MONITORING AND MEASURMENT PROGRAMME FOR ISO 14001 BASED ENVIRONMENTAL MANAGEMENT SYSTEMS

A thesis submitted to Thapar institute of engineering & technology, Patiala
in partial fulfilment of the requirements for the award of degree of
Master of Technology in Environmental Science and Technology

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CERTIFICATE

This is to certify that the thesis entitled "Monitoring and measurement programme for ISO 14001 based environmental management systems", submitted by Maninder Kaur (Roll no. 6040303), in partial fulfilment of the requirements for the award of degree of M.Tech. in Environmental Science and Technology to Thapar Institute of Engineering and Technology (Deemed University), Patiala, is a record of the student's own work, carried out by her under our supervision and guidance.

The report has not been submitted for the award of any other degree or certificate in this or any other university or institute.

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DECLARATION

I hereby declare, that the thesis report entitled, “Monitoring and measurement programme for ISO 14001 based environmental management systems” is written and submitted by me to Thapar Institute of Engineering and Technology (Deemed University), Patiala, in partial fulfilment of the requirements for the award of degree of Master of Technology in Environmental Science and Technology. This is my original work and conclusions drawn are based on the study done by me.

I further declare that this work has not been submitted to this or any other university for the award of any other degree, diploma or equivalent course.

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CHAPTER - 1: INTRODUCTION

1.1 Background

All organizations have their impacts on the natural environment either through the use of natural resources or through generation of wastes. However, organization's can achieve control over their environmental impacts by adoption of an environmental management system (EMS) approach. EMS approach is a systematic way for identification and management of the environmental aspects responsible for the impacts [(1)]. ISO 14001 specifies the requirements of an environmental management system. Environmental management system (EMS) of an organization must meet these requirements in order to achieve ISO 14001 certification by a third party [(1)]. According to ISO 14001[(2)], environmental management system (EMS) is defined as the part of an organization's management system that includes organizational structure, planning activities, responsibilities, practices, procedures, processes and resources used to develop and implement its environmental policy and manage its environmental aspects.

ISO 14001(2004) has seventeen elements that should be included in the environmental management system. These elements are categorized under plan, do, check and act (PDCA cycle) [(2)]. Monitoring and measurement is one of these seventeen elements and comes under the check phase of PDCA cycle [(2)]. Please see figure-1 for details. ISO 14001(1996) has been similar to ISO 14001:2004 except that it has a separate clause on environmental management programme(s) and has clubbed the clause related to monitoring and measurement with the clause related to evaluation of compliance [(3)].

Development and implementation of a well planned and structured monitoring and measurement programme can help in the optimal use of available resources and can provide information that could be effectively used for future environmental performance improvement of the organization.

The present study conceptualizes a generic monitoring and measurement programme for ISO 14001 based environmental management systems. This programme is applicable to process industries. Further, a monitoring and measurement programme has been developed for a selected industrial plant (milk plant) as a case study.

Monitoring and measurement

Monitoring implies observation, supervision and keeping under review (using monitoring devices). It involves measuring or testing at intervals, especially for the purpose of regulation or control. [(4)] M*easurement* considers determination of a physical quantity, magnitude or dimension (using measuring equipment). [(4)]

Measurement is of two types: monitoring measurement and investigative measurement. [(5)]

1. Monitoring measurement: Monitoring measurements act as indicators of the general health of the process. For example, body temperature is an overall indication of the health of the human body. This measurement is made over a long period, so that trends and variation can be understood and points where specified limits or target values are exceeded can be identified. The monitoring measurement should satisfy the following points:
    - It should identify the presence of problems, but not necessarily the causes.
    - It should not be intrusive and should not upset the process in any way.
    - It should be repeatable and made under similar conditions.
    - It should be possible for measurements to be made on a regular basis.
    - It should be relatively inexpensive and easy to perform.
2. Investigative measurement: Investigative measurements are made specifically to find out root causes for known problems. This is similar to specific medical tests such as measuring blood pressure of a patient on prescription of doctor. The investigative measurement differs from monitoring measurement in several ways:
    - Measurement is intrusive.
    - The cost of measurement is not particularly important.
    - Many different measurements may be made, where each measurement covers a specific area in more detail.

1.3 Importance of monitoring and measurement

1.3.1 Monitoring and measurement as one of the elements of ISO 14001

Monitoring and measurement is one of the seventeen elements of an ISO 14001 based the environmental management system. Figure-1 shows the various elements of ISO 14001.

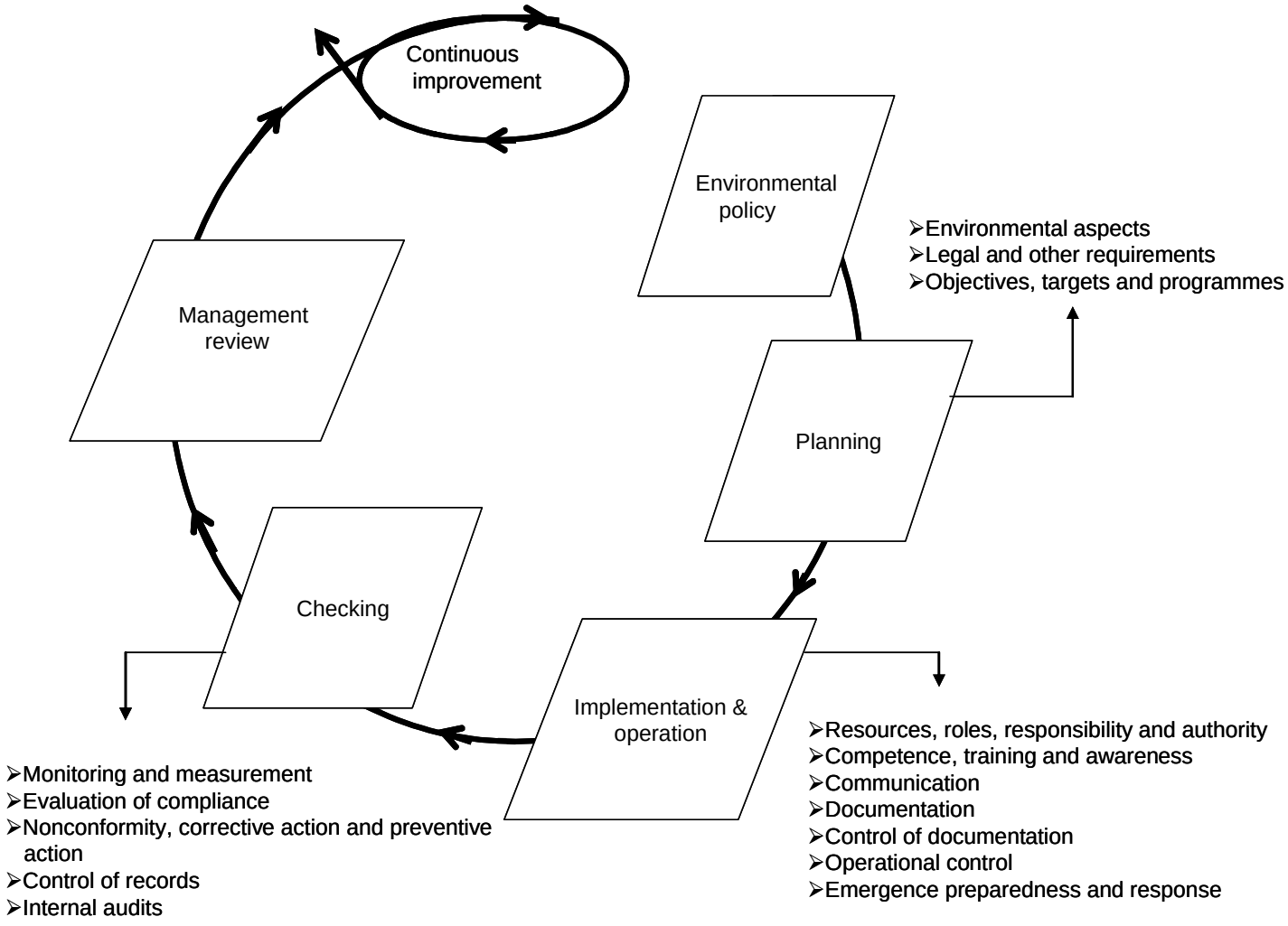

FIGURE-1
Elements of ISO 14001[(2)]

1.3.2 Need for monitoring and measurement [(6)]

As per ISO 14001, an organization is required to monitor key characteristics of its operations and activities that can have significant environmental impacts for the following reasons:

1. To assess implementation of operational controls.
2. To track environmental performance of organization.

3. To evaluate compliance with applicable laws and regulations.

In addition, monitoring and measurement is supposed to enable an organization to achieve the following:

1. Identifying areas requiring corrective action.
2. Improving performance and increasing efficiency.
3. Tracking performance of various elements of EMS in achieving objectives and targets.

Thus, monitoring and measurement helps in managing the organization better. Pollution prevention and other strategic opportunities for improvement can be identified more readily when current and reliable data is available through monitoring and measurement.

1.4 Present study

The objectives of the present study are to conceptualize a generic monitoring and measurement programme for process industry and to develop a monitoring and measurement programme for one industrial plant as a case study.

The scope of the work is limited to a monitoring and measurement programme that satisfies the requirements of an ISO 14001 based environmental management system. The generic programme is relevant and limited to process industry. For case study, a milk plant, which is processing five lakh litres of milk per day into ghee, casein, milk minerals and lactose, has been chosen.

1.5 Overview of chapters

The thesis report is divided into the following six chapters:

Chapter-1 “Introduction”. It includes the background, definition of monitoring and measurement, types of measurement, monitoring and measurement as one of the elements of ISO 14001, need for monitoring and measurement, present study, overview of chapters, usefulness and limitations of study.

Chapter-2 “Literature Review”. It contains review of literature related to definition of measurement, types of measurement, components of measurement, objective of measurement, monitoring as a type of measurement, monitoring and measurement as

one of the elements of ISO 14001 based EMS, need for monitoring and measurement especially in the context of operational control, evaluation of legal compliance and environmental performance evaluation, definitions related to monitoring and measurement programme, features of monitoring and measurement programme based on ISO 14031 and ISO 17025, strategies for development and implementation of monitoring and measurement programmes and guidelines for development of monitoring and measurement programme for ISO14001 based EMS.

Chapter-3 “Methodology”. It includes objectives, scope, work elements involved and approach followed.

Chapter-4 “Brief manufacturing process overview”. It includes manufacturing process details of the various units and process details of the various utilities for the selected industrial plant taken up as case study. These have been supplemented with process flow diagrams.

Chapter-5 “Monitoring and measurement programme”. It includes requirements to be satisfied by monitoring and measurement programme for conformance with ISO 14001 and compliance with Indian Environmental Law, elements of the monitoring and measurement programme for ISO 14001 based EMS, procedure for the identification of parameters for monitoring and measurement, protocol for documentation of a procedures and identification of monitoring and measurement requirements for the selected milk plant.

Chapter-6 “Conclusions”

1.6 Usefulness of study

Monitoring and measurement is a resource intensive activity. Hence, a well designed and structured monitoring and measurement programme is required to systematize the organization’s efforts to make optimal use of the available resources and to generate useful information. This study will provide guidelines to various process industries, having or interested in having ISO 14001 based Environmental management system, in developing, implementing and maintaining a monitoring and measurement programme.

1.7 Limitations of study

1. The selected industrial plant did not have a well designed monitoring and measurement programme since it is not ISO 14001 certified and hence could not provide much information relating to its monitoring and measurement function and activities.
2. Lack of availability of literature on this topic.
3. Because of time constraints and other logistics problems though a milk plant has been studied, detailed monitoring and measurement programme specific to the case could not be worked out.

CHAPTER - 2: REVIEW OF LITERATURE

2.1 INTRODUCTION

Literature review has been limited to the last ten years i.e. 1996 to 2005. It has concentrated on the following aspects:

1. Measurement.
2. Monitoring and measurement as one of the elements of ISO 14001 based EMS.
3. Monitoring and measurement and its need.
4. Monitoring and measurement programme.

2.2 Measurement

2.2.1 Definition of measurement

Measurement is an estimation of a quantity or a distance based upon the systematic application of a standardized procedure or device [7].

2.2.2 Types of measurement [8]

Based on the information gathered measurements are two types: quantitative and qualitative.

Quantitative measurement: The easiest type of information to measure and use is a numeric quantity. Numbers are precise and help to make clear decisions. Tools, which use quantitative data, often work by using a combination of mathematical calculation and comparison of numbers against one another or against a fixed and critical value.

Qualitative measurement: Quantitative data is not always available and not always enough. Qualitative information is non-numeric, and typically appears as written text. This often comes in 'chunks', where a phrase or sentence describes a single, independent piece of information. Tools, which use qualitative data, typically organize and structure these chunks relative to one another, thus revealing further information.

Often, a situation is best described by a combination of numeric and non-numeric information, where the qualitative text helps to put the quantitative numbers into context, for example, describing who was using a machine, where, under what conditions, etc.

2.2.3 Components of measurement [8]

Units: Measurements are in some kind of units. Use of units prevents the situations of confusion in calculations and displays. The units chosen should reflect the range of possible values, for example, it is probably better to measure length of a wood log in meters rather than in centimeters.

Scale: Scale is simply the possible range of measured values. It is typically made up of a defined and discrete set of values. Many measurements are made in the form of numbers, as this is an absolute and flexible format. In some situations, however, numbers are not so useful, for example, identification of the possible actions of a customer upon finding a defective product. It is easier to describe the satisfaction level as 'high' or 'low' rather than '1' or '10'.

Limits: There is often some kind of action limits, beyond which the measurement should not go. If the measured value falls outside such *specification limits*, then some kind of action may be defined, such as rejection of the measured item or an investigation into the cause of failure.

Tool: A measurement may be made using some kind of measuring device. It is essential that this device is accurate and reliable. An uncertain measuring tool will result in worthless measurement values.

Process of measurement: If the process of measurement is clear and well defined, the measurement can be made consistently, and this enables comparison of the successively measured values. Detailing a measurement process usually puts the actual work (that has to be done to collect the data) into proper perspective, and enables scheduling of the requisite time and resources. A measurement process may include the following details:

- What is to be measured, including items and sampling rules?
- The tools to be used, including calibration details.
- When the measurement is done, including times, events and frequencies?
- How the measurements are recorded, including design of Check Sheets?
- What is to be done with the compiled data, including storage and actions?
- Who is doing the measuring and how it is to be ensured that he/she knows what to do?

2.2.4 Objective of measurement [5]

In any problem solving, desirable outcome of the process may be described in the form of a statement of objective. Sometimes the objective is implicit, but it is usually worth writing down the objective in a short sentence. This will help to achieve consensus within the project group. Further, a written objective can act as a guideline for decisions and actions. It is good if the statement is worded in a way that helps to clearly identify the data that needs to be collected. For example, when setting the objective of an improvement project, the specifics of what is to be improved may be included in the objectives statement, such as, “Increase the accuracy and timeliness of the processing system”. In this case, it is clear that accuracy and time must be measured.

2.2.5 Monitoring as a type of measurement [5]

Based on the reasons for measurement, measurements are categorized into two types: monitoring measurement and investigative measurement.

Monitoring measurement: Monitoring measurements act as indicators of the general health of the process being measured. For example, temperature gives an overall indication of the health of the human body. Monitoring measurement is made over a long period, so that trends and variation can be understood, and points where specified limits or target values are exceeded can be identified. The following considerations may be taken into account while identifying the monitoring measurements required:

- The measurement should be capable of identifying the presence of problems, but not necessarily the cause.
- The measurement should not be intrusive or it should not upset the process in any way.
- The measurement should be repeatable when made under similar conditions (comparison on an equal footing becomes possible).
- It should be possible for measurements to be made on a regular basis for facilitating identification of trends, etc.
- As it is made frequently, the measurement should be relatively inexpensive and easy to perform.

Investigative measurement: Investigative measurements are made specifically to find out more about known problems or causes. This is similar to specific medical tests such as measuring blood pressure. These measurements may differ from monitoring measurements in several ways:

- The measurement may be intrusive.
- Cost of the measurement is not particularly important.
- Many different measurements may be made in this case to cover a specific area in more detail.

2.3 Monitoring and measurement as one of the elements of ISO 14001 based environmental management systems [(2)]

2.3.1 EMS and ISO 14001

These days Environmental Management System (EMS) approach is widely followed by organizations for the management of their environmental functions. Under this approach organizations develop, implement and maintain an EMS for assessing, in a methodical way, impacts of their activities on the natural environment, and controlling and continuously reducing such environmental impacts [(1)]. Essential elements of a third party certifiable EMS are prescribed by ISO 14001 standard. EMS prescribed by ISO 14001 is based on the plan-do-check-act (PDCA) methodology introduced by Shewart and Deming and endorses the concept of continual improvement [(6)].

EMS prescribed by ISO 14001 includes altogether seventeen elements (environmental policy, three elements under ‘plan’, seven elements under ‘do’, five elements under ‘check’, and management review). Please see figure-1 for details. Monitoring and measurement is one among these seventeen elements and comes under ‘check’. In addition to this, evaluation of compliance another element of ISO 14001 under ‘check’ also has relevance to the monitoring and measurement.

2.3.2 Monitoring and measurement as one of the elements of ISO 14001[(2)]

Monitoring and measurement clause of ISO 14001:2004 states the following:

“The organization shall establish, implement and maintain a procedure(s) to monitor and measure, on a regular basis, the key characteristics of its operations that can have a significant environmental impact. The procedure(s) shall include the documenting of information to monitor

performance, applicable operational controls and conformity with the organization's environmental objectives and targets.

The organization shall ensure that calibrated or verified monitoring and measurement equipment is used and maintained and shall retain associated records."

Another clause of ISO14001:2004 which has relevance to monitoring and measurement is the clause on evaluation of compliance. This clause states the following:

"Consistent with its commitment to compliance, the organization shall establish, implement and maintain a procedure(s) for periodically evaluating compliance with applicable legal requirements. The organization shall keep records of the results of the periodic evaluations.

The organization shall evaluate compliance with other requirements to which it subscribes. The organization may wish to combine this evaluation with the evaluation of legal compliance referred above or to establish a separate procedure(s). The organization shall keep records of the results of the periodic evaluations".

Hence a functional monitoring and measurement programme should include procedures to monitor and measure the key characteristics of its operations/activities serving the following purposes:

- Controlling of operations that have or can have significant environmental impacts and/or compliance consequences through documentation of information.
- Monitoring environmental performance including progress in achieving objectives and targets through documentation of information.
- Evaluating compliance with the applicable environmental laws and regulations and maintaining related records.
- Ensuring calibrated and/or verified monitoring equipment is used and maintaining related records.

2.4 Monitoring and measurement and its need

Monitoring implies observation, supervision and keeping under review (using monitoring devices. It involves measuring or testing at intervals, especially for the purpose of regulation or control. M*easurement* considers determination of a physical quantity, magnitude or dimension (using measuring equipment) **(4)**.

An environmental management system without effective monitoring and measurement processes is like driving an automobile at night without the headlights on, it is known that one is moving but can't be told where one is going [6]. Peter ducker, a management expert, has said "If you can't measure it, you can't manage it" [6].

Measurement is one of the seven critical factors that could be used by managers in assessing and improving their environmental management practices [9]. Monitoring and measurement is supposed to enable an organization to achieve the following:

- Evaluate environmental performance.
- Assessing compliance with legal requirements.
- Identifying areas requiring corrective action.
- Improving performance and increasing efficiency [6].

In short, monitoring and measurement helps in managing the organization better. Pollution prevention and other strategic opportunities for improvement can be identified more readily when current and reliable data is available [6].

Monitoring and measurement is essentially required for the following three purposes:

- For operational control.
- For legal compliance assessment.
- For environmental performance evaluation.

2.4.1 Monitoring and measurement for operational control

It is important that an industry can identify where control of its activities is required so that the desired level of environmental performance can be maintained. Operational control includes those policies, procedures and instructions in place to minimize the potential environmental impacts of industrial activities and processes [10]. They help to ensure regulatory compliance and to achieve environmental objectives and targets [11]. They may include the following elements:

- Good house keeping practices.
- Preventive maintenance procedures.
- Corrective maintenance procedures.
- Written operational control procedures [12].

Apart from the above elements, inspection logs, checklists and signs are also considered as elements of operational control. [13]

Monitoring and measurement is an integral part of most of the operational control procedures. Usually, the operational procedures have standard operating criteria which states the limits for a parameter within which an operation/ activity should be carried out. In order to know the value of the selected parameter and check whether it is within the permissible limits monitoring and measurement is required. For example, a thermometer on plating bath is required to make sure that the temperature is within the optimal range for plating quality so as to reduce the need for replating, which causes significant waste through product rework.

2.4.2 Monitoring and measurement for the evaluation of legal compliance

Under the 'check' step of ISO 14001 organization's compliance with the applicable legal requirements is measured and assessed at regular intervals [2]. Evaluation of legal compliance may be considered to include the following:

1. Assessment of compliance with the applicable waste discharge standards.
2. Monitoring of consumption of environmentally and ecologically important resources and hazardous substances.
3. Monitoring of generation, recycling and reuse of wastes and recovery of byproducts and resources from wastes.
4. Maintaining logs and records and timely submission of returns to regulatory authorities.

The applicable legal requirements can be found from the review of the following environmental Acts and Rules listed under:

1. The Water (Prevention and Control of Pollution) Act, 1974 [14]
2. The Water (Prevention and Control of Pollution) Rules, 1975[14]
3. The Water (Prevention and Control of Pollution) Cess Act, 1977 [14, 15]
4. The Water (Prevention and Control of Pollution) Cess Rules, 1978 [14]
5. The Air (Prevention and Control of Pollution) Act, 1981 [14]
6. The Air (Prevention and Control of Pollution)(Union Territories) Rules, 1983 [14]
7. The Environmental (Protection) Act, 1986 [14]
8. The Environmental (Protection) Rules, 1986 [14,15]
9. The Hazardous Wastes (Management and Handling) Rules, 1989 [14,15]

10. The Manufacture, Storage and Import of Hazardous Chemical Rules, 1989[14,15]
11. The Noise Pollution (Regulation and Control) Rules, 2000[14,15]

2.4.3 Monitoring and measurement for environmental performance evaluation [16]

ISO 14031 provides guidelines on environmental performance evaluation. Environmental performance means results of an organization's management of its environmental aspects. Environmental performance usually means much more than compliance with applicable regulations. It may include things, such as, which inputs (hazardous or non-hazardous) a facility chooses or how efficiently a facility uses ecological and environmental resources in the production process [17]. Measuring pollution prevention achievements can also be a part of tracking environmental performance [11]. Environmental performance evaluation can be meant for knowing current status of the organization's EMS with respect to the established objectives and targets as well as fulfilling the stakeholders demand for environmental accountability [17].

Information describing the organization's environmental performance can be derived from a set of selected indicators by using calculations, statistical methods and/ or graphical techniques or indexing, aggregating or weighing. According to ISO 14031 there are two general categories of indicators for environmental performance evaluation i.e. environmental performance indicators (EPI's) and environmental condition indicators (ECI's). EPI's are further subdivided into two categories i.e. management performance indicators (MPI's) and operational performance indicators (OPI's). Monitoring and measurement is needed for knowing values of the selected indicators and evaluating the environmental performance.

2.5 Monitoring and measurement programme

2.5.1 Definitions

System: It is a group of interacting, interrelated or interdependent elements or parts that function together as a whole to accomplish a goal [18].

Monitoring and measurement system: It is an ongoing system to collect data on a programme's activities and outputs and designed to provide feedback on whether the programme is fulfilling its functions [19]. For example, a monitoring and measurement system can be used to evaluate the performance of a pollution prevention programme [20].

Programme: It is an organized set of activities directed towards a common goal or purpose, undertaken or proposed by an agency in order to carry out its responsibilities [(21)]. Water quality monitoring programme [(22)], environmental management programme [(3)], and environmental audit programme [(23)] are examples.

Monitoring and measurement programme: This term is very less used and proper definition for it could not be found from literature. Instead monitoring and measurement procedure and monitoring and measurement system terms have been used.

Protocol: A document that describes the objective(s), design, methodology, statistical consideration, and organization of a trial [(24)]. Sampling protocol [(22)] is an example.

Procedure: It is a specified way of carrying out an activity or process [(2)].

Monitoring and measurement procedure: Planned observation or measurement of a parameter, at a specified point or time, which is then compared to a target (i.e., a standard, an operational limit, a critical limit) [(25)].

2.5.2 Features of a monitoring and measurement programme based on ISO 14031 and ISO 17025

According to ISO 14031 [(16)], the monitoring and measurement programme for environmental performance evaluation should have the following features:

1. The monitoring and measurement programme should be appropriate to the size, location and type of organization and its needs and priorities.
2. The monitoring and measurement programme should be cost effective and part of the regular business functions and activities of an organization.
3. The monitoring and measurement programme meant for tracking performance should include the following elements:
    - Planning for deciding the scope and the environmental performance criteria and selecting indicators.
    - Collecting and analyzing data.
    - Assessing information against environmental performance criteria.
    - Reporting and communicating results.
    - Reviewing the programme at regular intervals.

4. Depending on the capabilities and resources of the organization, the initial scope of the monitoring and measurement programme should be limited to those elements of its activities, products and services which are given highest priority by management.
5. The environmental performance of an organization with EMS in place should be assessed against its environmental policy, objectives and targets while the significant environmental aspects should be treated as environmental performance criteria for organizations without an EMS.
6. The significant environmental aspects should be identified based on scale and nature of material and energy use, emissions, risks, condition of environment, possibility of incidents, legal, regulatory and other requirements to which the organization subscribes.
7. Sufficient number of relevant and understandable indicators should be selected to assess environmental performance. The number of selected indicators should reflect the nature and scale of the organizations operations.
8. A combination of environmental performance indicators (EPIs), including management performance indicators (MPIs) and operational performance indicators (OPIs) and environmental condition indicators (ECIs) should be selected to provide a comprehensive assessment of performance related to complex environmental aspects.
9. If a specific condition in the environment has been a result of an organization's activities, then the environmental performance indicators (including MPIs and OPIs) that link management efforts and operational performance to changes in environmental conditions should be selected.
10. Data should be collected regularly and systematically at frequencies decided during planning stage.
11. Data collection procedures should ensure its reliability by incorporating quality control and quality assurance practices.
12. Procedure should be defined for data identification, filing, storage, retrieval and disposition.
13. Data analysis should have consideration for the data quality, validity, adequacy, and completeness necessary to produce reliable information.
14. Data analysis should ensure its verifiability, consistency, comparability and understandability.

15. Information describing the environmental performance of an organization should be communicated throughout that organization on a timely basis.
16. The results of environmental performance evaluation communicated to the external interested parties should be reliable, substantive and understandable.
17. The monitoring and measurement programme should be reviewed periodically to identify opportunities for improvement.

According to ISO 17025 [(26)], a monitoring and measurement programme should make arrangements for satisfying the following requirements:

1) Equipment:

1. Ensuring that the equipment used is capable of achieving the accuracy required and complies with the specifications relevant to the monitoring and measurement concerned.
2. Equipment is operated by authorized personnel.
3. Ensuring ready availability of up-to-date instructions on the use and maintenance of equipment to appropriate personnel.
4. Ensuring that all measuring and test equipment are properly calibrated or verified and these operations are documented in sufficient detail.
5. Ensuring that before being placed into service, equipment is calibrated and checked to establish that it meets the specifications given in monitoring and measurement programme.
6. Safeguarding equipments from adjustment which would invalidate the results.
7. Ensuring that defective equipment is taken out of service, clearly identified and stored at a specific place until it is repaired.
8. Ensuring that each of the equipment and its items including reference material are properly labeled and identified to indicate the calibration status.
9. Maintaining records for the monitoring and measurement equipments.

2) Measurement, traceability and calibration:

Ensuring that testing equipments are subjected to in-service checks between calibrations and verifications.

3) Sampling:

1. Ensuring that a sampling plan and sampling procedures are documented and made available at locations where sampling is undertaken.
2. Establishment of procedures for recording relevant data and operations relating to sampling procedure used, identification of sampler, environmental conditions and sampling location.

4) Working procedures:

Ensuring that staff has access to the current issues of working procedures covering the full range of the monitoring and measurement requirements.

5) Records :

1. Maintenance of record on all original observations, calculation, derived data and calibration records.
2. Ensuring that the records include the identity of personnel involved in sampling, calibration or testing.
3. Assigning the responsibility of filling up of records to a person.
4. Ensuring that all records are legible and protected from loss, damage and misuse.
5. Ensuring that all records are retained for an appropriate period of time.

6) Handling of calibration or test items:

1. Ensuring that a documented system for identifying the items to be tested or calibrated exists in order to ensure that there is no confusion regarding the identity of such items at any time. The identity of the item is maintained throughout the life of the item in the testing procedure.
2. Ensuring that documented procedures and appropriate facilities are present to avoid deterioration of the test item during storage, handling, preparation and testing.
3. Ensuring that the environmental conditions are maintained, monitored and recorded when items have to be stored under specific environmental conditions.

7) Results:

Ensuring that the result of each test is reported accurately, clearly, unambiguously and objectively.

2.5.3 Strategies for development and implementation of monitoring and measurement programmes

US EPA [21] in the context of watershed management proposes the following ten step procedure for the development of a monitoring and measurement programme:

Step-1: Defining the programme objectives: Once the objectives are defined, it is also essential to establish the scope for the programme.

Step-2: Assessing data needs: It involves deciding the parameters (that can provide information for addressing programme's objectives) to be monitored and measured. Consideration should be given to the technical approaches that will be used to analyse and assess the data.

Step-3: Assessing sources of the data: Data quality required for the objectives is an important factor to be considered in the design of a monitoring and measurement programme. Giving due consideration to the existing data, identification of information gaps and establishing priorities for new data collection, etc., can make the data collection process cost-effective.

Step-4: Assessing availability of resources (economic, technological and human resources): Expenses are first estimated based on the programme objectives and the identified data needs. If the budget exceeds the available sources of funding, the programme should be redesigned. Further, strategies and innovative approaches, such as, networking with third party organizations (collaborative agreements), establishing centralized corporate facilities, etc., can also be thought of for downsizing the budget of the monitoring and measurement programme.

Step-5: Review and revision of the objectives: The objectives should be reviewed and revised in the light of the available time and resources, practicability of achieving, and priorities of the organization.

Step-6: Conceptualization or development of the monitoring and measurement programme: What to monitor or measure and where, frequency of monitoring or measurement, methods of monitoring and measurement, responsibilities for monitoring and measurement, data logging and analysis, etc. will be organized in this step for implementation.

Step-7: Implementation of the monitoring and measurement design: This step involves creating necessary facilities, ensuring availability of capabilities and establishing the mechanisms for the implementation of the monitoring and measurement plan/programme.

Procurement and commissioning of monitoring and measurement equipment, training of staff, defining (and documenting) responsibilities, etc., are integral parts of this step.

Step-8: Data management: Observations and measurements made prove to be valuable sources of data only if they are properly recorded and managed. Field logs, observation sheets, etc., are part of the data management. Analysis of the collected data and appropriate real time or reasonable time communication of the resultant information may also be considered as part of the data management.

Step-9: Assessment and reporting: The collected and stored data should be routinely interpreted, assessed and reported for ensuring necessary corrective and preventive actions.

Step-10: Review and revision of the programme: For ensuring continued suitability, adequacy and effectiveness, the programme should be reviewed and revised in the light of changing objectives, requirements and organization's priorities.

According to PPRC (Pollution Prevention Resource Center) of Washington [(20)], the steps involved in the development of an environmental performance monitoring and measurement system are as follows:

Step-1: It includes the following three sub-steps:-

- Identify the reason for measuring environmental performance which may be regulatory or compliance or strategic planning.
- Review, understand and prioritize strategic and environmental plans and goals.
- Identify the level of financial resources available for conducting monitoring and measurement activities.

Step-2: Identify what needs to be known to satisfy the reason for measuring such as progress over time towards meeting goals or effectiveness of pollution prevention programme.

Step-3: Set specific, measurable targets which indicate progress towards plans, goals and objectives. An example of target is reduction in energy consumption by 10 % per year.

Step-4: Identify specific measures or metrics based on the targets. If target is to reduce toxic expose to the employees and the surrounding community then a few examples of metrics include: actual quantity reduction in use of toxic materials, staff training in

personal protection equipment, quantity of emissions and effluent released and reduction in respiratory illness in the community. Metrics can be absolute, relative, normalized or aggregated in an index.

Step-5: Select an optimal number of metrics. Selection of metrics is based on analysis method employed, existing measurement system in place, understanding level of audience, source of data and level at which measurement is made (i.e., global, community or organization). The metrics should be accurate, tangible, easy to collect and track in a timely and cost-effective manner, drive future improvements rather than just measure performance and satisfy the needs of the targets.

Step-6: Determine the frequency of data gathering for each of the selected metric. Frequency of data gathering may vary from metric to metric, budget allowance, level of automation, etc.

Step-7: Design the collection, sampling and tracking methods for each metric. This may include manual log sheets, electronic spreadsheets and database tools.

Step-8: Evaluate costs and benefits of the proposed monitoring and measurement system. The investments of the monitoring and measurement system should be worth the perceived benefits.

Step-9: Implement a trial period operation of the system to test and refine the system and train its users.

Step-10: Collect historical data/ baseline data from other sources.

Step-11: Collect new data on the selected metrics with the collection method and frequency already decided.

Step-12: Analyse the measurements made by performing calculations, using analytical methods and using statistical methods in order to improve their understandability. Interpret of results to verify whether the resulting impacts can be attributed to the environmental efforts. Communicate the results to employees, customers and suppliers. There should be a link between the programme's achievements and the result communicated.

Step-13: Evaluate the monitoring and measurement system in the light of changing plans and strategies in order to maintain its utility.

2.6 Monitoring and measurement programmes for ISO 14001 based EMS

Literature survey [28 to 36] indicated that the term procedure, rather than the term programme, is mostly used with the monitoring and measurement element of the EMS. This may be due to the use of the term procedure in the ISO 14001 standard under clause 4.5.1 ('the organization shall establish, implement and maintain a procedure(s) to monitor and measure ….') [2]. Monitoring and measurement actually includes a set of activities while procedure is defined as a 'specified way of doing an activity or process' [2], and hence the term procedure may not be appropriate.

2.6.1 Guidelines for the development of a monitoring and measurement programme for ISO 14001 based EMS

Reddy [27] proposed the following guidelines to a process industry for development of a monitoring and measurement programme for ISO 14001 based EMS:

1. The key activities supposed to be performed by a monitoring and measurement programme are:
    - Identification of key parameters for monitoring and measurement.
    - Documentation of procedures related to monitoring of each of the identified key parameters.
    - Calibration and maintenance of monitoring equipment.
2. For the identification of key parameters to be monitored and measured industrial units can do the following:
    - Review the operations/activities of the organization for identifying those operations/ activities which have significant environmental aspects and require operational controls and for identifying the key parameters of each such critical operations and activities that require regular monitoring.
    - Review the relevant environmental legislation and regulations periodically to identify the additional key parameters that need to be monitored and measured for the assessment of compliance with applicable legal requirements.
    - For environmental performance assessment, indicators such as the following can be used:

- Consumption of raw materials, hazardous chemicals, ecologically important inputs, water, energy and other resources including consumption of recycled materials.
- Generation of wastes and pollution including fraction of the generated wastes being recycled and reused.

- Consider the parameters that help in tracking performance of each of the elements of EMS against their objectives.

3. For each of the identified parameters, decisions related to frequency of monitoring and measurement and method of monitoring and measurement, recording of results, analysis and use of results and reporting/communication of results should be taken. The existing facilities (including monitoring equipment) should be reviewed for assessing their adequacy for the monitoring and measurement in order to identify and create additional facilities if required.

4. Monitoring and measurement procedure should be documented for each of the identified key parameters. Such procedure can include the following:
    - Purpose/objective.
    - Frequency of monitoring and measurement.
    - Step by step procedure for monitoring.
    - Recording of results.
    - Analysis of the results and use for the stated purpose.
    - Reporting/communication of results.
    - Responsibilities associated with the monitoring and measurement and with the analysis, reporting and communication of results.

5. The calibration and maintenance of monitoring equipment function can include the following:

    - Identification of the equipment used for the monitoring and measurement of each of the key parameters.
    - Attaching a separate calibration and maintenance card (showing the actual date and due date for calibration and verification of calibration, person responsible for calibration and verification of calibration and maintenance and method of

calibration on reverse side) to each of the equipment that requires calibration and maintenance.

- Documenting the procedure for calibration and maintenance of monitoring equipment and for the verification of calibration and maintenance. The documented procedure can include the following:
  - Identification of equipment to be calibrated and maintained.
  - Details of procedure for calibration and maintenance.
  - Frequency of calibration and maintenance.
  - Responsibility of calibration and maintenance.
  - Responsibility of verification of calibration and maintenance.
- Maintaining the records related to calibration and maintenance of monitoring equipments. These records can include details of the monitoring equipment such as its functional area, the parameter monitored by the equipment, frequency of calibration of equipment, due date of calibration, actual date of calibration and verification of calibration, responsibility of calibration and verification of calibration.

According to US EPA [(11)], the monitoring and measurement programme should perform the following four activities:

1. **Monitor key characteristics of its operations/activities that have significant environmental impacts and/or compliance consequences:** These key characteristics are usually a combination of outcome measures and process measures. Outcome measures concentrate on the results of a process or activity such as number of spills that occurred while process measures concentrate on upstream factors such as amount of paint used per unit of product.
2. **Track performance:** Tracking performance has wider scope and may include the following:
   - Tracking overall success of the EMS.
   - Tracking performance of each of the components of the EMS.
   - Tracking progress in meeting the objectives and targets.

- Tracking pollution prevention achievements.
- Tracking operational performance.

3. **Calibrate and maintain monitoring equipment:** The monitoring equipments that affect environmental performance of the organization should be identified and placed under a special calibration and maintenance programme.
4. **Periodically evaluate compliance with applicable laws and regulations:** Environmental compliance audits can be conducted for systematically identifying, correcting and preventing violations with regulations.

CHAPTER-3: METHODOLOGY

3.1 Objectives

The present study has the following two objectives:

1. Conceptualization of a generic monitoring and measurement programme for process industry.
2. Development of monitoring and measurement programme for one industrial plant as a case study.

3.2 Scope

Scope of the work is limited to a monitoring and measurement programme that satisfies the requirements of an ISO 14001 based environmental management systems. The generic programme is relevant and limited to process industry. For case study, a milk plant which is processing 5 lakh litres of milk per day into ghee, casein, milk minerals and lactose, has been chosen.

3.3 Work elements involved

For achieving the objectives, the following work elements have been identified to work on:

1. Review of ISO series of standards for understanding the requirements of a monitoring and measurement programme.
2. Review of the Indian Environmental Law for understanding monitoring and measurement requirements of process industries from legal compliance point of view.
3. Review of literature on environmental monitoring and measurement programmes/ procedures/systems.
4. Detailed survey of the selected industrial plant (milk plant) for understanding its environmental monitoring and measurement requirements.

5. Conceptualization of a generic monitoring and measurement programme that satisfies the requirements of ISO 14001 based environmental management system and Indian Environmental Law.
6. Development of monitoring and measurement programme for the selected industrial plant (milk plant) surveyed.

3.4 Approach followed

2. **Review of ISO series of standards for understanding the requirements of a monitoring and measurement programme:** Requirements that must be satisfied by the monitoring and measurement programme to be conceptualized and developed have been identified on the basis of review of the following ISO series of standards:

   - ISO 14001: Environmental management systems- specification with guidance for use
   - ISO 14004: Environmental management systems- General guideline on principles, system and supporting techniques
   - ISO 14031: Environmental management- Environmental performance evaluation- Guideline
   - ISO 14032: Environmental management- Examples of environmental performance evaluation (EPE)
   - ISO 17025: General requirements for the competence of testing and calibration laboratories

2. **Review of the Indian Environmental Law for understanding monitoring and measurement requirements of process industries from legal compliance point of view:** The requirements that must be satisfied by the monitoring and measurement programme to be conceptualized and developed in order to be functional in assessment of legal compliance have been identified on the basis of review of the following Indian Environmental Acts and Rules made there under:

   - The Water (Prevention and Control of Pollution) Act, 1974
     - The Water (Prevention and Control of Pollution) Rules, 1975
   - The Water (Prevention and Control of Pollution) Cess Act, 1977

- The Water (Prevention and Control of Pollution) Cess Rules, 1978

➢ The Air (Prevention and Control of Pollution) Act, 1981

- The Air (Prevention and Control of Pollution) (Union Territories) Rules, 1983

➢ The Environmental (Protection) Act, 1986

- The Environmental (Protection) Rules, 1986
- The Hazardous Wastes (Management and Handling) Rules, 1989
- The Manufacture, Storage and Import of Hazardous Chemical Rules, 1989
- The Noise Pollution (Regulation and Control) Rules, 2000

3. **Review of literature on environmental monitoring and measurement programmes/procedures/systems:** The structure of the monitoring and measurement programme to be conceptualized and developed has been based on literature review. Review literature has been limited to last ten years i.e., 1996 to 2005. It has concentrated on the following four aspects:

- Measurement.
- Monitoring and measurement as one of the elements of ISO 14001 based EMS.
- Monitoring and measurement and its need.
- Monitoring and measurement programme.

The currently available e-literature on the topic has been reviewed. Apart from that the following books have been depended on:

- "ISO 14001 Environmental Systems Handbook" by Ken Whitelaw
- "An implementation guide for small and medium sized organization" prepared by NSF international

4. **Detailed survey of the selected industrial plant (milk plant) for understanding its environmental monitoring and measurement requirements:** The monitoring and measurement requirements of the selected industrial plant (milk plant) surveyed have been evaluated in the light of monitoring and measurement requirements identified in

step-1 and step-2 by having an understanding of its industrial processes and knowing its current environmental monitoring and measurement practices.

5. **Conceptualization of a generic monitoring and measurement programme that satisfies the requirements of ISO 14001 based environmental management system and Indian Environmental Law:** A generic monitoring and measurement programme has been conceptualized which satisfies the requirements of ISO 14001 while being functional for the Indian Environmental Law and having its structure articulated on the basis of literature review.
6. **Development of monitoring and measurement programme for the selected industrial plant (milk plant) surveyed:** A monitoring and measurement programme has been developed for the selected industrial plant surveyed, in the light of its monitoring and measurement requirements and using the generic monitoring and measurement programme developed.

CHAPTER-4: MANUFACTURING PROCESS OVERVIEW

4.1 Introduction

The milk plant under study manufactures ghee, casein, lactose, milk minerals and whey protein concentrate. It uses chilled raw milk, chilled concentrated milk, chilled skimmed milk and skimmed milk powder as raw materials. It is a seasonal industry and operates from August to May. The plant has been divided into the following three core processing units:

1. Raw milk receiving and processing unit
2. Casein unit
3. Whey processing unit

Apart from processing units, the plant has the following supporting processes:

1. Boiler house and steam supply system
2. Electrical power system inclusive of D.G. set
3. Water treatment and supply system inclusive of soft water unit
4. Chilled water unit and circulating chilled water system
5. Cooling tower and circulating cooling water system
6. Instrumental air supply system
7. Effluent treatment plant

4.2 Core processing units

4.2.1 Raw milk reception and processing unit

Milk is received in tankers. After weighing and sampling, it is filtered, unloaded and stored in raw milk silos.

Skimmed milk powder(SMP), received in poly-lined poly-ply Kraft paper bags with poly-liner inside, is reconstituted with soft water and pumped to a cream separator and then sent to casein unit or it is pumped and mixed with raw milk and taken to raw milk silo or cream separator.

The raw milk is pumped from the raw milk silos through milk pasteurizer and cream separator. The cream separated out is passed through cream pasteurizer and stored in cream storage tank. After cream separation, the milk (also known as skimmed milk) is sent to casein unit.

The cream is then passed through butter making machine. The butter produced is melted in a butter melting vat. The buttermilk generated at butter making machine is taken back into processing through mixing with raw milk. The fat rich layer of molten butter is transferred to ghee boiler while the serum layer is disposed off after fat recovery. The ghee from the ghee boiler is filtered and cooled and then sent for packing. The residue portion left in the ghee boiler is taken out as ghee residue. These residues are disposed off after recovering residual ghee from them.

The filtered and clarified ghee is packed in poly-pouches, poly-jars and tins.

Please see figure-2.1, figure-2.2, figure- 2.3 and figure-2.4 for process details.

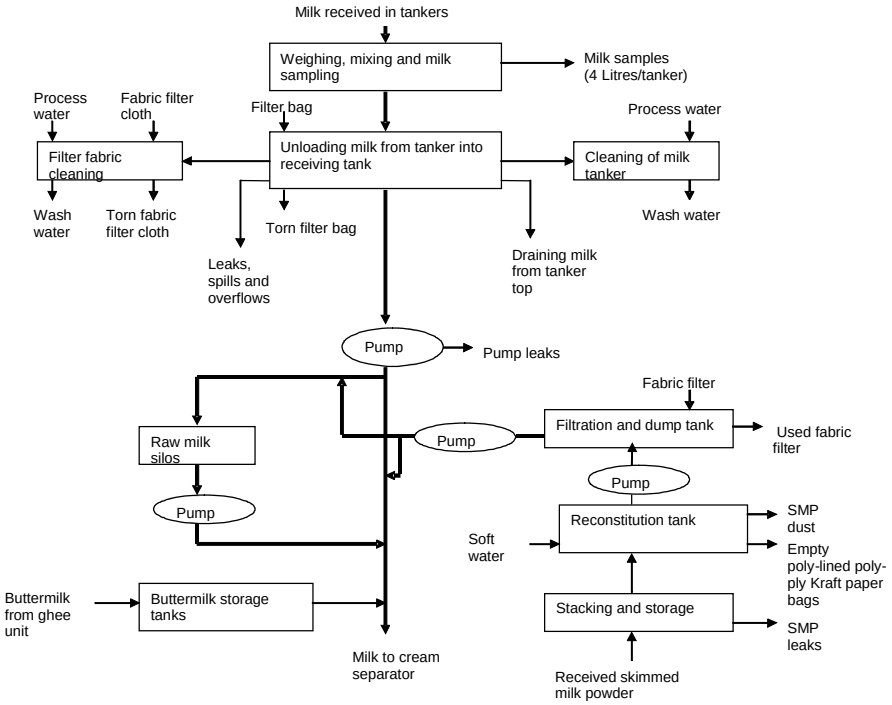

FIGURE-2.1

Reception of milk and reconstitution of skimmed milk

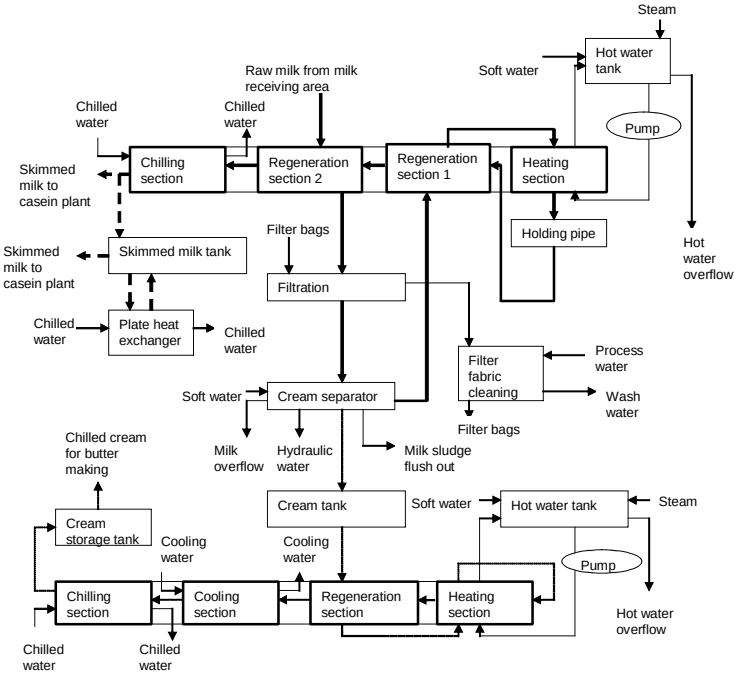

FIGURE-2.2

Pasteurization and cream separation

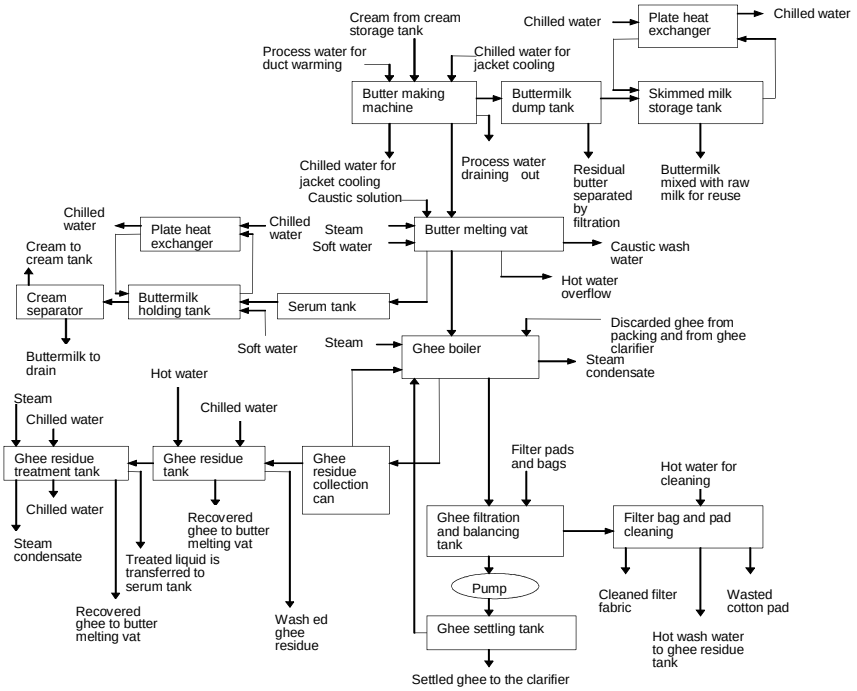

FIGURE-2.3

Melting of butter and manufacturing of ghee

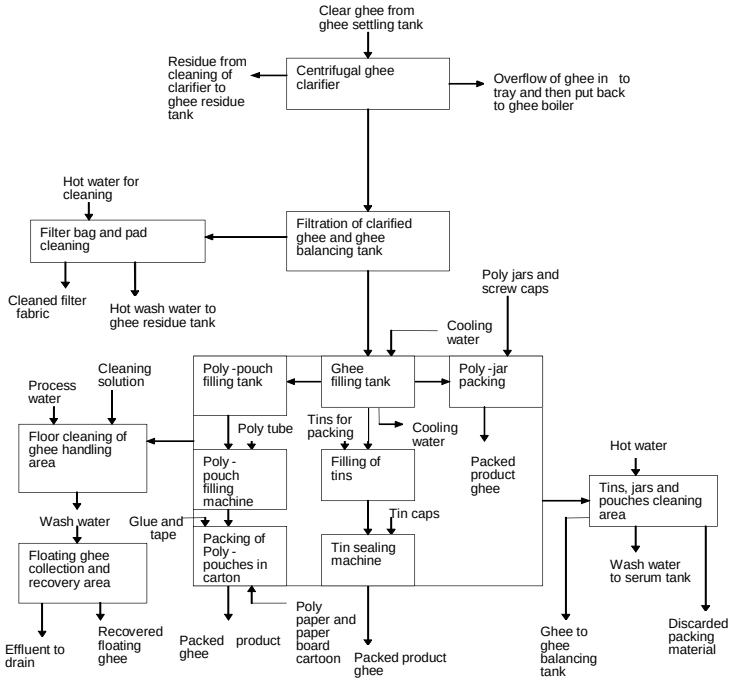

FIGURE-2.4

Packing of ghee

4.2.2 Casein unit

Skimmed milk from the silos is pumped, preheated and dosed with HCl for curding. After proper curding, the curd (casein) is separated by passing through an inclined screen. The liquid portion separated at inclined screen is known as whey. The curd separated is washed with acidic process water in five stage counter current washing. Wash water generated is also collected as whey and mixed with whey generated at inclined screen and sent to whey silos. Washed casein is dewatered and then dried in a ring drier with hot dry air. The product is separated from the air stream with the help of cyclone separator and cooled in a fluidized bed cooler. The cooled casein is tampered, sorted on the basis of granule size and packed. Please see figure-3.1, figure-3.2, figure-3.3 and figure- 3.4 for process details.

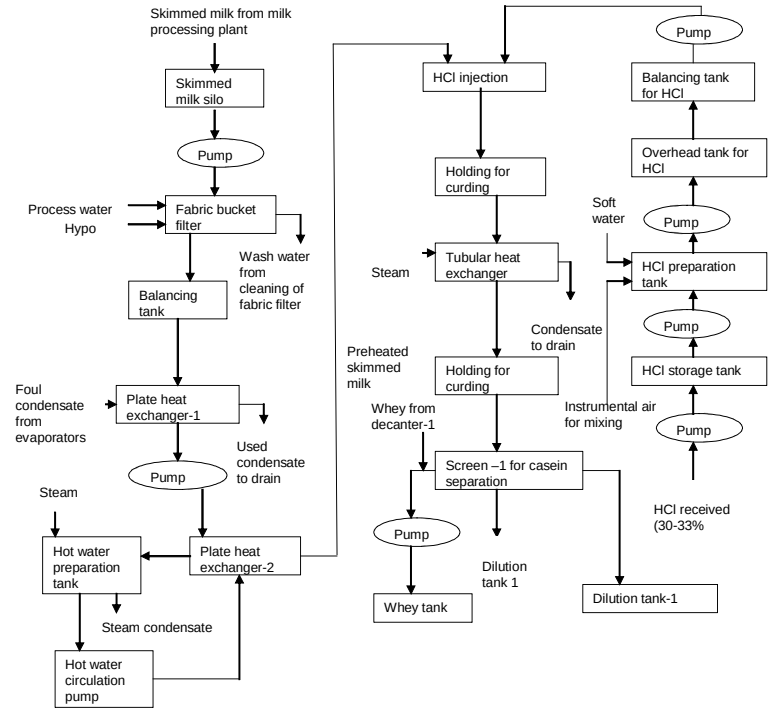

FIGURE-3.1

Curding of skimmed milk and separation of casein

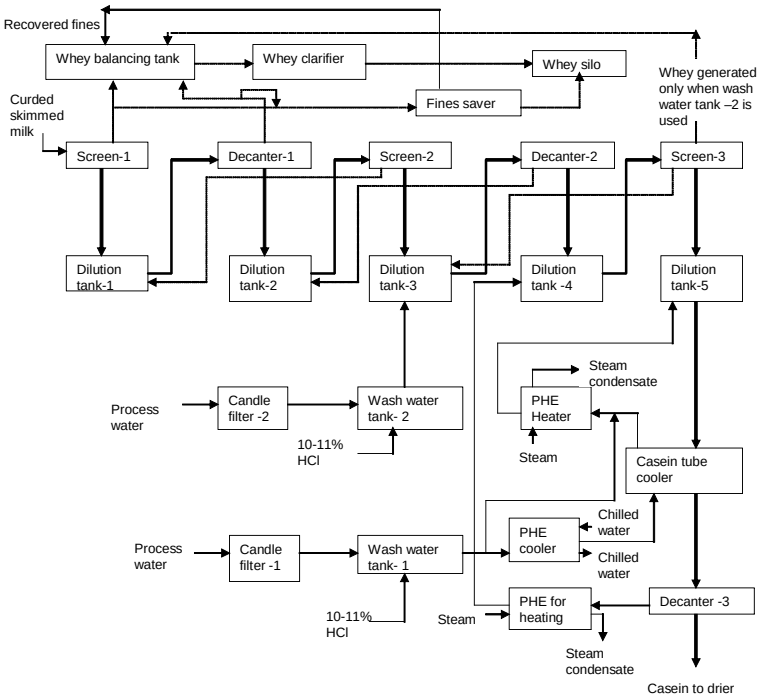

FIGURE-3.2

Washing and dewatering of the separated casein

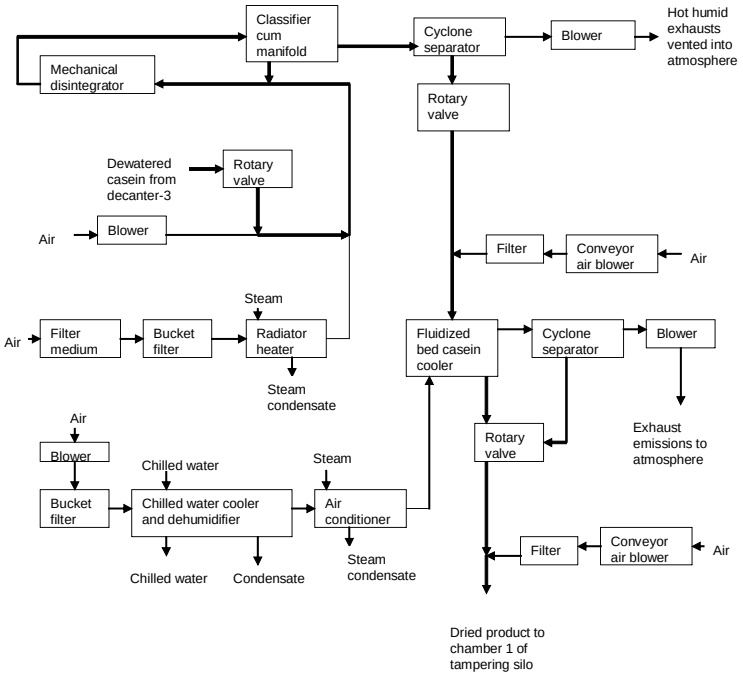

FIGURE-3.3
Drying of dewatered casein

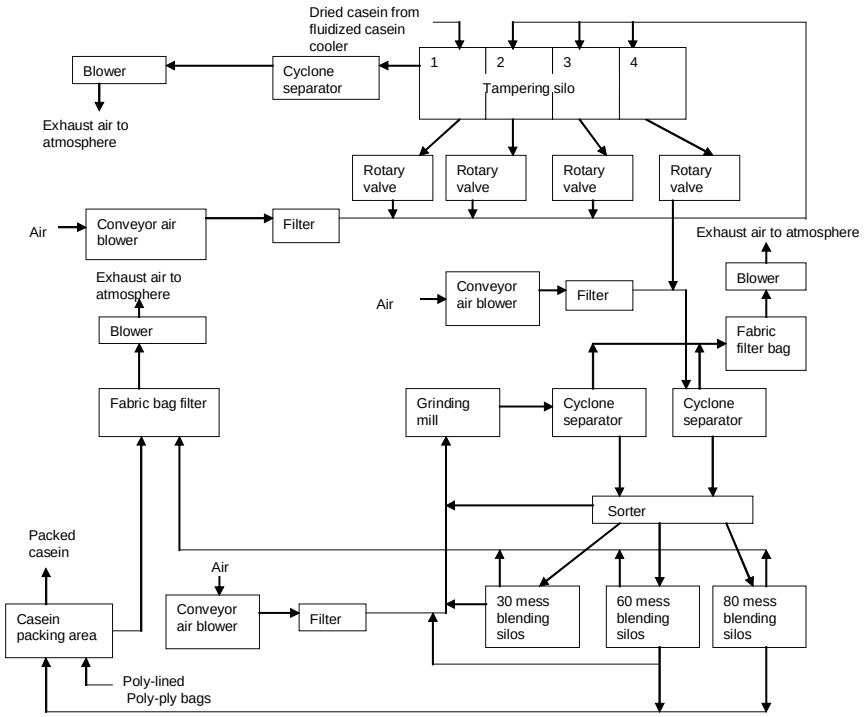

FIGURE-3.4
Tampering, sorting and packing of casein

4.2.3 Whey processing unit

Whey, which is stored in the whey silos, is preheated, filtered and pumped through a five stage ultra filtration unit. Permeate generated from ultra filtration stages-1, 2 is collected and pumped to permeate silo while permeate generated from ultra filtration stages-3, 4 and 5 is collected and supplied to milk minerals manufacturing unit. The whey retentate generated by ultra filtration is stored as Whey Protein Concentrate (WPC) in WPC storage tanks. Please see figure-4 for process details.

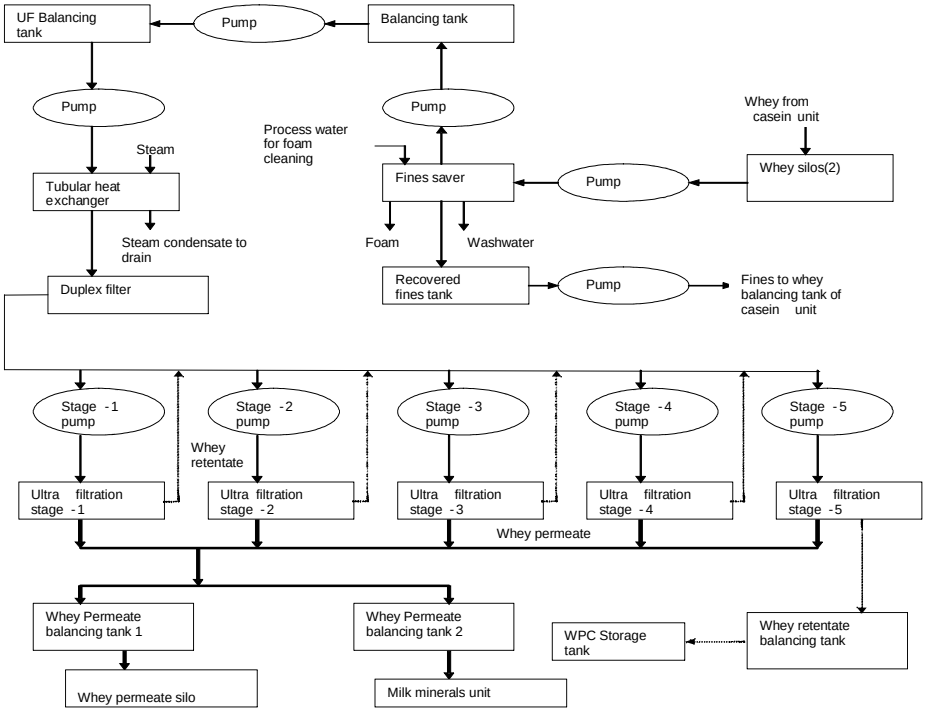

FIGURE-4

Ultra filtration of whey and handling of whey permeate and whey retentate

Whey permeate supplied to milk minerals manufacturing unit is neutralized by bringing pH to 6.8 through addition of caustic solution in horizontal cylindrical tanks. This results in precipitation of milk minerals, which are separated as bottom slurry after decanting the supernatant. The bottom milk mineral slurry is dewatered, wash dewatered and tray dried. The dried product (milk minerals) is milled, graded and packed. The decanted supernatant is taken to permeate silo. See figure-5 for process details.

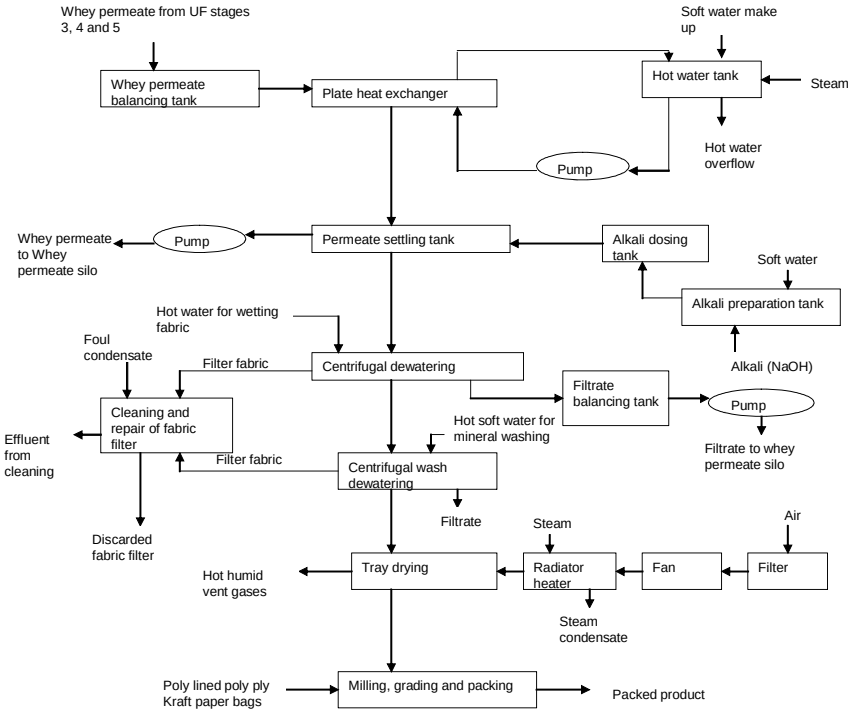

FIGURE-5
Milk minerals manufacturing

Evaporators section is used for concentrating the whey permeate from 4.5-6 % to 60 % total solids level and whey retentate from 8-9 % to 35 % total solids level. There are two loops in the evaporative concentration system: a MVR (mechanical vapour recompression) loop and a TVR (thermal vapour recompression) loop. Concentration of whey permeate involves use of both MVR and TVR loop while concentrating of whey retentate involves use of only the MVR loop.

The concentrating process involves pre-heating of the liquid to the boiling point and then passing through a series of vacuum evaporation effects (VEEs). Each VEE has three zones: heating, flashing and vapour separation. Saturated steam or flashed vapours of previous effect or both is used as heating medium. Condensing steam and condensing vapours come out as steam condensate and foul condensate respectively. In the case of MVR loop, the heat required for the concentration is supplied in the form of both mechanical energy and thermal energy. Mechanical energy is used to compress vapours. Compression leads to condensation of some fraction of vapours and heating of the remaining vapours by the released latent heat of condensation. Accumulation of non-condensable gases (NCG) is controlled through their extraction by a system of surface condensers and steam ejectors. See figure-6 and figure-7 for process details.

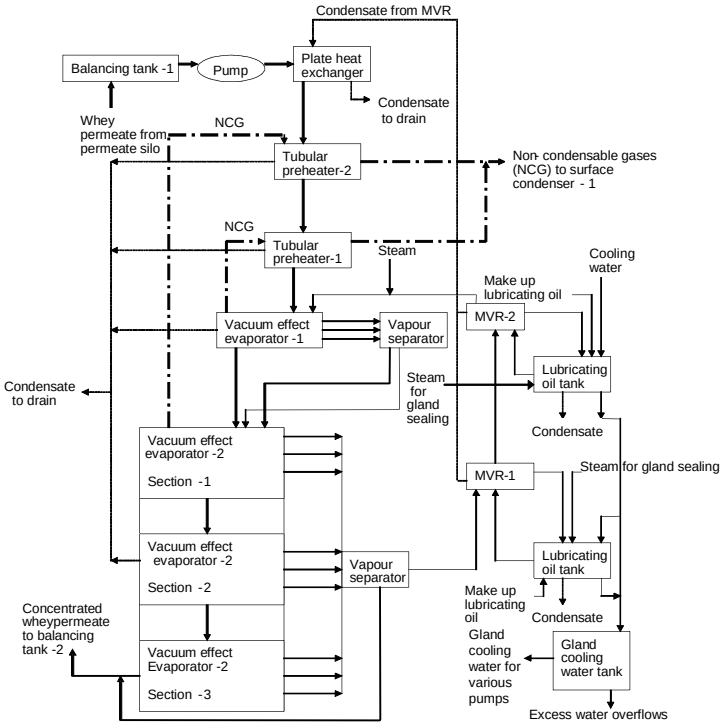

FIGURE-6
MVR loop

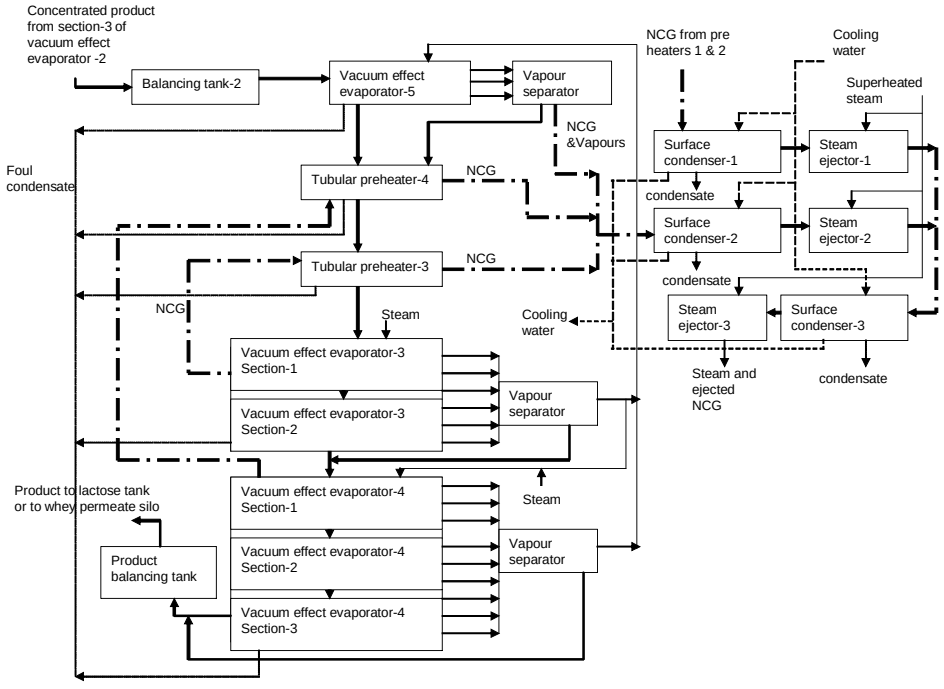

FIGURE-7
TVR loop

Two grades of lactose are manufactured i.e., dairy gold grade and pharma grade. Concentrated permeate is gradually cooled to 15^0C over 24 hours in crystallization tank for lactose crystallization. The lactose crystals formed are separated from mother liquor in a decanter and dried to obtain dairy gold grade. For obtaining pharma grade, the lactose obtained through decanting is purified by wash decanting and then by refining. For refining, the lactose is dissolved in hot water, treated with activated carbon and filtered through filter press. The filtrate is re crystallized by gradual cooling to 15^0C over 24 hour time. The crystals formed are separated from mother liquor in a decanter and dried in hot air drier comprised of primary and secondary drier. The dried product is recovered in fabric bag filter house and packed. Please see figure-8.1 and figure-8.2 for process details.

Clean In Place (CIP) Centre: There is a CIP centre which provides flushing solutions for cleaning various sections of different units of the milk industry. This centre supplies hot water for pre-flushing and post-flushing and caustic and nitric acid solution for circulation cleaning. Sometimes, formalene and hypo solution is also used for circulation cleaning.

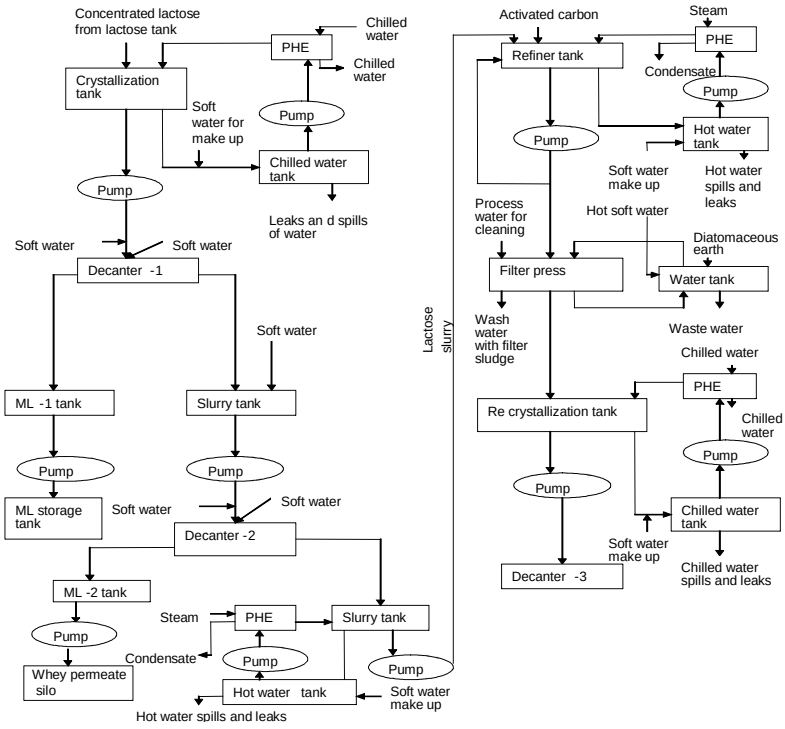

FIGURE-8.1

Crystallization and decantation of dairy grade and pharma grade lactose

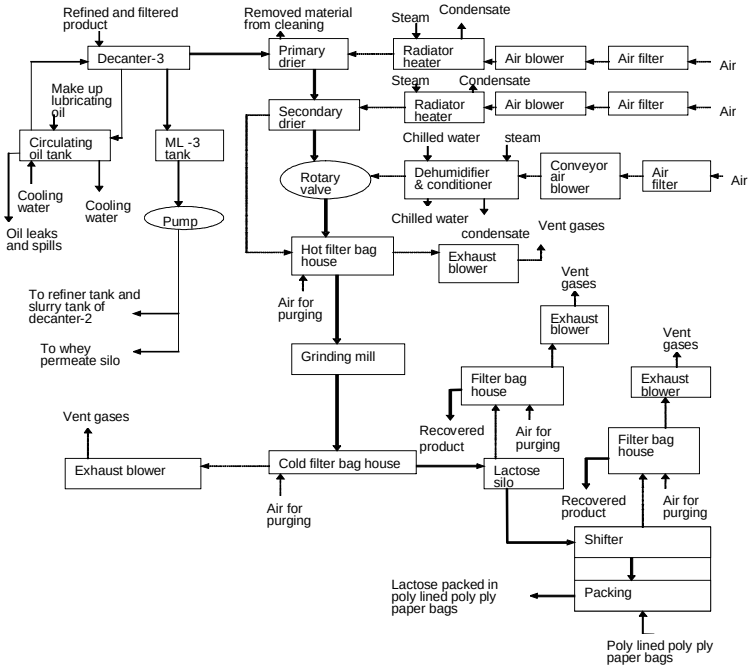

FIGURE-8.2

Drying and packing of lactose

4.3 Utilities unit

4.3.1 Boiler house and steam supply system

Rice husk, screened over a vibratory screen, is used as fuel in steam boiler. There are two compartments in the boiler and each of the compartments is separately fed with rice husk. Each compartment has a fluidized bed-burning zone. Hot flue gases from the furnace enter inside fire tube boiler within which they make three passes and are finally discharged to the atmosphere through a stack after passing through a multi cyclone. Soft water after preheating and chemical treatment is used as boiler feed water. For controlling the TDS level, blow down of the boiler is practiced. The flyash generated is quenched with water and disposed in the low-lying areas of the industry. Saturated steam is extracted from the boiler at 15.5 kg/cm^2 and supplied to various parts of the plant as heating medium. Please see figure-9 for details.

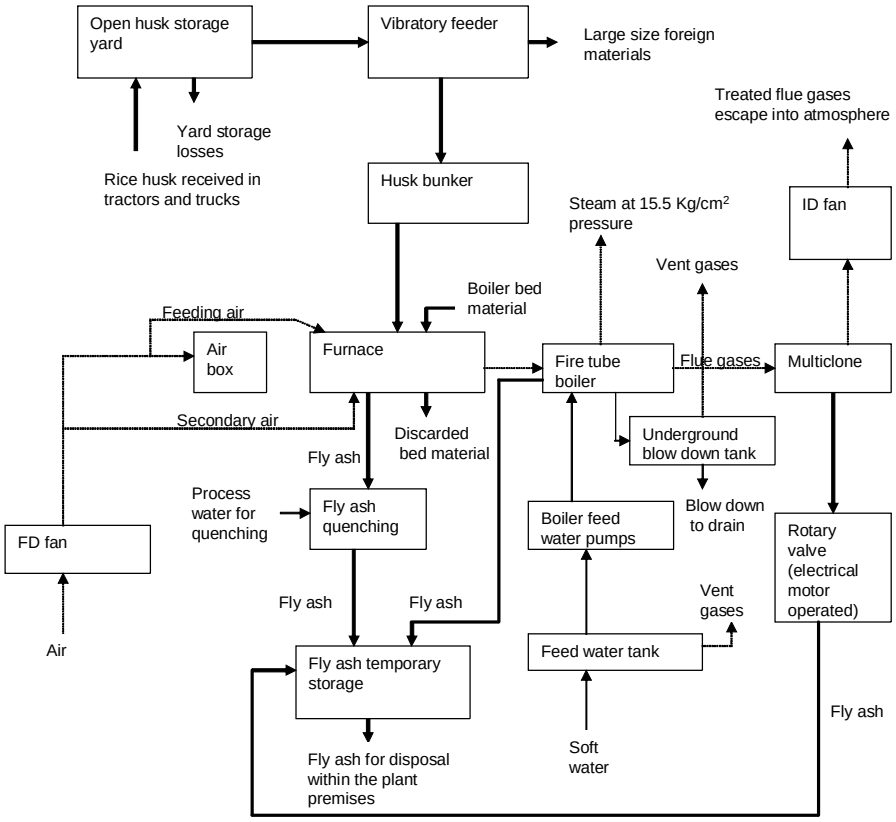

FIGURE-9
Boiler house

4.3.2 Water treatment and supply system

Ground water is extracted from two tube wells and stored in a raw water tank. From the raw water tank, water is pumped, passed through pressure sand filters, stored in the process water tank and supplied to the plant as process water. A part of the process water goes to the soft water unit where cation exchange resin beds are used. The soft water generated is stored in the soft water tank and supplied to the plant for use. Backwashing of pressure sand filters and regeneration of ion exchange resin beds generates wastewater. Please see figure-10 for details.

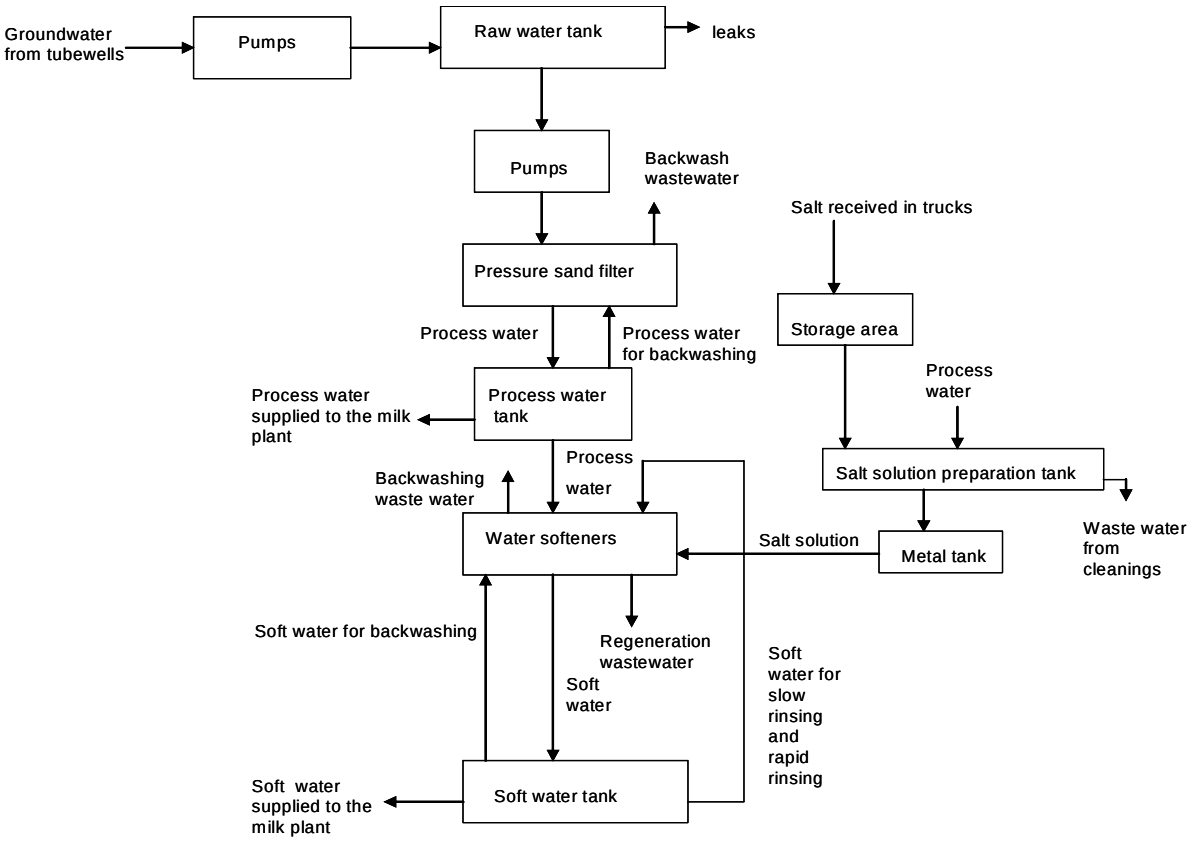

FIGURE-10
Water treatment unit

4.3.3 Cooling tower and circulating cooling water system

The cooling tower has three fans for ensuring counter current flow of water and air. From sump cooling water is pumped to all point of use. Used cooling water is conveyed back to cooling tower for cooling. Once in a week, 7 to 8% of the cooling tower sump contents are blown down for removing accumulated contaminants. Soft water is used as make up water. Cooling tower is cleaned once in lean season. Please see figure-11 for details.

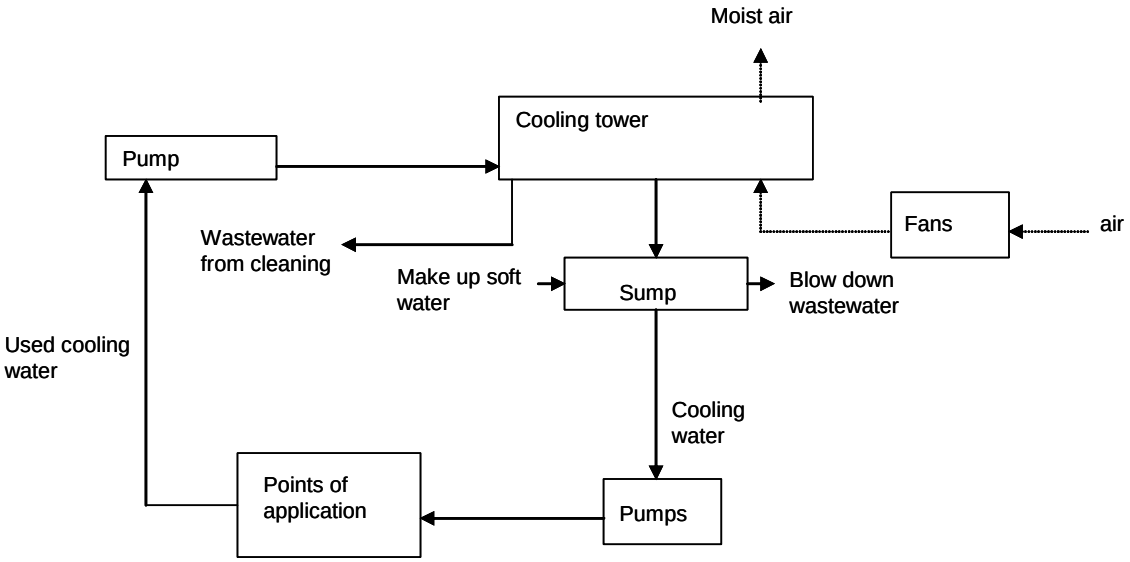

FIGURE-11
Cooing tower

4.3.4 Chilled water unit and circulating chilled water system

There are insulated ice bank tanks in which soft water is maintained at desired level through addition of soft water and chilled to desired temperature through evaporating liquid ammonia. Ammonia vapours formed are continuously removed and compressed with the help of screw rotary compressors. The hot compressed ammonia vapours are cooled in water-cooled condensers and stored in receiver tanks. Stored ammonia liquid is supplied to the ice bank tanks for chilling water usually after further cooling. Please see figure-12 for details.

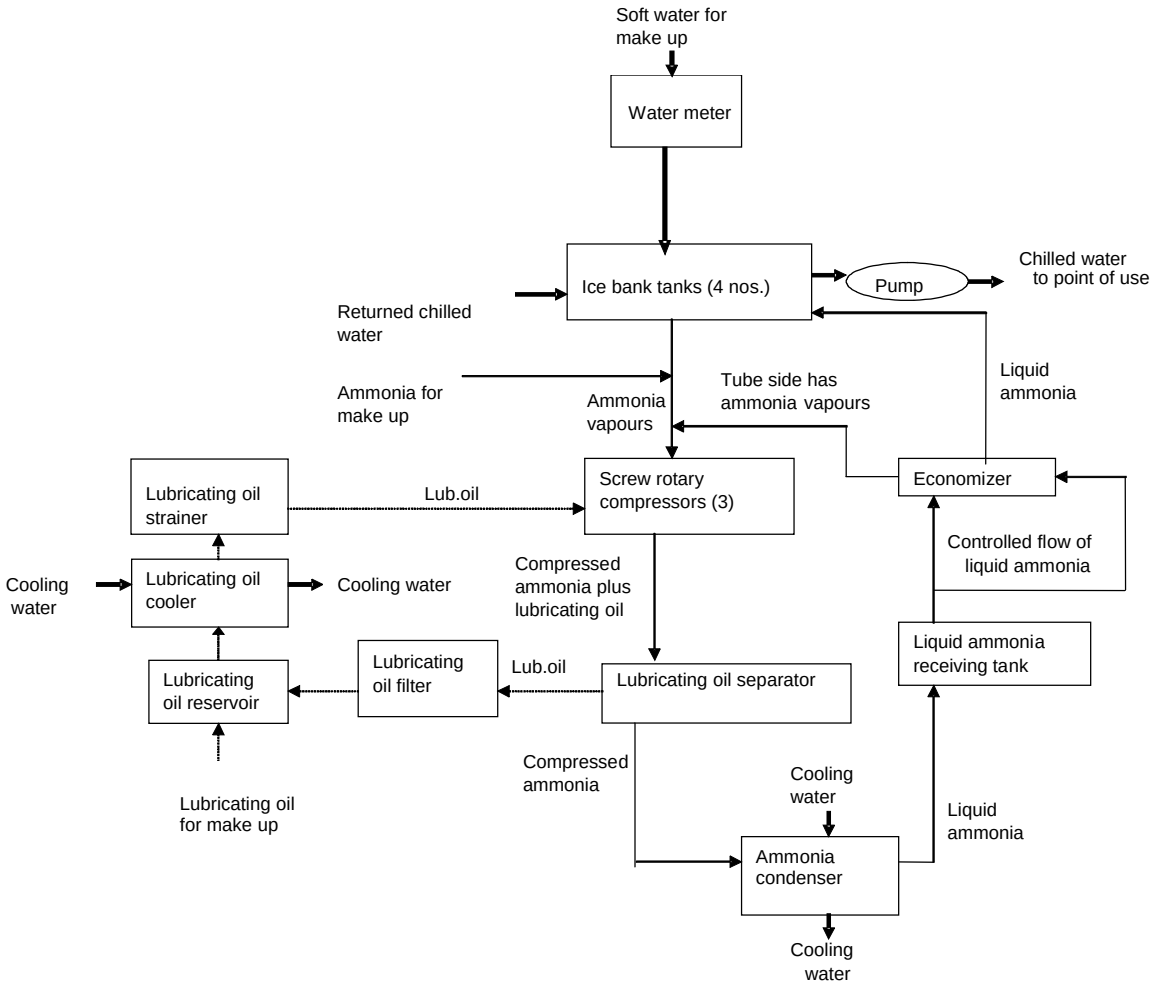

FIGURE-12
Chilled water unit

4.3.5 Effluent treatment plant

Effluent generated by the processing section of the industry comes to ETP in two streams: Effluent from raw milk reception and processing unit and effluent from casein and whey processing unit. In addition, wastewater from utilities is conveyed to ETP by two separate drains: one from rice husk fired boiler and second from water treatment unit and cooling water unit. The ETP has the following units:

- Screening chamber
- Degreasing tank
- Neutralization tank
- Equalization tank
- Up flow anaerobic sludge blanket
- Aeration tank
- Secondary clarifier
- Sludge drying beds

The treated effluent is disposed off on land through irrigation. Please see figure-13 for details.

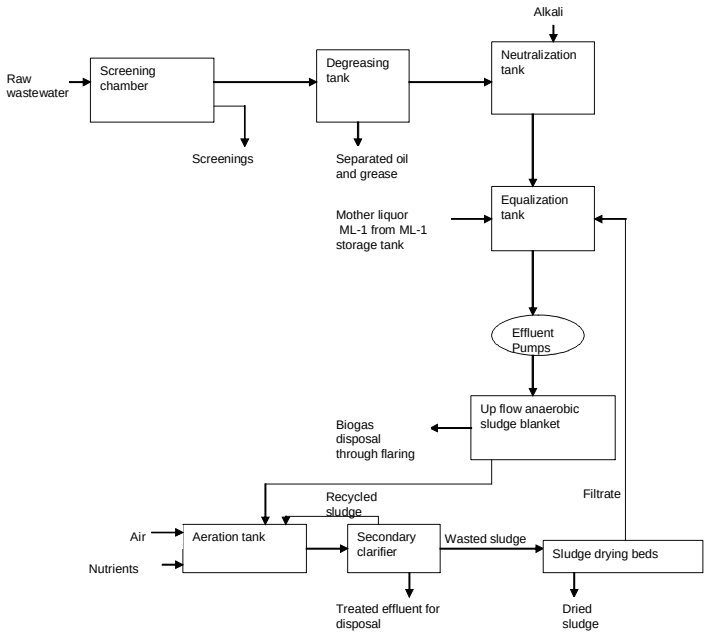

FIGURE-13
Effluent treatment plant

4.3.6 Electrical power system

The electricity is consumed from the P.S.E.B. grid. After metering, it is sent to HT control panel. A part of it is converted to the desired voltage with the help of a step-down transformer and sent to LT control panel. It is then supplied to points of use in industry through a HT/ LT control panel. At times of power failure or peak demands, electricity is provided by captive energy unit i.e., D.G. set of 700 KVA.

CHAPTER-5: MONITORING AND MEASUREMENT PROGRAMME

5.1 Introduction

Monitoring and measurement programme includes organizational structure, planning activities, responsibilities, practices, procedures, processes and resources for developing, implementing and maintaining the monitoring and measurement policy and objectives. It is also called monitoring and measurement procedure or monitoring and measurement system by certain organizations.

5.2 Requirements to be satisfied by monitoring and measurement programme

A monitoring and measurement programme for ISO 14001 based EMS should satisfy the requirements for conformance with ISO 14001 and the requirements for compliance with the Indian environmental law. Apart from these requirements, it should include answers to following questions [8] :

1. What should be measured, where, how frequently and why?
2. Who will measure and how?
3. What logistics are needed for the measurement?
4. How will he/she ensure accuracy of measurement?
5. How the measured data is recorded, maintained and used?

5.2.1 Requirements to be satisfied by monitoring and measurement programme for conformance with ISO 14001

The monitoring and measurement programme for conformance with ISO 14001 should satisfy the following requirements:

1. Establishing, implementing and maintaining procedures to monitor and measure key characteristics of operations/ activities having significant impacts on the environment. These procedures shall include documenting of information to monitor performance, applicable operational controls and conformity with the organization's environmental objectives and targets.

2. Establishing, implementing and maintaining procedure (including maintenance of records) to evaluate compliance with environmental legislation and regulations.
3. Ensuring use of calibrated or verified monitoring equipment and maintenance of related records.

5.2.2 Requirements to be satisfied by monitoring and measurement programme for compliance with Indian Environmental Law

The monitoring and measurement programme should provide the necessary information for performing the following activities that are required for compliance with the Indian Environmental Law:

1. The Water (Prevention and Control of Pollution) Act, 1974 and The Water (Prevention and Control of Pollution) Rules, 1975

1. For filling details required in the application form for grant or renewal of water consent.
2. For checking compliance with the water consent conditions.
3. For providing required information, if asked, to state pollution control board (SPCB) related to abstraction of water or discharge of wastewater into a stream/well and construction, installation of treatment and disposal system.
4. For checking compliance with the prescribed standards of SPCB for effluent discharge and for filing any self-monitoring returns if required by the SPCB.
5. For intimating about the discharge of water polluting matter beyond the standards prescribed by SPCB, if any, due to any accident or unforeseen act to prescribed authority.
6. For furnishing records and information to the inspecting agency.

2. The Water (Prevention and Control of Pollution) Cess Act, 1977 and The Water (Prevention and Control of Pollution) Cess Rules, 1978

1. For filing of the monthly water consumption returns. These returns shall show the monthly water consumption from various sources (municipal water mains, well/tubewell, canal, river, and other source) and for various purposes (industrial cooling or spraying in mine pits or boiler feed, domestic purpose, processing whereby water gets polluted and the pollutants are easily bio-degradable and/or toxic, processing whereby water gets polluted and the pollutants are non-

biodegradable and/or toxic). Information on the functioning of the effluent treatment plant should also be included in the returns.

2. For checking compliance with the conditions for affixing standardized water meters at desired places.

3. Air (Prevention and Control of Pollution) Act, 1981 and The Air (Prevention and Control of Pollution)(Union Territories) Rules, 1983

1. For filling details required in the application form for the grant or renewal of air consent.
2. For checking compliance with the consent conditions.
3. For checking compliance with the standards for emission discharge into atmosphere as prescribed by SPCB and for filing any self-monitoring returns if required by the SPCB.
4. For intimating about the emission of air pollutant into atmosphere beyond the standards prescribed by SPCB, if any, due to any accident or unforeseen act to prescribed authority.
5. For furnishing records and information to the inspecting agency.

4. Environmental (Protection) Act, 1986

For furnishing records and information to the inspecting agency.

4.1 Environmental (Protection) Rules, 1986

1. For checking compliance with the applicable emission/discharge standards specific to the industry in question, boilers, D.G. sets and general standards stated in schedule –I and schedule-VI.
2. For checking compliance with ambient air quality standards w.r.t. noise (schedule- III).
3. For preparing and filing of annual environmental statement.
4. For intimating about the discharge of any environmental pollutant beyond the standards prescribed due to any accident or unforeseen act to prescribed authority.

The Hazardous Waste (Management and Handling) Rules, 1989

1. For preparing and maintaining inventories of hazardous wastes.
2. For filing of application for the grant or renewal of authorization for the management and handling of hazardous wastes from SPCB.
3. For maintaining records of hazardous wastes about their collection, reception, treatment, storage and disposal.
4. For filing of annual returns regarding disposal of hazardous waste.
5. For maintaining records of hazardous waste imported.

Manufacture, Storage and import of Hazardous Chemicals Rules, 1989

1. For identifying the hazardous chemicals and knowing their maximum liable quantity. The legal requirements of this rule applicable to the industry in question depend on the relation between maximum liable quantity and the threshold value and may include the following:
    - Preparation and maintenance of safety datasheets.
    - Clear labelling and marking of every container of hazardous waste.
    - Provision of information, training and personal protection equipment to staff handling hazardous chemicals.
    - Identification of potential major hazards and taking adequate steps to limit their consequences.
    - Notification of occurrence of major accident.
    - Submission of report about the analysis of the major accident.
    - Obtaining approval of concerned authority before undertaking any industrial activity.
    - Preparation of on-site emergency plan.
    - Provision of necessary information about the industrial activity to the concerned authority involved in the preparation of off-site emergency plan.
    - Preparation and update of safety reports.
    - Preparation of safety audits by an external expert.

- Provision of information to the persons liable to be affected by a major accident about the nature of the accident and safety measures which they should adopt in the event of a major accident.

4.4 The Noise Pollution (Regulation and Control) Rules, 2000

For checking compliance with ambient air quality standards with respect to noise.

5.3 Monitoring and measurement programme for ISO 14001 based EMS

5.3.1 Elements of monitoring and measurement programme for ISO 14001 based EMS

From the review of monitoring and measurement programmes for various organizations having ISO 14001 based EMS [28 to 36], it is proposed that a monitoring and measurement programme should have the following elements:

1. **Objectives/Purposes:** These are overall goals that an organization sets for being achieved by the monitoring and measurement programme. The mandatory objectives of an organization's monitoring and measurement programme, in order to comply with ISO 14001, are as follows:
   i. To establish, implement and maintain procedures (including recording of information for tracking performance, for tracking operational controls and for tracking conformance with the objectives and targets) to monitor and measure the key characteristics of its operations and activities that can have a significant environmental impact.
   ii. To establish, implement and maintain procedures (including maintenance of relevant records) to calibrate and maintain monitoring equipments.
   iii. To establish, implement and maintain procedures (including maintenance of relevant records) for periodically evaluating compliance with the relevant environmental legislation and regulations.
2. **Scope:** It tells the extent or boundary limits of implementation of the monitoring and measurement programme. The monitoring and measurement programme can cover all the significant environmental aspects of the organization as well as of its

suppliers and contractors over which the organization has control. These environmental aspects should be related to the objectives of this programme.

The programme can be scoped to include all the monitoring and measurement activities that are related to the evaluation of compliance with the applicable legal requirements; to the operational controls that are identified as essential for the management of the environmental aspects associated with the operations; and to the evaluation of environmental performance. The monitoring and measurement activities are limited to the areas that fall within the scope of the EMS.

3. **Programme:** It is a sequence of activities which has to be performed for achieving the objectives of the monitoring and measurement programme. The activities that comprise the proposed monitoring and measurement programme include the following:
    1. Maintain a documented procedure for the identification of the parameters/characteristics that need to be monitored and measured for satisfying the objectives/purposes of the monitoring and measurement programme.
    2. Identify and select the parameters/characteristics that need to be monitored and measured by following the procedure specified for their identification. Then set threshold values/targets/standards/benchmarks for each of the identified parameters.
    3. Decide on the mode of monitoring and measurement of each of the identified parameters (online/onsite/use of organization's centralized facilities/use of corporate facilities/use of third party facilities through networking or review of existing records) and how frequently each of them will be monitored and measured.
    4. Maintain an up-to-date list of parameters to be monitored containing details about the purpose of monitoring, the place of monitoring, the frequency of monitoring, the mode of monitoring and the threshold value for each parameter.
    5. Select a monitoring and measurement method for each of the parameters identified on the basis of (i) the resources needed, (ii) the facilities already

existing in place, (iii) accuracy and reproducibility required, (iv) practicability, (v) tangibility especially in terms of providing real and reasonable time results.

6. Assess the facilities and provisions required for the monitoring and measurement of each of the parameters identified for the monitoring and measurement. Assess the facilities already existing and create the additional facilities (including monitoring equipment) required for the monitoring and measurement.
7. Design analysis of the collected data, tracking of the identified parameters/characteristics and follow up action in case of non-compliance with threshold values/ targets/standards/ benchmarks.
8. Document the procedure for the monitoring and measurement of each of the selected parameters/characteristics while following the organization's prescribed protocol for the purpose. The procedure should include data analysis, parameter tracking and follow-up action components.
9. Define a monitoring and measurement plan giving details of the parameters to be monitored, mode of monitoring and measurement, place of monitoring and measurement, frequency of monitoring and measurement, reference to the relevant monitoring and measurement procedures and relevant personnel having the responsibilities of monitoring and measurement. Then document and communicate the monitoring and measurement plan to all the relevant and responsible personnel.
10. Identify the monitoring equipment/devices that require regular calibration and/or maintenance and develop method for the calibration and/or maintenance of each of the monitoring equipment/devices. Maintain an up-to-date list of monitoring equipment/devices containing details about their place of use, the frequency of calibration and/or maintenance and the parameter monitored and/or measured by each of the equipment/device.

11. Document the procedure (including records) for the calibration and/ or maintenance of each of the monitoring equipment identified while following the organization's prescribed protocol for the purpose.
12. Define a calibration and maintenance plan giving details of monitoring equipments that require calibration/maintenance, mode of calibration/maintenance, frequency of calibration and/or maintenance or verification of calibration and/or maintenance of monitoring equipments, reference to relevant calibration and/or maintenance procedure and relevant persons having responsibilities of the calibration and/or maintenance or verification of calibration and/or maintenance of monitoring equipments. Document the calibration and/or maintenance plan and communicate it to all the relevant and responsible personnel.
13. Train the responsible personnel in the relevant monitoring and measurement activities and calibration and/or maintenance activities.
14. Calibrate and/or maintain each of the monitoring equipment as per the plan while strictly adhering to the documented procedure for the calibration and/or maintenance. Further, maintain the records as specified in the associated calibration and/or maintenance procedure.
15. Carry out monitoring and measurement activities as per the plan and collect data. Record the collected data, analyse/process it and communicate the information as specified in the procedure and initiate follow up action, if any is required.
16. Review and revise the monitoring and measurement programme in the light of :
    i. Changes in the EMS policy, objectives and targets.
    ii. Revised significant environmental aspects, operational controls and key characteristics.
    iii. Changed legal requirements applicable to the organization.
    iv. Altered list of indicators for environmental performance evaluation.

The review and revision should emphasize on maintaining the programme suitable, adequate and effective.

4. **Responsibilities:** Duties shall be defined, documented and communicated for each of the activities identified in the programme in order to facilitate effective implementation of monitoring and measurement programme. Distribution of responsibilities can depend on the hierarchical structure of the organization. One possible way of assigning responsibilities is shown in table-1.

Activity/activities	**Responsibility**
1. Documentation of the procedure for identification of the monitoring parameters 2. Identification of monitoring parameters and setting threshold values 3. Deciding mode of frequency and measurement 4. Maintenance of list of identified parameters 5. Review and revise monitoring and measurement programme	Cross functional team
1. Selection of monitoring and measurement method 2. Identification of facilities and provisions for the monitoring and measurement 3. Assessment of facilities already existing 4. Creation of additional facilities required for monitoring and measurement 5. Designing analysis of the collected data, tracking of the identified parameters and follow up action in case of non-compliance 6. Defining and documentation of a monitoring and measurement plan	Functional head
1. Development of methods for the calibration and maintenance of monitoring equipment/devices 2. Maintaining list of monitoring equipment/devices 3. Defining and documentation of a calibration and maintenance plan 4. Calibration and maintenance of monitoring equipment/devices	Maintenance head
Training of relevant personnel	Human resource development manager
1. Documentation of monitoring and measurement procedures for the identified parameters 2. Monitoring and measurement of identified parameters	Responsible person

TABLE-1

Distribution of responsibilities in monitoring and measurement programme

5. **References:** It includes documents that are referred to within the monitoring and measurement programme. Some of the documents that constitute references can be the following:

    i. List of parameters/characteristics identified for monitoring and measurement.
    ii. List of monitoring equipments used in the monitoring and measurement and requiring calibration and maintenance.
    iii. Procedure for the identification of parameters/characteristics for monitoring and measurement.
    iv. Protocol for documentation of procedures.
    v. Documented procedures for monitoring and measurement of each of the identified parameters/ characteristics.
    vi. Documented procedure for calibration and maintenance of each of the identified monitoring equipment/device.

6. **Revision history:** It includes the new version level/ number, summary of the change introduced in the monitoring and measurement programme, the date when the change was released, signature of the person who has brought the change in the programme and signature of the person verifying such the change in the programme. The tabular format of the revision history is shown in table-2.

Revision number	Date of revision	Revision summary	Signature of the person who proposed change in the programme	Signature of the verifier of the revision

TABLE-2
Format of revision history

5.3.2 Procedure for the identification of parameters for monitoring and measurement

1. Purpose:

To establish a procedure for identifying the parameters for monitoring of operations/activities that have significant environmental impacts, for the monitoring

compliance with applicable legal requirements and for monitoring environmental performance including assessment of progress against objectives and targets.

2. Scope:

The scope of the procedure includes the operations/activities having significant environmental impacts, aspects for which legal requirements are applicable, objectives and targets of EMS and accepted criteria for environmental performance evaluation.

3. Procedure:

1. Review process mapping of the industrial plant and identify the significant environmental aspects of each of its operations/activities that require operational controls. For each of the operations/activities that require control for managing their environmental aspects, identify the parameters that need monitoring and measurement. Maintain an up-to-date list of identified parameters giving details of the corresponding operations/activities and remarks regarding the use of the identified parameters.
2. Review EMS objectives and targets of the organization and identify the parameters/indicators that can be used to assess the degree of meeting each of the targets. Maintain a list of parameters/indicators identified.
3. Review all the applicable legal requirements and for each of the requirements identify parameter(s) for assessing compliance. List the parameters that are required for assessing compliance with the legal requirements.
4. Review the organization’s environmental criteria (decided by the management) for environmental performance evaluation and identify environmental performance indicators. Against each of the identified indicators select the parameter(s) that need monitoring for quantifying the environmental performance indicator in question. List the parameters thus identified.
5. Decide on the mode of monitoring and measurement (online/onsite/use of organization’s centralized facilities/ use of corporate facilities/use of third party facilities through networking or review of records), the place of monitoring, the

frequency of monitoring, data required to be collected from monitoring and measurement and data analysis requirements for each of the identified parameters.

6. Maintain a list of all the parameters identified along with the data collection needs, mode of monitoring and measurement, place of monitoring, frequency of monitoring and data analysis requirements.
7. Apply the procedure annually to update the list of parameters to be monitored and measured.

4. Overall responsibility:

Environmental coordinator

5. References:

1. Process mapping of industrial plant
2. Operational controls for operations/activities
3. EMS objectives and targets
4. Register of applicable legal requirements
5. Environmental performance criteria

6. Records:

1. Updated list of parameters identified for monitoring and measurement for the following reasons: operational controls, evaluation of progress in achieving objectives and targets, evaluation of legal compliance and environmental performance evaluation.
2. A list of all the parameters identified along with the frequency of monitoring, mode of monitoring and measurement, place of monitoring, data collection needs and data analysis requirements.

5.3.3 Protocol for documentation of a procedure [37]

1. **Writing rough draft:** Actually perform the activity or ask someone to perform the activity whose procedure is to be written. Identify the sequence of discrete actions involved in the activity and list them down.

2. **Planning for the first draft[38]:** Planning involves taking decisions in the following areas:

   - Decision of the language in which procedure is to be written: It should be based on the language proficiency of users.
   - Decision of the level of details required in the procedure: This should be based on frequency of performing the activity, number of people involved, amount of variation allowed in performance, importance of activity and competence of users.
   - Decision of the format of the procedure: A procedure may follow the format as given below:
     - Title
     - Name of the author
     - Revision number
     - Date on which the revision of the procedure became effective
     - Purpose / Objective
     - Scope
     - Frequency of application
     - Points of application
     - Logistics
     - Step-by step procedure followed for the activity
     - Recording the data
     - Quality assurance of the data
     - Analysis of data and use of data for stated purpose/objective
     - Response to non-conformance
     - Reporting/communication of results
     - Responsibilities associated with performing the activity and with data recording and checking, data analysis, reporting of results and communication of results
     - Control of the documents and maintenance of records
     - References

3. **Writing the first draft:** The first draft is written by improving the rough draft and structured as per the plan decided in step-2. The first draft should fulfil the following conditions:

    - Be concise, clear, unambiguous and easy to understand.
    - Provide diagrams wherever necessary to improve understandability.
    - Include safety precautions.
    - Explain only the essential terminology and concepts in the procedure.
    - Limit each step to one task.
    - Steps should be finite and too much fragmentation should be avoided.
    - Be in active tense.
    - Have restricted use of acronyms and abbreviations.
    - Have important information in the start or end of statements.
    - Make use of words consistently.
    - Have short sentences.
    - Be written in hierarchical steps or graphical format or flowchart for long procedures.

4. **Internal review:** Provide each user of the procedure with a copy of the draft procedure. Ask them to review the draft procedure and suggest changes that make the procedure more accurate and easier to understand.

5. **External review:** Provide the technical advisors of the organization with a copy of the draft procedure and ask them to suggest changes that will make the procedure clear and effective.

6. **Revise the draft procedure:** Revise the draft procedure according to the suggestions of the users and technical advisors.

7. **Testing:** Ask a user unfamiliar with the activity, to perform the activity using the draft procedure. Note the steps that cause confusion to the user and revise them.

8. **Communication:** Get the procedure approved and post the final draft to the point of use.

9. **Use of up to date copy of procedure:** Ensure the users make use of up-to-date copy of the procedure for performing the activity in question.
10. **Revision of the procedure:** Update the procedure annually.

5.4 Identification of monitoring and measurement requirements for the selected milk plant

List of parameters required to be monitored and measured for operational control							
Parameter	**Data collection needs**	**Mode**	**Place of monitoring**			**Frequency of monitoring**	**Data analysis required and remarks**
			Unit	**Section**	**Point(s) of monitoring**		
Stability of milk , intermediates and milk products	Temperature	Online	Raw milk reception and processing unit	Dockyard	• Raw milk silos • Skimmed milk silos	• Continuous • Continuous	The temperature of milk, intermediates and milk products should lie within the prescribed limits. If the temperature is on the higher side then increase the rate of circulation of cooling water.
			Raw milk reception and processing unit	Cream separation and ghee manufacturing section	• Cream storage tanks • Buttermilk holding tank • Heating and chilling sections of cream and milk pasteurizers	• Continuous • Continuous • Continuous	
			Whey processing unit	Ultra filtration and storage of whey permeate and whey retentate section	• WPC tanks • Concentrated WPC tanks	• Continuous • Continuous	

Parameter	Data collection needs	Mode	Place of monitoring			Frequency of monitoring	Data analysis required and remarks
			Unit	Section	Point(s) of monitoring		
Lactose recovery	Temperature	Online	Whey processing unit	Lactose manufacturing section	• Lactose crystallization tank • Lactose recrystallization tank	• Continuous • Continuous	Compare the temperature with the prescribed limits. If the temperature is on the higher side increase the rate of circulation of cooling water
Overflow from storage tanks of milk, intermediates, products and mother liquor	Liquid level	Online	Raw milk receiving and processing unit	Dockyard	• Raw milk silos • Skimmed milk silos	• Continuous • Continuous	Compare the liquid level with the prescribed limits. If the liquid level is on the higher side then the loading rate of milk, intermediates and products should be reduced.
			Raw milk reception and processing unit	Cream separation and ghee manufacturing section	• Cream storage tanks	• Continuous	
			Casein unit	Washing and dewatering of casein	• Dilution tanks • Whey silos	• Continuous	
			Whey processing unit	Ultra filtration and storage and handling of whey permeate and whey retentate section	• Whey permeate silos • WPC storage tanks • Concentrated WPC storage tanks	• Continuous • Continuous • Continuous	
			Whey processing unit	Lactose manufacturing section	• Mother liquor - 1 storage tank	• Continuous	

Parameter	Data collection needs	Mode	Place of monitoring			Frequency of monitoring	Data analysis required and remarks
			Unit	Section	Point(s) of monitoring		
Efficiency of ultra filtration	Protein concentration in whey permeate	Onsite	Whey processing unit	Ultra filtration section	Ultra filtration	Once in every batch of operation prior to cleaning	The protein concentration in whey permeate should be within the permissible limits. A high protein concentration shows that the ultra filters are not working properly and hence may need replacement.
Provision of optimal heat for drying casein	• Moisture content of dewatered casein to be dried • Temperature of hot air inside drier • Flow rate of supplied air • Flow rate of casein supplied for drying	• Onsite • Online • Online • Online	Casein unit	Drying section	• Casein inlet in ring drier • Air outlet of radiator heater of ring drier • Air outlet of radiator heater • Casein inlet in ring drier	• Once in a day • Continuous • Continuous • Continuous	Calculate the amount of heat required per unit time to dry casein based on the moisture content of the casein and its flow rate. This heat is to be supplied by hot air. Given the flow rate of the supplied air, decide the temperature of the air required for drying the product completely.

Parameter	Data collection needs	Mode	Place of monitoring			Frequency of monitoring	Data analysis required and remarks
			Unit	Section	Point(s) of monitoring		
Indoor air pollution in casein unit	• Amount of vacuum created	• Online	• Casein unit	• Drying and packing section	Exhaust blower of: • Ring drier • Fluidized bed cooler • Tampering silos 1,2,3 • Tampering silo 4, grinding mill and sorter • Blending silos and packing area	• Continuous • Continuous • Continuous • Continuous • Continuous	Compare the vacuum created by exhaust blowers with the value specified in operational control criteria.
	• SPM level in indoor air	• Onsite	• Casein unit	• Drying and packing section	• Inside casein drying and packing section	• Once in a day	Compare the SPM level in the indoor air with the prescribed limits in operational control criteria.

Parameter	Data collection needs	Mode	Place of monitoring			Frequency of monitoring	Data analysis required and remarks
			Unit	Section	Point(s)of monitoring		
Provision of optimal heat for drying decanted lactose crystals	• Moisture content of decanted lactose crystals to be dried	• Onsite	Whey processing unit	Lactose manufacturing section	• Lactose inlet in primary drier	• Once in a day	Calculate the amount of heat required per unit time to dry lactose based on the moisture content of the lactose and its flow rate. This heat is to be supplied by hot air in primary and secondary drier. Given the flow rate of the supplied air in each drier, decide the temperature of the air required to be maintained in each drier for drying the product completely.
	• Temperature of hot air inside primary drier	• Online			• Air outlet of radiator heater of primary drier	• Continuous	
	• Temperature of hot air inside secondary drier	• Online			• Air outlet of radiator heater of secondary drier	• Continuous	
	• Flow rate of supplied air to primary drier	• Online			• Air outlet of radiator heater of primary drier	• Continuous	
	• Flow rate of air supplied to secondary drier	• Online			• Air outlet of radiator heater of secondary drier	• Continuous	
	• Flow rate of product supplied to inlet of primary drier	• Online			• Lactose inlet of primary drier	• Continuous	

Parameter	Data collection needs	Mode	Place of monitoring			Frequency of monitoring	Data analysis required and remarks
			Unit	Section	Point(s) of monitoring		
Indoor air pollution in whey processing unit	• Amount of vacuum created	• Online	• Whey processing unit	• Lactose manufacturing section	Exhaust blower of: • Hot bag filter house • Cold bag filter house • Lactose silo • Packing area	• Continuous • Continuous • Continuous • Continuous	Compare the vacuum created by exhaust blowers with the value specified in operational control criteria.
	• SPM level	• Onsite	• Whey processing unit	• Lactose manufacturing section	• Inside lactose drying and packing section	• Once in a day	Compare the SPM level in the indoor air with the prescribed limits in operational control criteria.
Leaks of steam from MVR and TVR loop	• Amount of whey permeate concentrated • Amount of steam consumed	• Online • Online	Whey processing unit	Lactose manufacturing section	Evaporators	• Continuous • Continuous	Compare with steam efficiency with the prescribed value. A lower steam efficiency indicates loss of steam at some point.

Parameter	Data collection needs	Mode	Place of monitoring			Frequency of monitoring	Data analysis required and remarks
			Unit	Section	Point(s) of monitoring		
Amount of boiler blow down	TDS in boiler water	Online	Utility	Boiler	Inside boiler	Continuous	Calculate the boiler blow down to keep the TDS in boiler water within the prescribed limits.
Amount of cooling water blow down	TDS in circulating cooling water	Online	Utility	Cooling tower	Inside circulating cooling water loop	Continuous	Calculate the cooling tower blow down to keep the TDS level in circulating cooling water within the prescribed limits.
Amount of boiler make up water	Cumulative water consumption	Online	Utility	Boiler	Feed water pipe of boiler	Continuous	The cumulative water consumption should fall within the prescribed limits. A higher cumulative water consumption shows that quantity of boiler blow down is more than required.

Parameter	Data collection needs	Mode	Place of monitoring			Frequency of monitoring	Data analysis required and remarks
			Unit	Section	Point(s) of monitoring		
Amount of cooling water make up water	Cumulative water consumption	Online	Utility	Cooling tower	Feed water pipe of cooling tower	Continuous	The cumulative water consumption should fall within the prescribed limits. A higher cumulative water consumption shows that quantity of cooling tower blow down is more than required.
Quality of rice husk as fuel	• % dust in rice husk • % moisture in rice husk	• Central lab. • Central lab.	Utility	Boiler	Rice husk storage yard	Each of the trucks of rice husk received is sampled.	Accept rice husk as fuel only when the % dust and % moisture are within prescribed limits
Air to fuel ratio and combustion efficiency	• $\%O_2$ • Feed rate of rice husk • % CO_2 • % CO	• Central lab. • Onsite • Central lab. • Central lab.	Utility	Boiler	• Flue gases from boiler • Rice husk conveyor • Flue gases of boiler • Flue gases of boiler	• Once in a month • Daily • Once in a month • Once in a month	Calculate combustion efficiency and air fuel ratio. A lower air fuel ratio and combustion efficiency shows improper supply of air.

Parameter	Data collection needs	Mode	Place of monitoring			Frequency of monitoring	Data analysis required and remarks
			Unit	Section	Point(s) of monitoring		
pH of wastewater	Neutralization of Effluent(lime dosing)	Onsite	Utility	Effluent treatment plant	Neutralization tank	After 2 hrs.	Compute the appropriate lime dosing for waste water. A lower lime dosing will not help in bringing pH within the prescribed limits.
Nutrient addition to wastewater	COD: N: P of wastewater	Central lab.	Utility	Effluent treatment plant	Inlet to aeration tank	Once in a day	Compare the COD: N: P ratio of the waste water with the prescribed value and compute amount of nutrients that are required to be added to the waste water.
Sludge recycle ratio	MLSS concentration in aeration tank	Central lab.	Utility	Effluent treatment plant	Aeration tank	Once in a day	Compare the MLSS concentration in the aeration tank with the prescribed value. If the MLSS concentration is less than the prescribed value then increase the recycling rate.

Parameter	Data collection needs	Mode	Place of monitoring			Frequency of monitoring	Data analysis required and remarks
			Unit	Section	Point(s) of monitoring		
Stability of operation of UASB	• pH • Volatile fatty acids	• Onsite • Central lab.	Utility	Effluent treatment plant	UASB	• 1 hourly • Need based	The pH and volatile fatty acids of UASB should lie within the prescribed limits. A high pH and volatile fatty acid amount shows instability of UASB.

List of parameters required to be monitored and measured for legal compliance							
Parameter	**Data collection needs**	**Mode**	**Place of monitoring**			**Frequency of monitoring**	**Data analysis required and remarks**
			Unit	**Section**	**Point(s) of monitoring**		
Compliance of emissions with emission standards	SPM	Third party monitoring	Utility	Boiler	Boiler stack	Once in six months	Compare the SPM level with the prescribed legal requirements.
			Casein unit	Casein drying section	Stack associated with • Ring drier • Fluidized bed cooler • Tampering silo 4, grinding mill and sorter • Blending silos and packing area		
			Whey processing unit	Lactose manufacturing section	Stack associated with • Hot filter bag house • Cold filter bag house • Filter bag house of lactose silo • Filter bag house of lactose packing area		

Parameter	Data collection needs	Mode	Place of monitoring			Frequency of monitoring	Data analysis required and remarks
			Unit	Section	Point(s) of monitoring		
Compliance of treated effluent with standards for treated effluent	• pH • BOD_5 • Suspended solids • Oil and grease • Waste water generation rate in m^3/ Kl of milk processed - wastewater generation rate - milk processed per day	• Online • Central lab. • Central lab. • Central lab. • Online • Records of production section of each unit	• Utility • Utility • Utility • Utility • Utility • All manufacturing units	• ETP • ETP • ETP • ETP • ETP • Production section	• Outlet of ETP • Outlet of ETP • Outlet of ETP • Outlet of ETP • Outlet of ETP • Records	• Continuous • Monthly • Monthly • Monthly • Continuous • Monthly review of records	Compare the values of the parameters with the values prescribed legal requirements.
Dates on which breakdown or failure of ETP occurred or underperformance was noticed	• Dates on which breakdown or failure of ETP occurred • Dates on which underperformance of ETP was noticed	Review of ETP records	Utility	Effluent treatment plant	Records	Monthly review of records	Maintain record of dates on which breakdown or failure of ETP occurred or underperformance was noticed. This information will help in filing of the monthly water cess returns.

Parameter	Data collection needs	Mode	Place of monitoring			Frequency of monitoring	Data analysis required and remarks
			Unit	Section	Point(s) of monitoring		
Noise level of D.G. set	Noise level of D.G. set	Third party monitoring	Utility	D.G. set	D.G. set enclosure	After six months	Compare the noise level with the prescribed standards.
Ambient noise levels	Ambient noise levels	Third party monitoring	---	----	Adjoining to residential areas	After six months	Compare the noise level with the prescribed standards.

Parameter	Data collection needs	Mode	Place of monitoring			Frequency of monitoring	Data analysis required and remarks
			Unit	Section	Point(s) of monitoring		
Amount of solid waste generated	Amount of each type of solid waste generated - Flyash - Dried sludge - Process waste of fats and oil - Empty poly lined kraft paper bags - Defective packing material - Ghee residue - Waste cotton pads - Filter press wastes - Waste fabric filters	Onsite	• Utility	• Boiler	• Fly ash dump place	Daily	Maintain daily record of each type of waste generated. This information is required to be filled in the environmental statement.
			• Utility	• ETP	• Dried sludge • Waste of fats and oil		
			• Raw milk reception and processing unit	• Dockyard	• Waste poly lined kraft paper bags at SMP reconstitution vat		
			• Raw milk reception and processing unit	• Ghee manufacturing section	• Ghee residues • Process waste of fats and oil • Waste cotton pads used in filtration of ghee • Defective ghee packing material		
			• Casein unit	• Casein packing area	• Defective packing material (poly lined kraft paper bags)		
			• Whey processing unit	• Lactose packing area	• Defective packing material (poly lined kraft paper bags) • Filter press wastes		
			• All units	• Related sections	• Fabric filters		

Parameter	Data collection needs	Mode	Place of monitoring			Frequency of monitoring	Data analysis required and remarks
			Unit	Section	Point(s) of monitoring		
Water consumption	• Ground water being pumped for use	• Online	• Utility	• Water treatment system	• Tubewells	• Continuous	Maintain records of monthly water consumption for various purposes. This information is required to be filled in the monthly water consumption returns.
	• Water consumed as boiler feed water and cooling tower water	• Online	• Utility	• Boiler and cooling tower	• Water feed line to boiler and cooling tower	• Continuous	
	• Water consumed for domestic use	• Online	---	---	• Water meter of canteen and toilets	• Continuous	
	• Water consumed in industrial processing whereby it gets polluted with easily biodegradable and/or non-toxic pollutants	• Online	---	---	• Water meter of various milk processing units	• Continuous	
	• Water consumed in industrial processing whereby water gets polluted with non-biodegradable and/or toxic pollutants	• Online	---	• CIP Section	• Water meter of CIP section	• Continuous	

Parameter	Data collection needs	Mode	Place of monitoring			Frequency of monitoring	Data analysis required and remarks
			Unit	Section	Point(s) of monitoring		
Amount of hazardous waste generated	Amount of each type of hazardous waste generated - Waste oil and used oil - Used batteries - Empty cans of hazardous chemicals	Onsite	• Utility	• D.G. set	• Used batteries • Waste oil	Maintenance of daily record and annual review of records	The information regarding quantity and type of hazardous waste handled is required to be filled in the annual returns regarding hazardous wastes.
			• Utility	• Control panel	• Used batteries		
			• Utility	• Chilled water system	• Used lubricating oil • Empty cans of hazardous chemicals		
			• Utility	• Compressed air system	• Used lubricating oil		
			• Casein unit	• Washing and dewatering of casein	• Used hydraulic oil and lubricating oil in decanters		
			---	• CIP centre	• Empty cans of hazardous chemicals		
			• Whey processing unit	• Lactose manufacturing unit	• Used lubricating oil and hydraulic oil in decanters		

Parameter	Data collection needs	Mode	Place of monitoring			Frequency of monitoring	Data analysis required and remarks
			Unit	Section	Point(s) of monitoring		
Method of disposal of each type of hazardous waste	Names of authorized recyclers and quantity of used oil and used batteries sold to them	Onsite	---	Hazardous waste store	Hazardous waste store	Daily records of wastes sold	A list of authorized recyclers to whom the waste oil/used oil and used batteries are sold is required to be maintained as part of legal compliance responsibilities.
Type and amount of hazardous chemicals used	Type and amount of hazardous chemicals used - Ammonia - Formaldehyde - Nitric acid - Sodium hydroxide	Review of records of chemical procurement and storage section	---	Chemical procurement and storage section	Records	Annual review of records of purchase/ procurement and issue of chemicals.	Maintain records of hazardous chemicals used and in store as part of the legal compliance responsibilities. This will help in identifying major accidental hazards linked with them and in providing necessary information, training and personal protection equipment to the workers.

List of parameters required to be monitored and measured for environmental performance evaluation							
Parameter	**Data collection needs**	**Mode**	**Place of monitoring**			**Frequency of monitoring**	**Data analysis required and remarks**
			Unit	**Section**	**Point(s) of monitoring**		
Product recovery	• Quantity of milk processed • % fat, %SNF and % proteins in the supplied milk • Production of ghee, casein, lactose and WPC	• Review of records of milk procured and processed • Review of records of raw milk analysis • Review of records of production	--- • Raw milk reception and processing unit • All units	--- • Dockyard lab. and central lab. • Production section	• Records • Records • Records	• Daily • Daily • Daily	Comparison is made with the benchmark and theoretical product recovery.
Product lost in lactose mother liquor	• Lactose content • Protein content • Milk minerals content • Quantity of lactose mother liquor generated	• Central lab. • Central lab. • Central lab. • Online	Whey processing unit	Lactose manufacturing unit	Decanter-1	• Batch wise • Batch wise • Batch wise • Continuous	Compare the milk mineral content, lactose content and protein content of lactose mother liquor with the benchmarks. A higher value of any of the above mentioned constituents shows that product is lost in mother liquor.

Parameter	Data collection needs	Mode	Place of monitoring			Frequency of monitoring	Data analysis required and remarks
			Unit	Section	Point(s) of monitoring		
Pollution potential of mother liquor	• COD • TDS	• Central lab. • Central lab.	Whey processing unit	Lactose manufacturing section	Decanter-3	Monthly	Compare the COD and TDS levels of lactose mother liquor with the benchmarks.
Resource lost in the form of foul condensate	• COD • TDS/Conductivity • Temperature	• Central lab. • Online • Online	Whey processing unit	Lactose manufacturing section	Evaporators	• Daily • Continuous • Continuous	Compare the COD, TDS/Conductivity, temperature of foul condensate with the targets.
Leak history of raw materials, intermediates and products	• Level of leakage • Number of leaks per day	Onsite	All units and utilities	All sections	Place of leakage	Daily	Compare the number of leaks and the level of leakage with the targets.
Consumption of fuel by boiler	• Rice husk consumption • Total production	• Review of records of rice husk storage area • Review of records of production	• Utility • All manufacturing units	• Boiler • Production section	• Records • Records	• Monthly review of records • Monthly review of records	Compare the consumption of fuel per unit production with the benchmark.

Parameter	Data collection needs	Mode	Place of monitoring			Frequency of monitoring	Data analysis required and remarks
			Unit	Section	Point(s) of monitoring		
Consumption of electrical energy	• Electrical energy consumption • Total production	• Review of records of control panel • Review of records of production	• Utility • All manufacturing units	• Electrical power system • Production section	• Records • Records	Daily, weekly, monthly and annual review of records of energy consumption and industrial production	Compare the energy consumption per unit of production with the benchmark.
Consumption of ground water	• Water consumption • Total production	• Online with cumulative metering • Review of records of production	• Utility • All manufacturing units	• Ground water pumping, treatment and supply system • Production section	• Tubewells • Records	Daily, weekly, monthly and annual review of records of ground water consumption and industrial production	Compare the groundwater consumption per unit of production with the benchmark.
% of steam condensate recovery and reuse	• Steam generated • Soft water makeup in boiler • Soft water used as boiler feed water • Boiler blowdown	Records of boiler	Utility	Boiler	Records	Daily review of records of boiler section	Compare the % of steam recovery and reuse with the target set.

CHAPTER - 6: CONCLUSIONS

Monitoring and measurement is one of the seventeen elements of ISO 14001. According to the monitoring and measurement clause of ISO 14001:1996, monitoring and measurement is required for the following purposes:

- Tracking operational controls.
- Tracking progress towards objectives and targets.
- Tracking evaluation of legal compliance.
- Tracking environmental performance.

The monitoring and measurement should be done with calibrated equipment and the information obtained should be properly recorded and used. ISO 14001:2004, edition has reduced the requirements of monitoring and measurement clause and has placed evaluation of compliance with applicable legal and other requirements in a separate clause.

Having a structured and systematic programme is necessary for effective performance of the monitoring and measurement function, for optimal use of the available resources and for real and reasonable time monitoring and measurement. Literature survey has indicated that organizations are yet to go for monitoring and measurement programme. Organizations are actually using procedures for monitoring and measurement which are not sufficiently structured and systematic and do not fit to the definition of programme. Further, the procedures are not sufficiently comprehensive and ambiguous in describing the monitoring and measurement function and the associated activities.

In the present study an attempt has been made to develop a generic monitoring and measurement programme for ISO 14001 based EMS, applicable to process industry. Further, monitoring and measurement needs of a selected industrial plant (milk plant) have been identified. The programme developed is based on PDCA cycle. It has laid emphasis on the following points:

- Identification of monitoring and measurement needs of the organization.
- Proper planning of the monitoring and measurement function.

- Proper documentation of the programme, protocols and procedures.
- Proper definition, documentation and communication of responsibilities for the activities associated with monitoring and measurement.
- Carrying out of monitoring and measurement with calibrated and well maintained equipment/devices.
- Recording, analysis and effective use of the data collected from the monitoring and measurement.
- Regular review of the monitoring and measurement programme for ensuring suitability, adequacy and effectiveness.

This work can help organizations in developing, implementing and maintaining monitoring and measurement programme specially by providing necessary guidelines. Though monitoring and measurement is an essential element of ISO 14001 certifiable EMS, the present work can be of help even to those organizations which are not interested in ISO14001 certification in organizing their monitoring and measurement efforts into a unified, structured and systematic function.

The main input for conceptualizing this generic monitoring and measurement programme has been the literature review. Input from industries with ISO 14001 certified EMS might have made the study much more meaningful and conceptualized programme might have been better. Further, conceptualizing monitoring and measurement programmes and suggesting guidelines for their development, implementation and maintenance for each of the industries may be needed.

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