PART B OF THE SUPPORTING STATEMENT

Populations, Usage and Emissions of Diesel Nonroad Equipment

OMB Control Number 2060-0553

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1 SURVEY OBJECTIVES, KEY VARIABLES AND OTHER PRELIMINARIES

1(a) Survey Objectives

This collection is a pilot survey designed to inform development of methods and protocols for programmatic collection designed to estimate the population, usage and emissions of nonroad equipment. In this context, nonroad equipment is synonymous with Anonroad vehicle@ as defined in the Clean Air Act:

> ... Anonroad vehicle@ is defined as a vehicle that is powered by a nonroad engine...@ ('216 (11).

A nonroad engine, in turn, is defined as Aan internal combustion engine (including fuel system) that is not used in a motor vehicle... (or vehicle used solely for competition),@ and Amotor vehicle@ is defined as Aany self-propelled vehicle designed for transporting persons or property on a street or highway@ (' 216 (10)).

Because of the breadth of the category, it is simpler to define nonroad equipment in negative rather than positive terms. The statutory definition includes vehicles powered by combustion engines, designed to perform a wide variety of tasks other than street or highway transportation. Thus, the term Anonroad equipment@ covers a broad variety of machines including lawnmowers, snowmobiles, forklifts, crawler dozers, tractors, and excavators. Lists of equipment types commonly used in specific economic sectors and subsectors are provided in Appendix B.1.

The main objective of the pilot collection is to evaluate a survey method based on a frame that lists equipment owners (commercial establishments), rather than equipment itself. This approach is indicated because unlike on-highway motor vehicles, nonroad equipment is not registered by states. Thus, frame lists of equipment pieces are impractical to construct, whereas adequate lists of establishments are available. To achieve this goal, the pilot will answer specific research questions:

- What fraction of establishments in each targeted economic sector (e.g., construction, manufacturing, etc.), use diesel nonroad equipment? Estimates of this parameter will inform estimation of the numbers of establishments in each sector that must be drawn to obtain desired samples of eligible engines.

- What are the fractions of the equipment populations are owned by employers or by non-employers? Do these fractions vary by economic sector?

- Can selection of counties and establishments on the basis of Aprobability proportional to size@ (PPS) effectively reduce differences in sampling probabilities between individual engines?

- Do response rates differ among employers and non-employers?

- What is the average number of diesel engines used per establishment? How variable is this parameter? Does it differ among economic sectors, or among employers and non-employers?

- What techniques can be used to access the electronic control systems of engines so equipped (Control Area Network, CAN)? Electronic controls became available on engines produced in during the late nineties Our goal is to successfully access the network on 90% of engines so equipped.

- How does engine speed as measured by using a data-logger correlate with that recorded through the engine's own CAN interface For engines equipped with CAN, our goal is to successfully correlate CAN measurements with independent data-logger measurements on 90% of measured engines.

- A critical aspect of measuring particulate matter is to draw a continuous sample of exhaust flow of known volume that is directly proportional to the engine's entire exhaust flow. In terms of its results, the proportionality model must achieve adequate correlation between sample and exhaust flows. Adequacy is defined as a linear coefficient of determination of 0.98 or better, or as a standard error of estimation of 3% or lower at high exhaust flow.

1(b) Key Variables

Variables to be surveyed or measured include:

- *Equipment Use Fraction*. The fraction of establishments that use nonroad equipment, where Ause@ means Aown, rent or lease.@ Only establishments that use equipment are eligible respondents, but eligibility cannot be determined in advance from the sample frame. This parameter will be estimated for each targeted economic sector.

- *Equipment Density*. This variable is defined as the average number of diesel engines per establishment. Density can be multiplied by numbers of establishments to estimate equipment populations at local or regional scales.

- *Equipment Activity*. This variable represents equipment usage, express in terms of operating time per reference period (e.g., hours/week, hours/month, hours/quarter, hours/year).

- Engine speed: the number of revolutions of the engine per unit time (revolutions per minute rpm).

- Coefficient of determination for independent measurements of engine speed.

- Coefficient of determination for the proportional exhaust sampling model

- *Emission Rates*. This variable represents exhaust or Atailpipe@ emissions, expressed in terms of mass normalized to fuel consumption (g/gal, g/kg). Emissions will be measured for the following exhaust constituents:
  - carbon dioxide (CO_2),
  - oxides of nitrogen (NO_x),
  - carbon monoxide (CO),
  - total hydrocarbon (THC)
  - particulate matter (PM).

  Measurement of CO_2 provides the basis for estimation of fuel consumption and derivation of fuel-based emission rates. Oxides of nitrogen, carbon monoxide, and particulate matter are criteria air pollutants regulated under the Clean Air Act. Engine standards also exist for total hydrocarbons due to their role in formation of ozone, another criteria pollutant.

1(c) Statistical Approach

While not all objectives for this collection are to be evaluated statistically, we plan to conduct employ statistical sampling. The reason for this approach is that we plan to continue to develop methods of conducting emissions measurement in the field in the context of a sampling design. It is our goal to acquire experience in the deployment of the sample design as well as the measurement methods.

1(d) Feasibility

Obstacles to Participation. We do not anticipate substantial obstacles to participation, because we have modified the design and proposed collection methods that remove or minimize obstacles that have limited participation in similar past studies. Until recently, a statistical survey of heavy equipment emissions would have been infeasible and prohibitively expensive. It would have been necessary to bring equipment to an adequately equipped laboratory, lift the engine, and place it in a test cell. This process is slow and expensive, with costs on the order of $100,000 to conduct measurements on a single engine. The geographic scope of any study would also have been limited to areas where such facilities exist. Finally, it would also have been unduly burdensome and costly for respondents to donate their equipment for the time periods necessary to conduct laboratory measurements.

Fortunately, the availability of portable instrumentation changes this situation. It is now possible to Atake the laboratory to the respondent,@ and to conduct measurements in the field in an efficient and cost-effective way. We can measure emissions from heavy equipment on site during its normal operation, using non-intrusive portable instruments. This approach also dramatically reduces respondent burden. Aside from responding to brief interviews, the respondent need not modify their schedule or operation to participate. There is no need to make time to take equipment off-site, or to operate in the absence of key equipment pieces, because technicans can install the instruments during down periods, and instrumentation does not interfere with the equipments= operation.

Availability of Funds. At present we expect to have adequate funds available to conduct the survey as designed. Funds will be contributed by two government partners and one industry partner. The first government partner is the Assessment & Standards Division within the EPA Office of Transportation and Air Quality (OTAQ). The industry partner is the Coordinating Research Council (CRC), a nonprofit research organization whose members include the American Petroleum Institute (API), the Society of Automotive Engineers (SAE), General Motors, Ford Motor, Chrysler, Volkswagen and Honda.

However, if funding shortfalls occur, we can take measures to reduce sampling costs. One possibility would be to reduce the number of primary sampling units (counties), and increase the size of second-stage clusters (sample more establishments and equipment pieces per county). This approach would reduce costs primarily by reducing travel time to and from PSUs. We do not anticipate that this measure would substantially affect the survey results, because we do not expect that intraclass correlation within counties would be high enough to noticeably affect sampling efficiency.

Another approach that could be implemented alone or in combination with the first would be to reduce the numbers of engines to be measured, or reduce the measurement period for emissions measurement.

2 SURVEY DESIGN

2(a) Target Population and Coverage

The target population includes equipment powered by nonroad diesel engines, as defined above in section 1, used by commercial establishments in the construction and manufacturing sectors (NAICS 23 and 31-33).

Work is to be conducted in two areas. The first area includes Clay County, MO and Shawnee County, MO. The purpose for working in these areas is to complete work initiated during the previous approval period. The second area is EPA Region 5 (including states of WI, IL, ID, MI and OH).

2(b) Sample Design

2(b)(i) Sample Frame

The sample frame will include listings of commercial establishments for the defined study area.

In work to date, we have drawn samples of establishments from the *Comprehensive Business Samples* database (CBS), compiled and maintained by Survey Sampling, Inc., Fairfield, CT (SSI). SSI compiles listings from telephone directories and additional industry-specific sources, including government listings, bank records, trade directories, city directories and proprietary sources. Listings are verified and updated on a continuous basis. To our knowledge, this source is the most comprehensive listing of industrial and commercial establishments publicly available.

In our experience, this listing has a very high rate of frame blanks, meaning in this context that over 50% of establishments listed as construction establishments did not report themselves as being in construction. The high incidence of blanks requires that large numbers of establishments must be screened to identify eligible establishments.

To address this problem, we propose to supplement SSI with one or more additional sources. A promising candidate is a database compiled by Equipment Data Associates, Inc. (EDA). This database is a nation-wide compilation of Uniform-Commercial-Code filings that record transactions in which nonroad equipment are financed, leased or used as collateral (UCC). EDA specializes in compiling such UCC records and marketing the resulting database. Their typical clients include equipment dealers who use the database to identify potential sales prospects within their territories. In combination with SSI, the EDA database could substantially reduce the screening needed to identify establishments that lease or own equipment. Another advantage of the EDA database is that it allows construction of direct measures of establishment size in terms of numbers of pieces for purposes of sampling.

2(b)(ii) Sample Sizes

The goal is to measure emissions on 50 pieces and activity on 50 pieces, with the possibility that both may be measured on some pieces. Due to the methodological nature of this work, these samples are based on practical rather than statistical considerations.

Sample sizes for interviews will be based on the amount of screening needed to achieve the targets for measurement. Based on our experience, it has been necessary to screen, verify eligibility and attempt recruitment for approximately 30 establishments to obtain participation and successful completion of emissions and activity measurements. On this basis, we project a need to interview up 1,500 establishments, although this number may be lower if the supplementary frame reduces the level of screening.

2(b)(iii) Stratification Variables

Due to the pilot nature of the survey, our intent has been to keep stratification to a minimum. However, to address potential difficulties in implementing the design, we plan to employ two levels of stratification.

Sampling Certainty. In the first stage of sampling, no stratification is planned, for reasons described in 'Sampling Methods' below.

In the second stage, we plan to stratify establishments by size, where 'size' is defined as the number of equipment pieces owned or leased by the establishment. Establishments having more than 50 equipment pieces will be sampled with certainty, and those having 50 pieces or fewer will be sampled with uncertainty.

Economic Sector. In drawing second-stage samples of establishments, we plan to employ stratification by economic sector. In this case, the reason for stratification is primarily to ensure representation in each sector. Sampling will be allocated proportionally among sectors.

2(b)(iv) Sampling methods

To reduce travel time and associated expense for field technicians installing and maintaining instrumentation on site, we plan to draw the equipment sample in three stages, as follows:

First Stage	(Primary)	County or groups of counties
Second Stage	(Secondary)	Establishment (within county)
Third Stage	(Tertiary)	Equipment Piece (within establishment)

Specifics of the design at each stage are discussed in sub-section 2(b)(v), AMulti-stage sampling.@

2(b)(v) Multi-stage sampling

2(b)(v)(1) First-stage Sample

In the previous approval period, we rew samples of counties as primary sampling units (PSUs) with probability-proportional-to-size (PPS) techniques. For construction and manufacturing establishments, we used the estimated number of employees in these sectors as a measure of size (MOS). Experience with this approach has shown that this MOS performed poorly, as the correlation between the MOS used and the numbers of equipment pieces owned by establishments is not high enough.

Additionally, we have concluded that it is logical to include non-employers as well as employers in the study population, which would require adoption of an MOS not defined in terms of employees.

To avoid the need for sampling by size in the first stage, we propose to construct PSUs of roughly equal size, where size will be defined as the numbers of establishments in the PSU, as obtained from sources such as County Business Patterns and Census non-employer statistics.

2(b)(v)(2) Second-stage Sample

Within each PSU, commercial establishments will be the secondary sampling unit (SSU), drawn with selection probabilities proportional to size. The establishment MOS will be an estimate of the number of equipment pieces owned or leased by the establishment, as constructed from the Equipment Data Associates database.

2(b)(v)(3) Third-stage Sample

In the third stage, two to six equipment pieces will be drawn for emissions or activity measurement from a listing of eligible pieces used by each selected establishment (n_{equip}). Equipment will be selected with probability proportional to size and usage, using a stratified approach as shown in table B-?. In this context, 'size' means an equipment pieces's rated power, with pieces rated as <= 100 or > 100 hp as "small" and "large," respectively. "Usage" refers to "life-time average usage," calculated as the machine's hour-meter reading divided by its age (hr/yr). Pieces with <= 500 hr/yr and > 500 hr/yr are classified as "low" and "high" usage, respectively. If either size or usage cannot be classified, the piece is assigned to an "unknown" stratum. on each piece's size and life-time average usage, differential weights are assigned to each piece, also shown in the table.

Table B-1 Differential weights assigned to equipment pieces in third-stage sampling

Size	Life-time Average Usage (hr/yr)		
	"high usage"	"low usage"	"unknown"
"large"	3	2	1
"small"	2	1	1
"unknown"	1	1	1

2(c) Precision Requirements

2(c)(i) Precision Targets

Screening interviews.

Questions targeted for statistical analysis include whether response rates for screening interviews differ between non-employers and employers, or between construction and manufacturing establishments. To examine differences in response rates for screening interviews, the numbers of establishments projected for screening interviews will allow testing of actual response rates against a no-effect scenario with 90% power at the 95% confidence level.

2(c)(ii) Non-Sampling Error

2(c)(ii)(1) Frame-coverage error

This error is defined as potential bias in key variables resulting from imperfections in the sample frame. One issue of concern is the presence of Aforeign elements@ or Ablanks@ in the sample frame, where these terms are defined as follows. AForeign elements@ are establishments listed in the frame that are not members of the defined target populations, whereas Ablanks@ are empty listings, for example, establishments that have moved, changed names or gone out of business (Kish, 1965). However, the central issue is incomplete coverage, in which members of the target population are simply absent from the frame. The bias that may result from incomplete coverage may reduce the representativeness of the sample in a way analogous to that from whole-survey non-response. We have incorporated measures in the survey plan to detect and reduce the effects of these errors on the survey results.

Foreign elements and blanks. The Equipment Ownership Questionnaire contains questions specifically designed to identify establishments that are not members of the target population. Based on binary responses to these questions, we can calculate a binomial proportion of foreign elements in the frame before drawing the equipment samples. After estimating this proportion and its confidence interval, we can use the proportion to adjust the number of establishments drawn for the equipment sample to achieve the desired sample sizes.

Incomplete Coverage. To address issues related to incomplete coverage, we propose to employ the following measures:

We have defined target populations to correspond exactly to populations as defined for the Economic Census and the Census Bureau's Non-employer statistics. Based on these definitions, it is possible to evaluate establishment counts in the frame to those reported by the Census Bureau for the study areas selected.

2(c)(ii)(2) Non-response error

As in any survey, non-response is one of the most important potential sources of error in final results. Survey non-response occurs when no response at all is obtained from a potential participant in the study, whereas Aitem-nonresponse@ occurs when a respondent provides

responses to some but not all items. Survey non-response occurs if a respondent refuses to participate, or if they prove to be unavailable after multiple attempts at contact.

Item-nonresponse may occur in a number of ways. A respondent may answer some items but refuse others, or may break off an interview for unrelated reasons. A form of item-nonresponse detrimental to emissions measurement but unrelated to the respondent could occur in cases where equipment malfunction or measurement errors make emissions or activity datasets for specific equipment pieces unsuitable for subsequent analysis.

2(c)(ii)(3) Measurement error

The measurement of emissions, and to a lesser extent activity, during normal equipment operation requires the use of complex instrumentation in a harsh environment. The Emissions-measurement instrument is specifically designed to collect data from heavy nonroad equipment during normal operation. Its components have been Aruggedized@ to withstand the sharp and powerful shocks that an object mounted to the frame of a piece of heavy equipment experiences. Nonetheless, despite rugged design, additional steps will be take prior to and following data collection to detect measurement errors in resulting data.

Calibration. Prior to installation and following removal, the instrument=s sensors and analyzers will be calibrated. The outcome of the calibration is an equation or system of equations that translates voltage output from sensors into values of target variables, e.g., exhaust volume in the case of the flowmeter, and relative concentration in the case of the oxygen sensor. Technicians will record settings and results for pre- and post-calibrations. Comparison of the sets of coefficients demonstrates that the instrument=s calibration was stable over the measurement period, i.e., that the instrument did not show substantial Adrift@ between installation and removal. During analysis, knowledge of both sets of coefficients allows estimation of the degree of measurement error expected for results obtained from a given machine.

Equipment malfunction. Following download of the data, additional quality-assurance measures will be taken to verify that the instrument operated correctly and that the results are reliable for further analysis. These measures involve the use of computer programs that automatically scan the time-series for patterns that may suggest instrument error, combined with graphic presentation of the data to allow case-by-case visual inspection. Quality-assurance measures are are further described in subsection 5(a)(ii).

Respondent error. The emphasis on collection of key information for the survey through direction inspection and instrumentation involves a conscious decision to reduce reliance on human memory to the maximum extent possible. A primary example is the use of electronic dataloggers to measure equipment activity. Previous efforts in this area have relied on one to three interview questions to solicit information on operation or fuel usage from users of equipment such as all-terrain vehicles or snowmobiles (CPSC, 1998; Rubin et al., 2001). Analysis of the results obtained through such surveys shows that some proportion of respondents give answers that seem implausible, but which are difficult to disprove directly, or that different questioning strategies give widely divergent results. Hence we believe that the use of instrumentation is more objective and reliable and simultaneously reduces respondent burden.

Despite the emphasis on measurement, it remains necessary to request respondents to report information about their operations and equipment. As much as possible, we have restricted interview items to general questions that can be easily answered without involved or detailed estimation and without heavy reliance on human memory. Additionally, the interview questions themselves, while important, primarily set the stage for the equipment selection and measurement to follow.

Data entry error. Information obtained through phone interviews, personal interviews and field inspections will entered directly into computer databases. To reduce the potential for data entry error, Adouble-entry@ methods will be employed. All information will be entered independently by two persons, and the two file versions checked against each other.

Emissions results and other data collected electronically will not be input manually. Data files will be downloaded directly from the measurement instrument and transferred to the database, following quality-assurance procedures.

2(d) Questionnaire Design

2(d)(i) Equipment Ownership Questionnaire

The equipment ownership questionnaire will be administered to all establishments. It is very short, containing only thirteen items designed to support evaluation of the proposed frames in relation to target populations, to obtain direct estimates of proposed measures of establishment size, and to estimate proportions of eligible establishments in each sector.

At the outset, the interviewer will identify themselves, and let the respondent know that the call concerns a study of diesel equipment or machinery used by organizations in the respondent=s sector. If the respondent appears unclear on the meaning of the term >nonroad diesel equipment or machinery,= the interviewer will read examples from a list of equipment types commonly used. The interviewer will then briefly describe the study, and attempt to obtain the respondent=s consent to proceed with questionnaire items, as follows:

Item 1: *Verify Respondent=s Name and Address*: This item is intended to verify that the party contacted is in fact the intended respondent, and whether the respondent has changed its name or address since the last update of the sample frame.

Item 2: *Verify Respondent=s Primary Business Activity*: This item contributes to frame development by verifying that the sample frame correctly classifies the respondent by business activity, defined as the three-digit NAICS category.

Item 3: *Respondent=s Diesel Equipment Usage*. This item verifies that the respondent uses at least one piece of diesel machinery or equipment, where >use= is defined as >own,= >rent= or >lease.= Establishments that reply in the negative are not eligible for further questions, and the interviewer will end the interview at this point. The question solicits a binary response, to contribute directly to estimation of the proportion of establishments in the two-digit NAICS sector that do not use diesel equipment as targeted by the survey.

Item 4: *Respondent=s Employer Status*. This item contributes to on-going frame development by ascertaining whether the respondent employer or non-employer subgroups or the target population The answer will be yes or no, with results used to estimate a proportions of employers and non-employers in the establishment population.

Item 5: *Self-Reported Number of Paid Employees*. This item requests the respondent to report the number of paid employees in the organization. The response will serve as a direct self-reported estimate of the proposed measure of establishment size for respondent group 1. The response will also support frame development by providing a check on classification of respondents by establishment size class in the sample frame, measured by a proportion of correctly classified establishments.

Item 6: *Respondent=s Self-reported Number of Employees*. This item is a follow-up on item 5, if the respondent seems unable or reluctant to report an exact number of employees in item five. It restates the question in a more passive mode, asking the respondent to identify the establishment size class that best fits their organization, using the size classes listed in Table B.19.

Item 7: *Number of Equipment Pieces used by Respondent*: This item serves two objectives. The first is to get an estimate of >establishment size= in terms of equipment pieces. Responses will be correlated in relation to that from the supplementary sample frame, if available This item also provides the basis for initial estimates of the number of equipment pieces per establishment in the target sectors.

Item 8: *Respondent=s Self-reported Number of Equipment Pieces*. This item is a follow-up on item 8, if the respondent seems unable or reluctant to report an exact number of equipment pieces. It restates the question in a more passive mode, asking the respondent to identify a size class that best fits their organization, where >size= is defined in terms of the number of equipment pieces.

Items 9-10: *Eligibility for Emissions Measurement*. This item requests respondents to report whether at least one the diesel equipment pieces used by the organization has an engine power rating of at least 25 or 50 horsepower or more. This criterion identifies the presence of at least one equipment piece large enough to allow installation of the emissions measurement instrument.

Item s 11-12: *Respondent's Equipment Acquisition*: These items requests respondents to report whether they acquire equipment by purchase, leasing or both, and whether equipment acquisition is financed. It contributes to evaluation of the supplementary frame (Equipment Data Associates) by determining whether an establishment would be expected to be present in EDA.

2(d)(ii) On-site Equipment Inventory

For respondents determined to be eligible, the step following the initial ownership interview is to obtain a listing of equipment that is eligible for instrumentation. This listing serves as a third-stage sample frame, and also will serve to describe the age and size distribution of equipment

used by the respondent. The interviewer will continue with additional questions regarding the respondent=s operation and use of equipment. For respondents who use equipment at multiple sites or on a continuous shift basis, additional sampling steps will be employed as appropriate to access equipment while retaining control of selection probabilities for individual pieces. The interviewer continues with the items below:

Item 13: *Respondent=s work sites*. This question is intended to determine if a respondent has equipment stored or in operation at sites other than the home site listed in the establishment sample frame.

Item 14: *No. work sites with equipment*. This question determines the number of work sites at which the respondent stores or uses equipment. If the number is greater than 1, the technicians will select one site, using SRS, to reduce the number of sites to be visited. This step simplifies field operations and reduces respondent burden, as it may be impractical to schedule multiple appointments at different sites and times to inventory all pieces used by the respondent. Also for practical purposes, technicians may consider remote sites ineligible if they are beyond a pre-determined maximum distance from the respondent=s home site.

Item 15: *Listing of work sites*. The interviewer requests the respondent to list multiple work sites at which equipment is used.

Item 16: *Additional Contact Information*. If a remote site is selected, the interviewer will request a name(s) and contact information for one or more contacts at the remote site.

Item 17: *Contact=s Information*. The interviewer will request name and phone number for remote contact(s).

Item 18: *Contact times*. This item requests one or more times at which the knowledgeable respondent or remote contacts can be reached.

Items 19-20: *No. Shifts per 24-hour Period*. These items determine whether the respondent operates equipment in shifts and whether equipment is operated over more than one shift in a 24-hour period. The object is to determine whether a site visit can be scheduled at any time when all equipment would be idle. If the number is greater than one, the technicians will select one shift, using SRS, and schedule a time to inventory the equipment when it is off-shift.

Item 21: *Shifts Operated*: If the respondent operates equipment in shifts, the interviewer will request confirmation regarding during which shifts equipment is operated.

After selection of the home site or a remote site for piece selection, the technicians will complete an inventory of all equipment pieces on the site. They will obtain five items needed to uniquely identify individual pieces and their specifications. These items include:

- equipment type,
- equipment manufacturer,
- equipment model,
- equipment model year, and

- equipment serial number.

In addition, acquisition of these items allows the technicians to determine other equipment specifications directly without burdening the respondent with additional highly specific questions. For example, the equipment serial number allows determination of the equipment model year through commercially available serial number guides (EquipmentWatch, 2001a). Determination of manufacturer and model also allows determination of other specifications such as power and speed ratings from commercially available specification references or manufacturers= specifications (EquipmentWatch, 2001b). Again, the goal is to avoid the need to trouble respondents with detailed questions that are difficult to remember or that may require consultation of records.

Equipment Piece Selection (Third-stage sampling). To select equipment pieces, interviewers will perform sampling with probability proportional to weighting as described above. After selection of an eligible equipment piece for either emissions or activity measurement, interviewers will confirm the owner's consent to instrument the piece.

2(d)(iii) Equipment Identification, Description and Instrumentation Parameters

In the course of instrumenting an equipment piece, the technicians will acquire additional information necessary to properly install the instrument(s) and reduce and apply resulting data. This information will be provided by technicians directly or obtained through direct inspection of the equipment piece itself. The respondent need not be present and acquisition of this information imposes no additional burden on respondents. Each information block is briefly described below.

Equipment Selection: This block contains information needed to determine the selection probability for the selected piece:(1) the number of sites from the piece=s site was chosen, (2) the number of shifts over which equipment operated, and (3) the number of eligible pieces at the site.

Equipment Description: This information duplicates the information obtained during the site inventory, which again serves to uniquely identify the piece to be instrumented, and provide a means to determine the piece=s detailed specifications.

Hour-meter: Whereas motor vehicles typically have odometers that record the number of miles traveled by the vehicle, nonroad equipment often has hour-meters that record the number of hours operated. This item records the piece=s hour-meter reading, if available, plus auxiliary information needed to use the reading to estimate the piece=s average lifetime annual activity (hours/year).

Visual inspection: This block records results of an inspection to determine whether an instrument can be installed on the piece. For example, a piece with major leaks evident in the exhaust system cannot be instrumented for emissions, because the exhaust flow volume cannot be accurately measured. Similarly, an unreliable alternator speed signal precludes installation of either instrument, because engine speed cannot be accurately measured.

Date & Time: This block records the date and time for installation and removal of an instrument.

Engine rating: This block stores the engine=s speed and power ratings. This information, whether determined from the engine plate or from a reference source, is vital in assessing the reliability of data collected by the instrument.

Installation parameters. This block primarily contains exhaust pipe measurements used in installation of the flowmeter on the outlet.

Instrument identification: This block indicates the type of instrument installed and uniquely identifies the components of a specific instrument.

Instrument calibration: This block identifies calibration curves for the emissions measurement instrument. Each instrument is to be calibrated prior to installation and following removal from an equipment piece. The calibration equations, which are unique to each instrument, convert voltage signals from different sensors into appropriate units. For example, the flow-meter calibration converts voltage to exhaust flow volume, and the oxygen sensor calibration converts voltage to oxygen concentration. Comparison of pre- and post- calibrations is a quality-assurance step that ensures that the sensors were stable over the measurement period.

Maintenance Log: This log records the reason and outcome of visits, if any, during a measurement period to tend or maintain an instrument. It will record the reasons for a visit, any actions taken and the outcome in relation to the acceptability of data collected prior to the visit.

3 PRETESTS AND PILOT TESTS

3(a) Pretests

As the instruments proposed for this collection have been tested and fielded, we do not plan additional pre-testing.

3(b) Pilot Tests

At the outset, of the collection, an initial PSU will be fielded as a test of the instruments, sampling, recruitment and logistics involved in implementing the collection. These interviews and site visits will serve to further test the revised instruments and modify questions or items found to be unclear or impractical. Following completion of the initial samples, respective quality-assurance steps and operating procedures will be finalized before the resumption of data collection and field measurements.

4 COLLECTION METHODS AND FOLLOW-UP

4(a) Collection Methods

The initial screening and eligibility interview will be administered by phone. This method was selected due to the simplicity and brevity of the initial interview. The interview was designed so that a respondent with knowledge of the establishment=s operation will be able to quickly and easily provide answers to all items without a need to consult associates or records. Using telephone as the collection mode will also enable interviewers to identify and make contact with a knowledgeable respondent, especially for large respondents where targeting a mail-out questionnaire to a knowledgeable respondent would be difficult.

Due to the simple factual nature of the interview questions, it is more important that interviewers have training and experience in recruitment and interview methods than extensive technical knowledge in the survey=s subject matter. Nonetheless, project-specific training for interviewers will be provided, and will cover an introduction to common equipment types in the targeted economic sectors, as well as the NAICS classification of the target sectors to the three-digit level.

After obtaining consent to instrument an equipment piece, equipment emissions and activity will be measuring using electronic instrumentation.

To install and maintain the instruments, technicians require knowledge of basic physical and chemical concepts involving measurement of compressible air-flow and concentrations of chemical constituents at variable temperature and pressure conditions, and calibration and operation of standard laboratory and electronic instrumentation. An associate=s or higher degree

in engineering technology, engineering or related physical sciences will be considered adequate academic preparation. In addition, technicians will be provided with intensive project-specific training in the conceptual basis and practical aspects of instrument installation and operation. To review and interpret data for purposes of validation and quality-assurance, knowledge of the design, operation and emissions characteristics of diesel engines is required. Personnel reviewing and interpreting data will have bachelor=s or higher degrees in engineering or related physical sciences.

4(a)(i) Emissions measurement

Exhaust emissions will be measured using portable on-board instrumentation. These systems enable quick and inexpensive measurement of emissions from heavy equipment during normal operation. In addition to their portability, the instruments are non-intrusive. Installation does not require removal of any components or modification of the equipment piece in any way. A team of several technicians can install the instrument while the equipment is not operating or off-shift, without assistance from the respondent. Once installed, the instrument does not interfere with the equipment=s normal operation.

Within the instrument, different sensors measure key engine parameters during normal operation, at intervals of one second (1.0 hertz). Primary parameters measured include:

- engine speed (revolutions per minute, rpm),
- oxygen concentration in the exhaust stream ([O_2], percent by weight, wt%),
- oxides of nitrogen concentration in the exhaust stream ([NO_x], parts per million, ppm),
- carbon monoxide concentration in the exhaust stream ([CO], percent by weight, wt%)
- total hydrocarbon concentration in the exhaust stream, ([THC), parts per million, ppm)
- particulate concentration in the exhaust stream ([PM], ng/m^3)
- ambient temperature (C),
- exhaust temperature (C),
- relative humidity (%), and
- barometric pressure (kilo-Pascals, kPa).
- date/time stamp

Collection of the primary parameters observed allows derivation of secondary parameters, which include the key variables for the survey. Derived measurements include:

- exhaust flow volume (adjusted to standard temperature and pressure, cu. ft/min),
- fuel flow volume (kg/sec),
- carbon dioxide emission rate (kg/sec, kg/gal),
- pollutant emission rates for NO_x, CO, THC, and PM, (g/sec, g/gal).

The typical measurement period for emissions will be one work day.

4(a)(ii) Activity measurement

Equipment usage or activity will be measured by on-board instrumentation, based on tested, Aoff-the-shelf@ technology. The instrument is very simple, consisting of a data-logger that records when the engine is turned on and off, along with an associated date/time stamp. These data allow the characterization of when and how long the equipment was operated while the instrument was installed.

These instruments are also non-intrusive, and do not interfere with normal equipment operation. Active tending by a technician during data collection is not required, nor is tending or effort on the part of the respondent is required.

The target measurement period for activity approximately one month. This period is long enough to directly measure daily, weekly and monthly usage, and with appropriate caution, also allows reasonable extrapolation to annual periods.

4(b) Contacts and Expected Response

4(b)(i) Contact and Followup Schedule

The goal for the initial interview is to make contact with a knowledgeable respondent by phone and to complete the Equipment Ownership interview over a period of approximately two weeks. At the outset, each contact will be mailed a letter that describes the survey, stresses importance of response, and lets the contact know that they will be contacted by phone for a brief interview.

After mailing the letter, interviewers will attempt to contact the respondent by telephone over a period of two work weeks. Interviewers will make repeated attempts to reach respondents, and will rely on their experience and judgment in deciding how to reach particular respondents. Interviewers will document each attempt and its outcome. Information recorded for all contacts will include date, time, outcome, any comments, and the interviewer I.D. number.

Following completion of the interview, if the respondent is eligible, the interviewer will solicit participation for emissions or activity measurement. After obtaining consent, the interviewer will make an appointment for an additional site visit, as necessary. At a mutually agreed-upon time, the interviewer and one or more technicians will complete the site inventory and the on-site equipment inventory and then select an equipment piece for instrumentation. After confirming consent to instrument a particular piece, the technician will arrange a time to return to the site to instrument the piece while it is off-shift. Following selection of an equipment piece, the technician will complete the Equipment Identification, Description and Installation Parameters at the time of instrumentation.

4(b)(ii) Calculation of Response Rate

The target response rate for the survey will be 75%. This target value applies separately to both the establishment and equipment samples. In addition, separate response rates will be calculated for each key variable, as appropriate, to address both whole-survey and item non-response. For a specific key variable, the response rate will be calculated as:

$$\text{response rate} = \frac{\text{total completions}}{\text{total contacts attempted}} \cdot 100$$

where terms as defined as follows:

- *total completions*: the number of useable responses obtained following all follow-up steps.
- *total contacts attempted*: defined as the sum of:
  (1) *total completions*, as above,
  (2) *unuseable responses*, and
  (3) *refusals*, defined as establishments contacted that decline to respond following all follow-up steps and a reasonable waiting period,
  less the sum of:
  (4) *ineligible establishments*, and
  (5) establishments proving unreachable at addresses and phone numbers listed in the sample database.

The sum of (2) and (3) will be designated as *total non-response*. With respect to item (4), note that eligibility is defined differently for the establishment and equipment samples.

Follow-up efforts will characterize establishments or households that decline to participate or fail to respond. General data items, such as industrial category, establishment size, and geographic location can be readily compiled from the sampling frame.

4(b)(iv) Nonresponse Followup

To address issues related to item or survey non-response, we plan to derive non-response adjustment weights, as described in sub-section 5(b)(ii), ANon-response adjustment weights.@

We also plan to conduct analyses to detect and estimate the magnitude and direction of frame-coverage and non-response biases, as described in sub-sections 2(c)(ii) ANon-sampling error,@ and 5(b)(iv) ABias detection.@ These analyses will be performed for each key variable, as appropriate.

5 ANALYZING AND REPORTING SURVEY RESULTS

5(a) Data Preparation

5(a)(i) Interview and Equipment Inventory Information

Phone interviewing will be conducted using computer-assisted telephone interviewing (CATI).

When conducting site inventories, technicians will record respondents= information on paper data sheets. At the end of each shift or workday, personnel will enter results into computer files to prevent loss of data should the originals be lost or damaged.

5(a)(ii) Emissions and Activity Data

Technicians will download emissions and activity data directly from the instruments prior to removal. Following calibration and quality-assurance, these data will be loaded into the Mobile-Source Observation Database (MSOD), a relational database of emissions measurements and supporting data developed and maintained by the USEPA National Vehicle and Fuel Emissions Laboratory.

During the process of loading the data into MSOD, quality assurance measures will be taken to ensure that the instruments were operating correctly and that the data are reliable for further analysis. Computer programs have been written and tested that detect problems in time-series data.

In addition, computer programs have been written to graphically represent the entire time-series for an equipment piece on a daily and hourly basis. These plots allow visual inspection of an entire dataset for irregular or unexpected behavior in the engine=s operating parameters, and also to compare measurements to ranges expected, given the size of the machine. A variety of comparisons of this type can be made:

- Idle and peak engine speeds can be compared to the engine=s ratings. For example, diesel engines typically idle at speeds between 550 and 750 rpm, and peak speeds are typically around 2,200-2,300 rpm.

- Ambient temperatures should increase gradually during the day, decrease at night, and be reasonable given the date and location of the measurement.

- Exhaust flow volume should be in a reasonable range given the size of the engine.

- Exhaust flow temperatures should increase sharply and exponentially when the engine shifts from idle to work, and should decline exponentially and stabilize during extended idle.

- Oxygen concentrations should not exceed 21% and never be less than 0%.

Again, graphs will be interpreted on a case-by-case basis by engineers and scientists, who will decide whether to reject portions of datasets or entire datasets for individual machines.

5(b) Data Analysis

5(b)(i) Multi-stage Sampling Weights

Three-Stage Equipment Sample. The three-stage selection probability for an equipment piece will be product of the first-, second- and third-stage probabilities (P_{PSU}, P_{SSU} and P_{TSU}, respectively), given by

$$P_{\text{piece}} = P_1 P_2 P_3 = \left(\frac{n_1}{n_{\text{PSU}}} \right) \left(\frac{n_2 MOS_2}{MOS_{\text{PSU}}} \right) \left(\frac{n_3 w_3}{\sum w_3} \right)$$

Where n_1 = the number of counties (PSUs) in the first-stage sample (30),
n_2 = the number of establishments (SSUs) in a given PSU,
n_3 = the number of equipment pieces (TSUs) in a given SSU,

w_3 = the weight assigned to each equipment piece, depending on its size and activity classes,
n_{PSU} = total number of PSUs in the study area,
MOS_2 = the measure of size value for a given PSU,
MOS_{PSU} = the measure of size value for the entire study area, equal to the sum of all MOS_2.

The third-stage sampling weight for each piece is the reciprocal of the sampling probability, or $1/P_{piece}$. Similarly, the second-stage sampling weight for each establishment will be calculated in a manner identical to that for the equipment sample, except that the final stage is the establishment, rather than the equipment piece. The two-stage selection probability P_{establ} will be given by P_1P_2, as defined above, and the corresponding second-stage sampling weight $w_{sample,2}$ will be given by $1/P_{establ}$.

5(b)(ii) Analysis of Key Variables

The section describes analyses designed to derive the key variables for the survey. Evaluation of these results will provide answers to the survey=s research questions. All analyses will incorporate the use of final sampling weights.

5(b)(ii)(1) Frame Blank Fraction

This parameter will be defined as the proportion of blank elements in the sample frame, calculated separately for each economic sector. It will represent the proportion of establishments that have moved out of a PSU, have gone out of business, or who prove unreachable based on the frame listings. The proportion will be defined as the ratio of the sums of final second-stage weights for establishment listings determined to be blanks (*YES*) and all listed establishments (*YES+NO*), given by

$$\hat{p}_{\text{blank}} = \frac{\sum^{YES} w_2}{\sum^{YES+NO} w_2}$$

5(b)(ii)(2) Equipment Use Fraction

This parameter will be defined as the proportion of establishments in each target sector that use diesel nonroad equipment. We will calculate it from the results of the screening interviews, based on item 7 of the Equipment Ownership Questionnaire. It will be defined as the ratio of the

$$\hat{p}_{\text{use}} = \frac{\sum^{YES} w_2}{\sum^{YES+NO} w_2}$$

sums of final two-stage weights for those establishments reporting use of equipment (*YES*) and all establishments (*YES+NO*), given by

5(b)(ii)(3) Equipment Density (D)

Equipment density will be defined as the number of pieces of diesel equipment per establishment in a given economic sector (D_{sector}), calculated as the weighted mean

$$D = \frac{\sum_{j=1}^{n_{establ}} w_2 n_{equip,j}}{\sum_{j=1}^{n_{establ}} w_2}$$

where w_2 are sampling weights and $n_{equip,j}$ is the equipment count for establishment j, out of a total of n_{establ} establishments in the sample. Equipment density provides a means of estimating equipment populations for larger areas such as states or Region 7, as the product of D_{sector} and estimated establishment populations, as reported by the Economic Census or the Census of Agriculture. Calculation of variances and standard errors for D_{sector} will give estimates of the magnitude of sampling error in the resulting equipment populations.

5(b)(ii)(4) Engine speed correlation

For engines equipped with electronic controls, we will acquire two independent measures of engine speed, one through the machine's control area network (CAN), and a second from a separate datalogger. For purposes of quality assurance, the goal is to correlate the data logger measurement against that obtained from the CAN. The correlation will be performed for all eligible engines measured, with the goal of achieving a simple R^2 of 98% for at least 95% of engines measured.

5(b)(ii)(5) Verification of Exhaust Flow Sampling

For engines instrumented for emissions measurement, proportional sample flow volume will be correlated with total exhaust flow volume. This analysis will be repeated for all instrumented engines, with the goal of achieving a simple R^2 of 98% on at least 95% of measured engines.

5(c) Reporting Results

Results of the survey will be made available to the public and within the Agency through the following means:

Mobile-Source Observation Database. Results of the survey will be uploaded into Mobile Source Observation Database (MSOD). The MSOD is a database of emissions measurements and supporting data, developed and maintained by the USEPA National Vehicle & Fuel Emissions Laboratory. Results for key variables plus necessary supporting data, such as final sampling weights, will be entered. However, the identities of respondents will be protected. Any information that could serve to identify a specific respondent will not be entered, or will be modified so as to prevent indirect disclosure of the identities of respondents. Disclosure prevention methods will be applied in described in Part A, 3(f). This database is available to the public upon request, in CD-ROM format.

Data Sharing. Results or summaries of results will be made available to respondents and study co-sponsors, upon their request.

Guidance Development. Based on survey results and experience gained during the conduction of this collection, we plan to draft a guidance document for states or other interested parties to initiate similar data collections to meet regional and local data collection needs. States and their regional Air Quality Associations have a strong demand for emissions inventory data that is more specific geographically than EPA can provide. Given the availability of portable instruments for emissions and activity measurement, a guidance will provide a blueprint for state and local agencies to follow to develop representative emission inventories at regional and smaller scales.

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APPENDIX B-1

Questionnaires

Screening and Equipment Inventory Interviews

Populations, Usage and Emissions of Diesel Nonroad Equipment in EPA Region 7
Integrated Sample Full Interview
Phase 01 (EOI) and Phase 02 (Inventory/Instrumentation)

INTRO PHASE 01

Hello. May I speak with <FIRST NAME> <LAST NAME>? My name is _____ and I am calling on behalf of the Environmental Protection Agency. We are conducting a study with construction companies about the diesel equipment and machinery used in their daily operations.

REPEAT INTRO ONLY IF REFERRED TO A MORE KNOWLEDGEABLE RESPONDENT

Hello, Mr./Ms. <FIRST NAME—DO NOT READ> <LAST NAME>? My name is _____ and I am calling on behalf of the Environmental Protection Agency. We are conducting a study with construction companies about the diesel equipment and machinery used in their daily operations. IF NEEDED: Examples of the types of equipment that we're interested in include,

Loaders	Dozers	Generator sets
Cranes	Excavators	Backhoes
Paving/surfacing equipment	Backhoes	Forklifts
Graders	Off-highway trucks	

We would like to do a brief survey with you that lasts less than ten minutes. Your company was scientifically selected for this study. Your participation is voluntary and your name and company will not be connected with your answers in any way. .

1. First, I would like to verify that your organization is <Establishment Name> and that your address is <Establishment Address>. Is this correct?

YES	01
NO	02
DK	98
RF	99

IF 'NO,' OBTAIN UPDATED ADDRESS OR ESTABLISHMENT NAME.

2. Now, I would like to verify that your organization's primary function is construction-related. Please specify whether you perform one or more of the following construction-related services.

Building, developing and general contracting	01	
Heavy construction	02	
Special trade contractor	03	
Concrete contractor	04	
Water well drilling	05	
Structural steel erection	06	
Excavation	07	
Wrecking and demolition	08	
Machinery or equipment installation	09	
OTHER (SPECIFY)	97	
DK	98	TERMINATE 01
RF	99	TERMINATE 01

3. Does your organization own, rent or lease at least one item of equipment or machinery that runs on diesel fuel? IF UNSURE READ EXAMPLES FROM ATTACHED LIST FOR APPROPRIATE PRIMARY FUNCTION SPECIFIED IN Q2.

YES	01	
NO	02	TERMINATE 01
DK	98	ASK FOR MORE KNOWLEDGEABLE PERSON
RF	99	ASK FOR MORE KNOWLEDGEABLE PERSON

4. Aside from owners, proprietors or partners, did your organization have one or more paid employees at any time during the last twelve months?

YES	01	
NO	02	TERMINATE 01

IF NECESSARY, CLARIFY THAT 'PAID EMPLOYEE' INCLUDES FULL OR PART TIME, PERMANENT, TEMPORARY OR SEASONAL EMPLOYEES.

5. How many paid employees work for your organization?

Specify Number	_____	SKIP to Q.7
DK ➔ PROBE FOR BEST GUESS Q.6	98	
RF ➔ PROBE FOR BEST GUESS Q.6	99	

6. I'm going to read you some numbers. Stop me when you think I get to the one that best describes your organization.

2 to 4 employees	01
5 to 9 employees	02
10 to 19 employees	03
20 to 49 employees	04
50 or more employees	05
DK	98
RF	99

7. Earlier you mentioned that you owned, rented or leased at least one piece of equipment. About how many pieces of diesel equipment or machinery are used by your organization?

SPECIFY NUMBER	_____	SKIP to Q.9
DK	98	
RF	99	

8. I'm going to read you some numbers. Stop me when you think I get to the one that best describes the number of equipment units or machines are used by your organization

1 to 4 pieces	01
5 to 9 pieces	02
10 to 19 pieces	03
20 to 49 pieces	04

50 or more pieces	05	
DK	98	
RF	99	

9. Of the equipment you've told me about, does at least one piece have a 25-horsepower or larger engine?

YES	01	
NO	02	
DK	98	
RF	99	

10. Does at least one piece have a 50-horsepower or larger engine?

YES	01	
NO	02	
DK	98	
RF	99	

11. Do you buy any or have you bought any of the equipment that you use?

YES	01	
NO	02	GO TO Q.13
DK	98	GO TO Q.13
RF	99	GO TO Q.13

12. When your company buys equipment, do you finance the purchase?

YES	01
NO	02
DK	98
RF	99

<SCRIPT NOTE: END OF EOI>

14-INTRO: FOR ALL RESPONDENTS:

To help EPA gather emissions data on diesel off-road equipment we'd like to list the equipment your company uses and then take measures on one or two pieces. This would involve sending a technical specialist to inventory the equipment at one of your worksites and scientifically selecting one or two pieces for instrumentation. Trained technicians would install the instrument before a workday begins and remove it after the workday ends. The process doesn't affect equipment performance in any way. And you or someone from your company are welcome to observe the installation.

Do you have any questions about this phase of the study before I ask you just a few more questions?

PROGRAMMER NOTE:

- NEED A DISPOSITION AT THIS POINT TO MONITOR RESPONDENT BAIL OUT RATE.

13. Is all of your equipment located at your company address <READ ADDRESS> or do you also have equipment located or in use at other work sites?

Equipment is all at company address	01	Skip to Q.17
Equipment is at other work sites	02	
DK	98	
RF	99	

IF Q14 = DK/RF (98 or 99) ASK FOR MORE KNOWLEDGEABLE PERSON AND REPEAT 14-INTRO, PREFACED WITH THE FOLLOWING:

Hello. My name is _____ and I am calling on behalf of the Environmental Protection Agency. We are conducting a study with construction companies about the off-road diesel equipment and machinery used in their daily operations. <INSERT NAME OF PREVIOUS RESPONDENT> has been participating with us on this study and has referred me to you as the person more knowledgeable about the equipment and machinery used by your company. Let me tell you about it. CONTINUE WITH 14-INTRO.

14. At how many sites or facilities do you have equipment stored or in operation?
    ENTER NUMBER: _____

15. Okay, we would like to select one of those sites at random, list the equipment there and select at least one piece of equipment for instrumentation. What is the name and location (address and city is okay) of each of the sites or facilities where you have equipment stored or in operation?
    LIST ALL SITES:_____

INTERVIEWER OR PROGRAMMER: RANDOMLY SELECT ONE SITE.

16. We would like to inventory equipment at the <SITE DESCRIPTION>site. Is there someone at the site that we should contact to schedule an appointment and let know that we have permission to visit the site and inventory the equipment?

NO, I AM THE CONTACT	01	SKIP TO Q19.
YES	02	

17. What is the name and phone number of this person(s)?

ENTER NAME1:_____

ENTER PHONE1:_____

ENTER NAME2:_____

ENTER PHONE2:_____

18. What would be the best times to contact < you or that person/them>?

ENTER TIME1:_____

ENTER TIME2:_____

19. At this site, do you have equipment operating around the clock, in shifts?

YES	01	
NO	02	TERMINATION 02
DK/NOT CERTAIN	98	TERMINATION 02

20. Does the equipment operate more than one shift in a 24-hour period?

YES	01	
NO	02	TERMINATION 02
DK/NOT CERTAIN	98	TERMINATION 02

21. Okay, what are the shifts that typically operate over a 24-hour period?

RECORD TIMES OF SHIFTS_____	TERMINATION 02
DK/NOT CERTAIN	TERMINATION 02

TERMINATION TEXT:

TERMINATION 01 (RESPONDENT IS NOT QUALIFIED). Thank you. Those are all the questions I have. We appreciate your taking time to help with this study.

TERMINATION 02 (RESPONDENT IS QUALIFIED). Thank you. In the next few days, a technical specialist will call to schedule a time to perform the inventory at <name of site>. We appreciate your taking time to help with this study.

APPENDIX B-2

Equipment Identification, Description and Instrumentation Parameters

EQUIPMENT SELECTION		
Respondent ID __ __ __ __ __ __ __ __ __ __	PieceID __ __ __ __ __ __ __ __	Date:__ __/__ __ /__ __ __ __

EQUIPMENT DESCRIPTION	
Equipment Type:	
Equipment manufacturer:	Engine manufacturer:
Equipment model:	Engine model:
Equipment model year:	Engine model year:
Equipment serial no.:__ __ __ __ __ __ __ __ __ __ __ __.	Engine serial no.:__ __ __ __ __ __ __ __ __ __ __ __.
Equipment Plate Code: ___ ___.	Engine Plate Code: ____ ____.
Equipment Comments:	Engine Comments:
Equipment Plate Codes: 01 = Not present 02 = Cannot locate 03 = Present but not specs not legible 04 = Present and legible 05 = Other	Engine Plate Codes: 11 = Not present 12 = Cannot locate 13 = Present but specs not legible 14 = Present and legible 15 = Other

HOUR-METER	
Hour-meter function code 1: ___ ___.	Hour-meter function code 2: ___ ___.
Beginning date for current meter reading (mm/dd/yyyy): __ __/__ __/__ __ __ __.	Engine hour-meter reading:__ __ __ __ ,__ __ __.
Hour-meter comments:	

Hour-meter Code 1:
21 = Meter not present
22 = Meter present but not functioning
23 = Original meter; reading can be presumed to represent hours since original purchase
24 = Original meter reset following maintenance or resale, can identify beginning date for current reading
25 = Original meter reset following maintenance or resale, CANNOT identify beginning date for current reading
26 = NOT original meter, can identify beginning date for current reading
27 = NOT original meter, CANNOT identify beginning date for current reading
28 = Other (DESCRIBE IN HOUR-METER COMMENTS)

Hour-meter Code 2:
30 = No reading available
31 = Current reading presumed accurate
31 = Current reading not accurate, reliable adjustment possible (DESCRIBE IN HOUR-METER COMMENTS)
33 = Current reading not accurate, reliable adjustment not possible (DESCRIBE IN HOUR-METER COMMENTS)
34 = Other (DESCRIBE IN HOUR-METER COMMENTS)

VISUAL INSPECTION			
Are major exhaust leaks present?	Y	N	(IF 'YES,' DO NOT INSTALL INSTRUMENT)
Is alternator speed signal reliable?	Y	N	(IF 'NO,' DO NOT INSTALL INSTRUMENT)
Are obvious modifications or mal-maintenance evident?	Y	N	(IF 'YES,' INSTALL INSTRUMENT AND DESCRIBE IN COMMENTS)
Comments:			

IF CANNOT INSTALL INSTRUMENT ON SELECTED PIECE, RECLASSIFY SELECTED PIECE AS 'INELIGIBLE,' SELECT ADDITIONAL PIECE AND REPEAT EQUIPMENT DESCRIPTION.

INSTALLATION DATE & TIME	
Date installed: ___ ___ / ___ ___ /___ ___ ___ ___.	Time installed: ___ ___: ___ ___ am pm
Date removed: ___ ___ / ___ ___ /___ ___ ___ ___.	Time removed: ___ ___: ___ ___ am pm
Comments:	

ENGINE RATING			
Rated Power			
number:___ ___ ___ ___.	units code: ___ ___.	source code:___ ___.	method code:___ ___.
Rated Speed			
number:___ ___ ___ ___.	units: RPM .	source code:___ ___.	method code:___ ___.
Peak torque			
number:___ ___ ___ ___.	units code: ___ ___.	source code:___ ___.	method code:___ ___.
Peak Speed			
number:___ ___ ___ ___.	units: RPM .	source code:___ ___.	method code:___ ___.
Comments:			

Units codes	Source codes	Method Codes
11 = horsepower (gross) 12 = horsepower (net) 13 = kilowatts (gross) 14 = kilowatts (net) 15 = foot-lbs(ft-lb) 16 = newton-meters (nm) 17 = Other (DESCRIBE)	21 = Owner's/user's verbal report 22 = Engine plate 23 = Manufacturer'specifications 24 = Reference source 25 = Unavailable 26 = Other (DESCRIBE)	31 = NETT SAE 32 = ISO 33 = Unknown 34 = Unavailable 35 = Other (DESCRIBE)

INSTALLATION PARAMETERS

Is exhaust after-treatment present? Y (= 1) N (= 0)
DESCRIBE AFTER-TREATMENT TECHNOLOGY:
Unit Power (volts): ___ ___ ___.
<u>Tailpipe Dimensions:</u> Outer diameter (inches): ___ ___ | ___ ___ ___ (MEASURE TO THREE DECIMAL PLACES). Pipe wall thickness (inches): ___ ___ | ___ ___ ___ (MEASURE TO THREE DECIMAL PLACES) Inner diameter (inches): ___ ___ | ___ ___ ___ (OD - 2× wall thickness)

INSTRUMENT IDENTIFICATION			
Instrument Code: ___ ___.			
Box No.: __ __-__ __.	Datalogger ID: __ __-__ __	Flowmeter ID.: __ __-__ __.	NO_x/O_2 Sensor Serial No. __ __ __ __ __ __ __ __ __ __
Cell No. __ __ __ -__ __ __ -__ __ __ __.			

<u>Instrument Codes</u>

01 = PAMS
02 = SPOT
03 = SEMTECH-D
04 = Other