

Appendix C

Work Sampling

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This appendix presents the principles and techniques of work sampling as related to contract auditing. It concentrates on the application of work sampling to estimate workforce utilization. General guidance is provided for the selection and use of appropriate work sampling methods for accomplishing audit objectives.

C-100 Section 1 – Work Sampling Overview [](#)**

C-101 Introduction [](#)**

The section presents an overview of work sampling with focus on background, definition, advantages, terminology, and software. In addition, the connection between work sampling and statistical sampling in general is demonstrated.

C-102 Background [](#)**

a. Work sampling is a commonly used industrial engineering technique designed to estimate how resources such as people, machines, facilities, or equipment are being utilized. The objective of work sampling is to assess the workforce utilization of a selected portion of an organization's operations. If an operation is to be audited, work sampling is a low cost alternative to continuous monitoring, just as sampling in the audit context is a low cost alternative to 100 percent evaluation of an account. The cost of

continuous monitoring of an entire operation is generally prohibitive, and work sampling can yield a reasonably accurate estimate at a fraction of that cost.

b. Work sampling studies are used by auditors to evaluate a contractor's labor utilization. When performing a work sampling study, the auditor makes a specified number of observations of contractor personnel involved in the operation being audited. Each observation is classified according to type of activity, the activity types being specified prior to sampling. Using information gathered during the study, the auditor can estimate the percentage of time that the workers actually spend in each activity.

c. With minimal specialized training, an auditor can identify various worker actions and determine whether a contractor's management practices yield reasonable and acceptable levels of working activity. Work sampling may disclose underutilized workers, poor work practices, overstaffing, inadequate training, inefficient plant layout, excessive delays (caused by poor planning, material scheduling, or tooling), or other deficiencies.

C-103 Definition **

a. Work sampling is broadly defined as the application of statistical sampling techniques to the study of work activities. In the audit context, work sampling is typically used to estimate the proportion of workers' time that is devoted to different elements of work activity. Work sampling is also known as activity sampling. It can be also used to estimate equipment or vehicle utilization.

b. For DCAA applications, the observed activities are grouped into one of two main classifications: working or nonworking.

(1) The working classification can be subdivided into desirable or undesirable. Hands-on activities like assembling, machining, drawing, designing, etc., are desirable work related efforts, while waiting for material handlers to move parts, talking to supervisor, cleaning work areas, or walking to get tools, though necessary, may be undesirable activities.

(2) Nonworking activities include unnecessary delays, needless walking, nonbusiness conversations, personal time, etc. These activities may be broken down further to help identify contributing factors. The degree of detail will depend on the overall objectives of sampling, the type of work environment, and the sampling plan.

C-104 Assessing the Reasonableness of Labor Costs **

a. Contractors develop labor estimates and budgets based on incurred labor cost history. If these costs reflect undesirable work activities, they are not a reasonable basis for estimating future costs. Typically, auditors perform two significant audits to determine whether incurred labor costs are allocable and reasonable. These audits are:

(1) Labor allocation audits determine whether the contractor's workers are charging the activities to which they are actually assigned.

(2) A work sampling study estimates the amount of time that workers spend on various activities.

b. The typical DCAA work sampling audit does not assess worker effectiveness or efficiency. Its primary concern is whether the work force is working.

C-105 Application of Statistical Sampling **

a. The statistical basis for work sampling is the same as that for the statistical sampling methods discussed in the [Attribute Sampling Guidebook](#). The objective of work sampling should be to make unbiased and representative observations. The observations to be made must be selected randomly from the entire work sampling universe. The observations themselves must be free of any bias. If these conditions are met, the sample results will differ from the actual conditions in a random manner and will be a representation of the activities in the universe under study. Furthermore, with an increasing number of observations, the sample results will more closely approximate the actual conditions.

b. Work sampling can enhance auditor productivity. Worker activities, like records or items in an account or bill of materials, can be sampled instead of being totally or continuously audited.

C-106 Advantages, Terminology, and Software **

a. Some of the primary advantages of work sampling are as follows:

(1) Sampling is less expensive than continuous observation techniques.

(2) Observers with minimal specialized training can conduct the sampling.

(3) The number of observations can be adjusted to meet desired levels of precision.

(4) Sampling is an effective means of collecting facts that would not normally be collected by other means.

(5) Sampling results in less anxiety and agitation among workers than continuous observation.

(6) There is minimal interference with the worker's normal routine.

b. An understanding of the principal work sampling terms is necessary to use this guidance and work sampling software. Key terms and their definitions are as follows:

(1) Survey Area (Universe): The total of all workers or machines to be covered in the survey.

(2) Preliminary Survey (Probe): The preliminary "work/no-work" observations are conducted to determine the general amount of nonworking in the survey area. This survey helps to estimate the approximate number of observations that will be required for the work sampling audit. Additionally, the preliminary survey aids in identifying the categories of nonworking activity.

(3) Preliminary Point Estimate: The preliminary estimate of nonworking activity determined either by the preliminary survey (probe) or past experience.

(4) Knowledge Workers: Those workers whose output is mostly intangible (e.g., accountants, engineers, clerks, etc.). Often referred to as nontouch workers.

(5) Physical Workers: Those workers whose output is mostly tangible (e.g., welders, machinists, assemblers, etc.). Often referred to as touch workers.

(6) Group Sampling: A method in which groups of workers are collectively observed at randomly selected areas and times.

(7) Individual Sampling: A method in which the workers are randomly selected and individually observed at randomly selected times.

(8) Observation Tour (Round): A tour performed at a specific time to determine the work classification of an individual worker or a group of workers.

(9) Observation: The recorded results of an individual or group sampling observation tour. An example of a group observation is: 5 working, 3 nonworking (2 nonbusiness talking, 1 reading newspaper).

(10) Observation Time: A randomly selected time for initiating an observation.

(11) Nonworking Activity: That effort which does not contribute to the output of the operation. Eating and nonbusiness talking are examples of nonworking activity.

(12) Working Activity: That effort which directly or indirectly contributes to the output of the operation. Assembling and designing are examples of working activity.

(13) Undesirable Working Activity: An activity that is classified as working but can be eliminated or reduced by improved procedures. Examples include walking, waiting, cleaning, etc.

(14) Confidence Level: The chance (or probability) that the true universe value that is being estimated by the sample is included in a specified range (see item (15) below). In evaluation of sample results, the desired confidence level is specified by the sampler and the precision range is computed accordingly. In sample size determination, both the desired confidence level and the desired precision range are specified, and the sample size is computed accordingly. For example, if the desired confidence level is 95 percent and the precision range computed from the sample results is from 12 to 18 percent nonworking, there is a 95 percent chance that the true

nonworking is between 12 and 18 percent. Normal desired confidence levels are 90 or 95 percent.

(15) Precision Range: A range of possible universe values that is determined according to the confidence level (see item (14) above). When computed from sample results to meet a specified confidence level, the precision range consists of an upper and lower limit. In sample size determination, the desired precision range (sometimes referred to as desired precision) is specified along with the desired confidence level. It does not depict an upper and lower limit, but instead it consists of a desired limit on the amount by which the sample point estimate might differ from the true universe value. In work sampling desired precision ranges are typically 6 percent.

(16) Consideration Factor: A factor or consideration to allow for some nonwork related activities which is determined based on the sampling plan to allow for some nonwork related activities, Accordingly, it is applied to reduce the observed non-work amount by that amount.

c. A spreadsheet program or DCAA software may be used to process the results of a work sampling study. The DCAA software was developed internally and can analyze individual or group sampling results. Consult your regional operations audit supervisor, or OTST for further information. A copy of the software is available on the DCAA intranet. The DCAA software computes the average percentage of nonworking activity, related precision ranges, and estimates of the number of observations required to achieve desired precision at various confidence levels. In addition, the program can be used to analyze causes, areas, and timeframes of nonworking activity.

C-200 Section 2 – Planning for Work Sampling **

C-201 Introduction **

The section presents the step-by-step procedures of planning and preparing for a work sample.

C-202 Decision to Sample **

The decision to work sample may be based on general perceptions or specific findings. Examples include routine floor checks that reveal a significant amount of non-work activities or unnecessary staffing, or volume adjustments that suggest the need for staffing reductions where none have occurred. Whatever the stimulus, a probe can be performed to determine the need for a detailed work sampling audit.

C-203 Planning the Work Sample **

a. At the outset, prepare an audit program with audit steps for the preparation of a sampling plan. Be sure to dedicate adequate time and resources to the sampling plan. General steps are as follows:

(1) Develop audit objective and define the universe.

- (2) Establish familiarity with contractor's operation.
 - (3) Choose either the group or individual sampling method.
 - (4) Obtain necessary data from contractor (such as organization charts, plant layouts, and shift schedules).
 - (5) Determine activity classifications for workers being audited.
 - (6) Design observation forms to accumulate and summarize data.
 - (7) Conduct a probe to evaluate classifications, estimate nonworking activity, evaluate observation areas, as well as any other required area or activity.
 - (8) Establish audit dates and duration.
 - (9) Estimate sample size and select audit staff.
 - (10) Prepare team folders containing such items as schedules, observation forms, and plant layouts.
 - (11) Train audit team observers.
 - (12) Estimate the consideration factor (I-204).
- b. The sequence and steps may be altered to fit specific situations as particular audits evolve or may be tailored to suit uniquely different audits.

C-203.1 Defining Audit Objective, Universe, and Work Sampling Method **

a. The auditor should begin by defining the audit objective. List various reasons for considering work sampling, such as excessive walking, idleness, and poor use of resources. Define the universe (area, population, and work periods) to be studied. These two steps will help clarify and focus the audit. As a part of the audit objective, develop a precise statement of purpose. Data accumulation and savings computations hinge on a precisely defined objective.

b. The auditor should become familiar with the target universe. Information sources include facility layouts, organization charts, department charters, product lines, process sheets, and occupation codes. Gather information about support service functions and areas including test labs, CAD/CAM rooms, technical libraries, tool cribs, stock rooms, production/quality control points, and setup and maintenance areas.

c. Choose either the individual or group sampling method.

(1) In individual sampling, for each observation, a worker is randomly selected from the defined population. The activities of the entire defined population are determined based on an analysis of the activities of the randomly selected workers. The advantages of the individual method are as follows:

(a) Individual sampling allows detailed scrutiny of employee work activities. The observation consists of only one individual worker at a time. Any missing worker in the sample must be accounted for.

(b) Individual sampling adapts readily to detailed classification of activities. This aids in the analysis of nonworking activities.

(2) In group sampling, for each observation, the activities of groups of workers from the defined population are recorded. The advantages of the group method are as follows:

(a) Group sampling requires, at maximum, less than half the time to conduct each observation round. Seeking specific individuals is time consuming.

(b) Group sampling is less disruptive to the work force because individuals are not singled out for sampling and, unlike individual sampling, no follow-up action to account for missing workers is required. Therefore, discussions with supervisors or coworkers to trace whereabouts of individuals are avoided.

(c) With group sampling, the potential for worker-induced bias is reduced. Workers are not forewarned, as is likely when specific individuals are sought.

d. Select the appropriate sampling plan and selection procedure. The sampling plan can be either simple or stratified, and random sample selection procedure can be either unrestricted or restricted.

(1) Restricted sample selection generally takes the form of systematic sampling. For a general discussion of random sample selection procedures geared to audit sampling, see the [Variable or Attribute Sampling Guidebooks](#). The concepts are fully applicable to work sampling. Systematic sample selection in work sampling generally is most useful in setting the time when rounds will be made. A fixed time interval between one observation and the next is established. The time interval must be large enough to give the sampler adequate time to make a round at one location and move to the next. The starting time, the time of the first observation, is selected randomly and can be anywhere between a specified minimum and maximum starting time. The difference between the minimum and maximum starting times must equal the fixed time interval the subsequent observations are to be made. Subsequent rounds must be made at fixed intervals from the randomly selected starting time.

(2) A stratified sampling plan consists of subdividing the universe into strata, which are essentially separate smaller universes. Either simple or systematic selection can be used on the individual strata. There are various reasons for stratification. As discussed in I-400, it enables the sampler to control the number of sample observations that are drawn from specified subsets (strata) of the universe. In group sampling, stratification can yield sample results that are more precise than those of simple random samples of the same sample size. This would be the case when certain areas of activity can be expected to have exceptionally high variation (or wide fluctuation) in nonproductive activity from one observation to the next. If stratification is done, the

strata should be well defined and the conclusions based on the sample from each stratum should be limited to that stratum.

C-203.2 Obtaining Contractor Data **

a. Notify the contractor of the pending work sampling audit. In a brief formal letter, explain the sampling technique, purpose, and tentative schedule. Request that the contractor assign a liaison contact. Also, if appropriate, propose a date for an entrance conference. Ask for support from key contractor and government personnel in not disclosing information to the workforce about the pending audit.

b. At some early point, ask the contractor for data needed to support the audit. Typical pre-sampling information includes:

- (1) Detailed maps or layouts of work areas and facilities.
- (2) Department charters, job classifications, and position descriptions.
- (3) Policies and schedules for work hours and break and lunch times.
- (4) Procedures for labor utilization and work measurement.
- (5) Organization charts and employee rosters.
- (6) Other relevant information or IT file access that will facilitate the audit.
- (7) Union environment and agreements

c. In addition, arrange to interview supervisors responsible for the areas to be sampled. Ascertain their understanding of policies and practices relative to their responsibilities. Emphasize the importance of not disclosing the upcoming work sampling activities to the workforce.

C-203.3 Classifying, Formatting, and Probing **

a. In work sampling, subcategorization of activities under "working" and "nonworking" is desirable. Define subcategories that are clear, concise, and mutually exclusive. Subcategories should permit "snapshot" observation and recording without time-consuming decisions. Create enough classifications to sustain audit objectives without being too exhaustive. If the number of classifications is excessive, sampling may become too cumbersome to accomplish effectively. Below is an example of subcategorization. W1 and W2 are subcategories of work activity, whereas N1, N2, N3, N4 are subcategories of nonworking activity. This example may be used as a model to develop a sampling plan. Modify or expand the subcategories as appropriate to reflect the sampling population and type of work being evaluated. Subcategories not described below may be required to perform a good work sample that meets the specific audit objectives.

- (1) Working subcategories:

W1: Operative or "hands-on" (such as machining, welding, setting up, cleaning, inspecting, adjusting, and monitoring)

W2: Business conversations (including conversing with supervisor, engineer, maintenance, material handler, and timekeeper)

(2) Nonworking subcategories:

N1: Idle (such as waiting on assignment, material, tools, maintenance, and inspection)

N2: Personal (including eating, drinking beverage, smoking, and tending to personal hygiene)

N3: Non-business talking (such as joking and chitchatting)

N4: Miscellaneous (such as horseplay, reading newspaper, gambling, and sleeping)

b. Design the observation form in a simple chart format. Leave adequate space to record brief comments that make each observation unique. For every round, one form is used to collect, summarize, and input observed activity. These forms become part of the working papers to support the audit position.

c. Conduct a probe to test the adequacy of the observation forms and the adequacy of overall preparation. The probe will also provide a preliminary point estimate. The point estimate is used to determine sample size from which an audit timeframe and staffing needs can be calculated. The probe also provides data that can be used to familiarize auditors with the Agency's work sampling software.

C-203.4 Scheduling, Sizing, and Staffing **

a. Schedule the dates and duration of work sampling to cover a period of operation that is typical of the contractor's normal business activity. Key factors to consider are required sample size, audit team availability, contractor production and work schedules (including shutdowns, holidays, and vacations), and the cyclical nature of worker activities. Sampling periods of 5 to 10 cumulative days in duration are preferred. Sampling periods should never be less than five days. If the number of work days in the sampling period is greater than the number of observation days, observation days should be selected randomly in the sampling period.

b. Sample size is estimated by using the Agency work sampling software.

(1) The sample size for individual sampling is derived by selecting an option- for sample size and specifying the point estimate, confidence level, and precision range.

(2) To estimate a sample size for group sampling, conduct the probe and input the requested data. The software will analyze the data and provide a table of sample size for five different confidence levels with precision ranges.

(3) The sample size will vary with the amount of nonworking activity, desired confidence level, and desired precision. However, precision has the largest effect on a sample size. The effect of each of these three factors on the sample size are as follows:

(a) For a given desired confidence and precision level, the required sample size will increase with the amount of nonworking activities until the nonworking activities reach 50 percent. After nonworking activities exceed 50 percent, the sample size will then begin to decrease with further increases in nonworking activities.

(b) For a given level of nonworking activity (the point estimate) and a given desired precision, the required sample size will increase with an increase in the desired confidence level.

(c) For a given level of nonworking activity and a given desired confidence level, the required sample size will increase with a decrease in precision range (more precise) and decrease with an increase in precision range (less precise).

c. Audit team staffing is based on sample size divided by potential number of observations per team per day (visits in the case of group sampling). Allow a sufficient margin of extra observations to compensate for possible problems. If possible, schedule about twenty percent additional observations. These extra observations will strengthen the audit.

(1) Determine the number of people required, select the individuals, and advise them of scheduled dates for training and auditing.

(2) Do not understaff. Work sampling is a physically demanding activity that will require occasional substitutes.

C-203.5 Training Audit Teams **

a. Prepare one folder for each team including predated and sequenced observation forms with specific times and locations (and people, if using individual sampling), daily summary sheets for tabulating observations, a copy of the defined activity classifications, facility maps, and any other relevant information.

b. Schedule a training day for all team members as close as possible to the first audit day. Key points to emphasize include:

(1) scope and objective of the work sampling study.

(2) classifications of activity.

(3) work sampling forms administration.

(4) use of maps and layouts.

(5) role of team members.

(6) observation techniques.

c. Provide the work sampling teams with an opportunity to practice under audit conditions. This practice may help air many remaining questions before the actual sampling begins.

C-204 Establishing the Consideration Factor **

a. Since some nonworking-related activity is virtually unavoidable and can be expected at any work place, a consideration factor is applied to lower the observed nonworking-related activities. This factor is known as the work sampling consideration.

b. In DCAA work sampling audits, the amount of the work sampling consideration will vary depending on variables such as the type of industry, work environment, sampling plan (classification of working and nonworking categories), sampling universe (time and area under observance), company policies and procedures, and union contracts. Because of the various complexities involved, there are no set guidelines in industry for developing work sampling consideration factors. Therefore, the judgment of the auditor in determining reasonableness of the observed levels of nonworking activities is extremely important. The following guidance is provided to help the auditor develop work sampling consideration factors.

C-204.1 General Discussion **

The normal industry or contractor PF&D (personal, fatigue, and minor delays) allowance factors used for setting labor standards for measuring productivity should not be applied to work sampling studies. These factors are used in situations where a job is scrutinized in great detail and the normal time for performing the task is determined by an industrial engineer or other experienced time-study staff. A DCAA work sampling study does not measure productivity. However, these factors can be used as a guide in estimating work sampling considerations. The auditor should analyze the contractor's PF&D factors and make any needed adjustments based on the sampling plan. A majority of DoD contractors do not use engineered work measurement standards and may not have PF&D factors that can be used for this guidance.

C-204.2 Personal Component **

a. Personal needs are normally met by visiting restrooms, water fountains, the cafeteria, and taking breaks in a work area. Companies normally allow one break in the morning and one in the afternoon, of 10 to 15 minutes duration, to meet these needs. This is equivalent to 4.2 to 6.3 percent of daily work time. The length of these breaks is normally specified in a union contract or in the company's policies and procedures.

b. In a work sampling study, DCAA does not normally make observations during break times. Additionally, personal needs during work periods are commonly met outside the immediate work areas. Therefore, very little consideration, if any, is required to compensate for personal needs.

c. In instances where employees do not have scheduled breaks or where their

break areas are not excluded from the sampling universe, some consideration is necessary. This consideration is necessary because some employees may prefer to take breaks in their work areas.

d. Generally a 4 to 5 percent consideration could be considered appropriate providing the following two conditions are met: (1) all areas except restrooms and lunchrooms are included in the sampling universe, and (2) all work hours, including break times, are included in the sampling universe.

C-204.3 Fatigue Component **

a. Fatigue normally results in a slowdown of work pace and, in some instances, a minor stoppage of work. However, it is believed that breaks help to reduce the effects of fatigue. Some experts in the field of work measurement suggest that no additional fatigue allowance is necessary in companies with scheduled work breaks, except in unusual situations.

b. DCAA work sampling does not measure the efficiency of employees or the speed at which they work. DCAA work sampling simply records whether an individual is working or not working. Therefore, under normal circumstances, a consideration for fatigue is not necessary.

c. However, certain work environments (e.g., hot and humid foundry working conditions, or the continuous observance of monitors) may necessitate workers taking short "breathers". These breathers may be accomplished in work areas and include eating, smoking, and talking to other workers; or they may take place outside work areas and include visiting a water fountain, using the restroom, or getting coffee. If unscheduled relief from monotonous work is achieved outside the workplace, DCAA work sampling will not normally observe it, in which case no consideration is necessary. However, if the relief from monotonous work is achieved at the workplace, some considerations may be necessary. Since each work environment is different, the consideration has to be left to the auditor's judgment. Normally a range of 1 to 3 percent consideration may be more than adequate.

C-204.4 Minor Delay Component **

a. Minor delays (such as talking to a supervisor, waiting for someone to get out of the way, or changing tools) are work interruptions over which an employee does not have direct control. Since these delays occur randomly, an individual performing a time-study to establish labor standards to measure labor productivity will exclude this time from total observed time. Then, based on the type of work observed, he or she adds a reasonable amount of time to the raw work time to compensate for the delays. In the absence of in-house developed allowances for delays, the manufacturing industry normally adds 5 percent to develop work standards.

b. Most traditional minor delays, which are considered undesirable when setting productivity standards, are normally identified as work-related activities in DCAA work sampling audits. Therefore, very little delay consideration for work sampling is

necessary. However, unusual situations (such as frequent waiting for inspectors to approve work) may result in employees performing activities other than those which are considered work related activities by the DCAA study. As addressed in I-204.4c., if it is determined that other work-related activities cannot be performed during these interruptions, a reasonable consideration may be necessary.

c. The work sampling study itself may identify various types of interruptions that commonly occur in the work area. Accordingly, the auditor may want to wait until the work sampling study is complete before making an evaluation for determining the reasonableness or the need of a delay consideration.

C-300 Section 3 - Conducting and Analyzing Work Sampling **

C-301 Introduction **

This section presents guidelines for conducting the actual work sample and analyzing the results.

C-302 Conducting the Work Sample **

One auditor should be designated as the overall coordinator for the work sampling application. The coordinator has the following responsibilities.

a. Arrange for adequate office space for teams to meet, communicate, and prepare daily reports. Team leaders are responsible for generating narrative summaries of each day's observation experience. Summaries should include potential causes for nonworking activity, contractor supervisor and employee attitudes, impact of environmental factors, etc. These summaries will be used in conjunction with the work sampling results to produce the final audit report.

b. Establish sampling schedules that are realistic and will minimize errors caused by haste. Emphasize the need to avoid personal absence and tardiness. Have substitutes readily available for unavoidable absences. Initial, as well as subsequent observations must be taken at the pre-selected times.

c. Meet with observers at the start and close of each day to make pairings and assignments and distribute folders. Use these sessions to verify completeness, organization, and accuracy of folder information and communicate collective concerns and resolve each day's problems.

d. Review each team's daily summaries and, as necessary, spot-check observation forms for accuracy and completeness. Arrange for input of data to DCAA software or other applicable software, request desired output, and analyze cumulative performance against objectives. Review the software output to:

(1) Compare and contrast team performances to isolate unusual trends. Rotate auditor pairings frequently to minimize the possibility of bias. Encourage team members to switch, at least once per day, the job of recording observations. Observations should

be made independently, but discussed and agreed upon before recording.

(2) Track daily point estimates to verify adequacy of projected sample size. This is done by computing an updated required sample size using the updated point estimate and the original values for the desired precision range and confidence level.

C-303 Evaluating the Work Sample Data **

The primary objective of work sampling is to determine how well contractors use their resources. Evaluation of sample data is the last step in that process.

a. The DCAA software provides different sort options for sample data. Subareas of the contractor's operation may be brought into focus by sorting the data with respect to such characteristics as date, time, shift, area, department, supervision, process, product, teams, etc.

b. Examine the data using various sorts to identify subareas of unusual nonworking activity. Concentrate analysis on subareas impacting audit objectives. Only subareas which make up a stratum (as defined in the original sampling plan) can be validly assessed statistically, but other examinations can still yield useful information.

c. Focus attention on the "nonworking" and "undesirable working" classifications in the sampling.

(1) For activities classified as non-working, expect to find histogram spikes occurring around start-up, break, lunch, and quit times. Late starts, extended breaks, and early quits are indicative of relaxed work rules. Another non-working classification, "talking," occurs frequently at remote and isolated work stations where direct supervision is infrequent or unstructured work is performed.

(2) Activities classified as undesirable working activity such as excessive walking, frequent business discussions, repetitive equipment and tool problems may indicate poorly trained employees or poorly engineered products, processes, or production environments.

d. Work sampling data is the "effect" portion of the "cause/effect" sequence. The contractor is ultimately responsible for determining cause and implementing corrective action. There may be data in the supporting summaries that suggests "cause". Sharing such useful information with the contractor is appropriate.

e. Undesirable activities should be documented for follow-up in future work sampling studies.

C-304 Summarizing the Audit **

a. Draft the audit report using the format in 10-400 and discuss findings with the supervisory auditor.

- b. Consult with the Agency technical specialists as necessary.
- c. Organize supporting documentation and arrange for exit conference.
- d. Conduct an exit conference in accordance with 4-304.
- e. Prepare final audit report.

C-400 Section 4 - Work Sampling Concerns **

C-401 Introduction **

The section discusses major concerns specific to the sample as a valid representation of the universe, stratification, and bias. An understanding of statistical sampling ([Variable and Attribute Sampling Guidebooks](#)) is recommended when using this section.

C-402 The Sample as a Valid Representation of the Universe **

The universe in a work sampling study is the contractor activity being audited. Operationally, it is defined in terms of the entire work environment connected with the activity, including the work force, the work period, the workplace, and the work itself. For purposes of statistical sampling, the universe consists of all possible observations of the activity that could be made. Any sample that gives every possible observation an equal chance of selection is a valid representation of the universe.

C-403 Stratification of the Work Sample **

a. Stratification divides the universe into separate smaller universes, or strata. Stratification in the typical audit context is discussed in the [Variable Sampling Guidebook](#), the primary reason cited being the potential for improvement in sampling precision. The same principles can be applied directly to work sampling but there are also other reasons for stratification. Among these reasons is control of the relative proportions of different types of observations that appear in the sample.

b. In work sampling, the observed event is the activity of the observed individual(s) at the moment of observation. However, the sampler is often interested in the nonworking status of specific subsets of the universe, categorized according to such characteristics as day of the week, type of work, or shift. There is an intuitive (but unwarranted) impulse to require that such characteristics be represented in the sample in the same proportions as they exist in the universe. However, a valid sampling procedure provides no guarantee that these characteristics will be proportionally represented.

c. The occurrence of specific characteristics in the sample can be controlled through stratification according to the characteristics. If it is considered important, for instance, that specific proportions of the sample items be drawn from each work shift, the universe could be stratified according to shift. This in effect would create a separate

universe (stratum) for each shift. Each stratum could be further stratified by type of work if so desired.

d. In work sampling, stratification by day of the week is the most frequent stratification scheme, yet there is little mention of stratification in work sampling handbooks or similar literature. The sampler may not even be aware of the stratification, but it is implicit anytime the work sampling plan calls for a specific number of observations per day. Error results not during the sampling itself but when evaluation of the sample results ignores the stratification.

e. For administrative and practical convenience, work sampling plans often require the same number of observations per day of the study. Handbook literature that deals with this practice ignores the implicit stratification. The reason for this omission is that with sufficiently large sample sizes, the effect of the practice is minimal. Work sampling studies typically involve at least several hundred observations, and often involve more than a thousand. With such large sample sizes, it is overwhelmingly likely that very close to the same number of observations per day would be drawn anyway, even if the daily constraint were not placed on sample selection. In such cases, the error incurred by evaluating the sample as though no stratification were done is minimal.

f. Workers within a population differ in numerous ways. There can be touch/nontouch, technical/administrative, hourly/salaried, union/nonunion, and supervisor/subordinate personnel within a given population. Because of these differences, the auditor should first define the population in which the study will be conducted. Depending on the audit objective, the contractor's population may be subdivided or stratified. The contractor's organizational structure may provide a logical population grouping. Exercise care when defining the strata.

g. Selection of the work sampling study period must be done carefully so that contractor operations during the period typify operations throughout the year. Periods include days of the year and times of the day.

(1) Most work sampling studies are conducted over a 1-2 week period. Special attention should be directed at period selection. It may be appropriate to consult with the contractor to arrive at a mutually acceptable time to conduct the study. Advance agreement should eliminate subsequent problems on this point.

(2) Consider the impact of shift work on worker behavior. As a general rule, working activity deteriorates from first to second to third shift. Reasons for the decline in work activity include inadequate offshift supervision and support.

(3) Exclude from consideration certain time periods in the contractor's universe that will bias the study. Examples include time segments surrounding major staffing or production schedule changes, holidays or pending plant shutdowns, or significant weather extremes which affect the work. Inclusion of these periods would distort the nonworking content in the study.

(4) The time period over which the sampling will be conducted should emulate a typical day's operations. To illustrate, consider cyclical variations which occur normally within a workweek. Monday morning and Friday afternoon are typically transition times. However, to avoid bias, each work day must be given an equal opportunity to contribute to the sample.

(5) Periodicity is the tendency of subjects to adapt to normal routine or fixed patterns. Examples of periodicity include start, break, lunch, and quit times. Typically, high nonworking activity clusters around these periods. Randomly selected observation times will ensure inclusion of these periods.

C-404 Avoiding Observation Bias **

a. Observation bias, sometimes referred to as measurement bias, is the tendency to either overestimate or underestimate the true value of the observed event. Intentional or otherwise, observation bias can be caused by both the observer and the observed.

b. Bias caused by observers can be eliminated through proper training and formation of observation teams.

(1) A team should normally consist of two people. It may consist of two auditors, though teaming an auditor with a procurement employee or a contractor's representative can promote acceptance of work sample results. Teams of more than two should be avoided because they become conspicuous, distract the work force, and thereby induce observation bias through their influence on the observed.

(2) Conduct training first in a classroom environment, then in the workplace. Establish clear, concise procedures and mutually exclusive classifications. Anticipate, discuss, and resolve "gray areas" (telephone or face-to-face conversation classifications) and issues of potential disagreement.

(3) Advocate techniques that prevent classification problems. Nonworking workers often alter their activity once aware of observers' presence. Avoid arriving too early for an observation. Loitering in the area will likely bias the observation.

(a) Classify based on the first impression; the "snapshot" observation. Use worker's subsequent behavior modification to confirm initial suspicion of nonworking activity.

(b) In some instances the snapshot is inadequate. A closer observation supplemented with listening may be required.

(4) Before the regular study, observers should tour the workplace. "Walk throughs" condition observers to the workers' environment, and reduce the likelihood of bias in actual observations.

(5) Work sampling does not require in-depth knowledge of the work being performed. The observer need know only whether the worker is working. Most of the

time that will be obvious. If questionable, classify them as “working”. The study will not suffer from these infrequent cases of indecision.

c. In addition to the observers, those being observed are sources of potential observation bias.

(1) The employees under observation can influence the outcome of the study. Workers might change their activity once they are aware of being observed. Such influence can be minimized or eliminated by varying routes, blending with appropriate attire, expediting observations, and being as nondisruptive as possible. Avoid discussions with the workers unless essential.

(2) If the first day or two of the audit reflects abnormal working activity, i.e., results substantially different from the preliminary probe, bias is to be expected. Routine will return as workers become accustomed to the observation teams. If strong bias exists, early data may be discounted.

(3) Delay or terminate the audit if deliberate biasing occurs. Overt attempts by contractor management to bias the sample may include: restricting access, staging work, limiting the universe, signaling workers, etc.