Intermodal Yard Activity and Emissions Evaluations

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ABSTRACT

The containerization of freight in the movement of goods has been a revolution in terms time, space, and cost efficient freight movement. This phenomenon has led to the growth of intermodal yard operations at ports, rail yards, and increased truck movements gaining the attention of local planners. Intermodal yards and truck terminals may have a significant impact on local communities prompting requests for analysis of these facilities' activities. The operations at intermodal yards include ship, locomotive, cargo handling equipment, and truck activity. The paper discusses the input activity parameters (equipment population, annual hours of operation, engine load and duty cycles) for marine vessels, rail locomotives, cargo handling equipment and other nonroad equipment, and truck movements associated with moving containers through the terminals and yards. From analysis of yards in California, the activity of mobile source equipment has been detailed to provide comparisons for other intermodal yards. The results of this work include scaling operations to freight movements and discuss the operational design options likely to be found at any terminal. The design of the yard and choice of technology used at these yards both affect the emissions from the yard's activity, and this paper describes the effect of several options for designing intermodal yards.

INTRODUCTION

The containerization of freight in the movement of goods has been a revolution in terms time, space, and cost efficient freight movement. This phenomenon has led to the growth of intermodal operations at ports, rail yards, and increased truck movements gaining the attention of local planners. Intermodal and truck terminals may have a significant impact on local communities prompting requests for analysis of these facilities' activities.

Containers are metal boxes usually 40 feet long though originally 20-foot long boxes were used and some of those still remain in use. Other sizes including 45 and 53-foot lengths may also found. The 53-foot containers and full truck trailer chassis are typically maximum lengths used in on-road trucking. The basic activity measure of an intermodal facility is called a 'lift,' which is defined as the movement of one box through the yard. Often ports refer to the twenty-foot equivalent units (TEU) to account for the size of the containers, but lifts is the primary method and a conversion factor to address boxes of different lengths is used to convert lifts to TEU for reporting.

Containers arrive and depart through an intermodal facility from marine vessels, railroad trains or on-road trucks as shown schematically in Figure 1. The movement of the containers within a yard is handled by off-road cargo handling equipment through the use of various cranes or specially designed forklifts that grab containers from the side or top, and yard tractors to ferry the containers around the facility. The most general movements of containers through an intermodal facility are outlined here.

Figure 1. Overview of intermodal facility operations

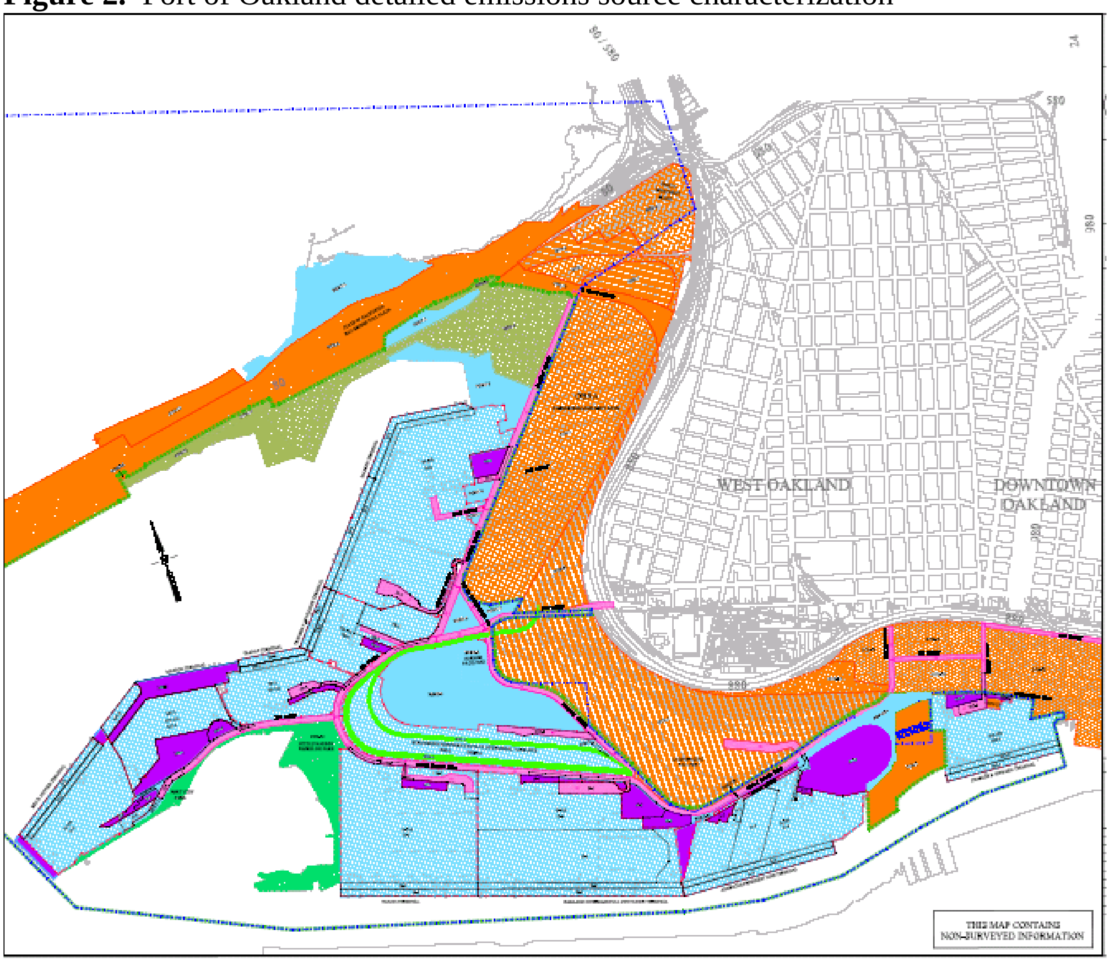
Ship ←→ Crane ←→ Hostler ←→ Stack ←→ Crane/Pick ←→ Truck/Rail

OR Rail ←→ Crane/Pick ←→ Hostler ←→ Stack ←→ Crane/Pick ←→ Truck

The design of the yard can have an effect on the air emissions, yard throughput or time, and labor required to move containers. The yard can be designed to affect each step or skipping steps in the process. For instance, on-dock rail can eliminate a step associated with drayage of containers to off-site rail yards and another use of cargo handling equipment at the rail yard. Likewise, long-haul trucks moving arriving and departing directly from the yard can eliminate the step to transfer containers to off-site truck depots or other distribution facilities.

In addition, intermodal yards have gained greater scrutiny with regard to the impact on neighboring communities. California has been conducting health risk assessments of existing and future facilities. These assessments have used detailed activity analysis mapped to a fine scale (within 10 meters) and input into AERMOD or CALPUFF dispersion models to determine the average exposure of these communities. This puts a burden on the emissions estimates to accurately determine the spatial and temporal emissions within the yard. An example of the level of detail for a site can be seen in the example for the Port of Oakland in Figure 2 where each color represents a different source category mapped to a specific area or route.

Figure 2. Port of Oakland detailed emissions source characterization

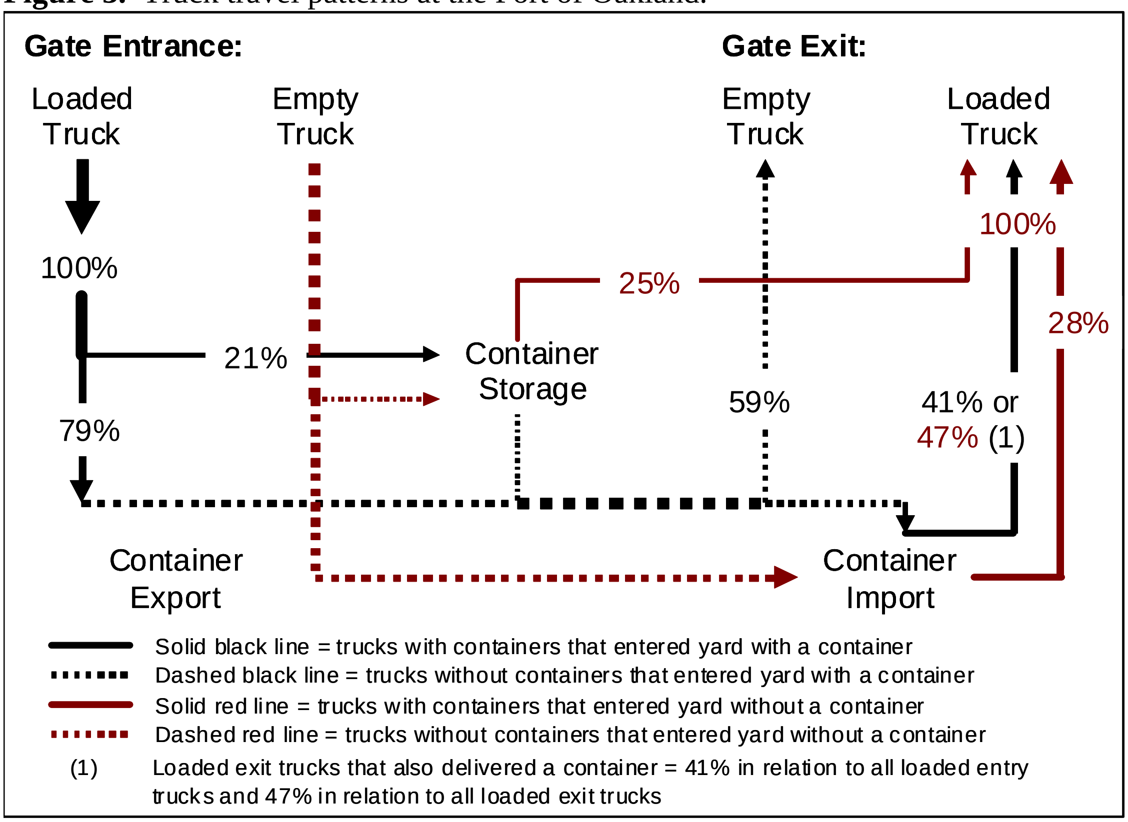


The remainder of the paper outlines considerations for each source category found at these sites including trucking, cargo handling and other off-road sources, locomotives, and ships.

TRUCKING ACTIVITY

In a rail or marine intermodal facility or terminal, trucks arrive with or without containers and depart with or without containers with a fraction of the truck both arriving and departing with a container resulting a in one truck round trip carrying two containers. A truck will most often carry only one container, but can carry two 20-foot container or two larger containers with a double trailer. In addition, trucks, either owned or contracted by the yard are used to move empty chassis or empty containers to or from off-site. Therefore the resulting number of truck visits (round trips in the yard) can be higher or lower than the number of lifts. In cases where the yard is space limited, trucks will move full containers and chassis off-site to be picked up by general-purpose trucks. A schematic of an example truck throughput types is shown in Figure 3. In addition to the modes shown, truck moving empty chassis and other activities may occur. Based on the work in California, the number of truck trips through the yard (both private fleets and those specifically contracted by the yard or terminal) typically ranges from 0.90 to 1.20 truck round trips for each lift within the yard.

Figure 3. Truck travel patterns at the Port of Oakland.



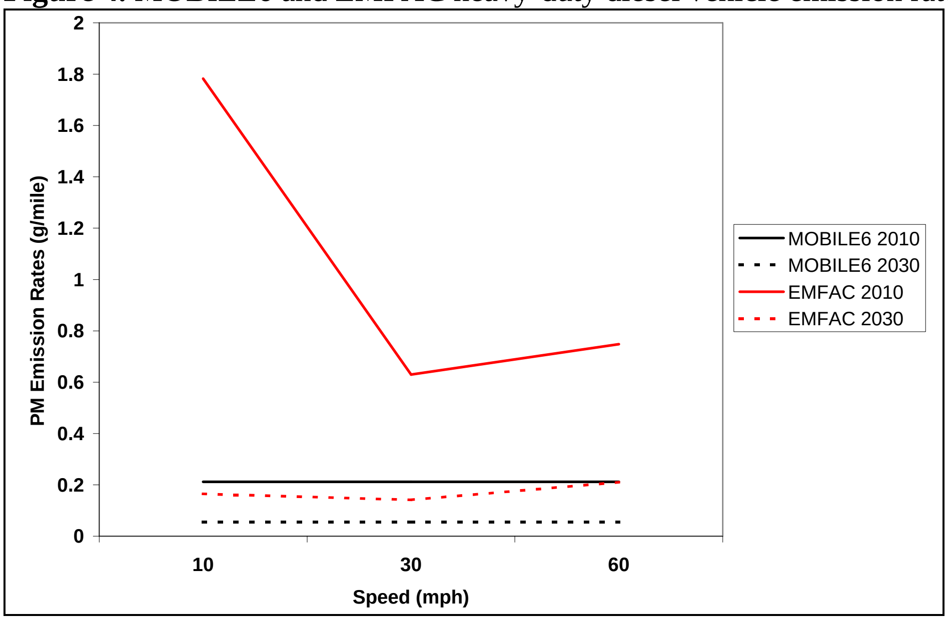
The activity of trucks within the yard is outlined in Table 1 and includes specific modes near port or rail intermodal facility, and, if necessary for the scope of the emissions inventory, off-site travel. Estimates of the activity included here are derived from rail and intermodal marine terminal operations.[1,2]

Table 1. Truck travel activity (Port of Oakland)

Activity	Idling Time (hours)	Distance (miles)	Speed (mph)
Entrance Queue	0.17	N/A	N/A
Movements in Yard	0.34	1.39	10
Exit Queues	0.05	N/A	N/A
Local Streets	N/A	1 – 5	20 – 30
Long Haul	N/A	<500	50 – 65+

The importance of vehicle speed on emissions may be critical to the emissions estimates because heavy-duty trucks are not as efficient during stop and go driving. The California EMFAC and EPA MOBILE6 model results are shown in Figure 4 for heavy-duty trucks. The EMFAC model is based upon more recent data than MOBILE6 for diesel trucks, and may be a hint for the next generation of the EPA emission factors model. The importance of these emission rates is that driving within a terminal is at low speed, so the emissions are more significant because of the higher emission rates.

Figure 4. MOBILE6 and EMFAC heavy-duty diesel vehicle emission rates.



Retrofits and other measures to reduce truck emissions have been well documented [3], and most involve purchase or retrofit to lower emission standards. While it might seem straightforward to identify and solicit truck owners for emission reduction programs, it can be difficult to identify owner/operators because they are private and sometimes single vehicle fleet operators.

Idle reductions measures include off-site parking with idle reducing hook-ups, appointment scheduling, 24-hour operations, and other measures to reduce queuing. The idle time and slow speed stop and go movements are significant emission sources at these sites sometimes adjacent to affected neighborhoods.

CARGO HANDLING EQUIPMENT (CHE)

A container will move through the yard from rail to and from truck or from ships to and from truck and rail. Each container move is accomplished by off-road equipment identified as cargo handling equipment (CHE) that include various types of cranes, specially designed forklifts called top or side picks, and specially designed yard trucks called hostlers. Other intermodal sites that handle bulk materials (coal, sand, aggregate, grain etc.) may use equipment found on construction sites including excavators, loaders, conveyors, pumps for liquid cargo, and others, but the focus of this paper is on container movements.

The container will be lifted in each case by a crane (large, often electric, cranes at ports) at marine ports, or rubber tire gantry (RTG) cranes or picks for truck and rail operations. In between each use of a crane or pick, the container is ferried around the yard using a hostler. Hostlers are the most important category of equipment in terms of fuel consumption and air emissions. Hostlers are small trucks with single cabs that are found in the NONROAD model under the category of "Terminal Tractors" usually diesel powered with Source Category Code of 2270003070. Figure 5 shows a hostler truck.

Figure 5. Yard hostler.

While the marine ports use very large cranes on dock to unload ships, these are primarily electric at most modern ports and so are not direct sources of air emissions. However, RTG cranes are a large category of CHE and can be quite physically large as shown in Figure 6.

Figure 6. RTG cranes in front of an electric port crane.

Other equipment types used at container intermodal facilities include picks (top or side) handling full or empty containers and handling chassis or other movements in the yard. Figure 7 shows a typical pick used at a container intermodal facility. These equipment types are similar to large forklifts in design and function.

Figure 7. Container pick.

The critical parameters for estimating emissions from cargo handling equipment are listed here:

- Population: number of pieces of equipment by type
- Rated Power: power of equipment
- Model Year: emission standards
- Hours: engine on hours of operations
- Load Factors (Duty cycle): average load or operational cycles
- Retrofit: modifications made to equipment

For the input parameters, it is necessary to determine the fleet characteristics and activity specific to each intermodal facility. Each facility will have its unique characteristics depending upon the design of the yard and demand; so average factors are not appropriate for any particular yard. The population and rated power of the equipment in-use at any given facility should be relatively easy to determine because fleet managers will usually have this equipment well characterized.

Hours of Operation

The activity estimates for CHE must include hours of operation, but this estimate may not be as straightforward as it sounds. The equipment population provided by a site will most likely be a snapshot of the equipment in-use at any given time.

The fleet of CHE changes during the course of a year as new equipment is purchased and older equipment is disposed, and activity growth can occur during the year as well. So if a snapshot of the fleet of equipment is used for the population, the hours of operation cannot be simply a year-end summary of the hours of operation because disposed equipment may be missed. Short-term studies can be performed, but with growth or if the activity is seasonal it may not be easy to scale the sample to a year unless growth and relative seasonal indicators can be identified.

Also, it is important to consider sampling the entire fleet of equipment because older, low power or specialty equipment may be used less than most of the pieces of equipment. Therefore, to eliminate the sampling bias, all equipment must be accounted before creating average activity rates.

Load Factor

Of the input parameters for off-road equipment, the most difficult to discern is the average load factor. The default load factors presented in the EPA NONROAD or ARB OFFROAD models do not reflect actual data, but an independent contractor's opinion of the average load. The load factor may not be the best measure of the emissions because intermodal equipment idles for significant periods of time and operates with transient loads. But load factor is the current means for estimating emissions from off-road equipment.

As an investigation of the load factor, ENVIRON and BNSF have conducted a study of the engine loads of hostlers working at a California yard using surveyed fuel consumption and downloads of long term engine time in mode from the engine's computer. Figure 8 shows the raw data collected for a hostler, and idle was considered to be the two lowest speed and power bins. The time percentage with negative torque was considered to be zero torque as the engine winds down during braking events. Using the engine map provided by Cummins that provided maximum torque at each engine speed, ENVIRON calculated the average power of each bin. Then the time weighted average load of the engine divided by the rated power provides the estimated average load factor. The summary load factor results of engines' download for hostler trucks are shown in Table 2.

Figure 8. Long term time in mode of hostlers from engine computer.

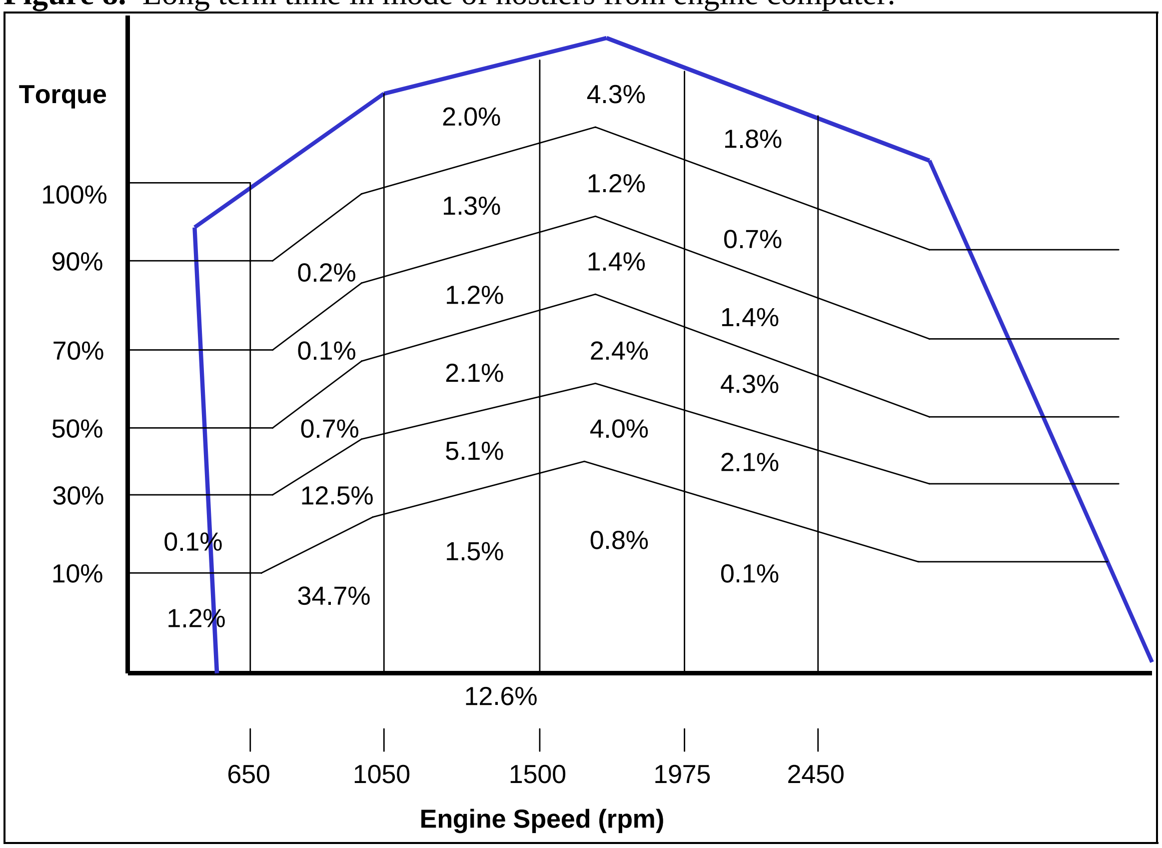


Table 2. Hostler summary load and time in idle.

Engine Model	Rated HP	Idle (%)	Load (%)	Load (%) w/o Idle
QSB	155	35.9%	17.9%	26.8%
QSB	155	33.3%	17.3%	25.0%
QSB	155	29.0%	19.7%	27.0%
QSB	155	34.9%	18.5%	27.4%
QSB	155	26.6%	20.4%	27.1%
QSB	155	30.5%	20.0%	28.0%
QSB	155	32.7%	18.0%	25.8%
QSB	155	31.1%	18.6%	26.2%
QSB	155	32.8%	17.8%	25.7%
QSB	155	26.6%	20.7%	27.5%
QSB	155	28.7%	19.1%	26.0%
QSB	155	26.3%	21.0%	27.8%
Average		**30.7%**	**19.1%**	**26.7%**

In addition, a fueling survey was conducted over several weeks recording engine hours (that are metered like a vehicle's odometer) and gallons refueled. The result of this study was a list of gallons of fuel consumed per hour of operation for the hostlers. The average load for the equipment based on the fuel consumption may be inferred from the engine maximum fuel consumption rate using fuel efficiency figures available in the ARB OFFROAD and EPA NONROAD models and the rated power of the engine. The comparison of the computer time-in-mode and fuel consumption measured load factors and those used in the ARB and EPA offroad emissions models are shown in Table 3. For hostlers, this study indicated that hostler average loads have been overestimated, and therefore the emissions as well.

Table 3. Hostler load factor comparisons.

Estimate	Number of Hostlers	Average Fuel Consumption Rate	Uncertainty (95% Confidence)	Load Factor Estimate	Uncertainty
Computer Download	12	N/A	N/A	19%	0.6%
Fuel Survey[a]	93	1.86	0.11	18% - ARB 23% - EPA	1.1% - ARB 1.4% - EPA
ARB	N/A	N/A	N/A	65%	N/A
EPA[b]	N/A	N/A	N/A	59%	N/A

[a] - Using brake specific fuel consumption (BSFC); 0.47 lb/hp-hr for ARB or 0.371 for EPA
[b] - ICF 2006 guidance[4] for SCC 2270003070, and EPA NONROAD model input files.

This study highlights that load factors need to be carefully reviewed with in field data collection studies. Other similar studies of cranes, picks, and other offroad equipment types are ongoing.

Emissions Rates and Retrofits

The emission rates of CHE can be estimated using the EPA NONROAD model or the California modified version of OFFROAD. The NONROAD model is not easy to use for small fleets of equipment because specific model years and equipment age and useage must be estimated cross-referenced to specific equipment types and engine rated power. The NONROAD emission factors input files can be converted to average emission rates and deterioration rates to estimate per piece of equipment emission levels that uniquely model that equipment.

Retrofit and other aftermarket controls can be applied as a percentage emission reduction from the base emissions levels. California has posted the results of retrofit testing that can be used to estimate the impact of the retrofits on the baseline emissions levels. [3]

Other control measures for CHE include innovative redesign of intermodal facilities to eliminate steps or change the flow of through the yard. The use of on-dock rail or better truck scheduling may eliminate the need for extra lifts to stack containers and lift again from the stack at a later date and hostler moves in between. The use of rail mounted electric cranes instead of diesel RTG cranes is another innovation to reduce the local emissions.

OTHER ON AND OFF-ROAD EQUIPMENT AND VEHICLES

Other equipment kept at these yards includes vehicle fleets and miscellaneous off-road equipment. Light-duty vehicle are based at the site for general-purpose use. Off-road equipment includes any number of industrial equipment types including sweepers, generators, pumps, light towers, and man lifts. Other on-road vehicles and off-road equipment should be treated similarly to CHE in a yard.

However, one main category of emissions are transport refrigeration units (TRU) that are used on containers and boxcars for perishable cargo. The units are not easily characterized except through a study of the time spent on each rail site. Though powered by small diesel engines, the time within the yard can be enough to significantly impact the on-site emissions. The time when the diesel engine is operating however is a fraction of the time when the TRU is refrigerating the cargo just as the refrigerator in your home cycles on and off as needed. From a study done in Southern California of 37 units, the average engine run times and the refrigerator times were compared and indicated that the engine ran 60% ± 4% that the refrigeration unit was running.

Some facilities have areas where the units can be plugged into the grid to reduce the emissions. Figure 9 shows TRU containers, while Figure 10 shows the units plugged in at the Port of Oakland.

Figure 9. TRU containers.

Figure 10. TRU plug in devices to reduce emissions.

LOCOMOTIVES

Locomotive activity can be divided into general types of activity associated with two types of locomotives, line-haul and switching engines. Line-haul engines are those that pull trains along the main line while switching engines break and build trains and move cars around the yard. Line-haul or engines otherwise used as switch engine sometimes are employed to pull short-haul local trains. The locomotive activities are outlined below, though not all of the activities described here occur at every yard.

- Servicing
  - Refill traction sand and refuel (movements to and idling during)
  - Engine inspection and repair
    - Load tests pre and post repair
    - Opacity testing
- Line-haul engines
  - Arriving and Departing (Terminating or Originating)
  - Set-out trains
  - Crew change
  - Adjacent mainline
    - Railroad line operation
    - Other railroads trackage rights
    - Passenger
- Switching engine
  - Classification yard
  - Hump yard
  - Short haul

Locomotive services include the basic service refueling and refilling the traction sand of the locomotives as well as engine maintenance. Locomotives move to service location usually set apart from the other yard operations, and may idle while waiting and during service. Engine maintenance will also include load testing to diagnose problems and assure that the maintenance was done correctly. Railroads have also begun performing opacity testing to reduce particulate emissions from locomotives and to determine any maintenance problems.

Line-haul engines enter a yard for any number of reasons. The train's destination may be the yard, or it may be setting out part of the train in the yard before continuing on, or the train may stop simply to change the crew. The line-haul engines that terminate and originate at the yard will stop, are disconnected from the train, move to the service area, move to ready tracks, and finally be assigned to an originating train. Each move will be accompanied by an idle event, and, if left unattended without an idle shut-off device, then it may idle for a significant period of time. While engine idling is not a large portion of a line-haul engine's annual activity, it is a major portion of its activity within a rail yard. Set-out and crew change trains will enter a yard and stop for a shorter period during which time the engines will likely continue to idle to provide brake air pressure and be ready to leave as quickly as possible. Usually no engine servicing will be done on the engines on these set-out and crew change trains. The line-haul engines usually have event recorders to determine the time in mode in each of several notch settings but it may be difficult to separate the activity within the yard from operations elsewhere along the railroad's system.

Switch engines are general-purpose engines used to break and build trains, and provide power to short haul trains servicing local customers. The train building may occur within a classification or a hump yard. The classification yard is most often a flat area requiring the cars to be pushed all the way into the yard, while a hump yard is specially built in a bowl only requiring that the switch engine to push the cars over the top of the bowl. The switch engines can be either older line-haul engines or specially designed switch engines. The older switch engines usually have higher power that is useful for local short-haul trains and pulling many cars at once. The lower power specially designed switch engines are limited to smaller numbers of cars such as at the head of a hump yard. Switch engines being generally older models often do not have event recorders so special studies are needed to determine its duty and annual activity.

Locomotives emissions in a rail yard are best represented by estimating the time in notch for each of several modes. Within a yard, the lower power notches and idling will be the primary operational modes. Shown in Table 4 is the engine power in each power setting and activity estimates for trains arriving and departing (TA/TD) and crew change line-haul and switch engines.

Table 4. Engine power and activity within a rail yard (example).

Notch	Line-Haul Gross HP	Line-Haul Time in Mode (hrs)		Switch Gross HP	Switch Relative Time in Mode (%)
		TA/TD	Crew		
8	4,454	0.003	0.007	2124	0.7
7	3,773	0.001	0.005	1810	0.3
6	3,046	0.004	0.004	1465	0.2
5	2,296	0.04	0.007	1161	0.4
4	1,683	0.08	0.017	871	0.8
3	1,187	0.26	0.025	589	1.3
2	587	0.39	0.029	333	2.3
1	268	0.60	0.015	98	2.8
Idle	17.0	4.00	0.23	15	69.7
Dynamic Brake	28.0	0.16	0.07	82	1.3

The emissions under each power setting need to be used to estimate emissions. Shown in Table 5 are the primary particulate emissions from locomotives by mode to use with the duty cycle developed for the yard.

Table 5. PM emission factors for locomotives used in the study, using the default fuel sulfur content (0.3%).

Locomotive Model Group	Cert Tier[f]	PM Emission Factors (g/hr) by Throttle Notch									
		Idle	DB[g]	1	2	3	4	5	6	7	8
Switchers [a]	Precntl	31.0	56.0	23.0	76.0	138.0	159.0	201.0	308.0	345.0	448.0
GP-3x [a]	Precntl	38.0	72.0	31.0	110.0	186.0	212.0	267.0	417.0	463.0	608.0
GP-4x [a]	Precntl	47.9	80.0	35.7	134.3	226.4	258.5	336.0	551.9	638.6	821.3
GP-50 [a]	Precntl	26.0	64.1	51.3	142.5	301.5	311.2	394.0	663.8	725.3	927.8
GP-60 [a]	Precntl	48.6	98.5	48.7	131.7	284.5	299.4	375.3	645.7	743.6	941.6
SD-7x [a]	Precntl	24.0	4.8	41.0	65.7	156.8	243.1	321.1	374.8	475.2	589.2
Dash-7 [a]	Precntl	65.0	180.5	108.2	121.2	359.5	327.7	331.5	299.4	336.7	420.0
Dash-9 [b]	Precntl	32.1	53.9	54.2	108.1	219.9	289.1	370.6	437.7	486.1	705.7
EMD 12-710G3 [c]	Precntl	27.5	54.5	34.0	112.5	208.0	234.5	291.0	423.0	545.0	727.5
GP-60 [d]	0	21.1	25.4	37.6	75.5	239.4	352.2	517.8	724.8	1125.9	1319.8
SD-7x [a]	0	14.8	15.1	36.8	61.1	230.4	379.8	450.8	866.2	1019.1	1105.7
Dash-8 [a]	0	37.0	147.5	86.0	133.1	291.4	293.2	327.7	373.5	469.4	615.2
Dash-9 [e]	0	33.8	50.7	56.1	117.4	229.2	263.8	615.9	573.9	608.0	566.6
Dash-9 [d]	1	16.9	88.4	62.1	140.2	304.0	383.5	423.9	520.2	544.6	778.1
ES44 [d]	2	7.7	42.0	69.3	145.8	304.3	365.0	405.2	418.4	513.5	607.5

a - ARB, 2006. [5]
b - "Diesel Fuel Effects on Locomotive Exhaust Emissions," Southwest Research Institute, October 2000. [6]
c - EPA, 1998. [7]
d - SwRI, 2006. [8]
e - Average of ARB and SwRI, 2006. [5,6]
f - Precntl: Precontrolled
g - DB: Dynamic Braking

EPA announced final emission standards [9]. The emission standards include a retrofit of existing equipment as well as new engine emission standards. Existing Tier 0, 1, and 2 engines will be subject to retrofit at the time of rebuild, so the engines will be rebuilt gradually throughout their remaining useful life.

The emissions standards and projected EPA emission factors are shown in Tables 6 and 7, and depend on the duty cycle chosen to certify the engines - either line-haul or switching engine duty cycles. The duty cycle for line-haul engines typically leads to lower emission on a gram per horsepower-hour (hp-hr) basis because the switching engine duty cycle has a considerable idling time (no hp-hr generated).

Table 6. Locomotive – Emission standards (g/hp-hr) for line-haul (duty cycle) engines.

Emission Standard	Applicable Year	HC (g/hp-hr)	CO (g/hp-hr)	NOx (g/hp-hr)	PM (g/hp-hr)
Uncontrolled Emissions	**Pre-1973**	**0.48**	**1.28**	**13.0**	**0.32**
Tier 0 – original	1973 – 2001	1.00	5.0	9.5	0.60
Tier 0 – final[a]	2008 / 2010	1.00	5.0	8.0	0.22
Tier 1 – original	2002 – 2004	0.55	2.2	7.4	0.45
Tier 1 – final[a]	2008 / 2010	0.55	5.0	7.4	0.22
Tier 2 – original	2005	0.30	1.5	5.5	0.20
Tier 2 – final[a]	2013	0.30	1.5	5.5	0.10
Tier 3	2012 – 2014	0.30	1.5	5.5	0.10
Tier 4 [b]	2015	0.14	1.5	1.3	0.03

a - These are retrofit standards at the time of rebuild and phased in as retrofit kit availability.
b - The Tier 4 NOx standard can be a 1.4 NOx + HC standard.

Table 7. Locomotive – Emission standards for switching (duty cycle) engines.

Emission Standard	Applicable Year	HC (g/hp-hr)	CO (g/hp-hr)	NOx (g/hp-hr)	PM (g/hp-hr)
Uncontrolled Emissions	**Pre-1973**	**1.01**	**1.83**	**17.4**	**0.44**
Tier 0 – original	1973 – 2001	2.10	8.0	14.00	0.72
Tier 0 – final[a]	2008 / 2010	2.10	8.0	11.80	0.26
Tier 1 – original	2002 – 2004	1.20	2.5	11.00	0.54
Tier 1 – final[a]	2008 / 2010	1.20	2.5	11.00	0.26
Tier 2 – original	2005	0.60	2.4	8.10	0.24
Tier 2 – final[a]	2008 / 2013	0.60	2.4	8.10	0.13
Tier 3	2011 - 2015	0.60	2.4	5.00	0.10
Tier 4 [b]	2015	0.14	2.4	1.30	0.03

a - These are retrofit standards at the time of rebuild and phased in as retrofit kit availability allows.
b - The Tier 4 NOx standard can be a 1.3 NOx + HC standard.

Other measure to reduce locomotive emissions include the use of locomotives built to emission rates well below the emissions standards using low emission technologies found in on-road and off-road engine design.

MARINE VESSELS

Marine vessels serve the same function as line-haul locomotives or long haul truck moving containers and other freight on routes to and from the intermodal yard. The primary difference is that marine vessels only use smaller auxiliary engines when tied up at the dock to supply electrical power for the vessels. The electrical power is primarily used for refrigeration of containers, but the vessel will have other electrical needs. In addition, marine vessels have auxiliary boilers to provide process heat for operations on board and may be more significant than previously considered.

The vessels usually have three to five auxiliary engines that are used sequentially to provide low to high loads. At low loads one engine will be used up to more than 50% load before a second engine will start. Therefore all engines will be used in an efficient manner with relatively consistent emissions depending upon the load.

Figure 11. Vessel idling at an intermodal port.

The berthing emissions, therefore, depend upon the time at berth and average load when at berth. The time at berth can be affected by the design and operation of intermodal yard. For instance the number of cranes and crews serving a ship will affect the time it takes to unload and load the vessel. Other ideas to reduce the time spent at dock include serving the vessel from both sides.

California has begun regulations to reduce emissions mandating the use of lower sulfur fuels in auxiliary engines and while tied up at intermodal yards by mandating the frequently calling ships plug into grid instead of running auxiliary engine while at berth. (http://www.arb.ca.gov/ports/shorepower/shorepower.htm) This method however will not completely eliminate the emissions because it takes a certain amount of time to connect and disconnect from grid power. In addition, infrequently calling vessels may be a significant portion of the shore emissions, and may not be adaptable or costly to convert the vessels to run on shore power.

CONCLUSIONS

The operations within a given intermodal yard can be quite complicated; however, this paper has outlined most of the site operations that can be followed when evaluating such a facility. Each facility will have its own unique characteristics that will need to be considered carefully with regard to freight flows, operating behavior and overall activity levels.

Despite their visibility to the local community, intermodal yards and port facilities are a typically a small regional source of emissions. However, because these facilities are an entry point to the freight supply chain and impact the local community where sited, they have gained the interest of regulators. Regulations have focused on reducing emission rates from equipment currently used on these sites through retrofit and replacement programs. Facility design and improved operations may have an equal impact on the sites' emissions profiles through reduce activity for the same freight throughput.

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KEYWORDS

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