North Central Texas Council of Governments

TEXAS EMISSIONS REDUCTION PLAN (TERP)

NORTH TEXAS EMISSIONS REDUCTION GRANT

Technical Supplement for

Locomotives

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Technical Supplement for Locomotives

Summary

This supplement contains the calculations for activities involving locomotives, including: new purchases and leases, replacement, repower, retrofit, and add-on activities.

Diesel-fueled compression-ignition engines will power most of the engines eligible under this program. However, engines powered by other fuels may also be eligible, subject to decisions by the NCTCOG for particular funding periods.

Use the worksheet provided (LO-1) at the end of this chapter to calculate the emission reductions and the cost-effectiveness of the activities proposed in your project.

This workbook is divided into three major steps.

Step 1: Does the activity meet the 25% NOx emissions reduction requirement?
Step 2: Calculate the NOx Emission Reductions.
Step 3: Calculate the Cost Per Ton.

These steps are explained in the following instructions. You should refer to the worksheet and use the instructions to complete each step of the calculations.

Step 1: Does the activity meet the 25% NOx emissions reduction requirement?

All new purchase or lease, replacement, repower, retrofit, and add-on activities must meet requirements related to reductions in NOx emission levels when compared to a baseline emission level. Use the worksheet to determine if your activity meets the minimum emission reduction requirements. Most of the calculations will require input of a NOx emission standard applicable to the engine and/or locomotive.

Baseline NOx Emission Standard

Criteria have been established to determine the eligibility of an activity, based on the NOx federal certified emission standard for locomotive engines (see table 4.1). In situations where the model year of the locomotive and the model year of the existing engine are different, the model year of the engine must be used to determine the baseline emission standard for emission reduction calculations.

Table 4.1 Diesel Locomotives NOx Emission Standard by Model Year

Duty Cycle	Tier Level	Model Year	NOx Emission g/bhp-hr
Line Haul	Uncontrolled	N/A	13
	Tier 0	1973-2001	9.5
	Tier 1	2002-2004	7.4
	Tier 2	2005+	5.5

Duty Cycle	Tier Level	Model Year	NOx Emission g/bhp-hr
Switchers	Uncontrolled	N/A	17.4
	Tier 0	1973-2001	14.0
	Tier 1	2002-2004	11.0
	Tier 2	2005+	8.1

Reduced NOx Emission Standard

The reduced NOx emission standard will normally be the certified or verified emissions of the reduced-emission locomotive or engine found in Table 4.1.

- **New Purchase or Lease.** Use the certified emission rate (g/bhp-hr) of the new locomotive. Certified means certified by the EPA or CARB, or otherwise accepted by the NCTCOG.
- **Replacement.** Use the certified emission rate (g/bhp-hr) of the replacement locomotive and engine. Certified means certified by the EPA or CARB, or otherwise accepted by the NCTCOG.
- **Repower.** Use the certified emission rate (g/bhp-hr) of the engine installed on the replacement locomotive. Certified means certified by the EPA or CARB, or otherwise accepted by the NCTCOG.
- **Retrofit/Add-on.** Use the verified or certified emission rate (g/bhp-hr) or emission reduction percentage for the retrofit or add-on device. The emission reductions must be verified or certified by the EPA or CARB, or otherwise accepted by the NCTCOG.

(Baseline Engine - Reduced Engine)) Baseline Engine
x 100 = Baseline Emission Rate Reduction

Example Calculations

Example calculation for determining 25% baseline emission rate reduction for new purchase/lease

Activity: Purchase of a line haul locomotive that has a certified NOx emission of 5.5.

Engine emission standard for current year model: 7.4 g/bhp-hr
New engine certified NOx emissions: 5.5 g/bhp-hr

Calculation of baseline emission rate reduction:
(7.4 g/bhp-hr - 5.5 g/bhp-hr) divided by 7.4 g/bhp-hr x 100 = 25.68% baseline emission rate reduction

Example calculation for determining 25% baseline emission rate reduction for a repower

Activity: Repowering of a 1970 line haul locomotive with a rebuilt 1999 engine.

Original engine emission standard: 13.0 g/bhp-hr

Replacement engine emission standard: 9.5 g/bhp-hr

Calculation of baseline emission rate reduction:
(13.0 g/bhp-hr - 9.5 g/bhp-hr) divided by 13.0 g/bhp-hr x 100 = 26.92% baseline emission rate reduction

Example calculation for determining 25% baseline emission rate reduction for a replacement

Activity: Replacement of a 1970 Line Haul locomotive with a 2003 Locomotive.

Original engine emission standard: 13 g/bhp-hr
Replacement engine emission standard: 7.4g/bhp-hr

Calculation of baseline emission rate reduction:
(13.0 g/bhp-hr - 7.4 g/bhp-hr) divided by 13.0 g/bhp-hr x 100 = 43.08% baseline emission rate reduction

Example calculation for determining 25% baseline emission rate reduction for a retrofit/add-on

Activity: Retrofitting a 1977 switcher with a device that has a certified emission of 8.1.

Engine emission standard for existing model year: 14.0 g/bhp-hr
Retrofit certified NOx emissions: 8.1 g/bhp-hr

Calculation of baseline emission rate reduction:
(14.0 g/bhp-hr - 8.1 g/bhp-hr) divided by 14.0 g/bhp-hr x 100 = 42.14% baseline emission rate reduction

Step 2: Calculate the NOx Emission Reductions

This step is divided into three main parts:

Part A: Determine the TxLED Correction Factor
Part B: Determine the NOx emission factors
Part C: Calculate the NOx emission reductions

Points to remember when performing Emission Reduction Calculations

- Emission reduction represents the difference in the emission level of a baseline engine and a reduced-emission engine.
- The emission level is calculated by multiplying an emission factor, an activity level, and a conversion factor, if necessary.
- In situations where the model year of the locomotive chassis and the model year of the existing engine are different, the model year of the engine shall be used to determine the baseline emissions for benefit calculations.
- Because conversion factors and the activity levels may be expressed in different units for the existing and replacement engines, the emission levels for the baseline and reduced-emission engines should be calculated separately and then differences taken to determine emission reductions.
- Emission reduction calculations should be consistent with the type of records maintained over the life of each activity.
- If the equipment operates in a county or counties that is in the TxLED region the TxLED conversion factor must be determined.

Part A: Texas Low Emission Diesel Correction Factor

The Texas Commission on Environmental Quality (TCEQ) has adopted rules (30 TAC '114.312 - '114.319) requiring that beginning on October 1, 2005, diesel fuel produced for use in compression-ignition engines in certain counties in Texas must meet new low emission diesel (TxLED) standards.

The counties affected by the new TxLED requirements currently include all of the counties eligible for TERP incentive funding, as listed in the *Guidelines*, except for El Paso County.

The new requirements set a maximum aromatic hydrocarbon content standard of 10 percent by volume per gallon. The requirements also set a minimum cetane number for TxLED of 48.

The TxLED requirements are intended to result in reductions in NOx emissions from diesel engines. Currently, a reduction factor of **5.7 percent** (0.057) for on-road use and **7.0 percent** (0.07) for non-road use has been accepted as an estimate for use of TxLED. However, this reduction estimate is subject to change, based on the standards accepted by the EPA for use in the Texas State Implementation Plan (SIP).

For locomotive activities in the applicable counties (not including El Paso County), a correction factor of **0.93** should be applied when calculating the baseline and/or reduced emissions for diesel engines.

Part B. Determine the NOx Emission Factors

To complete the calculation of the NOx emission reductions for the activity, you must convert the NOx emission rates (g/bhp-hr) to a NOx emission factor. For most locomotive activities, the NOx emission reduction factors should be based on annual hours of operation.

You should consult with the NCTCOG to determine the factors to use for non-diesel engines, or if you wish to use a different conversion factor.

For calculations based on annual fuel use, the energy consumption factor (ECF) should be used to convert the NOx emission rate (g/bhp-hr) to g/gal. **The default ECF for locomotives is 20.8.** As shown on the worksheet, because the estimated annual fuel use of the baseline locomotive/engine and the reduced emission locomotive/engine may differ, the g/gal factor is then multiplied by the number of gallons used per year, to determine the estimated g/year to be emitted by both the baseline and the reduced emission locomotive/engine. This factor is used to calculate the NOx emission reductions.

Example calculation for determining NOx emission factor based on annual fuel use

Activity: Replacement of a 1970 switcher with a 2003 switcher.

Original engine emission standard: 17.4 g/bhp-hr
Replacement engine emission standard: 11.0 g/bhp-hr **Energy conversion factor:** 20.8 bhp-hr/gal
Annual fuel use (baseline engine): 50,000gallons
Annual fuel use (reduced engine): 45,000gallons
TxLED Correction factor: 0.93

Baseline NOx Emission Factor (g/yr)
17.4 g/bhp-hr x 0.93 = 16.182 g/bhp-hr
16.182 g/bhp-hr x 20.8 bhp-hr/gal = 336.5856 g/gal
336,5856 g/gal x 50,000gal/yr = **16,829,280 g/yr**

Reduced NOx Emission Factor (g/yr)
11.0g/bhp-hr x 0.93 = 10.23 g/bhp-hr
10.23 g/bhp-hr x 20.8 bhp-hr/gal = 212.784 g/gal
212.784 g/gal x 45,000gal/yr = **9,575,280 g/yr**

Part C. Calculate the NOx Emission Reductions

Use the factors determined in Part B to calculate the NOx emission reductions for the activity. Note that the usage estimates entered onto the application and used to calculate the emission reductions, will be entered into the grant contract.

You must also enter the percentage of annual usage that will occur within the eligible counties. At least 75 percent of the annual usage must be projected to occur within those counties. A primary area will need to be identified in the project application form. Activities to be operated in different primary areas will need to be submitted in separate applications.

Finally, to complete the calculations, you will need to designate an activity life. This will be the number of years used to calculate the emission reductions. If awarded the grant, you must commit to operating the equipment within the eligible counties for this time period, and to track

and report on that use.

Activity life may not exceed the life of the locomotive. Table 4.2 lists the maximum activity life for locomotives. The minimum activity life is seven years, including leases. The applicant must also commit to using the locomotive in the eligible counties during the activity life of the locomotive.

Table 4.2 Maximum Contract Activity Life Locomotive Activities

	Minimum	Maximum*
New	5 years (1 year for lease)	20 years
Replacement	5 years	10 years
Repower	5 years	20 years
Retrofit/Add-on	5 years	20 years

* If an applicant feels that a longer activity life is warranted, they should contact the NCTCOG to discuss. Any request to use a longer activity life will need to be submitted in writing, and should include complete documentation and records of the historical use of similar equipment by the applicant.

Example calculation for determining NOx emission rate reduction based on annual fuel use

Activity: Replacement of a 1970 switcher with a 2003 switcher.

Baseline emission factor: 16,829,280 g/yr
Reduced emission factor: 9,575,280 g/yr
Percent time in affected counties: 100%

16,829,280 g/yr - 9,575,280 g/yr = 7,254,000 g/yr
7,254,000 g/yr x 1.00 = 7,254,000 g/yr
7,254,000) 907,200 g/ton = **7.996 ton/yr**

Step 3: Calculate the Cost Per Ton

The cost per ton for an activity is then determined by dividing the requested grant amount for that activity by the total NOx emission reductions for that activity.

For multi-activity projects, the cost per ton of the complete project is determined by dividing the requested grant amount for the entire project by the total NOx emission reductions for all of the activities included in that project.

Requested Grant Amount) Total NOx Emission Reductions = Cost Per Ton of NOx Reduced

Worksheet LO-1
Annual Fuel Use

Please fill in the following information. This information will help you with your calculations. Also, a link is available at www.nctcog.org/NTERG to an online calculator to assist you.

Base Information

Type of project ☐ New Purchase/Lease ☐ Repower ☐ Replacement ☐ Retrofit/Add-on	
What is the activity life of the project in years?	
What is the percent time the equipment is in the eligible counties?	
What is the requested grant amount for the activity?	

Baseline Engine Information

Model Year	
Fuel Type	
Locomotive Type	
Emission Standard (g/bhp-hr)	
Annual Fuel Consumption in Gallons	
Energy Consumption Factor(hp-hr/gal) **[default is 20.8]**	

Reduced Emission Engine Information

Model Year	
Fuel Type	
Locomotive Type	
Emission Standard (g/bhp-hr)	
Annual Fuel Consumption in Gallons	
Energy Consumption Factor(hp-hr/gal) **[default is 20.8]**	
If the activity is a retrofit/add-on, is there a verified percentage NOx emission reduction?	%

Step 1: Does this project meet the 25% NOx baseline emission rate reduction requirements?

Baseline Engine Emission Standard (g/bhp-hr)	
- Reduced Engine Emission Standard (g/bhp-hr)	
= Difference (g/bhp-hr)	
Baseline Engine Emission Standard (g/bhp-hr)	
x	100

= Emission Rate Reduction	

Step 2: What are your NOx emission reductions?

Part A. Calculate the TxLED Correction Factor (all areas except for El Paso County)

Non Road TxLED Correction Factor*1 - (0.07)*	**0.93**

Part B. Determine the NOx Emission Factor

Determine Baseline NOx Emission Factor (g/year)	
baseline engine NOx emission standard (g/bhp-hr)	
x TxLED correction factor (diesel engines only)	
= corrected NOx emission factor (g/bhp-hr)	
x energy consumption factor (bhp-hr/gal)	
x annual fuel consumption	
= baseline NOx emission factor (g/yr)	
Determine Reduced NOx Emission Factor (g/year)	
Option A. Reduced-emission engine certified to a specific emissions standard (g/bhp-hr)	
reduced engine NOx emission standard (g/bhp-hr)	
x TxLED correction factor (diesel engines only)	
= corrected NOx emission factor (g/bhp-hr)	
x energy consumption factor (bhp-hr/gal)	
x annual fuel consumption (gal)	
= reduced NOx emission factor (g/yr)	
Option B. Reduced-emission technology certified/verified to achieve a percentage reduction from the baseline.	
Baseline NOx emission factor (g/yr)	
x certified/verified percentage reduction from baseline	
= reduced NOx emission factor (g/yr)	

Part C. Calculate the NOx Emission Reduction Using Annual Fuel Use

baseline NOx emission factor (g/yr)	
- reduced NOx emission factor (g/yr)	
= grams reduced (g/yr)	
x percent within affected counties (%)	
= grams per year reduced (g/yr)	
907,200 grams per ton	
= estimated annual NOx emission reduction (tons/yr)	
x activity life (years)	
= estimated activity life NOx emission reduction (tons)	

Step 3: What is the cost per ton?

Grant activity amount ($):	
NOx emission reductions (tons):	
= cost per ton ($/ton)	