606	395	.
5	548	1440	15645	1922	524	.
6	714	1934	19531	3637	664	.
7	1020	2766	28916	6483	1034	.
8	1202	3267	34611	6998	1223	868

Duty Cycle: EMD Road Duty

DB	Idle	N1	N2	N3	N4	N5	N6	N7	N8
9.0%	**46.0%**	**4.0%**	**4.0%**	**4.0%**	**4.0%**	**4.0%**	**4.0%**	**4.0%**	**17.0%**

EMD SD-40 3000 HP Duty Cycle: EMD Road Duty					EMD SD-40 3000 HP Duty Cycle: EMD Road Duty			EMD SD-40 3000 HP Duty Cycle: EMD Road Duty			EMD SD-40 3000 HP Duty Cycle: EMD Road Duty			EMD SD-40 3000 HP Duty Cycle: EMD Road Duty		
%	HP	Fuel Consumption			NOx			CO			HC			PM		
		duty cycle lb/hr	lb/ bhp-hr	IG/ bhp-hr	g/hr	g/bhp-hr	Factor g/IG	g/hr	g/bhp-hr	Factor g/IG	g/hr	g/bhp-hr	Factor g/IG	g/hr	g/bhp-hr	Factor g/IG
9.0%		11.9			342			67			29					
46.0%	8	19.3			642			309			102			34		
4.0%	4	3.3			134			32			14					
4.0%	14	6.2			194			17			9					
4.0%	27	11.2			332			23			12					
4.0%	40	15.6			431			24			16					
4.0%	58	21.9			626			77			21					
4.0%	77	28.6			781			145			27					
4.0%	111	40.8			1157			259			41					
17.0%	555	204.3			5884			1190			208			147		
	893.9	363.1	0.4062	0.0481	10523.3	11.8	**244.9**	2143.8	2.4	**49.9**	478.2	0.5	**11.1**	181.8	0.2	**4.2**

9. Duty Cycle: ISO Europe

Throttle Position	Fuel Cons.	HP	NOx	CO	HC	PM
	lb/hr		g/hr	g/hr	g/hr	g/hr
DB	132	.	3804	740	322	.
Low Idle	28	.	869	567	206	.
Idle	42	18	1395	672	222	75
1	83	106	3360	804	343	.
2	154	351	4848	425	224	.
3	281	666	8304	587	302	.
4	389	992	10781	606	395	.
5	548	1440	15645	1922	524	.
6	714	1934	19531	3637	664	.
7	1020	2766	28916	6483	1034	.
8	1202	3267	34611	6998	1223	868

Duty Cycle: ISO Europe

DB	Idle	N1	N2	N3	N4	N5	N6	N7	N8
0.0%	**60.0%**	**0.0%**	**0.0%**	**0.0%**	**15.0%**	**0.0%**	**0.0%**	**0.0%**	**25.0%**

EMD SD-40 3000 HP Duty Cycle: ISO Europe					EMD SD-40 3000 HP Duty Cycle: ISO Europe			EMD SD-40 3000 HP Duty Cycle: ISO Europe			EMD SD-40 3000 HP Duty Cycle: ISO Europe			EMD SD-40 3000 HP Duty Cycle: ISO Europe		
%	HP	Fuel Consumption			NOx			CO			HC			PM		
		duty cycle lb/hr	lb/ bhp-hr	IG/ bhp-hr	g/hr	g/bhp-hr	Factor g/IG	g/hr	g/bhp-hr	Factor g/IG	g/hr	g/bhp-hr	Factor g/IG	g/hr	g/bhp-hr	Factor g/IG
0.0%		0.0			0			0			0					
60.0%	11	25.2			837			403			133			45		
0.0%	0	0.0			0			0			0					
0.0%	0	0.0			0			0			0					
0.0%	0	0.0			0			0			0					
15.0%	149	58.4			1617			91			59					
0.0%	0	0.0			0			0			0					
0.0%	0	0.0			0			0			0					
0.0%	0	0.0			0			0			0					
25.0%	817	300.5			8653			1750			306			217		
	976.4	384.1	0.3934	0.0466	11106.9	11.4	**244.4**	2243.4	2.3	**49.4**	497.9	0.5	**11.0**	261.7	0.3	**5.8**

10. Duty Cycle: RAC Branch/Yard

Throttle Position	Fuel Cons.	HP	NOx	CO	HC	PM
	lb/hr		g/hr	g/hr	g/hr	g/hr
DB	132	.	3804	740	322	.
Low Idle	28	.	869	567	206	.
Idle	42	18	1395	672	222	75
1	83	106	3360	804	343	.
2	154	351	4848	425	224	.
3	281	666	8304	587	302	.
4	389	992	10781	606	395	.
5	548	1440	15645	1922	524	.
6	714	1934	19531	3637	664	.
7	1020	2766	28916	6483	1034	.
8	1202	3267	34611	6998	1223	868

Duty Cycle: RAC Branch/Yard

DB	Idle	N1	N2	N3	N4	N5	N6	N7	N8
0.0%	**81.0%**	**2.0%**	**2.0%**	**2.0%**	**2.0%**	**2.0%**	**2.0%**	**2.0%**	**5.0%**

EMD SD-40 3000 HP Duty Cycle: RAC Branch/Yard					EMD SD-40 3000 HP Duty Cycle: RAC Branch/Yard			EMD SD-40 3000 HP Duty Cycle: RAC Branch/Yard			EMD SD-40 3000 HP Duty Cycle: RAC Branch/Yard			EMD SD-40 3000 HP Duty Cycle: RAC Branch/Yard		
%	HP	Fuel Consumption			NOx			CO			HC			PM		
		duty cycle lb/hr	lb/ bhp-hr	IG/ bhp-hr	g/hr	g/bhp-hr	Factor g/IG	g/hr	g/bhp-hr	Factor g/IG	g/hr	g/bhp-hr	Factor g/IG	g/hr	g/bhp-hr	Factor g/IG
0.0%		0.0			0			0			0					
81.0%	15	34.0			1130			544			179			60		
2.0%	2	1.7			67			16			7					
2.0%	7	3.1			97			8			4					
2.0%	13	5.6			166			12			6					
2.0%	20	7.8			216			12			8					
2.0%	29	11.0			313			38			10					
2.0%	39	14.3			391			73			13					
2.0%	55	20.4			578			130			21					
5.0%	163	60.1			1731			350			61			43		
	343.0	157.9	0.4603	0.0545	4688.2	13.7	**250.9**	1183.3	3.4	**63.3**	310.3	0.9	**16.6**	103.8	0.3	**5.6**

11. Duty Cycle: California Yard

Throttle Position	Fuel Cons.	HP	NOx	CO	HC	PM
	lb/hr		g/hr	g/hr	g/hr	g/hr
DB	132	.	3804	740	322	.
Low Idle	28	.	869	567	206	.
Idle	42	18	1395	672	222	75
1	83	106	3360	804	343	.
2	154	351	4848	425	224	.
3	281	666	8304	587	302	.
4	389	992	10781	606	395	.
5	548	1440	15645	1922	524	.
6	714	1934	19531	3637	664	.
7	1020	2766	28916	6483	1034	.
8	1202	3267	34611	6998	1223	868

Duty Cycle: California Yard

DB	Idle	N1	N2	N3	N4	N5	N6	N7	N8
0.0%	**82.0%**	**4.0%**	**4.0%**	**3.0%**	**3.0%**	**1.0%**	**0.0%**	**0.0%**	**2.0%**

EMD SD-40 3000 HP Duty Cycle: California Yard					EMD SD-40 3000 HP Duty Cycle: California Yard			EMD SD-40 3000 HP Duty Cycle: California Yard			EMD SD-40 3000 HP Duty Cycle: California Yard			EMD SD-40 3000 HP Duty Cycle: California Yard		
%	HP	Fuel Consumption			NOx			CO			HC			PM		
		duty cycle lb/hr	lb/ bhp-hr	IG/ bhp-hr	g/hr	g/bhp-hr	Factor g/IG	g/hr	g/bhp-hr	Factor g/IG	g/hr	g/bhp-hr	Factor g/IG	g/hr	g/bhp-hr	Factor g/IG
0.0%		0.0			0			0			0					
82.0%	15	34.4			1144			551			182			61		
4.0%	4	3.3			134			32			14					
4.0%	14	6.2			194			17			9					
3.0%	20	8.4			249			18			9					
3.0%	30	11.7			323			18			12					
1.0%	14	5.5			156			19			5					
0.0%	0	0.0			0			0			0					
0.0%	0	0.0			0			0			0					
2.0%	65	24.0			692			140			24			17		
	162.5	93.5	0.5756	0.0681	2893.4	17.8	**261.4**	795.0	4.9	**71.8**	254.9	1.6	**23.0**	78.6	0.5	**7.1**

12. Duty Cycle: California Local

Throttle Position	Fuel Cons.	HP	NOx	CO	HC	PM
	lb/hr		g/hr	g/hr	g/hr	g/hr
DB	132	.	3804	740	322	.
Low Idle	28	.	869	567	206	.
Idle	42	18	1395	672	222	75
1	83	106	3360	804	343	.
2	154	351	4848	425	224	.
3	281	666	8304	587	302	.
4	389	992	10781	606	395	.
5	548	1440	15645	1922	524	.
6	714	1934	19531	3637	664	.
7	1020	2766	28916	6483	1034	.
8	1202	3267	34611	6998	1223	868

Duty Cycle: California Local

DB	Idle	N1	N2	N3	N4	N5	N6	N7	N8
4.0%	**4.7%**	**9.0%**	**8.0%**	**8.0%**	**7.0%**	**4.0%**	**3.0%**	**3.0%**	**7.0%**

EMD SD-40 3000 HP Duty Cycle: California Local					EMD SD-40 3000 HP Duty Cycle: California Local			EMD SD-40 3000 HP Duty Cycle: California Local			EMD SD-40 3000 HP Duty Cycle: California Local			EMD SD-40 3000 HP Duty Cycle: California Local		
%	HP	Fuel Consumption			NOx			CO			HC			PM		
		duty cycle lb/hr	lb/ bhp-hr	IG/ bhp-hr	g/hr	g/bhp-hr	Factor g/IG	g/hr	g/bhp-hr	Factor g/IG	g/hr	g/bhp-hr	Factor g/IG	g/hr	g/bhp-hr	Factor g/IG
4.0%		5.3			152			30			13					
4.7%	1	2.0			66			32			10			4		
9.0%	10	7.5			302			72			31					
8.0%	28	12.3			388			34			18					
8.0%	53	22.5			664			47			24					
7.0%	69	27.2			755			42			28					
4.0%	58	21.9			626			77			21					
3.0%	58	21.4			586			109			20					
3.0%	83	30.6			867			194			31					
7.0%	229	84.1			2423			490			86			61		
	588.5	234.8	0.3991	0.0472	6828.9	11.6	**245.7**	1127.2	1.9	**40.6**	281.4	0.5	**10.1**	64.2	0.1	**2.3**

Ref 2 Source: SwRI Report No. 08-5374-024 (August 1995); page 45

EMD SD 75 710G3EC 4300 HP

1. Duty Cycle: Canadian Freight Pre 1990

Throttle Position	Fuel Cons. lb/hr	HP	NOx g/hr	CO g/hr	HC g/hr	PM g/hr
DB	34	14	1020	167	148	35
Low Idle	26	13	909	141	125	39
1	108	264	3450	248	157	64
2	200	537	7390	276	221	133
3	379	1062	15318	453	342	273
4	529	1531	24807	632	429	402
5	663	1944	29966	1023	535	527
6	926	2767	43501	3656	671	723
7	1231	3824	58836	3541	966	1089
8	1439	4431	54440	3724	1171	1223

Duty Cycle: Canadian Freight Pre 1990

DB	Idle	N1	N2	N3	N4	N5	N6	N7	N8
4.5%	61.1%	3.8%	4.7%	4.1%	3.5%	3.1%	2.8%	1.5%	10.9%

EMD SD-75 4300HP Duty Cycle: Freight Pre 1990					EMD SD-75 4300HP Duty Cycle: Freight Pre 1990			EMD SD-75 4300HP Duty Cycle: Freight Pre 1990			EMD SD-75 4300HP Duty Cycle: Freight Pre 1990			EMD SD-75 4300HP Duty Cycle: Freight Pre 1990		
%	HP	Fuel Consumption			NOx			CO			HC			PM		
		duty cycle lb/hr	lb/ bhp-hr	IG/ bhp-hr	g/hr	g/bhp-hr	Factor g/IG	g/hr	g/bhp-hr	Factor g/IG	g/hr	g/bhp-hr	Factor g/IG	g/hr	g/bhp-hr	Factor g/IG
4.5%		1.5			46			8			7			2		
61.1%	8	15.9			555			86			76			24		
3.8%	10	4.1			131			9			6			2		
4.7%	25	9.4			347			13			10			6		
4.1%	44	15.5			628			19			14			11		
3.5%	54	18.5			868			22			15			14		
3.1%	60	20.6			929			32			17			16		
2.8%	77	25.9			1218			102			19			20		
1.5%	57	18.5			883			53			14			16		
10.9%	483	156.9			5934			406			128			133		
	818.4	286.8	0.3504	0.0415	11539.5	14.1	**340.0**	749.9	0.9	**22.1**	305.9	0.4	**9.0**	245.6	0.3	**7.2**

2. Duty Cycle: Canadian Freight Post 1990

Throttle Position	Fuel Cons. lb/hr	HP	NOx g/hr	CO g/hr	HC g/hr	PM g/hr
DB	34	14	1020	167	148	35
Low Idle	26	13	909	141	125	39
1	108	264	3450	248	157	64
2	200	537	7390	276	221	133
3	379	1062	15318	453	342	273
4	529	1531	24807	632	429	402
5	663	1944	29966	1023	535	527
6	926	2767	43501	3656	671	723
7	1231	3824	58836	3541	966	1089
8	1439	4431	54440	3724	1171	1223

Duty Cycle: Canadian Freight Post 1990

DB	Idle	N1	N2	N3	N4	N5	N6	N7	N8
6.0%	53.6%	4.1%	5.6%	4.7%	3.9%	3.4%	3.2%	1.6%	13.8%

EMD SD-75 4300HP Duty Cycle: Freight Pre 1990					EMD SD-75 4300HP Duty Cycle: Freight Pre 1990			EMD SD-75 4300HP Duty Cycle: Freight Pre 1990			EMD SD-75 4300HP Duty Cycle: Freight Pre 1990			EMD SD-75 4300HP Duty Cycle: Freight Pre 1990		
%	HP	Fuel Consumption			NOx			CO			HC			PM		
		duty cycle lb/hr	lb/ bhp-hr	IG/ bhp-hr	g/hr	g/bhp-hr	Factor g/IG	g/hr	g/bhp-hr	Factor g/IG	g/hr	g/bhp-hr	Factor g/IG	g/hr	g/bhp-hr	Factor g/IG
6.0%		2.0			61			10			9			2		
53.6%	7	13.9			487			76			67			21		
4.1%	11	4.4			141			10			6			3		
5.6%	30	11.2			414			15			12			7		
4.7%	50	17.8			720			21			16			13		
3.9%	60	20.6			967			25			17			16		
3.4%	66	22.5			1019			35			18			18		
3.2%	89	29.6			1392			117			21			23		
1.6%	61	19.7			941			57			15			17		
13.8%	611	198.6			7513			514			162			169		
	984.8	340.5	0.3458	0.0409	13656.1	13.9	**338.9**	879.5	0.9	**21.8**	344.2	0.3	**8.5**	288.8	0.3	**7.2**

3. Duty Cycle: Canadian Freight Combined

Throttle Position	Fuel Cons.	HP	NOx	CO	HC	PM
	lb/hr		g/hr	g/hr	g/hr	g/hr
DB	34	14	1020	167	148	35
Low Idle						
Idle	26	13	909	141	125	39
1	108	264	3450	248	157	64
2	200	537	7390	276	221	133
3	379	1062	15318	453	342	273
4	529	1531	24807	632	429	402
5	663	1944	29966	1023	535	527
6	926	2767	43501	3656	671	723
7	1231	3824	58836	3541	966	1089
8	1439	4431	54440	3724	1171	1223

Duty Cycle: Canadian Freight Combined

DB	Idle	N1	N2	N3	N4	N5	N6	N7	N8
5.1%	58.1%	3.9%	5.0%	4.4%	3.7%	3.3%	3.0%	1.5%	12.0%

EMD SD-75 4300HP Duty Cycle: Freight Combined					EMD SD-75 4300HP Duty Cycle: Freight Combined			EMD SD-75 4300HP Duty Cycle: Freight Combined			EMD SD-75 4300HP Duty Cycle: Freight Combined			EMD SD-75 4300HP Duty Cycle: Freight Combined		
%	HP	Fuel Consumption			NOx			CO			HC			PM		
		duty cycle lb/hr	lb/ bhp-hr	IG/ bhp-hr	g/hr	g/bhp-hr	Factor g/IG	g/hr	g/bhp-hr	Factor g/IG	g/hr	g/bhp-hr	Factor g/IG	g/hr	g/bhp-hr	Factor g/IG
5.1%		1.7			52			9			8			2		
58.1%	8	15.1			528			82			73			23		
3.9%	10	4.2			135			10			6			2		
5.0%	27	10.0			370			14			11			7		
4.4%	47	16.7			674			20			15			12		
3.7%	57	19.6			918			23			16			15		
3.3%	64	21.9			989			34			18			17		
3.0%	83	27.8			1305			110			20			22		
1.5%	57	18.5			883			53			14			16		
12.0%	532	172.7			6533			447			141			147		
	884.3	308.1	0.3484	0.0412	12385.3	14.0	**339.7**	800.7	0.9	**22.0**	321.1	0.4	**8.8**	262.7	0.3	**7.2**

4. Duty Cycle: 1990 RAC

Throttle Position	Fuel Cons.	HP	NOx	CO	HC	PM
	lb/hr		g/hr	g/hr	g/hr	g/hr
DB	34	14	1020	167	148	35
Low Idle						
Idle	26	13	909	141	125	39
1	108	264	3450	248	157	64
2	200	537	7390	276	221	133
3	379	1062	15318	453	342	273
4	529	1531	24807	632	429	402
5	663	1944	29966	1023	535	527
6	926	2767	43501	3656	671	723
7	1231	3824	58836	3541	966	1089
8	1439	4431	54440	3724	1171	1223

Duty Cycle: 1990 RAC

DB	Idle	N1	N2	N3	N4	N5	N6	N7	N8
0.0%	60.0%	4.0%	4.0%	4.0%	4.0%	4.0%	4.0%	4.0%	12.0%

EMD SD-75 4300HP Duty Cycle: 1990 RAC Freight					EMD SD-75 4300HP Duty Cycle: 1990 RAC Freight			EMD SD-75 4300HP Duty Cycle: 1990 RAC Freight			EMD SD-75 4300HP Duty Cycle: 1990 RAC Freight			EMD SD-75 4300HP Duty Cycle: 1990 RAC Freight		
%	HP	Fuel Consumption			NOx			CO			HC			PM		
		duty cycle lb/hr	lb/ bhp-hr	IG/ bhp-hr	g/hr	g/bhp-hr	Factor g/IG	g/hr	g/bhp-hr	Factor g/IG	g/hr	g/bhp-hr	Factor g/IG	g/hr	g/bhp-hr	Factor g/IG
0.0%		0.0			0			0			0			0		
60.0%	8	15.6			545			85			75			23		
4.0%	11	4.3			138			10			6			3		
4.0%	21	8.0			296			11			9			5		
4.0%	42	15.2			613			18			14			11		
4.0%	61	21.2			992			25			17			16		
4.0%	78	26.5			1199			41			21			21		
4.0%	111	37.0			1740			146			27			29		
4.0%	153	49.2			2353			142			39			44		
12.0%	532	172.7			6533			447			141			147		
	1016.7	349.7	0.3440	0.0407	14408.9	14.2	**348.2**	924.6	0.9	**22.3**	348.4	0.3	**8.4**	298.6	0.3	**7.2**

5. Duty Cycle: California Mixed Freight

Throttle Position	Fuel Cons. lb/hr	HP	NOx g/hr	CO g/hr	HC g/hr	PM g/hr
DB	34	14	1020	167	148	35
Low Idle						
Idle	26	13	909	141	125	39
1	108	264	3450	248	157	64
2	200	537	7390	276	221	133
3	379	1062	15318	453	342	273
4	529	1531	24807	632	429	402
5	663	1944	29966	1023	535	527
6	926	2767	43501	3656	671	723
7	1231	3824	58836	3541	966	1089
8	1439	4431	54440	3724	1171	1223

Duty Cycle: California Mixed Freight

DB	Idle	N1	N2	N3	N4	N5	N6	N7	N8
12.0%	49.0%	4.0%	4.0%	4.0%	4.5%	4.5%	4.0%	3.0%	12.0%

EMD SD-75 4300HP Duty Cycle: California Mixed Freight					EMD SD-75 4300HP Duty Cycle: California Mixed Freight			EMD SD-75 4300HP Duty Cycle: California Mixed Freight			EMD SD-75 4300HP Duty Cycle: California Mixed Freight			EMD SD-75 4300HP Duty Cycle: California Mixed Freight		
%	HP	Fuel Consumption			NOx			CO			HC			PM		
		duty cycle lb/hr	lb/ bhp-hr	IG/ bhp-hr	g/hr	g/bhp-hr	Factor g/IG	g/hr	g/bhp-hr	Factor g/IG	g/hr	g/bhp-hr	Factor g/IG	g/hr	g/bhp-hr	Factor g/IG
12.0%		4.1			122			20			18			4		
49.0%	6	12.7			445			69			61			19		
4.0%	11	4.3			138			10			6			3		
4.0%	21	8.0			296			11			9			5		
4.0%	42	15.2			613			18			14			11		
4.5%	69	23.8			1116			28			19			18		
4.5%	87	29.8			1348			46			24			24		
4.0%	111	37.0			1740			146			27			29		
3.0%	115	36.9			1765			106			29			33		
12.0%	532	172.7			6533			447			141			147		
	994.4	344.6	0.3465	0.0410	14116.8	14.2	**346.2**	902.0	0.9	**22.1**	347.5	0.3	**8.5**	292.3	0.3	**7.2**

6. Duty Cycle: California Intermodal

Throttle Position	Fuel Cons. lb/hr	HP	NOx g/hr	CO g/hr	HC g/hr	PM g/hr
DB	34	14	1020	167	148	35
Low Idle						
Idle	26	13	909	141	125	39
1	108	264	3450	248	157	64
2	200	537	7390	276	221	133
3	379	1062	15318	453	342	273
4	529	1531	24807	632	429	402
5	663	1944	29966	1023	535	527
6	926	2767	43501	3656	671	723
7	1231	3824	58836	3541	966	1089
8	1439	4431	54440	3724	1171	1223

Duty Cycle: California Intermodal

DB	Idle	N1	N2	N3	N4	N5	N6	N7	N8
10.0%	55.0%	3.0%	3.0%	4.0%	4.0%	4.0%	4.0%	3.0%	10.0%

EMD SD-75 4300HP Duty Cycle: California Intermodal					EMD SD-75 4300HP Duty Cycle: California Intermodal			EMD SD-75 4300HP Duty Cycle: California Intermodal			EMD SD-75 4300HP Duty Cycle: California Intermodal			EMD SD-75 4300HP Duty Cycle: California Intermodal		
%	HP	Fuel Consumption			NOx			CO			HC			PM		
		duty cycle lb/hr	lb/ bhp-hr	IG/ bhp-hr	g/hr	g/bhp-hr	Factor g/IG	g/hr	g/bhp-hr	Factor g/IG	g/hr	g/bhp-hr	Factor g/IG	g/hr	g/bhp-hr	Factor g/IG
10.0%		3.4			102			17			15			4		
55.0%	7	14.3			500			78			69			21		
3.0%	8	3.2			104			7			5			2		
3.0%	16	6.0			222			8			7			4		
4.0%	42	15.2			613			18			14			11		
4.0%	61	21.2			992			25			17			16		
4.0%	78	26.5			1199			41			21			21		
4.0%	111	37.0			1740			146			27			29		
3.0%	115	36.9			1765			106			29			33		
10.0%	443	143.9			5444			372			117			122		
	881.2	307.7	0.3491	0.0413	12679.9	14.4	**348.3**	819.2	0.9	**22.5**	320.1	0.4	**8.8**	262.8	0.3	**7.2**

7. Duty Cycle: GE Line Haul

Throttle Position	Fuel Cons. lb/hr	HP	NOx g/hr	CO g/hr	HC g/hr	PM g/hr
DB	34	14	1020	167	148	35
Low Idle						
Idle	26	13	909	141	125	39
1	108	264	3450	248	157	64
2	200	537	7390	276	221	133
3	379	1062	15318	453	342	273
4	529	1531	24807	632	429	402
5	663	1944	29966	1023	535	527
6	926	2767	43501	3656	671	723
7	1231	3824	58836	3541	966	1089
8	1439	4431	54440	3724	1171	1223

Duty Cycle: GE Line Haul

DB	Idle	N1	N2	N3	N4	N5	N6	N7	N8
4.0%	**50.0%**	**5.0%**	**5.0%**	**3.0%**	**4.0%**	**4.0%**	**3.0%**	**3.0%**	**14.0%**

EMD SD-75 4300HP Duty Cycle: GE Line Haul

%	HP	Fuel Consumption duty cycle lb/hr	lb/bhp-hr	IG/bhp-hr
4.0%		1.4		
50.0%	7	13.0		
5.0%	13	5.4		
5.0%	27	10.0		
3.0%	32	11.4		
4.0%	61	21.2		
4.0%	78	26.5		
3.0%	83	27.8		
3.0%	115	36.9		
14.0%	620	201.5		
	1035.5	355.0	0.3428	0.0406

%	NOx g/hr	NOx g/bhp-hr	NOx Factor g/IG
4.0%	41		
50.0%	455		
5.0%	173		
5.0%	370		
3.0%	460		
4.0%	992		
4.0%	1199		
3.0%	1305		
3.0%	1765		
14.0%	7622		
	14379.5	13.9	**342.3**

%	CO g/hr	CO g/bhp-hr	CO Factor g/IG
4.0%	7		
50.0%	71		
5.0%	12		
5.0%	14		
3.0%	14		
4.0%	25		
4.0%	41		
3.0%	110		
3.0%	106		
14.0%	521		
	920.4	0.9	**21.9**

%	HC g/hr	HC g/bhp-hr	HC Factor g/IG
4.0%	6		
50.0%	63		
5.0%	8		
5.0%	11		
3.0%	10		
4.0%	17		
4.0%	21		
3.0%	20		
3.0%	29		
14.0%	164		
	349.2	0.3	**8.3**

%	PM g/hr	PM g/bhp-hr	PM Factor g/IG
4.0%	1		
50.0%	20		
5.0%	3		
5.0%	7		
3.0%	8		
4.0%	16		
4.0%	21		
3.0%	22		
3.0%	33		
14.0%	171		
	301.7	0.3	**7.2**

8. Duty Cycle: EMD Road Duty

Throttle Position	Fuel Cons. lb/hr	HP	NOx g/hr	CO g/hr	HC g/hr	PM g/hr
DB	34	14	1020	167	148	35
Low Idle						
Idle	26	13	909	141	125	39
1	108	264	3450	248	157	64
2	200	537	7390	276	221	133
3	379	1062	15318	453	342	273
4	529	1531	24807	632	429	402
5	663	1944	29966	1023	535	527
6	926	2767	43501	3656	671	723
7	1231	3824	58836	3541	966	1089
8	1439	4431	54440	3724	1171	1223

Duty Cycle: EMD Road Duty

DB	Idle	N1	N2	N3	N4	N5	N6	N7	N8
9.0%	**46.0%**	**4.0%**	**4.0%**	**4.0%**	**4.0%**	**4.0%**	**4.0%**	**4.0%**	**17.0%**

EMD SD-75 4300HP Duty Cycle: EMD Road Duty

%	HP	Fuel Consumption duty cycle lb/hr	lb/bhp-hr	IG/bhp-hr
9.0%		3.1		
46.0%	6	12.0		
4.0%	11	4.3		
4.0%	21	8.0		
4.0%	42	15.2		
4.0%	61	21.2		
4.0%	78	26.5		
4.0%	111	37.0		
4.0%	153	49.2		
17.0%	753	244.6		
	1236.4	421.1	0.3406	0.0403

%	NOx g/hr	NOx g/bhp-hr	NOx Factor g/IG
9.0%	92		
46.0%	418		
4.0%	138		
4.0%	296		
4.0%	613		
4.0%	992		
4.0%	1199		
4.0%	1740		
4.0%	2353		
17.0%	9255		
	17095.5	13.8	**343.1**

%	CO g/hr	CO g/bhp-hr	CO Factor g/IG
9.0%	15		
46.0%	65		
4.0%	10		
4.0%	11		
4.0%	18		
4.0%	25		
4.0%	41		
4.0%	146		
4.0%	142		
17.0%	633		
	1106.1	0.9	**22.2**

%	HC g/hr	HC g/bhp-hr	HC Factor g/IG
9.0%	13		
46.0%	58		
4.0%	6		
4.0%	9		
4.0%	14		
4.0%	17		
4.0%	21		
4.0%	27		
4.0%	39		
17.0%	199		
	402.7	0.3	**8.1**

%	PM g/hr	PM g/bhp-hr	PM Factor g/IG
9.0%	3		
46.0%	18		
4.0%	3		
4.0%	5		
4.0%	11		
4.0%	16		
4.0%	21		
4.0%	29		
4.0%	44		
17.0%	208		
	357.4	0.3	**7.2**

9. Duty Cycle: ISO Europe

Throttle Position	Fuel Cons.	HP	NOx	CO	HC	PM
	lb/hr		g/hr	g/hr	g/hr	g/hr
DB	34	14	1020	167	148	35
Low Idle						
Idle	26	13	909	141	125	39
1	108	264	3450	248	157	64
2	200	537	7390	276	221	133
3	379	1062	15318	453	342	273
4	529	1531	24807	632	429	402
5	663	1944	29966	1023	535	527
6	926	2767	43501	3656	671	723
7	1231	3824	58836	3541	966	1089
8	1439	4431	54440	3724	1171	1223

Duty Cycle: ISO Europe

DB	Idle	N1	N2	N3	N4	N5	N6	N7	N8
0.0%	60.0%	0.0%	0.0%	0.0%	15.0%	0.0%	0.0%	0.0%	25.0%

EMD SD-75 4300HP Duty Cycle: ISO Europe					EMD SD-75 4300HP Duty Cycle: ISO Europe			EMD SD-75 4300HP Duty Cycle: ISO Europe			EMD SD-75 4300HP Duty Cycle: ISO Europe			EMD SD-75 4300HP Duty Cycle: ISO Europe		
%	HP	Fuel Consumption			NOx			CO			HC			PM		
		duty cycle lb/hr	lb/ bhp-hr	IG/ bhp-hr	g/hr	g/bhp-hr	Factor g/IG	g/hr	g/bhp-hr	Factor g/IG	g/hr	g/bhp-hr	Factor g/IG	g/hr	g/bhp-hr	Factor g/IG
0.0%		0.0			0			0			0			0		
60.0%	8	15.6			545			85			75			23		
0.0%	0	0.0			0			0			0			0		
0.0%	0	0.0			0			0			0			0		
0.0%	0	0.0			0			0			0			0		
15.0%	230	79.4			3721			95			64			60		
0.0%	0	0.0			0			0			0			0		
0.0%	0	0.0			0			0			0			0		
0.0%	0	0.0			0			0			0			0		
25.0%	1108	359.8			13610			931			293			306		
	1345.2	454.7	0.3380	0.0400	17876.5	13.3	**332.2**	1110.4	0.8	**20.6**	432.1	0.3	**8.0**	389.5	0.3	**7.2**

10. Duty Cycle: RAC Branch/Yard

Throttle Position	Fuel Cons.	HP	NOx	CO	HC	PM
	lb/hr		g/hr	g/hr	g/hr	g/hr
DB	34	14	1020	167	148	35
Low Idle						
Idle	26	13	909	141	125	39
1	108	264	3450	248	157	64
2	200	537	7390	276	221	133
3	379	1062	15318	453	342	273
4	529	1531	24807	632	429	402
5	663	1944	29966	1023	535	527
6	926	2767	43501	3656	671	723
7	1231	3824	58836	3541	966	1089
8	1439	4431	54440	3724	1171	1223

Duty Cycle: RAC Branch/Yard

DB	Idle	N1	N2	N3	N4	N5	N6	N7	N8
0.0%	81.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	5.0%

EMD SD-75 4300HP Duty Cycle: RAC Branch/Yard					Duty Cycle 2002 RAC Branch/Yard			Duty Cycle 2002 RAC Branch/Yard			Duty Cycle 2002 RAC Branch/Yard			Duty Cycle 2002 RAC Branch/Yard		
%	HP	Fuel Consumption			NOx			CO			HC			PM		
		duty cycle lb/hr	lb/ bhp-hr	IG/ bhp-hr	g/hr	g/bhp-hr	Factor g/IG	g/hr	g/bhp-hr	Factor g/IG	g/hr	g/bhp-hr	Factor g/IG	g/hr	g/bhp-hr	Factor g/IG
0.0%		0.0			0			0			0			0		
81.0%	11	21.1			736			114			101			32		
2.0%	5	2.2			69			5			3			1		
2.0%	11	4.0			148			6			4			3		
2.0%	21	7.6			306			9			7			5		
2.0%	31	10.6			496			13			9			8		
2.0%	39	13.3			599			20			11			11		
2.0%	55	18.5			870			73			13			14		
2.0%	76	24.6			1177			71			19			22		
5.0%	222	72.0			2722			186			59			61		
	470.7	173.7	0.3691	0.0437	7123.7	15.1	**346.5**	497.0	1.1	**24.2**	226.2	0.5	**11.0**	157.0	0.3	**7.6**

11. Duty Cycle: California Yard

Throttle Position	Fuel Cons. lb/hr	HP	NOx g/hr	CO g/hr	HC g/hr	PM g/hr
DB	34	14	1020	167	148	35
Low Idle						
Idle	26	13	909	141	125	39
1	108	264	3450	248	157	64
2	200	537	7390	276	221	133
3	379	1062	15318	453	342	273
4	529	1531	24807	632	429	402
5	663	1944	29966	1023	535	527
6	926	2767	43501	3656	671	723
7	1231	3824	58836	3541	966	1089
8	1439	4431	54440	3724	1171	1223

Duty Cycle: California Yard

DB	Idle	N1	N2	N3	N4	N5	N6	N7	N8
0.0%	82.0%	4.0%	4.0%	3.0%	3.0%	1.0%	0.0%	0.0%	2.0%

EMD SD-75 4300HP Duty Cycle: California Yard					Duty Cycle 2002 California Yard			Duty Cycle 2002 California Yard			Duty Cycle 2002 California Yard			Duty Cycle 2002 California Yard		
%	HP	Fuel Consumption			NOx			CO			HC			PM		
		duty cycle lb/hr	lb/ bhp-hr	IG/ bhp-hr	g/hr	g/bhp-hr	Factor g/IG	g/hr	g/bhp-hr	Factor g/IG	g/hr	g/bhp-hr	Factor g/IG	g/hr	g/bhp-hr	Factor g/IG
0.0%		0.0			0			0			0			0		
82.0%	11	21.3			745			116			103			32		
4.0%	11	4.3			138			10			6			3		
4.0%	21	8.0			296			11			9			5		
3.0%	32	11.4			460			14			10			8		
3.0%	46	15.9			744			19			13			12		
1.0%	19	6.6			300			10			5			5		
0.0%	0	0.0			0			0			0			0		
0.0%	0	0.0			0			0			0			0		
2.0%	89	28.8			1089			74			23			24		
	228.6	96.3	0.4213	0.0499	3771.2	16.5	**330.9**	253.8	1.1	**22.3**	169.5	0.7	**14.9**	89.8	0.4	**7.9**

12. Duty Cycle: California Local

Throttle Position	Fuel Cons. lb/hr	HP	NOx g/hr	CO g/hr	HC g/hr	PM g/hr
DB	34	14	1020	167	148	35
Low Idle						
Idle	26	13	909	141	125	39
1	108	264	3450	248	157	64
2	200	537	7390	276	221	133
3	379	1062	15318	453	342	273
4	529	1531	24807	632	429	402
5	663	1944	29966	1023	535	527
6	926	2767	43501	3656	671	723
7	1231	3824	58836	3541	966	1089
8	1439	4431	54440	3724	1171	1223

Duty Cycle: California Local

DB	Idle	N1	N2	N3	N4	N5	N6	N7	N8
4.0%	4.7%	9.0%	8.0%	8.0%	7.0%	4.0%	3.0%	3.0%	7.0%

EMD SD-75 4300HP Duty Cycle: California Local					Duty Cycle 2002 California Local			Duty Cycle 2002 California Local			Duty Cycle 2002 California Local			Duty Cycle 2002 California Local		
%	HP	Fuel Consumption			NOx			CO			HC			PM		
		duty cycle lb/hr	lb/ bhp-hr	IG/ bhp-hr	g/hr	g/bhp-hr	Factor g/IG	g/hr	g/bhp-hr	Factor g/IG	g/hr	g/bhp-hr	Factor g/IG	g/hr	g/bhp-hr	Factor g/IG
4.0%		1.4			41			7			6			1		
4.7%	1	1.2			43			7			6			2		
9.0%	24	9.7			311			22			14			6		
8.0%	43	16.0			591			22			18			11		
8.0%	85	30.3			1225			36			27			22		
7.0%	107	37.0			1736			44			30			28		
4.0%	78	26.5			1199			41			21			21		
3.0%	83	27.8			1305			110			20			22		
3.0%	115	36.9			1765			106			29			33		
7.0%	310	100.7			3811			261			82			86		
	845.1	287.6	0.3403	0.0403	12026.7	14.2	**353.3**	655.7	0.8	**19.3**	253.5	0.3	**7.4**	230.7	0.3	**6.8**

Ref 3 Source: SwRI Report No. 08-02062 (October 2000)

GE Dash 9 7FDL17N19 16 cylinders 4400 HP

1. Duty Cycle: Canadian Freight Pre 1990

Throttle Position	Fuel Cons.	HP	NOx	CO	HC	PM
	lb/hr		g/hr	g/hr	g/hr	g/hr
DB	41	23	1085.0	322	155.0	29.0
Low Idle		10	303.0	128	113.0	26.0
Idle	22	10	671.0	186	133.0	23.0
1	82	129	1577.0	153	93.0	38.0
2	188	419	4105.0	315	144.0	105.0
3	394	950	14340.0	902	316.0	240.0
4	570	1400	22890.0	1811	348.0	238.0
5	794	2053	33198.0	2817	605.0	274.0
6	1002	2734	39122.0	3409	680.0	264.0
7	1234	3440	47362.0	2535	708.0	257.0
8	1493	4103	54994.0	2276	823.0	326.0

Duty Cycle: Canadian Freight Pre 1990

DB	Idle	N1	N2	N3	N4	N5	N6	N7	N8
4.5%	61.1%	3.8%	4.7%	4.1%	3.5%	3.1%	2.8%	1.5%	10.9%

GE Dash 9 4400 HP Duty Cycle: Freight Pre 1990					GE Dash 9 4400 HP Duty Cycle: Freight Pre 1990			GE Dash 9 4400 HP Duty Cycle: Freight Pre 1990			GE Dash 9 4400 HP Duty Cycle: Freight Pre 1990			GE Dash 9 4400 HP Duty Cycle: Freight Pre 1990		
%	HP	Fuel Consumption			NOx			CO			HC			PM		
		duty cycle lb/hr	lb/ bhp-hr	IG/ bhp-hr	g/hr	g/bhp-hr	Factor g/IG	g/hr	g/bhp-hr	Factor g/IG	g/hr	g/bhp-hr	Factor g/IG	g/hr	g/bhp-hr	Factor g/IG
4.5%		1.9			48.8			14.5			7.0			1.3		
61.1%	6	13.4			410.0			113.6			81.3			14.1		
3.8%	5	3.1			59.9			5.8			3.5			1.4		
4.7%	20	8.8			192.9			14.8			6.8			4.9		
4.1%	39	16.1			587.9			37.0			13.0			9.8		
3.5%	49	20.0			801.2			63.4			12.2			8.3		
3.1%	64	24.6			1029.1			87.3			18.8			8.5		
2.8%	77	28.1			1095.4			95.5			19.0			7.4		
1.5%	52	18.5			710.4			38.0			10.6			3.9		
10.9%	447	162.7			5994.3			248.1			89.7			35.5		
	757.7	297.2	0.3923	0.0464	10930.1	14.4	**310.7**	718.0	0.9	**20.4**	261.8	0.3	**7.4**	95.2	0.1	**2.7**

2. Duty Cycle: Canadian Freight Post 1990

Throttle Position	Fuel Cons.	HP	NOx	CO	HC	PM
	lb/hr		g/hr	g/hr	g/hr	g/hr
DB	41	23	1085.0	322	155.0	29.0
Low Idle		10	303.0	128	113.0	26.0
Idle	22	10	671.0	186	133.0	23.0
1	82	129	1577.0	153	93.0	38.0
2	188	419	4105.0	315	144.0	105.0
3	394	950	14340.0	902	316.0	240.0
4	570	1400	22890.0	1811	348.0	238.0
5	794	2053	33198.0	2817	605.0	274.0
6	1002	2734	39122.0	3409	680.0	264.0
7	1234	3440	47362.0	2535	708.0	257.0
8	1493	4103	54994.0	2276	823.0	326.0

Duty Cycle: Canadian Freight Post 1990

DB	Idle	N1	N2	N3	N4	N5	N6	N7	N8
6.0%	53.6%	4.1%	5.6%	4.7%	3.9%	3.4%	3.2%	1.6%	13.8%

GE Dash 9 4400 HP Duty Cycle: Freight Post 1990					GE Dash 9 4400 HP Duty Cycle: Freight Post 1990			GE Dash 9 4400 HP Duty Cycle: Freight Post 1990			GE Dash 9 4400 HP Duty Cycle: Freight Post 1990			GE Dash 9 4400 HP Duty Cycle: Freight Post 1990		
%	HP	Fuel Consumption			NOx			CO			HC			PM		
		duty cycle lb/hr	lb/ bhp-hr	IG/ bhp-hr	g/hr	g/bhp-hr	Factor g/IG	g/hr	g/bhp-hr	Factor g/IG	g/hr	g/bhp-hr	Factor g/IG	g/hr	g/bhp-hr	Factor g/IG
6.0%		2.5			65.1			19.3			9.3			1.7		
53.6%	5	11.8			359.7			99.7			71.3			12.3		
4.1%	5	3.3			64.7			6.3			3.8			1.6		
5.6%	23	10.5			229.9			17.6			8.1			5.9		
4.7%	45	18.5			674.0			42.4			14.9			11.3		
3.9%	55	22.2			892.7			70.6			13.6			9.3		
3.4%	70	27.0			1128.7			95.8			20.6			9.3		
3.2%	87	32.1			1251.9			109.1			21.8			8.4		
1.6%	55	19.7			757.8			40.6			11.3			4.1		
13.8%	566	206.0			7589.2			314.1			113.6			45.0		
	911.9	353.7	0.3879	0.0459	13013.6	14.3	**310.9**	815.5	0.9	**19.5**	288.1	0.3	**6.9**	108.9	0.1	**2.6**

3. Duty Cycle: Canadian Freight Combined

Throttle Position	Fuel Cons. lb/hr	HP	NOx g/hr	CO g/hr	HC g/hr	PM g/hr
DB	41	23	1085.0	322	155.0	29.0
Low Idle		10	303.0	128	113.0	26.0
Idle	22	10	671.0	186	133.0	23.0
1	82	129	1577.0	153	93.0	38.0
2	188	419	4105.0	315	144.0	105.0
3	394	950	14340.0	902	316.0	240.0
4	570	1400	22890.0	1811	348.0	238.0
5	794	2053	33198.0	2817	605.0	274.0
6	1002	2734	39122.0	3409	680.0	264.0
7	1234	3440	47362.0	2535	708.0	257.0
8	1493	4103	54994.0	2276	823.0	326.0

Duty Cycle: Canadian Freight Combined

DB	Idle	N1	N2	N3	N4	N5	N6	N7	N8
5.1%	**58.1%**	**3.9%**	**5.0%**	**4.4%**	**3.7%**	**3.3%**	**3.0%**	**1.5%**	**12.0%**

GE Dash 9 4400 HP, Duty Cycle: Freight Post Combined

%	HP	Fuel Consumption duty cycle lb/hr	Fuel Consumption lb/bhp-hr	Fuel Consumption IG/bhp-hr	NOx g/hr	NOx g/bhp-hr	NOx Factor g/IG	CO g/hr	CO g/bhp-hr	CO Factor g/IG	HC g/hr	HC g/bhp-hr	HC Factor g/IG	PM g/hr	PM g/bhp-hr	PM Factor g/IG
5.1%		2.1			55.3			16.4			7.9			1.5		
58.1%	6	12.8			389.9			108.1			77.3			13.4		
3.9%	5	3.2			61.5			6.0			3.6			1.5		
5.0%	21	9.4			205.3			15.8			7.2			5.3		
4.4%	42	17.3			631.0			39.7			13.9			10.6		
3.7%	52	21.1			846.9			67.0			12.9			8.8		
3.3%	68	26.2			1095.5			93.0			20.0			9.0		
3.0%	82	30.1			1173.7			102.3			20.4			7.9		
1.5%	52	18.5			710.4			38.0			10.6			3.9		
12.0%	492	179.1			6599.3			273.1			98.8			39.1		
	819.1	319.8	0.3904	0.0462	11768.7	14.4	**311.0**	759.3	0.9	**20.1**	272.5	0.3	**7.2**	100.9	0.1	**2.7**

4. Duty Cycle: 1990 RAC

Throttle Position	Fuel Cons. lb/hr	HP	NOx g/hr	CO g/hr	HC g/hr	PM g/hr
DB	41	23	1085.0	322	155.0	29.0
Low Idle		10	303.0	128	113.0	26.0
Idle	22	10	671.0	186	133.0	23.0
1	82	129	1577.0	153	93.0	38.0
2	188	419	4105.0	315	144.0	105.0
3	394	950	14340.0	902	316.0	240.0
4	570	1400	22890.0	1811	348.0	238.0
5	794	2053	33198.0	2817	605.0	274.0
6	1002	2734	39122.0	3409	680.0	264.0
7	1234	3440	47362.0	2535	708.0	257.0
8	1493	4103	54994.0	2276	823.0	326.0

Duty Cycle: 1990 RAC

DB	Idle	N1	N2	N3	N4	N5	N6	N7	N8
0.0%	**60.0%**	**4.0%**	**4.0%**	**4.0%**	**4.0%**	**4.0%**	**4.0%**	**4.0%**	**12.0%**

GE Dash 9 4400 HP, Duty Cycle: 1990 RAC Freight

%	HP	Fuel Consumption duty cycle lb/hr	Fuel Consumption lb/bhp-hr	Fuel Consumption IG/bhp-hr	NOx g/hr	NOx g/bhp-hr	NOx Factor g/IG	CO g/hr	CO g/bhp-hr	CO Factor g/IG	HC g/hr	HC g/bhp-hr	HC Factor g/IG	PM g/hr	PM g/bhp-hr	PM Factor g/IG
0.0%		0.0			0.0			0.0			0.0			0.0		
60.0%	6	13.2			402.6			111.6			79.8			13.8		
4.0%	5	3.3			63.1			6.1			3.7			1.5		
4.0%	17	7.5			164.2			12.6			5.8			4.2		
4.0%	38	15.7			573.6			36.1			12.6			9.6		
4.0%	56	22.8			915.6			72.4			13.9			9.5		
4.0%	82	31.8			1327.9			112.7			24.2			11.0		
4.0%	109	40.1			1564.9			136.4			27.2			10.6		
4.0%	138	49.3			1894.5			101.4			28.3			10.3		
12.0%	492	179.1			6599.3			273.1			98.8			39.1		
	943.4	362.9	0.3846	0.0455	13505.6	14.3	**314.5**	862.4	0.9	**20.1**	294.3	0.3	**6.9**	109.6	0.1	**2.6**

5. Duty Cycle: California Mixed Freight

Throttle Position	Fuel Cons. lb/hr	HP	NOx g/hr	CO g/hr	HC g/hr	PM g/hr
DB	41	23	1085.0	322	155.0	29.0
Low Idle		10	303.0	128	113.0	26.0
Idle	22	10	671.0	186	133.0	23.0
1	82	129	1577.0	153	93.0	38.0
2	188	419	4105.0	315	144.0	105.0
3	394	950	14340.0	902	316.0	240.0
4	570	1400	22890.0	1811	348.0	238.0
5	794	2053	33198.0	2817	605.0	274.0
6	1002	2734	39122.0	3409	680.0	264.0
7	1234	3440	47362.0	2535	708.0	257.0
8	1493	4103	54994.0	2276	823.0	326.0

Duty Cycle: California Mixed Freight

DB	Idle	N1	N2	N3	N4	N5	N6	N7	N8
12.0%	**49.0%**	**4.0%**	**4.0%**	**4.0%**	**4.5%**	**4.5%**	**4.0%**	**3.0%**	**12.0%**

GE Dash 9 4400 HP Duty Cycle: California Mixed Freight					GE Dash 9 4400 HP Duty Cycle: California Mixed Freight			GE Dash 9 4400 HP Duty Cycle: California Mixed Freight			GE Dash 9 4400 HP Duty Cycle: California Mixed Freight			GE Dash 9 4400 HP Duty Cycle: California Mixed Freight		
%	HP	Fuel Consumption			NOx			CO			HC			PM		
		duty cycle lb/hr	lb/ bhp-hr	IG/ bhp-hr	g/hr	g/bhp-hr	Factor g/IG	g/hr	g/bhp-hr	Factor g/IG	g/hr	g/bhp-hr	Factor g/IG	g/hr	g/bhp-hr	Factor g/IG
12.0%		5.0			130.2			38.6			18.6			3.5		
49.0%	5	10.8			328.8			91.1			65.2			11.3		
4.0%	5	3.3			63.1			6.1			3.7			1.5		
4.0%	17	7.5			164.2			12.6			5.8			4.2		
4.0%	38	15.7			573.6			36.1			12.6			9.6		
4.5%	63	25.7			1030.1			81.5			15.7			10.7		
4.5%	92	35.7			1493.9			126.8			27.2			12.3		
4.0%	109	40.1			1564.9			136.4			27.2			10.6		
3.0%	103	37.0			1420.9			76.1			21.2			7.7		
12.0%	492	179.1			6599.3			273.1			98.8			39.1		
	925.1	359.9	0.3890	0.0460	13368.9	14.5	**313.9**	878.4	0.9	**20.6**	296.0	0.3	**6.9**	110.5	0.1	**2.6**

6. Duty Cycle: California Intermodal

Throttle Position	Fuel Cons. lb/hr	HP	NOx g/hr	CO g/hr	HC g/hr	PM g/hr
DB	41	23	1085.0	322	155.0	29.0
Low Idle		10	303.0	128	113.0	26.0
Idle	22	10	671.0	186	133.0	23.0
1	82	129	1577.0	153	93.0	38.0
2	188	419	4105.0	315	144.0	105.0
3	394	950	14340.0	902	316.0	240.0
4	570	1400	22890.0	1811	348.0	238.0
5	794	2053	33198.0	2817	605.0	274.0
6	1002	2734	39122.0	3409	680.0	264.0
7	1234	3440	47362.0	2535	708.0	257.0
8	1493	4103	54994.0	2276	823.0	326.0

Duty Cycle: California Intermodal

DB	Idle	N1	N2	N3	N4	N5	N6	N7	N8
10.0%	**55.0%**	**3.0%**	**3.0%**	**4.0%**	**4.0%**	**4.0%**	**4.0%**	**3.0%**	**10.0%**

GE Dash 9 4400 HP Duty Cycle: Calif Intermodal					GE Dash 9 4400 HP Duty Cycle: Calif Intermodal			GE Dash 9 4400 HP Duty Cycle: Calif Intermodal			GE Dash 9 4400 HP Duty Cycle: Calif Intermodal			GE Dash 9 4400 HP Duty Cycle: Calif Intermodal		
%	HP	Fuel Consumption			NOx			CO			HC			PM		
		duty cycle lb/hr	lb/ bhp-hr	IG/ bhp-hr	g/hr	g/bhp-hr	Factor g/IG	g/hr	g/bhp-hr	Factor g/IG	g/hr	g/bhp-hr	Factor g/IG	g/hr	g/bhp-hr	Factor g/IG
10.0%		4.1			108.5			32.2			15.5			2.9		
55.0%	6	12.1			369.1			102.3			73.2			12.7		
3.0%	4	2.4			47.3			4.6			2.8			1.1		
3.0%	13	5.6			123.2			9.5			4.3			3.2		
4.0%	38	15.7			573.6			36.1			12.6			9.6		
4.0%	56	22.8			915.6			72.4			13.9			9.5		
4.0%	82	31.8			1327.9			112.7			24.2			11.0		
4.0%	109	40.1			1564.9			136.4			27.2			10.6		
3.0%	103	37.0			1420.9			76.1			21.2			7.7		
10.0%	410	149.3			5499.4			227.6			82.3			32.6		
	820.9	321.0	0.3910	0.0463	11950.3	14.6	**314.6**	809.8	1.0	**21.3**	277.3	0.3	**7.3**	100.8	0.1	**2.7**

7. Duty Cycle: GE Line Haul

Throttle Position	Fuel Cons.	HP	NOx	CO	HC	PM
	lb/hr		g/hr	g/hr	g/hr	g/hr
DB	41	23	1085.0	322	155.0	29.0
Low Idle		10	303.0	128	113.0	26.0
Idle	22	10	671.0	186	133.0	23.0
1	82	129	1577.0	153	93.0	38.0
2	188	419	4105.0	315	144.0	105.0
3	394	950	14340.0	902	316.0	240.0
4	570	1400	22890.0	1811	348.0	238.0
5	794	2053	33198.0	2817	605.0	274.0
6	1002	2734	39122.0	3409	680.0	264.0
7	1234	3440	47362.0	2535	708.0	257.0
8	1493	4103	54994.0	2276	823.0	326.0

Duty Cycle: GE Line Haul

DB	Idle	N1	N2	N3	N4	N5	N6	N7	N8
4.0%	**50.0%**	**5.0%**	**5.0%**	**3.0%**	**4.0%**	**4.0%**	**3.0%**	**3.0%**	**14.0%**

GE Dash 9 4400 HP Duty Cycle: GE Line Haul					GE Dash 9 4400 HP Duty Cycle: GE Line Haul			GE Dash 9 4400 HP Duty Cycle: GE Line Haul			GE Dash 9 4400 HP Duty Cycle: GE Line Haul			GE Dash 9 4400 HP Duty Cycle: GE Line Haul		
%	HP	Fuel Consumption			NOx			CO			HC			PM		
		duty cycle lb/hr	lb/ bhp-hr	IG/ bhp-hr	g/hr	g/bhp-hr	Factor g/IG	g/hr	g/bhp-hr	Factor g/IG	g/hr	g/bhp-hr	Factor g/IG	g/hr	g/bhp-hr	Factor g/IG
4.0%		1.7			43.4			12.9			6.2			1.2		
50.0%	5	11.0			335.5			93.0			66.5			11.5		
5.0%	6	4.1			78.9			7.7			4.7			1.9		
5.0%	21	9.4			205.3			15.8			7.2			5.3		
3.0%	29	11.8			430.2			27.1			9.5			7.2		
4.0%	56	22.8			915.6			72.4			13.9			9.5		
4.0%	82	31.8			1327.9			112.7			24.2			11.0		
3.0%	82	30.1			1173.7			102.3			20.4			7.9		
3.0%	103	37.0			1420.9			76.1			21.2			7.7		
14.0%	574	209.0			7699.2			318.6			115.2			45.6		
	958.7	368.6	0.3845	0.0455	13630.4	14.2	**312.5**	838.4	0.9	**19.2**	289.0	0.3	**6.6**	108.8	0.1	**2.5**

8. Duty Cycle: EMD Road Duty

Throttle Position	Fuel Cons.	HP	NOx	CO	HC	PM
	lb/hr		g/hr	g/hr	g/hr	g/hr
DB	41	23	1085.0	322	155.0	29.0
Low Idle		10	303.0	128	113.0	26.0
Idle	22	10	671.0	186	133.0	23.0
1	82	129	1577.0	153	93.0	38.0
2	188	419	4105.0	315	144.0	105.0
3	394	950	14340.0	902	316.0	240.0
4	570	1400	22890.0	1811	348.0	238.0
5	794	2053	33198.0	2817	605.0	274.0
6	1002	2734	39122.0	3409	680.0	264.0
7	1234	3440	47362.0	2535	708.0	257.0
8	1493	4103	54994.0	2276	823.0	326.0

Duty Cycle: EMD Road Duty

DB	Idle	N1	N2	N3	N4	N5	N6	N7	N8
9.0%	**46.0%**	**4.0%**	**4.0%**	**4.0%**	**4.0%**	**4.0%**	**4.0%**	**4.0%**	**17.0%**

GE Dash 9 4400 HP Duty Cycle: EMD Road Duty					GE Dash 9 4400 HP Duty Cycle: EMD Road Duty			GE Dash 9 4400 HP Duty Cycle: EMD Road Duty			GE Dash 9 4400 HP Duty Cycle: EMD Road Duty			GE Dash 9 4400 HP Duty Cycle: EMD Road Duty		
%	HP	Fuel Consumption			NOx			CO			HC			PM		
		duty cycle lb/hr	lb/ bhp-hr	IG/ bhp-hr	g/hr	g/bhp-hr	Factor g/IG	g/hr	g/bhp-hr	Factor g/IG	g/hr	g/bhp-hr	Factor g/IG	g/hr	g/bhp-hr	Factor g/IG
9.0%		3.7			97.7			29.0			14.0			2.6		
46.0%	5	10.1			308.7			85.6			61.2			10.6		
4.0%	5	3.3			63.1			6.1			3.7			1.5		
4.0%	17	7.5			164.2			12.6			5.8			4.2		
4.0%	38	15.7			573.6			36.1			12.6			9.6		
4.0%	56	22.8			915.6			72.4			13.9			9.5		
4.0%	82	31.8			1327.9			112.7			24.2			11.0		
4.0%	109	40.1			1564.9			136.4			27.2			10.6		
4.0%	138	49.3			1894.5			101.4			28.3			10.3		
17.0%	698	253.8			9349.0			386.9			139.9			55.4		
	1147.1	438.1	0.3820	0.0452	16259.1	14.2	**313.6**	979.1	0.9	**18.9**	330.8	0.3	**6.4**	125.3	0.1	**2.4**

9. Duty Cycle: ISO Europe

Throttle Position	Fuel Cons. lb/hr	HP	NOx g/hr	CO g/hr	HC g/hr	PM g/hr
DB	41	23	1085.0	322	155.0	29.0
Low Idle		10	303.0	128	113.0	26.0
Idle	22	10	671.0	186	133.0	23.0
1	82	129	1577.0	153	93.0	38.0
2	188	419	4105.0	315	144.0	105.0
3	394	950	14340.0	902	316.0	240.0
4	570	1400	22890.0	1811	348.0	238.0
5	794	2053	33198.0	2817	605.0	274.0
6	1002	2734	39122.0	3409	680.0	264.0
7	1234	3440	47362.0	2535	708.0	257.0
8	1493	4103	54994.0	2276	823.0	326.0

Duty Cycle: ISO Europe

DB	Idle	N1	N2	N3	N4	N5	N6	N7	N8
0.0%	60.0%	0.0%	0.0%	0.0%	15.0%	0.0%	0.0%	0.0%	25.0%

GE Dash 9 4400 HP Duty Cycle: ISO Europe					GE Dash 9 4400 HP Duty Cycle: ISO Europe			GE Dash 9 4400 HP Duty Cycle: ISO Europe			GE Dash 9 4400 HP Duty Cycle: ISO Europe			GE Dash 9 4400 HP Duty Cycle: ISO Europe		
%	HP	Fuel Consumption			NOx			CO			HC			PM		
		duty cycle lb/hr	lb/ bhp-hr	IG/ bhp-hr	g/hr	g/bhp-hr	Factor g/IG	g/hr	g/bhp-hr	Factor g/IG	g/hr	g/bhp-hr	Factor g/IG	g/hr	g/bhp-hr	Factor g/IG
0.0%		0.0			0.0			0.0			0.0			0.0		
60.0%	6	13.2			402.6			111.6			79.8			13.8		
0.0%	0	0.0			0.0			0.0			0.0			0.0		
0.0%	0	0.0			0.0			0.0			0.0			0.0		
0.0%	0	0.0			0.0			0.0			0.0			0.0		
15.0%	210	85.5			3433.5			271.7			52.2			35.7		
0.0%	0	0.0			0.0			0.0			0.0			0.0		
0.0%	0	0.0			0.0			0.0			0.0			0.0		
0.0%	0	0.0			0.0			0.0			0.0			0.0		
25.0%	1026	373.2			13748.5			569.0			205.8			81.5		
	1241.8	471.9	0.3800	0.0450	17584.6	14.2	**314.9**	952.3	0.8	**17.1**	337.8	0.3	**6.0**	131.0	0.1	**2.3**

10. Duty Cycle: RAC Branch/Yard

Throttle Position	Fuel Cons. lb/hr	HP	NOx g/hr	CO g/hr	HC g/hr	PM g/hr
DB	41	23	1085.0	322	155.0	29.0
Low Idle		10	303.0	128	113.0	26.0
Idle	22	10	671.0	186	133.0	23.0
1	82	129	1577.0	153	93.0	38.0
2	188	419	4105.0	315	144.0	105.0
3	394	950	14340.0	902	316.0	240.0
4	570	1400	22890.0	1811	348.0	238.0
5	794	2053	33198.0	2817	605.0	274.0
6	1002	2734	39122.0	3409	680.0	264.0
7	1234	3440	47362.0	2535	708.0	257.0
8	1493	4103	54994.0	2276	823.0	326.0

Duty Cycle: RAC Branch/Yard

DB	**Idle**	**N1**	**N2**	**N3**	**N4**	**N5**	**N6**	**N7**	**N8**
0.0%	**81.0%**	**2.0%**	**2.0%**	**2.0%**	**2.0%**	**2.0%**	**2.0%**	**2.0%**	**5.0%**

GE Dash 9 4400 HP Duty Cycle: 1990 RAC Branch/Yard					GE Dash 9 4400 HP Duty Cycle: 1990 RAC Branch/Yard			GE Dash 9 4400 HP Duty Cycle: 1990 RAC Branch/Yard			GE Dash 9 4400 HP Duty Cycle: 1990 RAC Branch/Yard			GE Dash 9 4400 HP Duty Cycle: 1990 RAC Branch/Yard		
%	HP	Fuel Consumption			NOx			CO			HC			PM		
		duty cycle lb/hr	lb/ bhp-hr	IG/ bhp-hr	g/hr	g/bhp-hr	Factor g/IG	g/hr	g/bhp-hr	Factor g/IG	g/hr	g/bhp-hr	Factor g/IG	g/hr	g/bhp-hr	Factor g/IG
0.0%		0.0			0.0			0.0			0.0			0.0		
81.0%	8	17.8			543.5			150.7			107.7			18.6		
2.0%	3	1.6			31.5			3.1			1.9			0.8		
2.0%	8	3.8			82.1			6.3			2.9			2.1		
2.0%	19	7.9			286.8			18.0			6.3			4.8		
2.0%	28	11.4			457.8			36.2			7.0			4.8		
2.0%	41	15.9			664.0			56.3			12.1			5.5		
2.0%	55	20.0			782.4			68.2			13.6			5.3		
2.0%	69	24.7			947.2			50.7			14.2			5.1		
5.0%	205	74.6			2749.7			113.8			41.2			16.3		
	435.8	177.7	0.4078	0.0483	6545.1	15.0	**311.2**	503.3	1.2	**23.9**	206.8	0.5	**9.8**	63.3	0.1	**3.0**

11. Duty Cycle: California Yard

Throttle Position	Fuel Cons. lb/hr	HP	NOx g/hr	CO g/hr	HC g/hr	PM g/hr
DB	41	23	1085.0	322	155.0	29.0
Low Idle		10	303.0	128	113.0	26.0
Idle	22	10	671.0	186	133.0	23.0
1	82	129	1577.0	153	93.0	38.0
2	188	419	4105.0	315	144.0	105.0
3	394	950	14340.0	902	316.0	240.0
4	570	1400	22890.0	1811	348.0	238.0
5	794	2053	33198.0	2817	605.0	274.0
6	1002	2734	39122.0	3409	680.0	264.0
7	1234	3440	47362.0	2535	708.0	257.0
8	1493	4103	54994.0	2276	823.0	326.0

Duty Cycle: California Yard

DB	Idle	N1	N2	N3	N4	N5	N6	N7	N8
0.0%	**82.0%**	**4.0%**	**4.0%**	**3.0%**	**3.0%**	**1.0%**	**0.0%**	**0.0%**	**2.0%**

GE Dash 9 4400 HP — Duty Cycle: California Yard

%	HP	Fuel Consumption duty cycle lb/hr	Fuel Consumption lb/bhp-hr	Fuel Consumption IG/bhp-hr	NOx g/hr	NOx g/bhp-hr	NOx Factor g/IG	CO g/hr	CO g/bhp-hr	CO Factor g/IG	HC g/hr	HC g/bhp-hr	HC Factor g/IG	PM g/hr	PM g/bhp-hr	PM Factor g/IG
0.0%		0.0			0.0			0.0			0.0			0.0		
82.0%	8	18.0			550.2			152.5			109.1			18.9		
4.0%	5	3.3			63.1			6.1			3.7			1.5		
4.0%	17	7.5			164.2			12.6			5.8			4.2		
3.0%	29	11.8			430.2			27.1			9.5			7.2		
3.0%	42	17.1			686.7			54.3			10.4			7.1		
1.0%	21	7.9			332.0			28.2			6.1			2.7		
0.0%	0	0.0			0.0			0.0			0.0			0.0		
0.0%	0	0.0			0.0			0.0			0.0			0.0		
2.0%	82	29.9			1099.9			45.5			16.5			6.5		
	203.2	95.5	0.4701	0.0556	3326.3	16.4	**294.2**	326.3	1.6	**28.9**	161.0	0.8	**14.2**	48.2	0.2	**4.3**

12. Duty Cycle: California Local

Throttle Position	Fuel Cons. lb/hr	HP	NOx g/hr	CO g/hr	HC g/hr	PM g/hr
DB	41	23	1085.0	322	155.0	29.0
Low Idle		10	303.0	128	113.0	26.0
Idle	22	10	671.0	186	133.0	23.0
1	82	129	1577.0	153	93.0	38.0
2	188	419	4105.0	315	144.0	105.0
3	394	950	14340.0	902	316.0	240.0
4	570	1400	22890.0	1811	348.0	238.0
5	794	2053	33198.0	2817	605.0	274.0
6	1002	2734	39122.0	3409	680.0	264.0
7	1234	3440	47362.0	2535	708.0	257.0
8	1493	4103	54994.0	2276	823.0	326.0

Duty Cycle: California Local

DB	Idle	N1	N2	N3	N4	N5	N6	N7	N8
4.0%	**4.7%**	**9.0%**	**8.0%**	**8.0%**	**7.0%**	**4.0%**	**3.0%**	**3.0%**	**7.0%**

GE Dash 9 4400 HP — Duty Cycle: California Local

%	HP	Fuel Consumption duty cycle lb/hr	Fuel Consumption lb/bhp-hr	Fuel Consumption IG/bhp-hr	NOx g/hr	NOx g/bhp-hr	NOx Factor g/IG	CO g/hr	CO g/bhp-hr	CO Factor g/IG	HC g/hr	HC g/bhp-hr	HC Factor g/IG	PM g/hr	PM g/bhp-hr	PM Factor g/IG
4.0%		1.7			43.4			12.9			6.2			1.2		
4.7%	0	1.0			31.5			8.7			6.3			1.1		
9.0%	12	7.3			141.9			13.8			8.4			3.4		
8.0%	34	15.0			328.4			25.2			11.5			8.4		
8.0%	76	31.5			1147.2			72.2			25.3			19.2		
7.0%	98	39.9			1602.3			126.8			24.4			16.7		
4.0%	82	31.8			1327.9			112.7			24.2			11.0		
3.0%	82	30.1			1173.7			102.3			20.4			7.9		
3.0%	103	37.0			1420.9			76.1			21.2			7.7		
7.0%	287	104.5			3849.6			159.3			57.6			22.8		
	774.2	299.8	0.3872	0.0458	11066.8	14.3	**311.9**	709.8	0.9	**20.0**	205.4	0.3	**5.8**	99.3	0.1	**2.8**

APPENDIX G

FLEET PROFILE EFFECTS

ON

EMISSIONS FACTORS

Appendix G: Fleet Profile Effects on Emissions Factors

Fleet of 1990

Road Locomotives

Model	Engine	HP	No. of Locos.	Utilization	hrs/yr	Fuel Cons. lb/hr	Fuel Cons. L/hr	Fuel Cons. L/yr x 10^6
Other	MLW & Cat		257	89.0%	7798.2	250.4	133.8	268.1
SD-40	645	3000	1334	89.0%	7798.2	250.4	133.8	1391.4
SD-50	645	3600	60	89.0%	7798.2	285.5	152.5	71.4
SD-60	710	3800	64	89.0%	7798.2	266.0	142.1	70.9
Dash 8	7FDL	4000	52	89.0%	7798.2	270.2	144.3	58.5

Model	Engine	HP	Fuel Cons L/yr x 10^6	Emissions Factors NOx g/IG	CO g/IG	HC g/IG	PM g/IG
Other	MLW & Cat		268.1	247.5	52.7	12.9	4.7
SD-40	645	3000	1391.4	247.5	52.7	12.9	4.7
SD-50	645	3600	71.4	247.5	52.7	12.9	4.7
SD-60	710	3800	70.9	340.1	22.1	9.0	7.2
Dash 8	7FDL	4000	58.5	241.5	126.7	12.9	7.0
Factors - Road Locomotives:				**250.8**	**53.8**	**12.8**	**4.9**
Annual Fuel Consumption (L x10^6):			**1860.2**				
Annual Fuel Consumption (IG x10^6):			**409.7**				
Emissions Tonnage (Kilotonnes):				**102.8**	**22.1**	**5.2**	**2.0**
Using factor of 248 (Historical):				**101.6**	**24.6**	**5.4**	**2.8**

Passenger Locomotives

Model	Engine	HP	No. of Locos.	Utilization	hrs/yr	Fuel Cons. lb/hr	Fuel Cons. L/hr	Fuel Cons. L/yr x 10^6
MLW	251	3700	223	22.3%	1949.1	296.7	158.5	68.9
SD-40	645	3000	77	22.3%	1949.1	296.7	158.5	23.8
F59PH	710	3000	42	22.3%	1949.1	238.3	127.3	10.4

Model	Engine	HP	Fuel Cons. L/yr x 10^6	Emissions Factors NOx g/IG	CO g/IG	HC g/IG	PM g/IG
MLW	251	3700	68.9	247.2	55.2	12.2	6.3
SD-40	645	3000	23.8	247.2	55.2	12.2	6.3
F59PH	710	3000	10.4	324.1	22.4	8.7	7.4
Factors - Passenger:				**255.0**	**51.9**	**11.9**	**6.4**
Annual Fuel Consumption (L x10^6):			**103.1**				
Annual Fuel Consumption (IG x10^6):			**22.7**				
Emissions Tonnage (Kilotonnes):				**5.8**	**1.2**	**0.3**	**0.1**
Using factor of 248 (Historical):				**5.6**	**1.2**	**0.3**	**0.1**

Fleet of 1990

Yard & Switcher Locomotives								
Model	**Engine**	**HP**	**No. of**	**Utilization**		**Fuel**	**Fuel**	**Fuel**
			Locos.			**Cons.**	**Cons.**	**Cons.**
					hrs/yr	**lb/hr**	**L/hr**	**L/yr x 10^6**
8V	567	800	4	27.6%	2415.1	23.9	12.8	0.1
8V	567	900	19	27.6%	2415.1	26.9	14.3	0.7
12V	567	1200	172	27.6%	2415.1	61.4	32.8	13.6
	567	1500	2	27.6%	2415.1	76.7	41.0	0.2
	567	1750	104	27.6%	2415.1	89.5	47.8	12.0
12V	645	1200	131	27.6%	2415.1	63.4	33.9	10.7
12V	645	1350	8	27.6%	2415.1	71.3	38.1	0.7
	645	1500	15	27.6%	2415.1	79.3	42.3	1.5
	645	1750/1800	376	27.6%	2415.1	95.1	50.8	46.1
	645	2000	302	27.6%	2415.1	105.7	56.4	41.2
	645	3000	0	27.6%	2415.1	158.5	84.7	0.0
		other	309	27.6%	2415.1	63.4	33.9	25.3

Model	**Engine**	**HP**	**Fuel**	**Emissions Factors**			
			Cons.	**NOx**	**CO**	**HC**	**PM**
			L/yr x 10^6	**g/IG**	**g/IG**	**g/IG**	**g/IG**
SD-40	645		100.3	261.8	73.4	23.4	6.9
other	567 & MLW		51.9	245.6	72.8	22.0	8.8
Factors - Yard & Switcher:				**256.2**	**73.2**	**22.9**	**7.5**
Annual Fuel Consumption (L x10^6):			**152.2**				
Annual Fuel Consumption (IG x10^6):			**33.5**				
Emissions Tonnage (Kilotonnes):				**8.6**	**2.5**	**0.8**	**0.3**
Using factor of 277 (Historical):				**8.3**	**1.9**	**0.6**	**0.2**

Summary	**Emissions Factors**			
	NOx	**CO**	**HC**	**PM**
	g/IG	**g/IG**	**g/IG**	**g/IG**
Summary (F= Fleet Specific):				
Freight Tonnage (Kilotonnes):	**102.8**	**22.1**	**5.2**	**2.0**
Passenger Tonnage (Kilotonnes):	**5.8**	**1.2**	**0.3**	**0.1**
Switcher Tonnage (Kilotonnes):	**8.6**	**2.5**	**0.8**	**0.3**
Total Tonnage (Kilotonnes)	**117.2**	**25.7**	**6.3**	**2.4**
Summary (F= 248 Historical):				
Freight Tonnage (Kilotonnes):	**101.6**	**24.6**	**5.4**	**2.8**
Passenger Tonnage (Kilotonnes):	**5.6**	**1.2**	**0.3**	**0.1**
Switcher Tonnage (Kilotonnes):	**8.3**	**1.9**	**0.6**	**0.2**
Total Tonnage (Kilotonnes)	**115.6**	**27.7**	**6.3**	**3.1**

Fleet of 1997

Road Locomotives

Model	Engine	HP	No. of Locos.	Utilization	hrs/yr	Fuel Cons. lb/hr	Fuel Cons. L/hr	Fuel Cons. L/yr x 10^6
Other	MLW & Cat		81	72.5%	6346.6	250.4	133.8	68.8
SD-40	645	3000	1508	72.5%	6346.6	250.4	133.8	1280.1
SD-50	645	3600	66	72.5%	6346.6	285.5	152.5	63.9
SD-60	710	3800	69	72.5%	6346.6	266.0	142.1	62.2
SD 70	710	3000	5	72.5%	6346.6	238.3	127.3	4.0
SD 70	710	4000	26	72.5%	6346.6	300.0	160.2	26.4
SD-75	710	4300	139	72.5%	6346.6	280.4	149.8	132.1
Dash 8	7FDL	4000	109	72.5%	6346.6	270.2	144.3	99.8
Dash 9	7FDL	4400	291	72.5%	6346.6	297.2	158.7	293.2

Model	Engine	HP	Fuel Cons. L/yr x 10^6	Emissions Factors NOx g/IG	CO g/IG	HC g/IG	PM g/IG
Other	MLW & Cat		68.8	247.5	52.7	12.9	4.7
SD-40	645	3000	1280.1	247.5	52.7	12.9	4.7
SD-50	645	3600	63.9	247.5	52.7	12.9	4.7
SD-60	710	3800	62.2	340.1	22.1	9.0	7.2
SD 70	710	3000	4.0	324.1	22.4	8.7	7.4
SD 70	710	4000	26.4	338.8	21.9	9.1	7.3
SD-75	710	4300	132.1	339.5	22.2	9.1	7.3
Dash 8	7FDL	4000	99.8	241.5	126.7	12.9	7.0
Dash 9	7FDL	4400	293.2	310.7	20.4	7.4	2.7
Factors - Road Locomotives:				**266.5**	**48.3**	**11.7**	**4.8**
Annual Fuel Consumption (L x10^6):			**2030.6**				
Annual Fuel Consumption (IG x10^6):			**447.3**				
Emissions Tonnage (Kilotonnes):				**119.2**	**21.6**	**5.2**	**2.2**
Using factor of 248 (Historical):				**110.9**	**24.6**	**5.4**	**2.8**

Passenger Locomotives

Model	Engine	HP	No. of Locos.	Utilization	hrs/yr	Fuel Cons. lb/hr	Fuel Cons. L/hr	Fuel Cons. L/yr x 10^6
MLW	251	3700	29	35.5%	3109.8	296.7	158.5	14.3
SD-40	645	3000	59	35.5%	3109.8	296.7	158.5	29.1
F59PH	710	3000	45	35.5%	3109.8	238.3	127.3	17.8

Model	Engine	HP	Fuel Cons. L/yr x 10^6	Emissions Factors NOx g/IG	CO g/IG	HC g/IG	PM g/IG
MLW	251	3700	14.3	247.2	55.2	12.2	6.3
SD-40	645	3000	29.1	247.2	55.2	12.2	6.3
F59PH	710	3000	17.8	324.1	22.4	8.7	7.4
Factors - Passenger:				**269.6**	**45.7**	**11.2**	**6.6**
Annual Fuel Consumption (L x10^6):			**61.2**				
Annual Fuel Consumption (IG x10^6):			**13.5**				
Emissions Tonnage (Kilotonnes):				**3.6**	**0.6**	**0.2**	**0.1**
Using factor of 248 (Historical):				**3.3**	**0.6**	**0.2**	**0.1**

Fleet of 1997

Switcher Locomotives

Model	Engine	HP	No. of Locos.	Utilization	hrs/yr	Fuel Cons. lb/hr	Fuel Cons. L/hr	Fuel Cons. L/yr x 10^6
8V	567	800	4	22.8%	1997.3	23.9	12.8	0.1
8V	567	900	18	22.8%	1997.3	26.9	14.3	0.5
12V	567	1200	121	22.8%	1997.3	61.4	32.8	7.9
	567	1500	17	22.8%	1997.3	76.7	41.0	1.4
	567	1750	82	22.8%	1997.3	89.5	47.8	7.8
12V	645	1200	90	22.8%	1997.3	63.4	33.9	6.1
12V	645	1350	8	22.8%	1997.3	71.3	38.1	0.6
	645	1500	24	22.8%	1997.3	79.3	42.3	2.0
	645	1750/1800	467	22.8%	1997.3	95.1	50.8	47.4
	645	2000	301	22.8%	1997.3	105.7	56.4	33.9
	645	3000	0	22.8%	1997.3	158.5	84.7	0.0
		other	172	22.8%	1997.3	63.4	33.9	11.6

Model	Engine	HP	Fuel Cons. L/yr x 10^6	Emissions Factors NOx g/IG	CO g/IG	HC g/IG	PM g/IG
SD-40	645		90.0	261.8	73.4	23.4	6.9
other	567 & MLW		29.4	245.6	72.8	22.0	8.8
Factors - Yard & Switcher:				**257.8**	**73.2**	**23.0**	**7.3**
Annual Fuel Consumption (L x10^6):			**119.4**				
Annual Fuel Consumption (IG x10^6):			**26.3**				
Emissions Tonnage (Kilotonnes):				**6.8**	**1.9**	**0.6**	**0.2**
Using factor of 277 (Historical):				**6.5**	**6.5**	**6.5**	**6.5**

Summary	Emissions Factors NOx g/IG	CO g/IG	HC g/IG	PM g/IG
Summary (F= Fleet Specific):				
Freight Tonnage (Kilotonnes):	**119.2**	**21.6**	**5.2**	**2.2**
Passenger Tonnage (Kilotonnes):	**3.6**	**0.6**	**0.2**	**0.1**
Switcher Tonnage (Kilotonnes):	**6.8**	**1.9**	**0.6**	**0.2**
Total Tonnage (Kilotonnes)	**129.6**	**24.1**	**6.0**	**2.4**
Summary (F= 248 Historical):				
Freight Tonnage (Kilotonnes):	**110.9**	**24.6**	**5.4**	**2.8**
Passenger Tonnage (Kilotonnes):	**3.3**	**0.6**	**0.2**	**0.1**
Switcher Tonnage (Kilotonnes):	**6.5**	**6.5**	**6.5**	**6.5**
Total Tonnage (Kilotonnes)	**120.8**	**31.7**	**12.1**	**9.4**

Fleet of 1998

Road Locomotives

Model	Engine	HP	No. of Locos.	Utilization	hrs/yr	Fuel Cons. lb/hr	Fuel Cons. L/hr	Fuel Cons. L/yr x 10^6
Other	MLW & Cat		52	76.7%	6716.3	250.4	133.8	46.7
SD-40	645	3000	1180	76.7%	6716.3	250.4	133.8	1060.0
SD-50	645	3600	66	76.7%	6716.3	285.5	152.5	67.6
SD-60	710	3800	63	76.7%	6716.3	266.0	142.1	60.1
SD 70	710	3000	0	76.7%	6716.3	238.3	127.3	0.0
SD 70	710	4000	76	76.7%	6716.3	300.0	160.2	81.8
SD-75	710	4300	167	76.7%	6716.3	280.4	149.8	168.0
SD 90	710	6000	0	76.7%	6716.3	391.3	209.0	0.0
Dash 8	7FDL	4000	61	76.7%	6716.3	270.2	144.3	59.1
Dash 9	7FDL	4400	317	76.7%	6716.3	297.2	158.7	338.0

Model	Engine	HP	Fuel Cons. L/yr x 10^6	Emissions Factors NOx g/IG	CO g/IG	HC g/IG	PM g/IG
Other	MLW & Cat		46.7	247.5	52.7	12.9	4.7
SD-40	645	3000	1060.0	247.5	52.7	12.9	4.7
SD-50	645	3600	67.6	247.5	52.7	12.9	4.7
SD-60	710	3800	60.1	340.1	22.1	9.0	7.2
SD 70	710	4000	81.8	338.8	21.9	8.6	7.2
SD-75	710	4300	168.0	339.5	22.2	9.1	7.3
Dash 8	7FDL	4000	59.1	241.5	126.7	12.9	7.0
Dash 9	7FDL	4400	338.0	310.7	20.4	7.4	2.7
Factor - Road Locomotives:				**273.8**	**44.2**	**11.3**	**4.9**
Annual Fuel Consumption (L x10^6):			**1881.3**				
Annual Fuel Consumption (IG x10^6):			**414.4**				
Emissions Tonnage (Kilotonnes):				**113.5**	**18.3**	**4.7**	**2.0**
Using factor of 248 (Historical):				**102.8**	**24.6**	**5.4**	**2.8**

Passenger Locomotives

Model	Engine	HP	No. of Locos.	Utilization	hrs/yr	Fuel Cons. lb/hr	Fuel Cons. L/hr	Fuel Cons. L/yr x 10^6
MLW	251	3700	7	41.5%	3635.4	296.7	158.5	4.0
SD-40	645	3000	58	41.5%	3635.4	296.7	158.5	33.4
F59PH	710	3000	45	41.5%	3635.4	238.3	127.3	20.8

Model	Engine	HP	Fuel Cons. L/yr x 10^6	Emissions Factors NOx g/IG	CO g/IG	HC g/IG	PM g/IG
MLW	251	3700	4.0	247.2	55.2	12.2	6.3
SD-40	645	3000	33.4	247.2	55.2	12.2	6.3
F59PH	710	3000	20.8	324.1	22.4	8.7	7.4
Factors - Passenger:				**274.7**	**43.5**	**11.0**	**6.7**
Annual Fuel Consumption (L x10^6):			**58.3**				
Annual Fuel Consumption (IG x10^6):			**12.8**				
Tonnage (Kilotonnes):				**3.5**	**0.6**	**0.1**	**0.1**
Using factor of 248 (Historical):				**3.2**	**0.6**	**0.1**	**0.1**

Fleet of 1998

Switcher Locomotives

			No. of	**Utilization**		**Fuel**	**Fuel**	**Fuel**
Model	**Engine**	**HP**	**Locos.**			**Cons.**	**Cons.**	**Cons.**
					hrs/yr	**lb/hr**	**L/hr**	**L/yr x 10^6**
8V	567	800	1	27.1%	2374.0	23.9	12.8	0.0
8V	567	900	13	27.1%	2374.0	26.9	14.3	0.4
12V	567	1200	103	27.1%	2374.0	61.4	32.8	8.0
	567	1500	9	27.1%	2374.0	76.7	41.0	0.9
	567	1750	59	27.1%	2374.0	89.5	47.8	6.7
12V	645	1200	26	27.1%	2374.0	63.4	33.9	2.1
12V	645	1350	117	27.1%	2374.0	71.3	38.1	10.6
	645	1500	14	27.1%	2374.0	79.3	42.3	1.4
	645	1750/1800	377	27.1%	2374.0	95.1	50.8	45.5
	645	2000	288	27.1%	2374.0	105.7	56.4	38.6
	645	3000	0	27.1%	2374.0	158.5	84.7	0.0
		other	141	27.1%	2374.0	63.4	33.9	11.3

			Fuel	**Emissions Factors**			
Model	**Engine**	**HP**	**Cons.**	**NOx**	**CO**	**HC**	**PM**
			L/yr x 10^6	**g/IG**	**g/IG**	**g/IG**	**g/IG**
SD-40	645		98.1	261.8	73.4	23.4	6.9
other	567 & MLW		27.4	245.6	72.8	22.0	8.8
Factors - Yard & Switcher:				**258.2**	**73.2**	**23.1**	**7.3**
Annual Fuel Consumption (L x10^6):			**125.5**				
Annual Fuel Consumption (IG x10^6):			**27.6**				
Annual Tonnage (Kilotonnes):				**7.1**	**2.0**	**0.6**	**0.2**
Using factor of 277 (Historical):				**7.7**	**1.9**	**0.6**	**0.2**

Summary	**Emissions Factors**			
	NOx	**CO**	**HC**	**PM**
	g/IG	**g/IG**	**g/IG**	**g/IG**
Summary (F= Calculated):				
Freight Tonnage (Kilotonnes):	**113.5**	**18.3**	**4.7**	**2.0**
Passenger Tonnage (Kilotonnes):	**3.5**	**0.6**	**0.1**	**0.1**
Switcher Tonnage (Kilotonnes):	**7.1**	**2.0**	**0.6**	**0.2**
Total Tonnage (Kilotonnes)	**124.1**	**20.9**	**5.5**	**2.3**
Summary (F= 248 Historical):				
Freight Tonnage (Kilotonnes):	**102.8**	**24.6**	**5.4**	**2.8**
Passenger Tonnage (Kilotonnes):	**3.2**	**0.6**	**0.1**	**0.1**
Switcher Tonnage (Kilotonnes):	**7.7**	**1.9**	**0.6**	**0.2**
Total Tonnage (Kilotonnes)	**113.6**	**27.1**	**6.1**	**3.1**

Appendix G: Fleet Profile Effects on Emissions Factors

Fleet of 1999

Road Locomotives

Model	Engine	HP	No. of Locos.	Utilization	hrs/yr	Fuel Cons. lb/hr	Fuel Cons. L/hr	Fuel Cons. L/yr x 10^6
Other	MLW & Cat		78	73.2%	6414.1	250.4	133.8	66.9
SD-40	645	3000	1073	73.2%	6414.1	250.4	133.8	920.5
SD-50	645	3600	66	73.2%	6414.1	285.5	152.5	64.6
SD-60	710	3800	63	73.2%	6414.1	266.0	142.1	57.4
SD 70	710	4000	26	73.2%	6414.1	300.0	160.2	26.7
SD-75	710	4300	241	73.2%	6414.1	280.4	149.8	231.5
SD 90	710	6000	4	73.2%	6414.1	391.3	209.0	5.4
Dash 8	7FDL	4000	87	73.2%	6414.1	270.2	144.3	80.5
Dash 9	7FDL	4400	302	73.2%	6414.1	297.2	158.7	307.5

Model	Engine	HP	Fuel Cons. L/yr x 10^6	Emissions Factors NOx g/IG	CO g/IG	HC g/IG	PM g/IG
Other	MLW & Cat		66.9	247.5	52.7	12.9	4.7
SD-40	645	3000	920.5	247.5	52.7	12.9	4.7
SD-50	645	3600	64.6	247.5	52.7	12.9	4.7
SD-60	710	3800	57.4	340.1	22.1	9.0	7.2
SD 70	710	4000	26.7	338.8	21.9	8.6	7.2
SD-75	710	4300	231.5	339.5	22.2	9.1	7.3
SD-90	H	6000	5.4	473.1	30.9	12.0	10.0
Dash 8	7FDL	4000	80.5	241.5	126.7	12.9	7.0
Dash 9	7FDL	4400	307.5	310.7	20.4	7.4	2.7
Factors - Road Locomotives:				**275.5**	**44.9**	**11.3**	**4.9**
Annual Fuel Consumption (L x10^6):			**1761.1**				
Annual Fuel Consumption (IG x10^6):			**387.9**				
Emissions Tonnage (Kilotonnes):				**106.8**	**17.4**	**4.4**	**1.9**
Using factor of 248 (Historical):				**96.2**	**24.6**	**5.4**	**2.8**

Passenger Locomotives

Model	Engine	HP	No. of Locos.	Utilization	hrs/yr	Fuel Cons. lb/hr	Fuel Cons. L/hr	Fuel Cons. L/yr x 10^6
MLW	251	3700	7	41.7%	3652.9	296.7	158.5	4.1
SD-40	645	3000	57	41.7%	3652.9	296.7	158.5	33.0
F59PH	710	3000	45	41.7%	3652.9	238.3	127.3	20.9

Model	Engine	HP	Fuel Cons. L/yr x 10^6	Emissions Factors NOx g/IG	CO g/IG	HC g/IG	PM g/IG
MLW	251	3700	4.1	247.2	55.2	12.2	6.3
SD-40	645	3000	33.0	247.2	55.2	12.2	6.3
F59PH	710	3000	20.9	324.1	22.4	8.7	7.4
Factors - Passenger:				**275.0**	**43.4**	**11.0**	**6.7**
Annual Fuel Consumption (L x10^6):			**58.0**				
Annual Fuel Consumption (IG x10^6):			**12.8**				
Tonnage (Kilotonnes):				**3.5**	**0.6**	**0.1**	**0.1**
Using factor of 248 (Historical):				**3.2**	**0.6**	**0.1**	**0.1**

Fleet of 1999

Switcher Locomotives

Model	Engine	HP	No. of Locos.	Utilization	hrs/yr	Fuel Cons. lb/hr	Fuel Cons. L/hr	Fuel Cons. L/yr x 10^6
8V	567	800	1	20.2%	1765.1	23.9	12.8	0.0
8V	567	900	13	20.2%	1765.1	26.9	14.3	0.3
12V	567	1200	69	20.2%	1765.1	61.4	32.8	4.0
	567	1500	12	20.2%	1765.1	76.7	41.0	0.9
	567	1750	83	20.2%	1765.1	89.5	47.8	7.0
12V	645	1200	66	20.2%	1765.1	63.4	33.9	3.9
12V	645	1350	8	20.2%	1765.1	71.3	38.1	0.5
	645	1500	26	20.2%	1765.1	79.3	42.3	1.9
	645	1750/1800	410	20.2%	1765.1	95.1	50.8	36.8
	645	2000	292	20.2%	1765.1	105.7	56.4	29.1
	645	3000	0	20.2%	1765.1	158.5	84.7	0.0
		other	123	20.2%	1765.1	63.4	33.9	7.4

Model	Engine	HP	Fuel Cons.	Emissions Factors NOx	CO	HC	PM
			L/yr x 10^6	g/IG	g/IG	g/IG	g/IG
SD-40	645		98.1	261.8	73.4	23.4	6.9
other	567 & MLW		27.4	245.6	72.8	22.0	8.8
Factors - Yard & Switcher:				**352.8**	**100.1**	**31.5**	**9.9**
Annual Fuel Consumption (L x10^6):			**91.9**				
Annual Fuel Consumption (IG x10^6):			**20.2**				
Annual Tonnage (Kilotonnes):				**7.1**	**2.0**	**0.6**	**0.2**
Using factor of 277 (Historical):				**5.6**	**1.9**	**0.6**	**0.2**

Summary	Emissions Factors NOx	CO	HC	PM
	g/IG	g/IG	g/IG	g/IG
Summary (F= Calculated):				
Freight Tonnage (Kilotonnes):	**106.8**	**17.4**	**4.4**	**1.9**
Passenger Tonnage (Kilotonnes):	**3.5**	**0.6**	**0.1**	**0.1**
Switcher Tonnage (Kilotonnes):	**7.1**	**2.0**	**0.6**	**0.2**
Total Tonnage (Kilotonnes)	**117.5**	**20.0**	**5.1**	**2.2**
Summary (F= 248 Historical):				
Freight Tonnage (Kilotonnes):	**96.2**	**24.6**	**5.4**	**2.8**
Passenger Tonnage (Kilotonnes):	**3.2**	**0.6**	**0.1**	**0.1**
Switcher Tonnage (Kilotonnes):	**5.6**	**1.9**	**0.6**	**0.2**
Total Tonnage (Kilotonnes)	**105.0**	**27.1**	**6.1**	**3.1**

Fleet of 2000

Road Locomotives

Model	Engine	HP	No. of Locos.	Utilization	hrs/yr	Fuel Cons. lb/hr	Fuel Cons. L/hr	Fuel Cons. L/yr x 10^6
Other	MLW & Cat		57	77.5%	6787.2	250.4	133.8	51.7
SD-40	645	3000	990	77.5%	6787.2	250.4	133.8	898.7
SD-50	645	3600	64	77.5%	6787.2	285.5	152.5	66.2
SD-60	710	3800	63	77.5%	6787.2	266.0	142.1	60.8
SD 70	710	3000	7	77.5%	6787.2	238.3	127.3	6.0
SD-75	710	4300	240	77.5%	6787.2	280.4	149.8	244.0
SD 90	710	6000	4	77.5%	6787.2	391.3	209.0	5.7
Dash 8	7FDL	4000	84	77.5%	6787.2	270.2	144.3	82.3
Dash 9	7FDL	4400	272	77.5%	6787.2	297.2	158.7	293.1
Dash 9	Tier 0	new or rebuilt	80	77.5%	6787.2	297.2	158.7	86.2

Model	Engine	HP	Fuel Cons. L/yr x 10^6	Emissions Factors NOx g/IG	CO g/IG	HC g/IG	PM g/IG
Other	MLW & Cat		51.7	247.5	52.7	12.9	4.7
SD-40	645	3000	898.7	247.5	52.7	12.9	4.7
SD-50	645	3600	66.2	247.5	52.7	12.9	4.7
SD-60	710	3800	60.8	340.1	22.1	8.6	7.2
SD 70	710	4000	6.0	321.4	22.4	8.7	7.4
SD-75	710	4300	244.0	339.5	22.2	9.1	7.3
SD-90	H	6000	5.7	473.1	30.9	12.0	10.0
Dash 8	7FDL	4000	82.3	241.5	126.7	12.9	7.0
Dash 9	7FDL	4400	293.1	310.7	20.4	7.4	2.7
Dash 9	Tier 0	new or rebuilt	86.2	204.6	20.4	7.4	2.7
Factors - Road Locomotives:				**272.1**	**43.9**	**11.1**	**4.9**
Annual Fuel Consumption (L x10^6):			**1794.7**				
Annual Fuel Consumption (IG x10^6):			**395.3**				
Emissions Tonnage (Kilotonnes):				**107.6**	**17.4**	**4.4**	**1.9**
Using factor of 248 (Historical):				**98.0**	**24.6**	**5.4**	**2.8**

Passenger Locomotives

Model	Engine	HP	No. of Locos.	Utilization	hrs/yr	Fuel Cons. lb/hr	Fuel Cons. L/hr	Fuel Cons. L/yr x 10^6
MLW	251	3700	7	45.0%	3942.0	296.7	158.5	4.4
SD-40	645	3000	54	45.0%	3942.0	296.7	158.5	33.7
F59PH	710	3000	45	45.0%	3942.0	238.3	127.3	22.6

Model	Engine	HP	Fuel Cons. L/yr x 10^6	Emissions Factors NOx g/IG	CO g/IG	HC g/IG	PM g/IG
MLW	251	3700	4.4	247.2	55.2	12.2	6.3
SD-40	645	3000	33.7	247.2	55.2	12.2	6.3
F59PH	710	3000	22.6	324.1	22.4	8.7	7.4
Factors - Passenger:				**275.8**	**43.0**	**10.9**	**6.7**
Annual Fuel Consumption (L x10^6):			**60.7**				
Annual Fuel Consumption (IG x10^6):			**13.4**				
Emissions Tonnage (Kilotonnes):				**3.7**	**0.6**	**0.1**	**0.1**
Using factor of 248 (Historical):				**3.3**	**0.6**	**0.1**	**0.1**

Fleet of 2000

Switcher Locomotives

Model	Engine	HP	No. of Locos.	Utilization	hrs/yr	Fuel Cons. lb/hr	Fuel Cons. L/hr	Fuel Cons. L/yr x 10^6
8V	567	800	0	20.3%	1778.3	23.9	12.8	0.0
8V	567	900	14	20.3%	1778.3	26.9	14.3	0.4
12V	567	1200	62	20.3%	1778.3	61.4	32.8	3.6
	567	1500	30	20.3%	1778.3	76.7	41.0	2.2
	567	1750	259	20.3%	1778.3	89.5	47.8	22.0
12V	645	1200	60	20.3%	1778.3	63.4	33.9	3.6
12V	645	1350	3	20.3%	1778.3	71.3	38.1	0.2
	645	1500	11	20.3%	1778.3	79.3	42.3	0.8
	645	1750/1800	204	20.3%	1778.3	95.1	50.8	18.4
	645	2000	295	20.3%	1778.3	105.7	56.4	29.6
	645	3000	0	20.3%	1778.3	158.5	84.7	0.0
		other	154	20.3%	1778.3	63.4	33.9	9.3

Model	Engine	HP	Fuel Cons. L/yr x 10^6	Emissions Factors NOx g/IG	CO g/IG	HC g/IG	PM g/IG
SD-40	645		52.7	261.8	73.4	23.4	6.9
other	567 & MLW		37.5	245.6	72.8	22.0	8.8
Factors - Yard & Switcher:				**255.2**	**73.2**	**22.8**	**7.7**
Annual Fuel Consumption (L x10^6):			**90.1**				
Annual Fuel Consumption (IG x10^6):			**19.9**				
Annual Tonnage (Kilotonnes):				**5.1**	**1.5**	**0.5**	**0.2**
Using factor of 277 (Historical):				**5.5**	**1.9**	**0.6**	**0.2**

Summary	Emissions Factors NOx g/IG	CO g/IG	HC g/IG	PM g/IG
Summary (F= Calculated):				
Freight Tonnage (Kilotonnes):	**107.6**	**17.4**	**4.4**	**1.9**
Passenger Tonnage (Kilotonnes):	**3.7**	**0.6**	**0.1**	**0.1**
Switcher Tonnage (Kilotonnes):	**5.1**	**1.5**	**0.5**	**0.2**
Total Tonnage (Kilotonnes)	**116.3**	**19.4**	**5.0**	**2.2**
Summary (F= 248 Historical):				
Freight Tonnage (Kilotonnes):	**98.0**	**24.6**	**5.4**	**2.8**
Passenger Tonnage (Kilotonnes):	**3.3**	**0.6**	**0.1**	**0.1**
Switcher Tonnage (Kilotonnes):	**5.5**	**1.9**	**0.6**	**0.2**
Total Tonnage (Kilotonnes)	**106.9**	**27.1**	**6.1**	**3.1**

Fleet of 2001

Road Locomotives

Model	Engine	HP	No. of Locos.	Utilization	hrs/yr	Fuel Cons. lb/hr	Fuel Cons. L/hr	Fuel Cons. L/yr x 10^6
Other	MLW & Cat		57	79.5%	6964.2	250.4	133.8	53.1
SD-40	645	3000	890	79.5%	6964.2	250.4	133.8	829.0
SD-50	645	3600	64	79.5%	6964.2	285.5	152.5	68.0
SD-60	710	3800	63	79.5%	6964.2	266.0	142.1	62.3
SD 70	710	3000	7	79.5%	6964.2	238.3	127.3	6.2
SD 70	710	4000	12	79.5%	6964.2	300.0	160.2	13.4
SD-75	710	4300	240	79.5%	6964.2	280.4	149.8	250.3
SD 90	710	6000	4	79.5%	6964.2	391.3	209.0	5.8
Dash 8	7FDL	4000	55	79.5%	6964.2	270.2	144.3	55.3
Dash 9	7FDL	4400	229	79.5%	6964.2	297.2	158.7	253.2
Dash 9	Tier 0	new or rebuilt	179	79.5%	6964.2	297.2	158.7	197.9

Model	Engine	HP	Fuel Cons. L/yr x 10^6	Emissions Factors NOx g/IG	CO g/IG	HC g/IG	PM g/IG
Other	MLW & Cat		53.1	247.5	52.7	12.9	4.7
SD-40	645	3000	829.0	247.5	52.7	12.9	4.7
SD-50	645	3600	68.0	247.5	52.7	12.9	4.7
SD-60	710	3800	62.3	340.1	22.1	9.0	7.2
SD 70	710	3000	6.2	324.1	22.4	8.7	7.4
SD 70	710	4000	13.4	338.8	21.9	8.6	7.2
SD-75	710	4300	250.3	339.5	22.2	9.1	7.3
SD 90	710	6000	5.8	473.1	30.9	12.0	10.0
Dash 8	7FDL	4000	55.3	241.5	126.7	12.9	7.0
Dash 9	7FDL	4400	253.2	310.7	20.4	7.4	2.7
Dash 9	Tier 0	new or rebuilt	197.9	204.6	20.4	7.4	2.7

		NOx	CO	HC	PM
Factors - Road Locomotives:		**269.2**	**41.1**	**10.8**	**4.8**
Annual Fuel Consumption (L x10^6):	**1794.5**				
Annual Fuel Consumption (IG x10^6):	**395.3**				
Emissions Tonnage (Kilotonnes):		**106.4**	**16.3**	**4.3**	**1.9**
Using factor of 248 (Historical):		**98.0**	**24.6**	**5.4**	**2.8**

Passenger Locomotives

Model	Engine	HP	No. of Locos.	Utilization	hrs/yr	Fuel Cons. lb/hr	Fuel Cons. L/hr	Fuel Cons. L/yr x 10^6
MLW	251	3700	7	45.0%	3942.0	296.7	158.5	4.4
SD-40	645	3000	54	45.0%	3942.0	296.7	158.5	33.7
F59PH	710	3000	45	45.0%	3942.0	238.3	127.3	22.6

Model	Engine	HP	Fuel Cons. L/yr x 10^6	Emissions Factors NOx g/IG	CO g/IG	HC g/IG	PM g/IG
MLW	251	3700	4.4	247.2	55.2	12.2	6.3
SD-40	645	3000	33.7	247.2	55.2	12.2	6.3
F59PH	710	3000	22.6	324.1	22.4	8.7	7.4

		NOx	CO	HC	PM
Factors - Passenger:		**275.8**	**43.0**	**10.9**	**6.7**
Annual Fuel Consumption (L x10^6):	**60.7**				
Annual Fuel Consumption (IG x10^6):	**13.4**				
Tonnage (Kilotonnes):		**3.7**	**0.6**	**0.1**	**0.1**
Using factor of 248 (Historical):		**3.3**	**0.6**	**0.1**	**0.1**

Switcher Locomotives								
Model	Engine	HP	No. of	Utilization		Fuel	Fuel	Fuel
			Locos.			Cons.	Cons.	Cons.
					hrs/yr	lb/hr	L/hr	L/yr x 10^6
8V	567	800	0	20.3%	1778.3	23.9	12.8	0.0
8V	567	900	14	20.3%	1778.3	26.9	14.3	0.4
12V	567	1200	59	20.3%	1778.3	61.4	32.8	3.4
	567	1500	32	20.3%	1778.3	76.7	41.0	2.3
	567	1750	258	20.3%	1778.3	89.5	47.8	21.9
12V	645	1200	83	20.3%	1778.3	63.4	33.9	5.0
12V	645	1350	3	20.3%	1778.3	71.3	38.1	0.2
	645	1500	11	20.3%	1778.3	79.3	42.3	0.8
	645	1750/1800	200	20.3%	1778.3	95.1	50.8	18.1
	645	2000	264	20.3%	1778.3	105.7	56.4	26.5
	645	3000	20	20.3%	1778.3	158.5	84.7	3.0
		other	154	20.3%	1778.3	63.4	33.9	9.3

Model	Engine	HP	Fuel	Emissions Factors			
			Cons.	NOx	CO	HC	PM
			L/yr x 10^6	g/IG	g/IG	g/IG	g/IG
SD-40	645		53.6	261.8	73.4	23.4	6.9
other	567 & MLW		37.3	245.6	72.8	22.0	8.8
Factors - Yard & Switcher:				**255.1**	**73.1**	**22.8**	**7.6**
Annual Fuel Consumption (L x10^6):			**90.9**				
Annual Fuel Consumption (IG x10^6):			**20.0**				
Emissions Tonnage (Kilotonnes):				**5.1**	**1.5**	**0.5**	**0.2**
Using factor of 277 (Historical):				**5.0**	**1.5**	**0.5**	**0.2**

Summary	Emissions Factors			
	NOx	CO	HC	PM
	g/IG	g/IG	g/IG	g/IG
Summary (F= Calculated):				
Freight Tonnage (Kilotonnes):	**106.4**	**16.3**	**4.3**	**1.9**
Passenger Tonnage (Kilotonnes):	**3.7**	**0.6**	**0.1**	**0.1**
Switcher Tonnage (Kilotonnes):	**3.3**	**0.6**	**0.1**	**0.1**
Total Tonnage (Kilotonnes)	**113.4**	**17.4**	**4.6**	**2.1**
Summary (F= 248 Historical):				
Freight Tonnage (Kilotonnes):	**98.0**	**24.6**	**5.4**	**2.8**
Passenger Tonnage (Kilotonnes):	**3.3**	**0.6**	**0.1**	**0.1**
Switcher Tonnage (Kilotonnes):	**5.1**	**1.5**	**0.5**	**0.2**
Total Tonnage (Kilotonnes)	**106.4**	**26.6**	**6.0**	**3.0**

APPENDIX H

PROJECTIONS

ON THE

INFLUENCE OF

FUTURE FLEET PROFILE

ON EMISSIONS

Appendix H: Projections on the Influence of Future Fleet Profile on Emissions

Scenario 1: Fast Track

1-Year Projection

New:	**Required for 2.5% traffic growth**		**33**
	To replace retired SD-40		**67**
	Total:		**100**
Overhauled to Tier 0		**SD-75**	**50**
		GE Dash 9	**50**
Retired SD-40		**SD-40**	**90**

Road Locomotives

Model	**Engine**	**HP**	**No. of Locos.**	**Utilization**	**hrs/yr**	**Fuel Cons. lb/hr**	**Fuel Cons. L/hr**	**Fuel Cons. L/yr ($x10^6$)**
SD-40	645	3000	861	82.3%	7209.5	250.4	133.8	830.3
SD-50	645	3600	71	83.3%	7297.1	285.5	152.5	79.0
SD-60	710	3800	63	78.0%	6832.8	266.0	142.1	61.2
SD 70	710	4000	12	78.0%	6832.8	300.0	160.2	13.1
SD-70	710	3000	7	78.0%	6832.8	238.3	127.3	6.1
SD-75	710	4300	190	78.0%	6832.8	280.4	149.8	194.4
SD-75	Tier 0	rebuilt	50	78.0%	6832.8	280.4	149.8	51.2
SD 90	710	6000	4	78.0%	6832.8	391.3	209.0	5.7
Dash 8	7FDL	4000	84	78.0%	6832.8	270.2	144.3	82.8
Dash 9	7FDL	4400	179	78.0%	6832.8	297.2	158.7	194.2
Dash 9	Tier 0	new or rebuilt	230	78.0%	6832.8	297.2	158.7	249.5
Dash 9	Tier 1	new	100	78.0%	6832.8	297.2	158.7	108.5

Model	**Engine**	**HP**	**Fuel Cons L/yr ($x10^6$)**	**Emissions Factors NOx g/IG**	**CO g/IG**	**HC g/IG**	**PM g/IG**
SD-40	645	3000	830.3	247.5	52.7	12.9	4.7
SD-50	645	3600	79.0	247.5	52.7	12.9	4.7
SD-60	710	3800	61.2	340.1	22.1	9.0	7.2
SD 70	710	4000	13.1	338.8	21.9	8.6	7.2
SD-75	710	4300	194.4	339.5	22.2	9.1	7.3
SD-75	Tier 0	rebuilt	51.2	222.1	22.2	9.1	7.3
SD-70	710	3000	6.1	324.1	22.4	8.7	7.4
SD 90	710	6000	5.7	473.1	30.9	12.0	10.0
Dash 8	7FDL	4000	82.8	241.5	126.7	12.9	7.0
Dash 9	7FDL	4400	194.2	310.7	20.4	7.4	2.7
Dash 9	Tier 0	new or rebuilt	249.5	204.6	20.4	7.4	2.7
	Tier 1	new	108.5	159.4	20.4	7.4	2.7
Fuel Consumption Road (L $x10^6$):			**1875.9**				
Fuel Consumption Road (IG $x10^6$):			**413.2**				
Factor: Road (g/IG)				**256.4**	**39.2**	**9.9**	**4.3**
Annual Tonnage Road (Kilotonnes)				**106.0**	**0.5**	**0.1**	**0.1**

Appendix H: Projections on the Influence of Future Fleet Profile on Emissions

Passenger Locomotives

Model	Engine	HP	No. of Locos.	Utilization	hrs/yr	Fuel Cons. lb/hr	Fuel Cons. L/hr	Fuel Cons. L/yr x10^6
SD-40	645	3000	61	45.1%	3950.8	296.7	158.5	38.2
F59PH	710	3000	45	45.1%	3950.8	238.3	127.3	22.6

Model	Engine	HP	Fuel Cons. L/yr x10^6	Emissions Factors NOx g/IG	CO g/IG	HC g/IG	PM g/IG
SD-40	645	3000	38.2	247.2	55.2	12.2	6.3
F59PH	710	3000	22.6	324.1	22.4	8.7	0.0
Fuel Consumption Passenger (L x10^6):			**60.8**				
Fuel Consumption Passenger (IG x10^6):			**13.4**				
Factor: Passenger (g/IG)				**275.8**	**43.0**	**10.9**	**4.0**
Annual Tonnage Passenger (Kilotonnes)				**3.7**	**0.6**	**0.1**	**0.1**

Switcher Locomotives

Model	Engine	HP	No. of Locos.	Utilization	hrs/yr	Fuel Cons. lb/hr	Fuel Cons. L/hr	Fuel Cons. L/yr x10^6
8V	567	900	14	20.3%	1778.3	18.4	9.8	0.2
12V	567	1200	59	20.3%	1778.3	42.1	22.5	2.4
	567	1500	32	20.3%	1778.3	52.6	28.1	1.6
	567	1750	258	20.3%	1778.3	61.4	32.8	15.0
12V	645	1200	81	20.3%	1778.3	63.4	33.9	4.9
12V	645	1350	3	20.3%	1778.3	71.3	38.1	0.2
	645	1500	11	20.3%	1778.3	79.3	42.3	0.8
	645	1750/1800	193	20.3%	1778.3	95.1	50.8	17.4
	645	2000	264	20.3%	1778.3	105.7	56.4	26.5
	645	3000	20	20.3%	1778.3	158.5	84.7	3.0
		other	163	20.3%	1778.3	63.4	33.9	9.8

Model	Engine	HP	Fuel Cons. L/yr x10^6	Emissions Factors NOx g/IG	CO g/IG	HC g/IG	PM g/IG
SD-40	645		52.9	261.8	73.4	23.4	6.9
other			29.1	245.6	72.8	22.0	8.8
Fuel Consumption Switcher (L x10^6):			**82.0**				
Fuel Consumption Switcher (IG x10^6):			**18.1**				
Factor: Switcher (g/IG)				**256.0**	**73.2**	**22.9**	**7.5**
Annual Tonnage Switcher (Kilotonnes)				**4.6**	**1.3**	**0.4**	**0.1**
Total Tonnage Scenario 1 (1-Year Projection)				**114.3**	**2.4**	**0.7**	**0.2**

Appendix H: Projections on the Influence of Future Fleet Profile on Emissions

5-Year Projection

			2001	2002	2003	2004	2005	2006
	Horsepower requirement		5786800	5931470	6079757	6231751	6387544.4	6547233
New:	**Required for 2.5% traffic growth**			**33**	67	101	137	**173**
	To replace retired SD-40			**67**	133	199	263	**327**
	Total:			**100**	200	300	400	**500**
Overhauled to Tier 0		**SD-75**		**50**	100	150	200	**240**
		GE Dash 9		**50**	100	150	200	**230**
Retired SD-40		**SD-40**		**90**	200	299	395	**491**

Road Locomotives

Model	Engine	HP	No. of Locos.	Utilization	hrs/yr	Fuel Cons. lb/hr	Fuel Cons. L/hr	Fuel Cons. L/yr x10⁶
SD-40	645	3000	460	82.3%	7209.5	250.4	133.8	443.8
SD-50	645	3600	71	83.3%	7297.1	285.5	152.5	79.0
SD-60	710	3800	63	78.0%	6832.8	266.0	142.1	61.2
SD 70	710	4000	12	78.0%	6832.8	300.0	160.2	13.1
SD-75	710	4300	0	78.0%	6832.8	280.4	149.8	0.0
SD-75	Tier 0	rebuilt	240	78.0%	6832.8	280.4	149.8	245.6
SD 90	710	6000	4	78.0%	6832.8	391.3	209.0	5.7
Dash 8	7FDL	4000	84	78.0%	6832.8	270.2	144.3	82.8
Dash 9	7FDL	4400	0	78.0%	6832.8	297.2	158.7	0.0
Dash 9	Tier 0	new or rebuilt	408	78.0%	6832.8	297.2	158.7	442.5
Dash 9	Tier 1	new	500	78.0%	6832.8	297.2	158.7	542.3

Model	Engine	HP	Fuel Cons. L/yr x10⁶	Emissions Factors NOx g/IG	CO g/IG	HC g/IG	PM g/IG
SD-40	645	3000	443.8	247.5	52.7	12.9	4.7
SD-50	645	3600	79.0	247.5	52.7	12.9	4.7
SD-60	710	3800	61.2	340.1	22.1	9.0	7.2
SD 70	710	4000	13.1	338.8	21.9	8.6	7.2
SD-75	710	4300	0.0	339.5	22.2	9.1	7.3
SD-75	Tier 0	rebuilt	245.6	222.1	22.2	9.1	7.3
SD-70	710	3000	5.7	324.1	22.4	8.7	7.4
SD 90	710	6000	5.7	473.1	30.9	12.0	10.0
Dash 8	7FDL	4000	82.8	241.5	126.7	12.9	7.0
Dash 9	7FDL	4400	0.0	310.7	20.4	7.4	2.7
Dash 9	Tier 0	new or rebuilt	442.5	204.6	20.4	7.4	2.7
	Tier 1	new	542.3	159.4	20.4	7.4	2.7
Fuel Consumption Road (L x10⁶):			**1921.9**				
Fuel Consumption Road (IG x10⁶):			**423.3**				
Generalized Factor Road (g/IG)				**213.7**	**25.4**	**6.2**	**2.5**
Annual Tonnage Road (Kilotonnes)				**90.5**	**10.8**	**2.6**	**1.1**

Appendix H: Projections on the Influence of Future Fleet Profile on Emissions

Passenger Locomotives

Model	Engine	HP	No. of Locos.	Utilization	hrs/yr	Fuel Cons. lb/hr	Fuel Cons. L/hr	Fuel Cons. L/yr x10^6
SD-40	645	3000	61	45.1%	3950.8	296.7	158.5	38.2
F59PH	710	3000	45	45.1%	3950.8	238.3	127.3	22.6

Model	Engine	HP	Fuel Cons. L/yr x 10^6	Emissions Factors NOx g/IG	CO g/IG	HC g/IG	PM g/IG
SD-40	645	3000	38.2	247.2	55.2	12.2	6.3
F59PH	710	3000	22.6	324.1	22.4	8.7	0.0
Fuel Consumption Passenger (L x10^6):			**60.8**				
Fuel Consumption Passenger (IG x10^6):			**13.4**				
Generalized Factor Passenger (g/IG)				**275.8**	**43.0**	**10.9**	**4.0**
Annual Tonnage Passenger (Kilotonnes)				**3.7**	**0.6**	**0.1**	**0.1**

Switcher Locomotives

Model	Engine	HP	No. of Locos.	Utilization	hrs/yr	Fuel Cons. lb/hr	Fuel Cons. L/hr	Fuel Cons. L/yr x10^6
8V	567	900	14	20.3%	1778.3	18.4	9.8	0.2
12V	567	1200	59	20.3%	1778.3	42.1	22.5	2.4
	567	1500	32	20.3%	1778.3	52.6	28.1	1.6
	567	1750	258	20.3%	1778.3	61.4	32.8	15.0
12V	645	1200	81	20.3%	1778.3	63.4	33.9	4.9
12V	645	1350	3	20.3%	1778.3	71.3	38.1	0.2
	645	1500	11	20.3%	1778.3	79.3	42.3	0.8
	645	1750/1800	193	20.3%	1778.3	95.1	50.8	17.4
	645	2000	264	20.3%	1778.3	105.7	56.4	26.5
	645	3000	20	20.3%	1778.3	158.5	84.7	3.0
		other	163	20.3%	1778.3	63.4	33.9	9.8

Model	Engine	HP	Fuel Cons. L/yr x10^6	Emissions Factors NOx g/IG	CO g/IG	HC g/IG	PM g/IG
SD-40	645		52.9	261.8	73.4	23.4	6.9
other			29.1	245.6	72.8	22.0	8.8
Fuel Consumption Switcher (L x10^6):			**82.0**				
Fuel Consumption Switcher (IG x10^6):			**18.1**				
Generalized Factor Switcher (g/IG)				**256.0**	**73.2**	**22.9**	**7.5**
Annual Tonnage Switcher (Kilotonnes)				**4.6**	**1.3**	**0.4**	**0.1**
Total Tonnage Scenario 1 (5-Year Projection)				**98.8**	**12.7**	**3.2**	**1.3**

Scenario 2 Medium Track

1-Year Projection

New:	**Required for 2.0% traffic growth**		**27**
	To replace retired SD-40		**23**
	Total:		**50**
Overhauled to Tier 0		**SD-75**	**25**
		GE Dash 9	**25**
Retired SD-40		**SD-40**	**30**

Road Locomotives

Model	**Engine**	**HP**	**No. of Locos.**	**Utilization**	**hrs/yr**	**Fuel Cons. lb/hr**	**Fuel Cons. L/hr**	**Fuel Cons. L/yr x10⁶**
SD-40	645	3000	921	82.3%	7209.5	250.4	133.8	888.1
SD-50	645	3600	71	83.3%	7297.1	285.5	152.5	79.0
SD-60	710	3800	63	78.0%	6832.8	266.0	142.1	61.2
SD 70	710	4000	12	78.0%	6832.8	300.0	160.2	13.1
SD-75	710	4300	215	78.0%	6832.8	280.4	149.8	220.0
SD-75	Tier 0	rebuilt	25	78.0%	6832.8	280.4	149.8	25.6
SD 90	710	6000	4	78.0%	6832.8	391.3	209.0	5.7
Dash 8	7FDL	4000	84	78.0%	6832.8	270.2	144.3	82.8
Dash 9	7FDL	4400	205	78.0%	6832.8	297.2	158.7	222.4
Dash 9	Tier 0	new or rebuilt	204	78.0%	6832.8	297.2	158.7	221.3
Dash 9	Tier 1	new	50	78.0%	6832.8	297.2	158.7	54.2

Model	**Engine**	**HP**	**Fuel Cons. L/yr x10⁶**	**Emissions Factors NOx g/IG**	**CO g/IG**	**HC g/IG**	**PM g/IG**
SD-40	645	3000	888.1	247.5	52.7	12.9	4.7
SD-50	645	3600	79.0	247.5	52.7	12.9	4.7
SD-60	710	3800	61.2	340.1	22.1	9.0	7.2
SD 70	710	4000	13.1	338.8	21.9	8.6	7.2
SD-75	710	4300	220.0	339.5	22.2	9.1	7.3
SD-75	Tier 0	rebuilt	25.6	222.1	22.2	9.1	7.3
SD-70	710	3000	5.7	324.1	22.4	8.7	7.4
SD 90	710	6000	5.7	473.1	30.9	12.0	10.0
Dash 8	7FDL	4000	82.8	241.5	126.7	12.9	7.0
Dash 9	7FDL	4400	222.4	310.7	20.4	7.4	2.7
Dash 9	Tier 0	new or rebuilt	221.3	204.6	20.4	7.4	2.7
Dash 9	Tier 1	new	54.2	159.4	20.4	7.4	2.7
Fuel Consumption Road (L x10⁶):			**1879.1**				
Fuel Consumption Road (IG x10⁶):			**413.9**				
Generalized Factor Road (g/IG)				**262.1**	**41.1**	**10.4**	**4.5**
Annual Tonnage Road (Kilotonnes)				**108.5**	**17.0**	**4.3**	**1.9**

Appendix H: Projections on the Influence of Future Fleet Profile on Emissions

Passenger Locomotives

Model	Engine	HP	No. of Locos.	Utilization	hrs/yr	Fuel Cons. lb/hr	Fuel Cons. L/hr	Fuel Cons. L/yr x10^6
SD-40	645	3000	61	45.1%	3950.8	296.7	158.5	38.2
F59PH	710	3000	45	45.1%	3950.8	238.3	127.3	22.6

Model	Engine	HP	Fuel Cons. L/yr x10^6	Emissions Factors NOx g/IG	CO g/IG	HC g/IG	PM g/IG
SD-40	645	3000	38.2	247.2	55.2	12.2	6.3
F59PH	710	3000	22.6	324.1	22.4	8.7	6.3
Fuel Consumption Passenger (L x10^6):			**60.8**				
Fuel Consumption Passenger (IG x10^6):			**13.4**				
Generalized Factor Passenger (g/IG)				**275.8**	**43.0**	**10.9**	**6.3**
Annual Tonnage Passenger (Kilotonnes)				**3.7**	**0.6**	**0.1**	**0.1**

Switcher Locomotives

Model	Engine	HP	No. of Locos.	Utilization	hrs/yr	Fuel Cons. lb/hr	Fuel Cons. L/hr	Fuel Cons. L/yr x10^6
8V	567	900	14	20.3%	1778.3	18.4	9.8	0.2
12V	567	1200	59	20.3%	1778.3	42.1	22.5	2.4
	567	1500	32	20.3%	1778.3	52.6	28.1	1.6
	567	1750	258	20.3%	1778.3	61.4	32.8	15.0
12V	645	1200	81	20.3%	1778.3	63.4	33.9	4.9
12V	645	1350	3	20.3%	1778.3	71.3	38.1	0.2
	645	1500	11	20.3%	1778.3	79.3	42.3	0.8
	645	1750/1800	193	20.3%	1778.3	95.1	50.8	17.4
	645	2000	264	20.3%	1778.3	105.7	56.4	26.5
	645	3000	20	20.3%	1778.3	158.5	84.7	3.0
		other	163	20.3%	1778.3	63.4	33.9	9.8

Model	Engine	HP	Fuel Cons. L/yr x10^6	Emissions Factors NOx g/IG	CO g/IG	HC g/IG	PM g/IG
SD-40	645		52.9	261.8	73.4	23.4	6.9
other			29.1	245.6	72.8	22.0	8.8
Fuel Consumption Switcher (L x10^6):			**82.0**				
Fuel Consumption Switcher (IG x10^6):			**18.1**				
Generalized Factor Switcher (g/IG)				**256.0**	**73.2**	**22.9**	**7.5**
Annual Tonnage Switcher (Kilotonnes)				**4.6**	**1.3**	**0.4**	**0.1**
Total Tonnage Scenario 2 (1-Year Projection)				**116.8**	**18.9**	**4.9**	**2.1**

5-Year Projection							
		2001	2002	2003	2004	2005	2006
	Horsepower requirement	5786800	5902536	6020587	6140998	6263818.4	6389095
New:	Required for 2.0% traffic growth		26	53	80	108	**137**
	To replace retired SD-40		24	47	70	92	**113**
	Total:		50	100	150	200	**250**
Overhauled to Tier 0	SD-75		**25**	50	75	100	**125**
	GE Dash 9		**25**	50	75	100	**125**
Retired SD-40	SD-40		**30**	70	104	137	**170**

Road Locomotives

Model	Engine	HP	No. of Locos.	Utilization	hrs/yr	Fuel Cons. lb/hr	Fuel Cons. L/hr	Fuel Cons. L/yr $x10^6$
SD-40	645	3000	781	82.3%	7209.5	250.4	133.8	753.4
SD-50	645	3600	71	83.3%	7297.1	285.5	152.5	79.0
SD-60	710	3800	63	78.0%	6832.8	266.0	142.1	61.2
SD 70	710	4000	7	78.0%	6832.8	238.3	127.3	6.1
SD 70	710	4000	12	78.0%	6832.8	300.0	160.2	13.1
SD-75	710	4300	115	78.0%	6832.8	280.4	149.8	117.7
SD-75	Tier 0	rebuilt	125	78.0%	6832.8	280.4	149.8	127.9
SD 90	710	6000	4	78.0%	6832.8	391.3	209.0	5.7
Dash 8	7FDL	4000	84	78.0%	6832.8	270.2	144.3	82.8
Dash 9	7FDL	4400	105	78.0%	6832.8	297.2	158.7	113.9
Dash 9	Tier 0	new or rebuilt	304	78.0%	6832.8	297.2	158.7	329.7
Dash 9	Tier 1	new	250	78.0%	6832.8	297.2	158.7	271.2

Model	Engine	HP	Fuel Cons. L/yr $x10^6$	Emissions Factors NOx g/IG	CO g/IG	HC g/IG	PM g/IG
SD-40	645	3000	753.4	247.5	52.7	12.9	4.7
SD-50	645	3600	79.0	247.5	52.7	12.9	4.7
SD-60	710	3800	61.2	340.1	22.1	9.0	7.2
SD 70	710	4000	13.1	338.8	21.9	8.6	7.2
SD-75	710	4300	117.7	339.5	22.2	9.1	7.3
SD-75	Tier 0	rebuilt	127.9	222.1	22.2	9.1	7.3
SD-70	710	3000	5.7	324.1	22.4	8.7	7.4
SD 90	710	6000	5.7	473.1	30.9	12.0	10.0
Dash 8	7FDL	4000	82.8	241.5	126.7	12.9	7.0
Dash 9	7FDL	4400	113.9	310.7	20.4	7.4	2.7
Dash 9	Tier 0	new or rebuilt	329.7	204.6	20.4	7.4	2.7
Dash 9	Tier 1	new	271.2	159.4	20.4	7.4	2.7
Fuel Consumption Road (L $x10^6$):			**1961.4**				
Fuel Consumption Road (IG $x10^6$):			**432.0**				
Generalized Factor Road (g/IG)				**239.8**	**34.6**	**8.6**	**3.7**
Annual Tonnage Road (Kilotonnes)				**103.6**	**14.9**	**3.7**	**1.6**

Appendix H: Projections on the Influence of Future Fleet Profile on Emissions

Passenger Locomotives

Model	Engine	HP	No. of Locos.	Utilization	hrs/yr	Fuel Cons. lb/hr	Fuel Cons. L/hr	Fuel Cons. L/yr x10^6
SD-40	645	3000	61	45.1%	3950.8	296.7	158.5	38.2
F59PH	710	3000	45	45.1%	3950.8	238.3	127.3	22.6

Model	Engine	HP	Fuel Cons. L/yr x10^6	Emissions Factors NOx g/IG	CO g/IG	HC g/IG	PM g/IG
SD-40	645	3000	38.2	247.2	55.2	12.2	6.3
F59PH	710	3000	22.6	324.1	22.4	8.7	0.0
Fuel Consumption Passenger (L x10^6):			**60.8**				
Fuel Consumption Passenger (IG x10^6):			**13.4**				
Generalized Factor Passenger (g/IG)				**275.8**	**43.0**	**10.9**	**4.0**
Annual Tonnage Passenger (Kilotonnes)				**3.7**	**0.6**	**0.1**	**0.1**

Switcher Locomotives

Model	Engine	HP	No. of Locos.	Utilization	hrs/yr	Fuel Cons. lb/hr	Fuel Cons. L/hr	Fuel Cons. L/yr x10^6
8V	567	900	14	20.3%	1778.3	18.4	9.8	0.2
12V	567	1200	59	20.3%	1778.3	42.1	22.5	2.4
	567	1500	32	20.3%	1778.3	52.6	28.1	1.6
	567	1750	258	20.3%	1778.3	61.4	32.8	15.0
12V	645	1200	81	20.3%	1778.3	63.4	33.9	4.9
12V	645	1350	3	20.3%	1778.3	71.3	38.1	0.2
	645	1500	11	20.3%	1778.3	79.3	42.3	0.8
	645	1750/1800	193	20.3%	1778.3	95.1	50.8	17.4
	645	2000	264	20.3%	1778.3	105.7	56.4	26.5
	645	3000	20	20.3%	1778.3	158.5	84.7	3.0
		other	163	20.3%	1778.3	63.4	33.9	9.8

Model	Engine	HP	Fuel Cons. L/yr x10^6	Emissions Factors NOx g/IG	CO g/IG	HC g/IG	PM g/IG
SD-40	645		52.9	261.8	73.4	23.4	6.9
other			37.9	245.6	72.8	22.0	8.8
Fuel Consumption Switcher (L x10^6):			**90.8**				
Fuel Consumption Switcher (IG x10^6):			**20.0**				
Generalized Factor Switcher (g/IG)				**256.0**	**73.2**	**22.9**	**7.5**
Annual Tonnage Switcher (Kilotonnes)				**5.1**	**1.5**	**0.5**	**0.2**
Total Tonnage Scenario 2 (5-Year Projection)				**112.4**	**17.0**	**4.3**	**1.8**

Scenario 3 Slow Track

1-Year Projection

New:	**Required for 1.0% traffic growth**		**13**
	To replace retired SD-40		**12**
	Total:		**25**
Overhauled to Tier 0		**SD-75**	**12**
		GE Dash 9	**13**
Retired SD-40		**SD-40**	**18**

Road Locomotives

Model	**Engine**	**HP**	**No. of Locos.**	**Utilization**	**hrs/yr**	**Fuel Cons. lb/hr**	**Fuel Cons. L/hr**	**Fuel Cons. L/yr x10^6**
SD-40	645	3000	933	82.3%	7209.5	250.4	133.8	899.7
SD-50	645	3600	71	83.3%	7297.1	285.5	152.5	79.0
SD-60	710	3800	63	78.0%	6832.8	266.0	142.1	61.2
SD 70	710	4000	12	78.0%	6832.8	300.0	160.2	13.1
SD-75	710	4300	228	78.0%	6832.8	280.4	149.8	233.3
SD-75	Tier 0	rebuilt	12	78.0%	6832.8	280.4	149.8	12.3
SD 90	710	6000	4	78.0%	6832.8	391.3	209.0	5.7
Dash 8	7FDL	4000	84	78.0%	6832.8	270.2	144.3	82.8
Dash 9	7FDL	4400	217	78.0%	6832.8	297.2	158.7	235.4
Dash 9	Tier 0	new or rebuilt	192	78.0%	6832.8	297.2	158.7	208.3
Dash 9	Tier 1	new	25	78.0%	6832.8	297.2	158.7	27.1

Model	**Engine**	**HP**	**Fuel Cons. L/yr x10^6**	**Emissions Factors NOx g/IG**	**CO g/IG**	**HC g/IG**	**PM g/IG**
SD-40	645	3000	899.7	247.5	52.7	12.9	4.7
SD-50	645	3600	79.0	247.5	52.7	12.9	4.7
SD-60	710	3800	61.2	340.1	22.1	9.0	7.2
SD 70	710	4000	13.1	338.8	21.9	8.6	7.2
SD-75	710	4300	233.3	339.5	22.2	9.1	7.3
SD-75	Tier 0	rebuilt	12.3	222.1	22.2	9.1	7.3
SD-70	710	3000	5.7	324.1	22.4	8.7	7.4
SD 90	710	6000	5.7	473.1	30.9	12.0	10.0
Dash 8	7FDL	4000	82.8	241.5	126.7	12.9	7.0
Dash 9	7FDL	4400	235.4	310.7	20.4	7.4	2.7
Dash 9	Tier 0	new or rebuilt	208.3	204.6	20.4	7.4	2.7
Dash 9	Tier 1	new	27.1	159.4	20.4	7.4	2.7
Fuel Consumption Road (L x10^6):			**1863.6**				
Fuel Consumption Road (IG x10^6):			**410.5**				
Generalized Factor Road (g/IG)				**265.1**	**41.9**	**10.7**	**4.7**
Annual Tonnage Road (Kilotonnes)				**108.8**	**17.2**	**4.4**	**1.9**

Passenger Locomotives

Model	Engine	HP	No. of Locos.	Utilization	hrs/yr	Fuel Cons. lb/hr	Fuel Cons. L/hr	Fuel Cons. L/yr x10^6
SD-40	645	3000	61	45.1%	3950.8	0.0	0.0	0.0
F59PH	710	3000	45	45.1%	3950.8	238.3	127.3	22.6

Model	Engine	HP	Fuel Cons. L/yr x10^6	Emissions Factors NOx g/IG	CO g/IG	HC g/IG	PM g/IG
SD-40	645	3000	38.2	247.2	55.2	12.2	6.3
F59PH	710	3000	22.6	324.1	22.4	8.7	0.0
Fuel Consumption Passenger (L x10^6):			**60.8**				
Fuel Consumption Passenger (IG x10^6):			**13.4**				
Generalized Factor Passenger (g/IG)				**275.8**	**43.0**	**10.9**	**4.0**
Annual Tonnage Passenger (kilotonnes)				**3.7**	**0.6**	**0.1**	**0.1**

Switcher Locomotives

Model	Engine	HP	No. of Locos.	Utilization	hrs/yr	Fuel Cons. lb/hr	Fuel Cons. L/hr	Fuel Cons. L/yr x10^6
8V	567	900	14	20.3%	1778.3	18.4	9.8	0.2
12V	567	1200	59	20.3%	1778.3	42.1	22.5	2.4
	567	1500	32	20.3%	1778.3	52.6	28.1	1.6
	567	1750	258	20.3%	1778.3	61.4	32.8	15.0
12V	645	1200	81	20.3%	1778.3	63.4	33.9	4.9
12V	645	1350	3	20.3%	1778.3	71.3	38.1	0.2
	645	1500	11	20.3%	1778.3	79.3	42.3	0.8
	645	1750/1800	193	20.3%	1778.3	95.1	50.8	17.4
	645	2000	264	20.3%	1778.3	105.7	56.4	26.5
	645	3000	20	20.3%	1778.3	158.5	84.7	3.0
		other	163	20.3%	1778.3	63.4	33.9	9.8

Model	Engine	HP	Fuel Cons. L/yr x10^6	Emissions Factors NOx g/IG	CO g/IG	HC g/IG	PM g/IG
SD-40	645		52.9	261.8	73.4	23.4	6.9
other			37.9	245.6	72.8	22.0	8.8
Fuel Consumption Switcher (L x10^6):			**90.8**				
Fuel Consumption Switcher (IG x10^6):			**20.0**				
Generalized Factor Switcher (g/IG)				**255.0**	**73.1**	**22.8**	**7.7**
Annual Tonnage Switcher (Kilotonnes)				**5.1**	**1.5**	**0.5**	**0.2**
Total Tonnage Scenario 3 (1-Year Projection)				**117.6**	**19.2**	**5.0**	**2.1**

5-Year Projection

		2001	2002	2003	2004	2005	2006
	Horsepower requirement	**5786800**	**5844668**	**5903115**	**5962146**	**6021767.3**	**6081985**
New:	**Required for 1.0% traffic growth**		**13**	**26**	**40**	**53**	**67**
	To replace retired SD-40		**12**	24	35	47	**58**
	Total:		**25**	50	75	100	**125**
Overhauled to Tier 0	**SD-75**		**12**	24	36	48	**60**
	GE Dash 9		**13**	26	39	52	**65**
Retired SD-40	**SD-40**		**18**	35	53	70	**87**

Road Locomotives

Model	**Engine**	**HP**	**No. of Locos.**	**Utilization**	**hrs/yr**	**Fuel Cons. lb/hr**	**Fuel Cons. L/hr**	**Fuel Cons. L/yr x10^6**
SD-40	645	3000	864	82.3%	7209.5	250.4	133.8	833.3
SD-50	645	3600	71	83.3%	7297.1	285.5	152.5	79.0
SD-60	710	3800	63	78.0%	6832.8	266.0	142.1	61.2
SD 70	710	4000	12	78.0%	6832.8	300.0	160.2	13.1
SD-75	710	4300	180	78.0%	6832.8	280.4	149.8	184.2
SD-75	Tier 0	rebuilt	60	78.0%	6832.8	280.4	149.8	61.4
SD 90	710	6000	4	78.0%	6832.8	391.3	209.0	5.7
Dash 8	7FDL	4000	84	78.0%	6832.8	270.2	144.3	82.8
Dash 9	7FDL	4400	165	78.0%	6832.8	297.2	158.7	179.0
Dash 9	Tier 0	new or rebuilt	244	78.0%	6832.8	297.2	158.7	264.7
Dash 9	Tier 1	new	125	78.0%	6832.8	297.2	158.7	135.6

Model	**Engine**	**HP**	**Fuel Cons. L/yr x10^6**	**Emissions Factors NOx g/IG**	**CO g/IG**	**HC g/IG**	**PM g/IG**
SD-40	645	3000	833.3	247.5	52.7	12.9	4.7
SD-50	645	3600	79.0	247.5	52.7	12.9	4.7
SD-60	710	3800	61.2	340.1	22.1	9.0	7.2
SD 70	710	4000	13.1	338.8	21.9	8.6	7.2
SD-75	710	4300	184.2	339.5	22.2	9.1	7.3
SD-75	Tier 0	rebuilt	61.4	222.1	22.2	9.1	7.3
SD-70	710	3000	5.7	324.1	22.4	8.7	7.4
SD 90	710	6000	5.7	473.1	30.9	12.0	10.0
Dash 8	7FDL	4000	82.8	241.5	126.7	12.9	7.0
Dash 9	7FDL	4400	179.0	310.7	20.4	7.4	2.7
Dash 9	Tier 0	new or rebuilt	264.7	204.6	20.4	7.4	2.7
Dash 9	Tier 1	new	135.6	159.4	20.4	7.4	2.7
Fuel Consumption Road (L x10^6):			**1905.7**				
Fuel Consumption Road (IG x10^6):			**419.7**				
Generalized Factor Road (g/IG)				**253.5**	**38.6**	**9.7**	**4.2**
Annual Tonnage Road (Kilotonnes)				**106.4**	**16.2**	**4.1**	**1.8**

Passenger Locomotives

Model	Engine	HP	No. of Locos.	Utilization	hrs/yr	Fuel Cons. lb/hr	Fuel Cons. L/hr	Fuel Cons. L/yr x10^6
SD-40	645	3000	61	45.1%	3950.8	296.7	158.5	38.2
F59PH	710	3000	45	45.1%	3950.8	238.3	127.3	22.6

Model	Engine	HP	Fuel Cons. L/yr x10^6	Emissions Factors NOx g/IG	CO g/IG	HC g/IG	PM g/IG
SD-40	645	3000	38.2	247.2	55.2	12.2	6.3
F59PH	710	3000	22.6	324.1	22.4	8.7	0.0
Fuel Consumption Passenger (L x10^6):			**60.8**				
Fuel Consumption Passenger (IG x10^6):			**13.4**				
Generalized Factor Passenger (g/IG)				**275.8**	**43.0**	**10.9**	**4.0**
Annual Tonnage Passenger (Kilotonnes)				**3.7**	**0.6**	**0.1**	**0.1**

Switcher Locomotives

Model	Engine	HP	No. of Locos.	Utilization	hrs/yr	Fuel Cons. lb/hr	Fuel Cons. L/hr	Fuel Cons. L/yr x10^6
8V	567	900	14	20.3%	1778.3	18.4	9.8	0.2
12V	567	1200	59	20.3%	1778.3	42.1	22.5	2.4
	567	1500	32	20.3%	1778.3	52.6	28.1	1.6
	567	1750	258	20.3%	1778.3	61.4	32.8	15.0
12V	645	1200	81	20.3%	1778.3	63.4	33.9	4.9
12V	645	1350	3	20.3%	1778.3	71.3	38.1	0.2
	645	1500	11	20.3%	1778.3	79.3	42.3	0.8
	645	1750/1800	193	20.3%	1778.3	95.1	50.8	17.4
	645	2000	264	20.3%	1778.3	105.7	56.4	26.5
	645	3000	20	20.3%	1778.3	158.5	84.7	3.0
		other	163	20.3%	1778.3	63.4	33.9	9.8

Model	Engine	HP	Fuel Cons. L/yr x10^6	Emissions Factors NOx g/IG	CO g/IG	HC g/IG	PM g/IG
SD-40	645		52.9	261.8	73.4	23.4	6.9
other			37.9	245.6	72.8	22.0	8.8
Fuel Consumption Switcher (L x10^6):			**90.8**				
Fuel Consumption Switcher (IG x10^6):			**20.0**				
Generalized Factor Switcher (g/IG)				**255.0**	**73.1**	**22.8**	**7.7**
Annual Tonnage Switcher (Kilotonnes)				**5.1**	**1.5**	**0.5**	**0.2**
Total Tonnage Scenario 3 (5-Year Projection)				**115.2**	**18.2**	**4.7**	**2.0**