Anjuman-I-Islam's
M. H. Saboo Siddik Polytechnic

# Industrial Engineering & Quality Control (22660)

Topic Name: ***A Report on Various Sampling Plans followed in Industry.***

Subject: ***Industrial Engineering & Quality Control***

Subject Code: ***22660***

Course: ***Mechanical Engineering***

Course Code: ***ME – 6 – I***

Faculty: ***Professor Moizuddin***

Group Members:


***Khan Abdul Rehman Ab. Salam - 17127***

***Khan Saad Sameer - 17128***

***Khan Zishan Sultan - 17129***


Academic Year: ***2019 – 2020***

Institute: ***M. H. Saboo Siddik Polytechnic, Byculla***

Institute Code: ***0002***

# *Sampling Plan*

**Definition:** A **sampling plan** is a term widely used in research studies that provide an outline on the basis of which research is conducted. It tells which category is to be surveyed, what should be the sample size and how the respondents should be chosen out of the population.

Sampling plans may be classified as follows:

1. Single Sampling Plans

2. Double Sampling Plans

3. Multiple Sampling Plans

4. Sequential Sampling Plan

*1. Single Sampling Plans:*

A lot is accepted or rejected on the basis of a single sample drawn from that lot.

i. Under this plan, a lot is accepted or rejected on the basis of a single sample drawn from that lot.

ii. Method.

1. Draw a single sample of size n i.e., of n component parts. The sample size may either be

i. calculated, or

ii. found from tables.

2. Inspect the sample and find the number of defective components.

3. If defective pieces exceed the acceptance number C, the lot is rejected and vice versa.

4. In case the lot is rejected, inspect each and every piece of the lot and replace the defective parts or salvage and correct the defective parts.

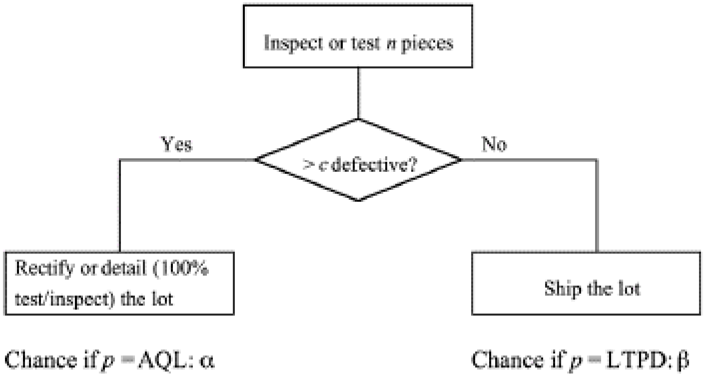
Calculation of sample size

Given AQL or $P_1$ = 2%

LTPD = 9.2%

∴ Operating ratio, $R_o$ = LTPD/AQL (or $P_1$) = 9.2/2 = 4.6

Figure 1: Single-Sample Acceptance Sampling Procedure




## Characteristics of Single Sampling Plan:

(i) A single sampling plan is easy to design, explain and administer.

(ii) It is the only practical type of sampling plan under conveyorized production conditions when only one sample can be selected.

(iii) It involves a lower cost of training and supervising employees, transporting and sorting samples, etc.

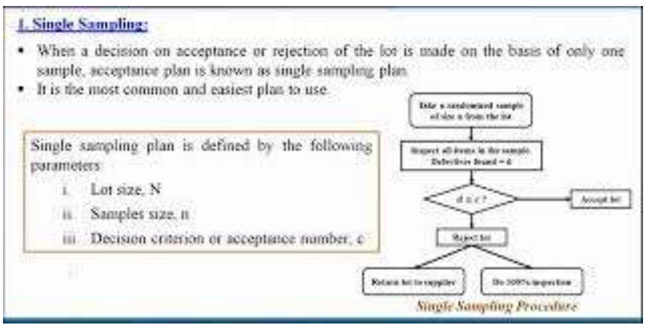
(iv) It very accurately estimates lot quality.

(v) It is more economical than double sampling plan when lots have their % defectives close to the AQL.

(vi) It involves a bigger sample size than the double sampling plan.

(vii) It involves record keeping less than that of double and multiple sampling plans.

(viii) A single sampling plan provides maximum information concerning the lot quality because each sample can be plotted on the control chart.



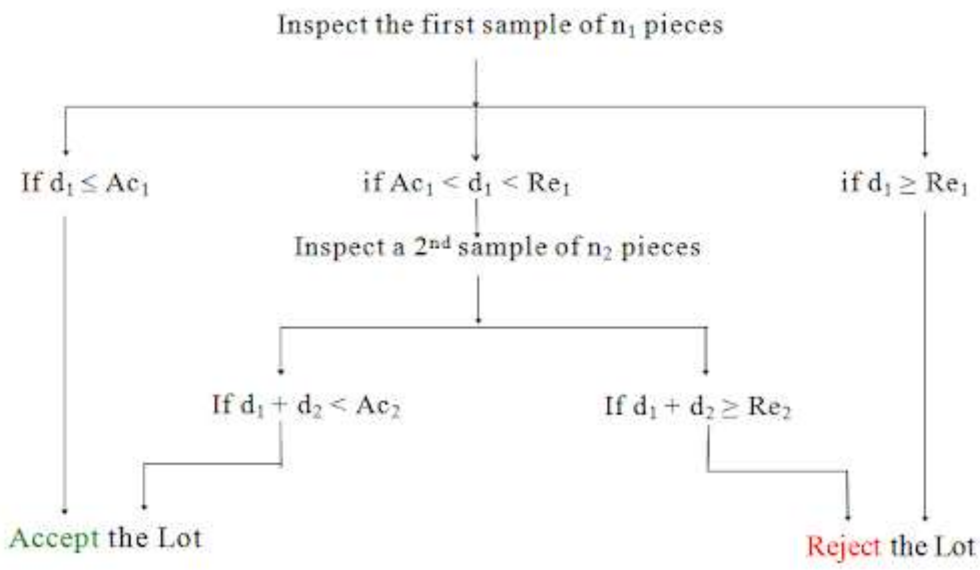
*2. Double Sampling Plans:*

If it is not possible to decide the fate of the lot on the basis of first sample, a second sample is drawn and the decision is taken on the basis of the combined results of first and second sample.

1. If it is not possible to decide the fate of the lot on the basis of the first sample, a second sample, is drawn out of the same lot and the decision whether to accept or reject the lot is taken on the basis of the combined results of first and second samples.

2. Double sampling plan procedure

Given $C_1$, and $C_2$ as acceptance numbers; $C_2 > C_1$




**Characteristics of double sampling plan:**

(i) A double sampling plan is more expensive to administer than a comparable single sampling plan.

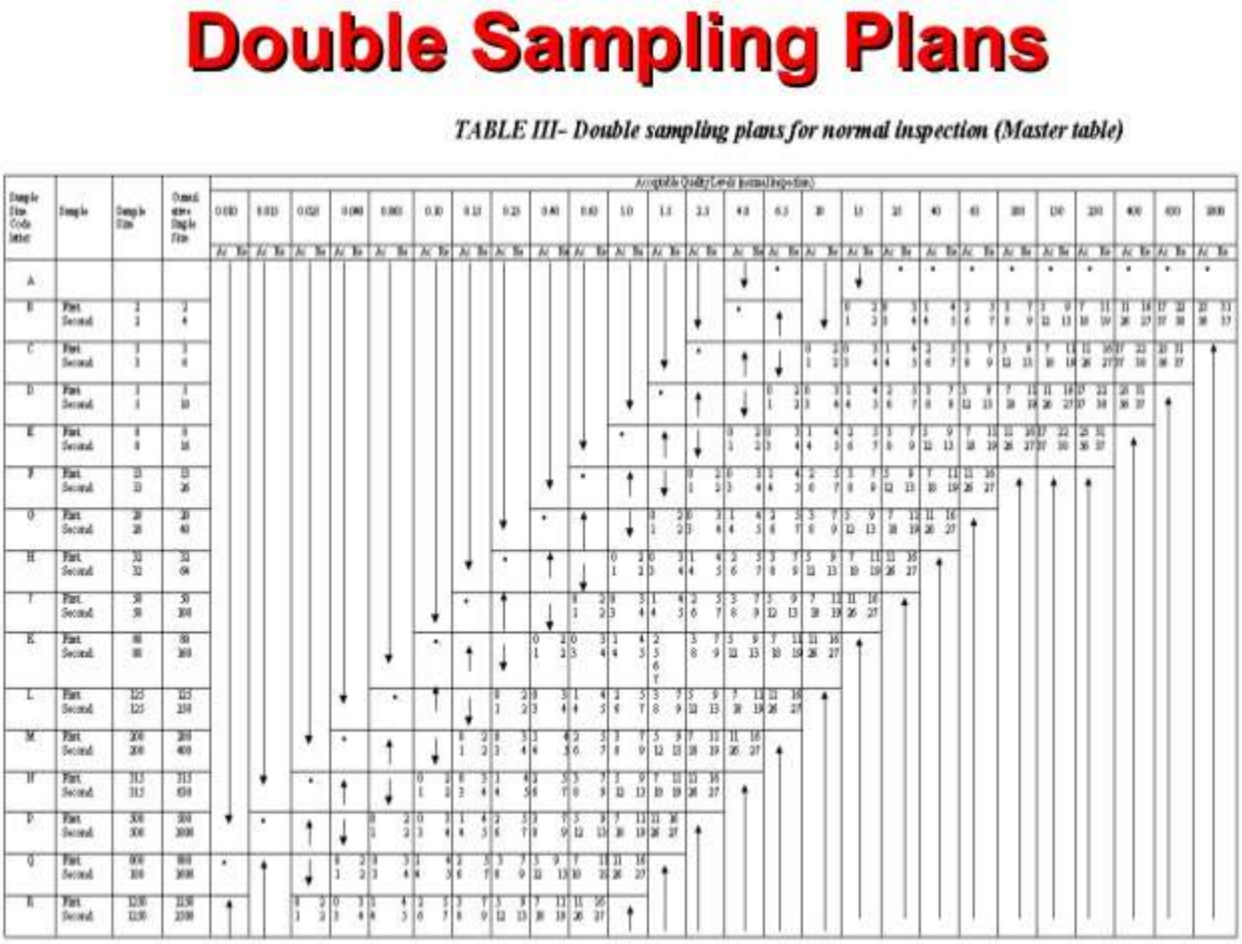
(ii)It involves less inspection than that required for a single sampling plan.

(iii) Double sampling plan is easier to sell to the personnel because psychologically the idea of giving a second chance to a lot before rejecting it exercises popular appeal.

(iv) It permits a smaller first sample than the sample size of the corresponding single sampling plan.

(v) A double sampling plan involves more overheads than a single sampling plan.

(vi) It involves more record keeping than a single sampling plan.



Double Sampling Plans

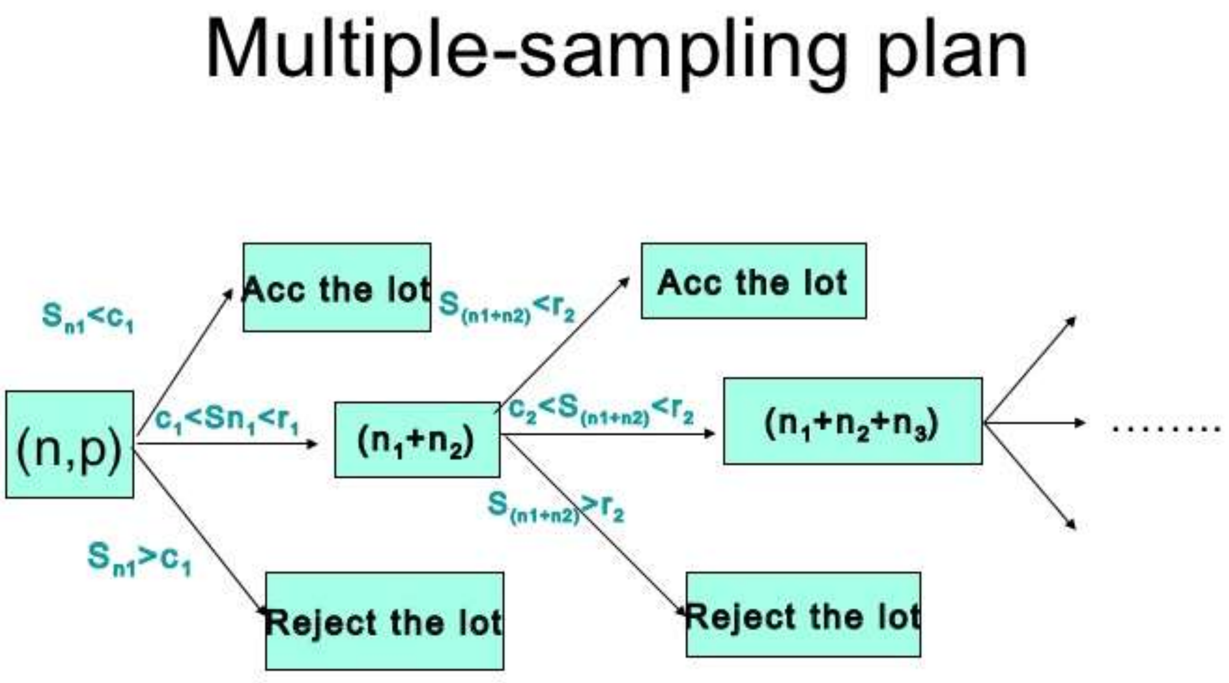
*TABLE III- Double sampling plans for normal inspection (Master table)*

*3. Multiple Sampling Plans:*

A lot is accepted or rejected based upon the results obtained from several samples (of parts) drawn from the lot.

i. A multiple sampling plan accepts or rejects a lot upon the results obtained from several samples (of component parts drawn from a lot).

ii. Multiple sampling plan procedure.




**Characteristics of multiple sampling plan:**

(i) A multiple sampling plan involves smaller first samples than single or double sampling plans.

(ii) A multiple sampling plan is comparatively difficult to design and explain, and expensive to administer.

(iii) It involves a higher overhead cost as compared to single and double sampling plans.

(iv) It involves more record keeping.

(v) In theory, multiple sampling may often permit lower total inspection than double sampling for a given degree of protection because of smaller sample sizes required.

(vi) New methods, which simplify multiple sampling, such as automatic sampling boxes may result in greatly improved efficiency in administering multiple sampling plans.

# OCC for a Multiple Sampling Plan

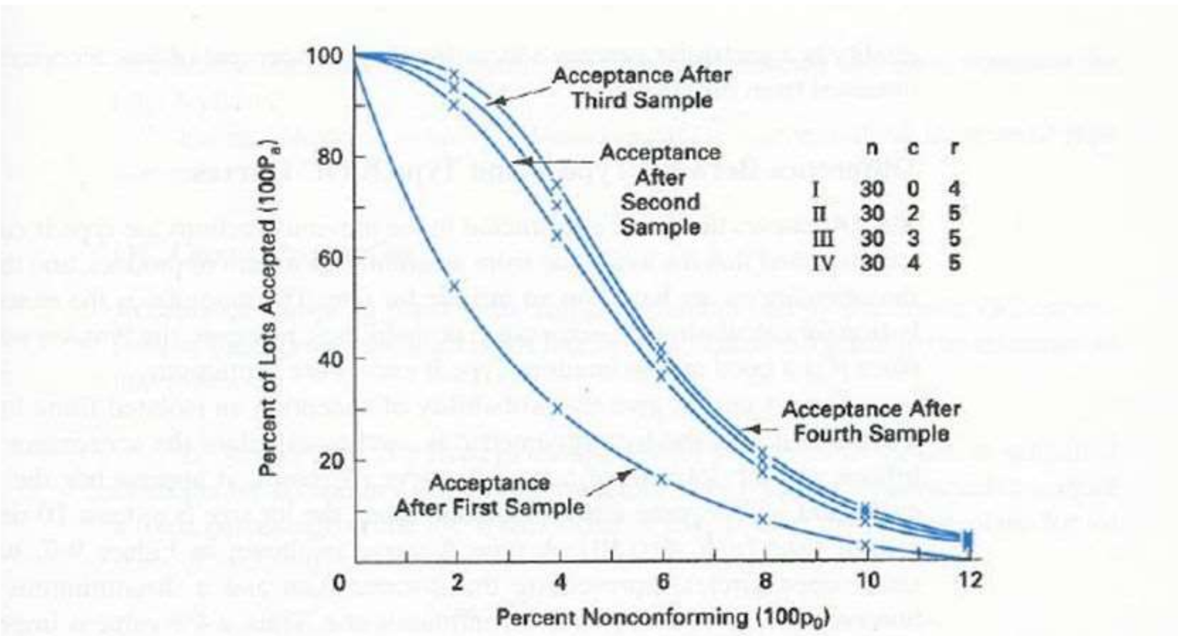


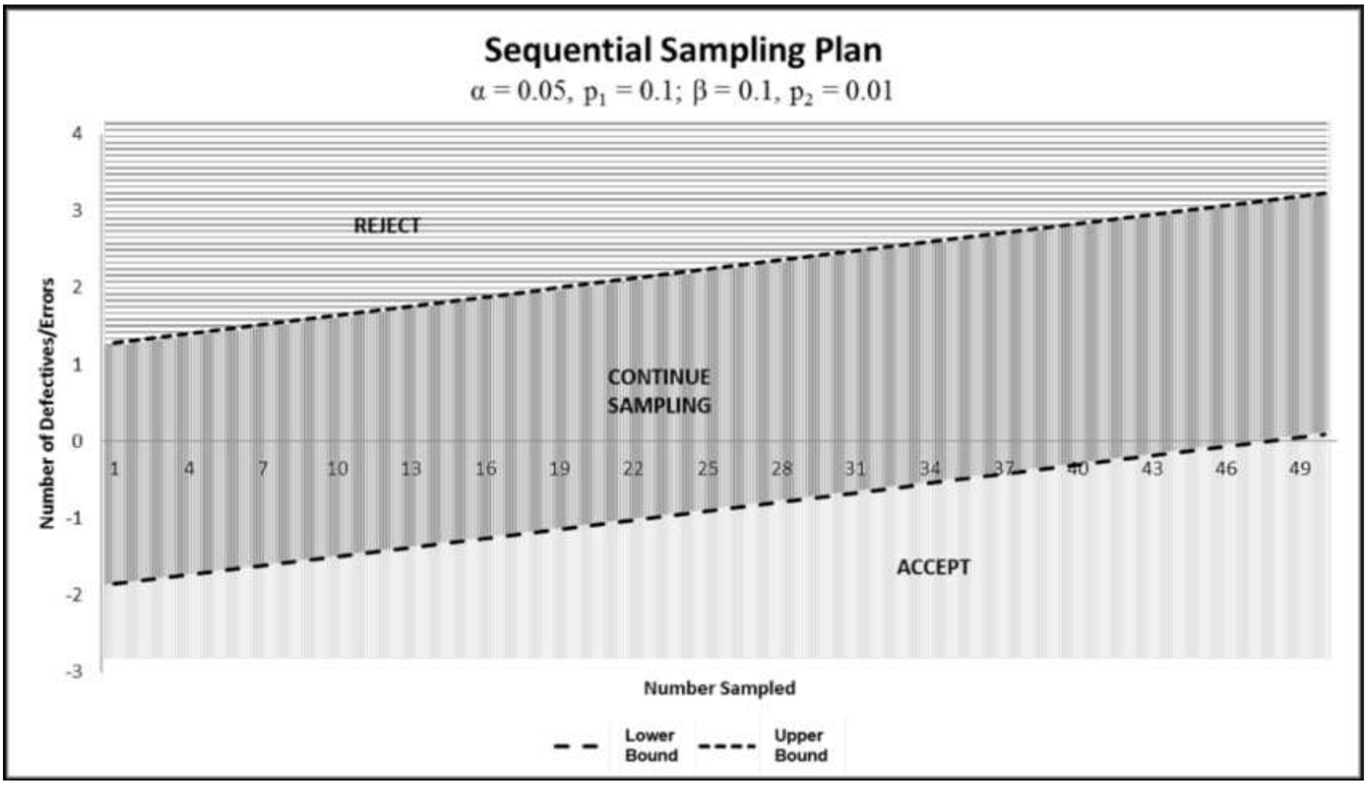

**FIGURE 9-6** **OC curve for a multiple sampling plan.**

*4. Sequential Sampling Plan (Item by Item Analysis):*

Sequential sampling involves increasing the sample size by one part at a time till the sample becomes large enough and contains sufficient number of defectives to decide intelligently whether to accept or reject the lot.

It is a plan in which sample size is increased by one piece (or part) at a time till the sample becomes large enough and contains sufficient number of defective pieces to decide intelligently whether to accept the lot or to reject it.

It is easy to design, but more expensive to administer than a comparable multisampling plan, since more steps are needed to take a decision. Since sample size is increased by one at a time, sample results are analysed much faster than in a single or double sampling plan. Sampling costs are least. Overhead cost is maximum. It is seldom used in lot acceptance control but is important because multiple sampling is based on it.



## *Sampling Strategies*

When it comes to sampling, the essential questions are: where to collect the samples, when to collect them, and how many samples to collect. Most environmental measurement domains are large and it is not easy to answer these questions. Some of the factors to be considered in determining a sampling strategy are:

- The study objectives: Different objectives require different sampling strategies. For example, if the objective is to measure the total release of heavy metals into a river by an industry, a 24 hour integrated sample may be taken. However, if the goal is to monitor for accidental releases, then sampling and analysis may have to be done almost continuously.
- The pattern and variability of environmental contamination: The number of samples to be collected in space and time depends upon the variability in the concentrations to be measured. For example, pollutant levels in air can vary significantly depending upon meteorological conditions, or traffic patterns. In general, if the spatial or temporal variability is high, a larger number of samples needs to be analyzed.
- Cost of the study: If more samples are analyzed, the information obtained will have higher precision and accuracy. However, more samples also require more money, time, and resources. So, it is necessary to design an effective sampling plan within the available resources.

Other factors such as convenience, site accessibility, limitation of sampling equipment and regulatory requirements often play important roles in developing a sampling plan, as well. A well designed strategy is needed to obtain the maximum amount of information from the number of samples. The strategy may be a statistical or a non-statistical one.

There are several approaches to sampling: systematic, random, judgmental (non-statistical), stratified, and haphazard. More than one of these may be applied at the same time. Very often, not much is known about the environmental area to be studied. A statistical approach is taken to increase the accuracy and decrease bias. An industrial discharge into a lake is shown in Figure 2.2. It would be expected that the concentration of the pollutants present in the wastewater outfall are at maximum near the discharge point. A systematic sampling plan would divide the water surface into a grid, and take samples in a regular pattern. Sampling a few of the grid blocks chosen in a genuinely random way constitutes random sampling. Judgmental sampling would concentrate on the area around the outfall. Taking a few samples at locations chosen by the person doing the sampling would be termed haphazard sampling. Finally, a *continuous monitor* may eliminate the time factor by giving real-time measurements all the time. This is still a sampling process, however, as the location of the sensor must serve as a typical location to give information about a larger area.

### *Systematic Sampling*

Measurements are taken at locations and/or times according to a predetermined pattern. For example, the area to be analyzed may divided by a grid, and a sample taken at each point of the grid. For air pollution studies, an air sample might be taken at fixed intervals of time, say every three hours. This approach does not require the prior knowledge of pollutant distribution, is easy to implement, and should produce unbiased samples. However, systematic sampling may require more samples to be taken than some of the other methods.

### *Random Sampling*

The basis of random sampling is that each population unit has equal probability of being selected. Random methods are good if the population does not have any obvious trends or patterns. When we think of random surveys of public opinion, for instance, we can readily see that a survey might come to very wrong conclusions if it relied on a door-to-door canvass taken on weekday mornings. All people who held 9 to 5 jobs would be essentially eliminated from the sample, probably skewing the results. Likewise, it would be foolish to rely on the opinions expressed by sampling a single street, when most of the people who live there are likely to be of the same class or background. If a system varies with time, as a stream might, we must sample at a variety of times, so that any time has an equal chance of being chosen. If the system varies with location within it, as a landfill would, we have to sample across the surface and down into it, so that any point in the three dimensional space of the landfill has an equal chance of being chosen.

Typically, the area to be sampled is divided into triangular or rectangular areas with a grid. Three dimensional grids are used if the variation in depth (or height) also needs to be studied. The grid blocks are given numbers. A random number generator or a random number table is then used to select the grid points at which samples should be collected. If a waste site contains numerous containers of unknown wastes and it is not possible to analyse every container, a fraction of the containers are selected at random for analysis.

### *Judgmental Sampling*

This is a non-statistical sampling procedure. Here, the prior knowledge of spatial and temporal variation of the pollutants is used to determine the location or time for sampling. In the lake example, samples might be collected just around the outfall point. This type of judgmental sampling introduces a certain degree of bias into the measurement. For example, it would be wrong to conclude that the average concentration at these clustered sampling points is a measure of the concentration of the entire lake. However, it is the point which best characterizes the content of the waste stream. In many instances, this may be the method of choice, especially when purpose of the analysis is simply to identify the pollutants present. Judgmental sampling usually requires fewer samples than statistical methods, but the analyst needs to be aware of the limitations of the samples collected by this method.

### *Stratified Sampling*

When a system contains several distinctly different areas, these may be sampled separately, in a stratified sampling scheme. The target population is divided into different regions or strata. The strata are selected so that they do not overlap each other. Random sampling is done within each stratum. For example, in a pond or a lagoon where oily waste floats over water and sediment settles to the bottom, the strata can be selected as a function of depth, and random sampling can be done within each stratum.

The strata in a stratified scheme do not necessarily have to be obviously different. The area may be divided into arbitrary subareas. Then a set of these are selected randomly. Each of these units is then sampled randomly. For example, a hazardous waste site can be divided into different regions or units. Then, the soil samples are collected at random within each region or within randomly selected regions. Stratification can reduce the number of samples required to characterize an environmental system, in comparison to fully random sampling.

### *Haphazard Sampling*

A sampling location or sampling time is chosen arbitrarily. This type of sampling is reasonable for a homogeneous system. Since most environmental systems have significant spatial or temporal variability, haphazard sampling often leads to biased results. However, this approach may be used as a preliminary screening technique to identify a possible problem before a full scale sampling is done.

## *Continuous Monitoring*

An ideal approach for some environmental measurements is the installation of instrumentation to monitor levels of pollutants continuously. These real-time measurements provide the most detailed information about temporal variability. If an industrial waste water discharge is monitored continuously, an accidental discharge will be identified immediately and corrective actions can be implemented while it is still possible to minimize the damage. A grab sample would have provided information about the accidental release only if a sample happened to be taken at the time the release was taking place, and that might well not have been when the problem began. A sample composited frequently enough could have identified the accidental release, but the time for preventive action would likely have passed.

Continuous monitoring is often applied to industrial stack emissions. Combustion sources, such as incinerators, often have CO monitors installed. A high CO concentration implies a problem in the combustion process, with incomplete combustion and high emissions. Corrective action can be triggered immediately. Continuous monitoring devices are often used in workplaces to give early warnings of toxic vapour releases. Such monitors can be lifesaving, if they prevent or minimize chemical accidents such as the one which occurred in Bhopal, India.

At present, a limited number of continuous monitoring devices are available. Monitors are available for gases such as CO, $NO_2$, and $SO_2$ in stack gases, and for monitoring some metals and total organic carbon in water. These automated methods are often less expensive than laboratory-analysed samples, because they require minimal operator attention. However, most of them do not have the sensitivity required for trace level determinations.

## *TYPES OF SAMPLES*

*Grab sample:* A grab sample is a discrete sample which is collected at a specific location at a certain point in time. If the environmental medium varies spatially or temporally, then a single grab sample is not representative and more samples need to be collected.

*Composite sample:* A composite sample is made by thoroughly mixing several grab samples. The whole composite may be measured or random samples from the composites may be withdrawn and measured.

A composite sample may be made up of samples taken at different locations, or at different points in time. Composite samples represent an average of several measurements and no information about the variability among the original samples is obtained. A composite of samples which all contain about the same concentration of analyte can give a result which is not different from that obtained with a composite made up of samples containing both much higher and much lower concentrations. During compositing, information about the variability, patterns, and trends is lost. When these factors are not critical, compositing can be quite effective. When the sampling medium is very heterogeneous, a composite sample is more representative than a single grab sample. For example, in a study of the exposure to tobacco smoke in an indoor environment, a several hour composite sample will provide more reliable information than several grab samples.

Composite samples may be used to reduce the analytical cost by reducing the number of samples. A composite of several separate samples may be analyzed and if the pollutant of interest is detected, then the individual samples may be analyzed individually. This approach can be useful for screening many samples. A common practice, for example, in clinical laboratories screening samples for drug abuse among athletes is to analyze a composite of about ten samples. If the composite produces a positive result, then the individual samples are tested.

A typical compositing scheme is shown in Figure 2.3. Here a field sample is taken at a random time point once within each hour. These twenty four field samples per day are mixed to form two composites. From each composite two sub-samples are taken and each subsample could also include two repeat samples.