Total Quality Management

'M' Scheme Syllabus

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TOTAL QUALITY MANAGEMENT

PREFACE

This book of Total Quality Management covers all the topics in a clear and organized format for the Third year Diploma in Printing Technology students as prescribed by the Directorate of Technical Education, Chennai, Tamilnadu. It is confidently believed that this book furnishes the students the necessary study material. The topics covered were neatly illustrated for better understanding of the students.

The book is prepared step-by-step lessons in large, eye pleasing calligraphy make it suitable for both direct one-to-one tutoring and regular classroom use. The highlight of this book is its simple English with clear and easy explanation of each topic.

All the topics are explained with supporting diagram for diploma level students to understand effectively.

This book majorly deals with Basics of Quality control Process, Material Inspection and Testing, Process Control, Control tools, equipments & Procedure of calibration Process and Implementation of ISO for Print Quality etc.

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CONTENTS

UNIT - I – INTRODUCTION

1.1 DEFINITION:

Quality is sometimes defined as **"meeting the requirements of the customer."**

The term quality assurance describes any systematic process for ensuring quality during the successive steps in developing a product or service. ISO 9000 is a standard for ensuring that a company's quality assurance system follows best industry practices.

Quality in business, engineering and manufacturing has a pragmatic interpretation as the non-inferiority or superiority of something; it is also defined as “fitness for purpose”. Consumers may focus on the specification quality of a product/service, or how it compares to competitors in the marketplace.

There are five aspects of quality in a business context:

- Producing - providing something.
- Checking - confirming that something has been done correctly.
- Quality Control - controlling a process to ensure that the outcomes are predictable.
- Quality Management – directing an organization so that it optimizes its performance through analysis and improvement.
- Quality Assurance – obtaining confidence that a product or service will be satisfactory. (Normally performed by a purchaser)

Meaning of the term – quality

Quality has many meanings – many of them are subjective, such as the term “excellent” or “outstanding” quality. In the quality management field, quality has a more specific meaning.

“According to ISO 9001:2008, quality is defined as “the degree to which a set of inherent characteristics fulfills requirements”.

The very favorable experience of the client of a business when they have received a good or service that significantly surpasses what they had initially anticipated.

A marketing department can use instances of customer delight to a company's advantage by requesting referrals and obtaining testimonials from delighted customers that can help attract new customers.

Definition: Quality assurance

It refers to the processes and procedures that systematically monitor different aspects of a service, process or facility to detect, correct and ensure that quality standards are being met.

Assurance: The act of giving confidence, the state of being certain or the act of making certain.

Quality Assurance: The planned and systematic activities implemented in a quality system so that quality requirements for a product or service will be fulfilled.

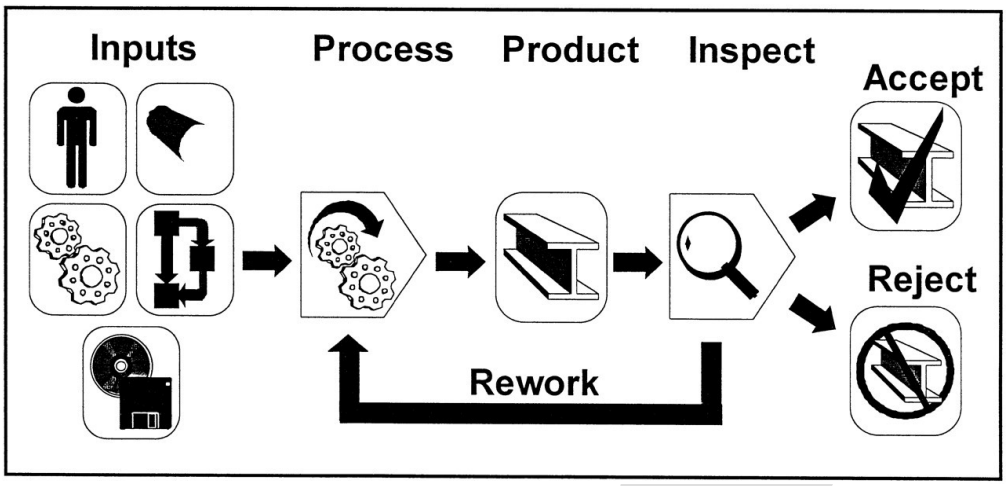
Control: An evaluation to indicate needed corrective responses; the act of guiding a process in which variability is attributable to a constant system of chance causes.

Quality Control: The observation techniques and activities used to fulfill requirements for quality.

Customers demand high-quality print jobs without variations or defects. Specifications, measurements, and controls must be established in every department to ensure predictable, reliable printing and a quality finished product. Quality controls facilitate the superior and consistent results you expect and that your customers demand.

Definition: Process control refers to the methods that are used to control process variables when manufacturing a product. For example, factors such as the proportion of one ingredient to another, the temperature of the materials, how well the ingredients are mixed, and the pressure under which the materials are held can significantly impact the quality of an end product. Manufacturers control the production process for three reasons:

- Reduce variability
- Increase efficiency
- Ensure safety



What is Total Productive Maintenance (TPM)?

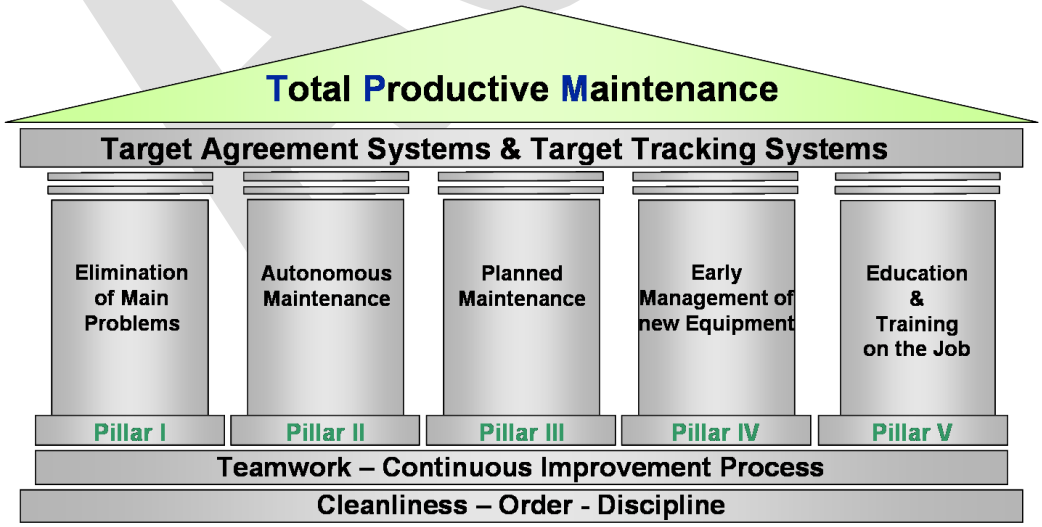
In industry, total productive maintenance (TPM) is a system of maintaining and improving the integrity of production and quality systems through the machines, equipment, processes, and employees that add business value to an organization.

TPM focuses on keeping all equipment in top working condition to avoid breakdowns and delays in manufacturing processes.

Analyzing the three words of T, P, M we have

- Total – all-encompassing maintenance and production individuals working together.
- Productive – production of goods and services that meet or exceed customers' expectations.
- Maintenance - keeping equipment and plant in as good as better than the original condition at all times.

The 5 Pillars of TPM-Concept



What is Total quality management (TQM)?

TQM is a set of systematic activities carried out by the entire organization to effectively and efficiently achieve company objectives so as to provide products and services with a level of quality that satisfies customers, at the appropriate time and price.

TQM – Definition "Explanation of key terms"

- Systematic activities – Planned, strong leadership, Mid and long term vision, strategies and policies
- Entire organization – everyone at all levels, across functions
- Effective and efficient – achieve planned results with least resources
- Quality – usefulness, reliability, safety

A scientific, systematic, companywide activity "in which a company is devoted to customers through its products and services.

Focuses on customer satisfaction – the only guarantee for long term survival assured "quality" in every process is the objective of TQM.

What is ISO?

The International Organization for Standardization (ISO) is an international standard-setting body composed of representatives from various national standards organizations.

International Organization for Standardization

Founded on 23 February 1947, the organization promotes worldwide proprietary, industrial and commercial standards. It is headquartered in Geneva, Switzerland and as of March 2017 works in 162 countries.

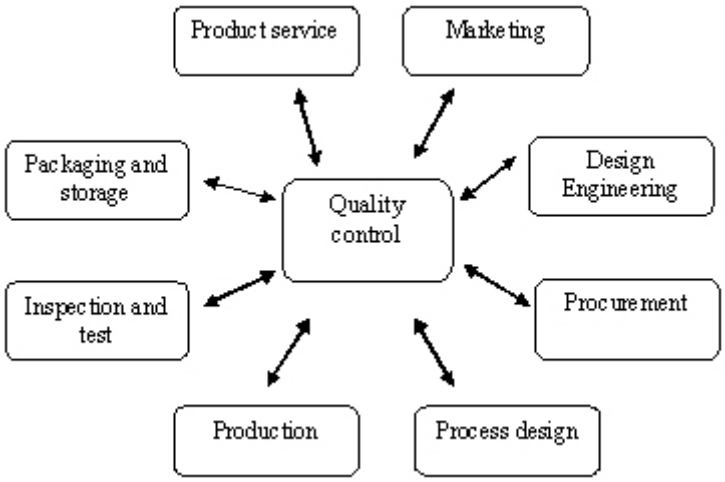
- Use of the standards aids in the creation of products and services that are safe, reliable and of good quality.
- The standards help businesses increase productivity while minimizing errors and waste.
- The standards also serve to safeguard consumers and the end-users of products and services, ensuring that certified products conform to the minimum standards set internationally.

1.2 QUALITY CONTROL PROCESS:

A system for maintaining desired standards in a product or process by inspecting samples of the product.

Maintenance of standards of quality of manufactured goods.

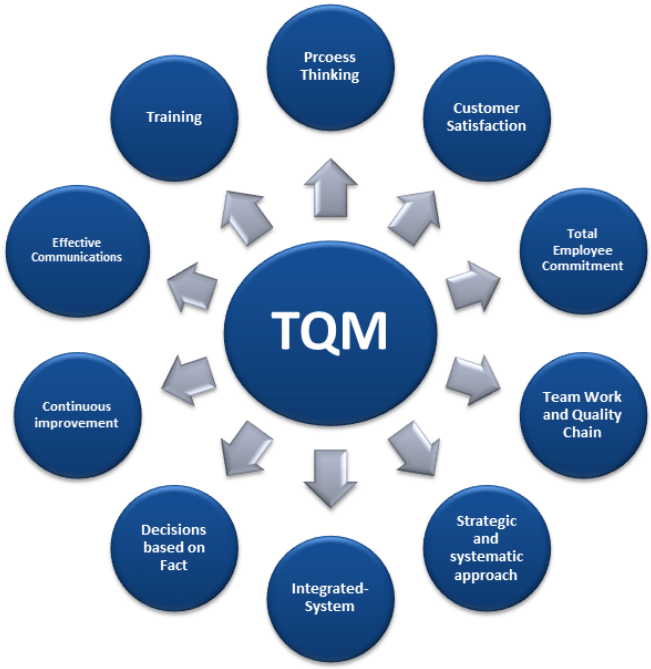
Quality is the key element in every stage of the production process from raw materials to finished product. Every manufacturer is faced with the problem if maintenance of the quality of his product.



Quality Control is systematic control by management of the variables in the manufacturing process that affect goodness of the end product. Quality control may be defined as that technique or group of techniques of the industrial management by means of which products of uniform acceptable quality are manufactured.

Elements of success

1. Management support
2. Mission statement
3. Proper planning
4. Bottom line
5. Focus on customer
6. Measurement system
7. Empowerment of employees
8. Teamwork
9. Continuous improvement process
10. Dedicated resources



1. Management support

- If an organisation is serious about implementing TQM, the lead has to be taken by the top management with full commitment.
- The top management should continue all the efforts and provide the resources to continue quality improvement programmes.
- This is provided by collecting, reporting and use of quality related cost information.

2. Mission statement

- A mission statement is a short sentence or paragraph used by a company to explain, in simple and concise terms, its purpose(s) for being.
- These statements serve a dual purpose by helping employees to remain focused on the tasks at hand, as well as encouraging them to find innovative ways of moving towards an increasingly productive achievement of company goals.

3. Proper planning

- A quality plan is a document, or several documents, that together specify quality standards, practices, resources, specifications, and the sequence of activities relevant to a particular product, service, project, or contract.
- Quality planning focuses on taking all of the information available to you at the beginning of the project and figuring out how you will measure quality and prevent defects.

4. Bottom line Growth

- Bottom line refers to a company's net earnings, net income or earnings per share (EPS).
- The reference to "bottom" describes the relative location of the net income figure on a company's income statement.
- Most companies aim to improve their bottom lines through two simultaneous methods: growing revenues (i.e., generate top-line growth) and increasing efficiency (or cutting costs).

5. Focus on customer

- The customer is usually viewed as the one who purchases the printed product produced by the printing company - e.g. brochure, book, magazine, label, package, etc. These customers are referred to as **external customers**.
- However, there are customers who are part of the process e.g., sales request, estimate, artwork, assembled image, color separation, printing plate, printing, and finished product or - the delivery of this product. These customers are referred to as **internal customers.**
- These needs must be translated into specifications that can be met or exceeded on a consistent basis.

6. Measurement system

- A measurement systems analysis evaluates the test method, measuring instruments, and the entire process of obtaining measurements to ensure the integrity of data used for analysis (usually quality analysis) and to understand the implications of measurement error for decisions made about a product or process.

- MSA (measurement systems analysis) analyzes the collection of equipment, operations, procedures, software and personnel that affects the assignment of a number to a measurement characteristic.

7. Empowerment of employees

- The empowerment goal is to improve quality, productivity, and service.
- To empower the work force means more than listening to requests for changes in materials, working procedures, equipment, training, communication systems, and other areas that will assist the employee in doing the job more effectively.
- Empowerment means encouraging and training the work force to take responsibility for making decisions relating to quality, productivity, and service to the customer.

8. Teamwork

- Teams must be trained in how to function, and they must be given the tools needed to work together effectively.
- Members must be able to offer suggestions and resolve particular problems in a timely and cost-effective manner.
- Teams cannot be set up without being given the proper time to train, time allocations for results, and financial support to sustain their efforts.

9. Continuous improvement process

- TQM comprises of a continuous process of improvement covering people, equipment, suppliers, materials and procedures.
- It includes every aspect of an operation in an organisation.
- In Japan the word “Kaizen” is used to describe the continuous process of improvement. In USA, TQM zero defects and six-sigma are used to describe such efforts.

10. Dedicated resources

The TQM resources grant access to a wealth of knowledge that can help foster the development of any organization. Resources to help you improve your quality management system include:

- Understanding some basic principles of quality management
- Understanding what ISO 9001 says and requires
- Using some quality tools, such as the PDCA cycle and root cause analysis.

1.3 Basic elements of Total Quality Management

- Human resource
- Development and management,

- DMAIC Process - Define, measure, analyse, improve and control,
- DMADV Process – Design and validate.

Human resource

- At the heart of the TQM is the concept of essential motivation-involvement in decision making by the employees.
- Employee involvement is a process for em powering members of an organization to make decisions and to solve problems appropriate to their levels in the organization.
- The type of training depends on the need of the particular company.
- The areas that should be common to all organizations' training program is problem solving and communication skills.
- All members should receive training in quality awareness (TQM), statistical process control (SPC), safety, and technical aspects of job.
- The only difference among types of training is that some may be required more often and for greater length of times than others.

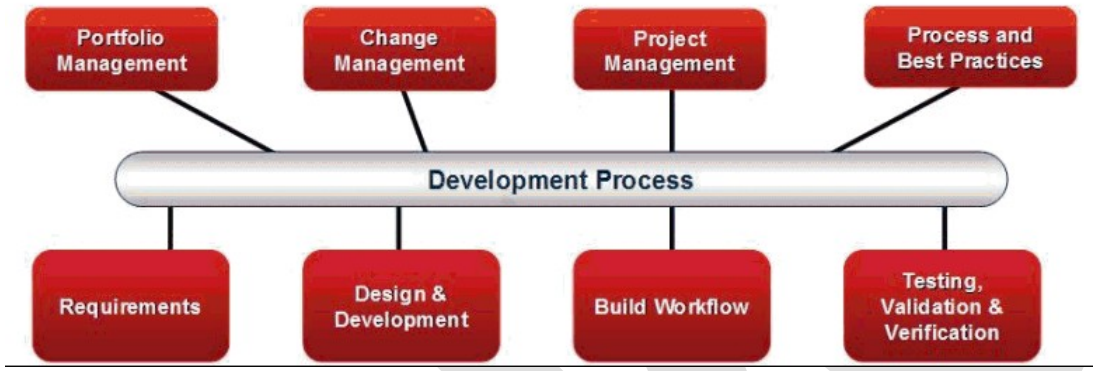
Five Ground Rules for Stimulating and Encouraging Suggestion System are:

1. Be Progressive by regularly asking your employees for suggestions
2. Remove fear by focusing on the process and not on the person.
3. Simplify the process so it is easy to participate
4. Respond quickly to suggestions and within specified period of time
5. Reward the idea with published recognition so that everyone knows the value of contribution.

Development and management

- Management development is the overall concept that describes the many ways in which organizations help employees develop their personal and organizational skills, either as managers in a management job or with an eventual management job in mind.

- Organizations need a process for developing the skills of their managers as these employees direct and organize the work of all of your other employees.
- Employee Performance Management is about aligning the organisational objectives with the employees' agreed measures, skills, competency requirements, development plans and the delivery of results.
- The emphasis is on improvement, learning and development in order to achieve the overall business strategy and to create a high performance workforce.



Performance Management and Development in the General Work System

- Define the purpose of the job, job duties, and responsibilities.
- Define performance goals with measurable outcomes.
- Define the priority of each job responsibility and goal.
- Define performance standards for key components of the job.
- Hold interim discussions and provide feedback about employee performance, preferably daily, summarized and discussed, at least, quarterly. (Provide positive and constructive feedback.)
- Maintain a record of performance through critical incident reports. (Jot notes about contributions or problems throughout the quarter, in an employee file.)
- Provide the opportunity for broader feedback. Use a 360-degree performance feedback system that incorporates feedback from the employee's peers, customers, and people who may report to him.

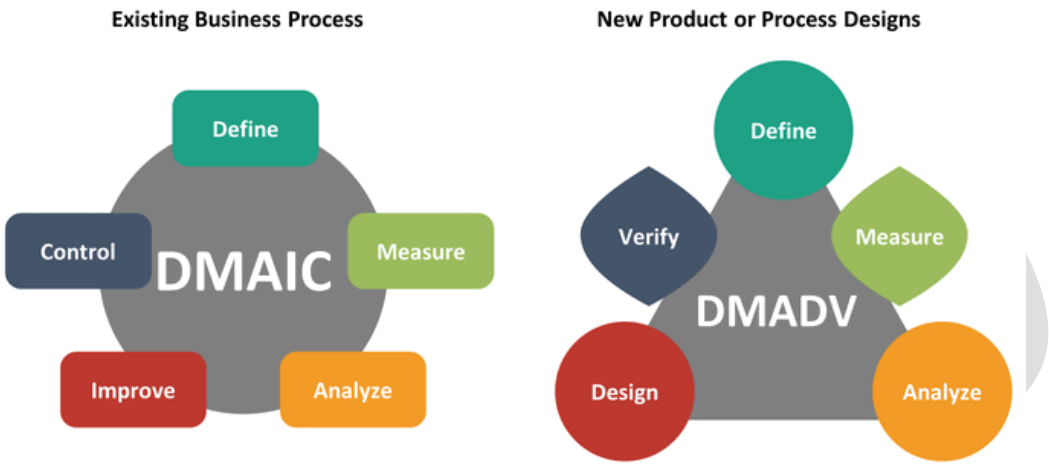
Develop and administer a coaching and improvement plan if the employee is not meeting expectations.

Internal management development can include the following opportunities for employees' growth and ongoing development.

- Employee training
- Employee career paths
- Coaching

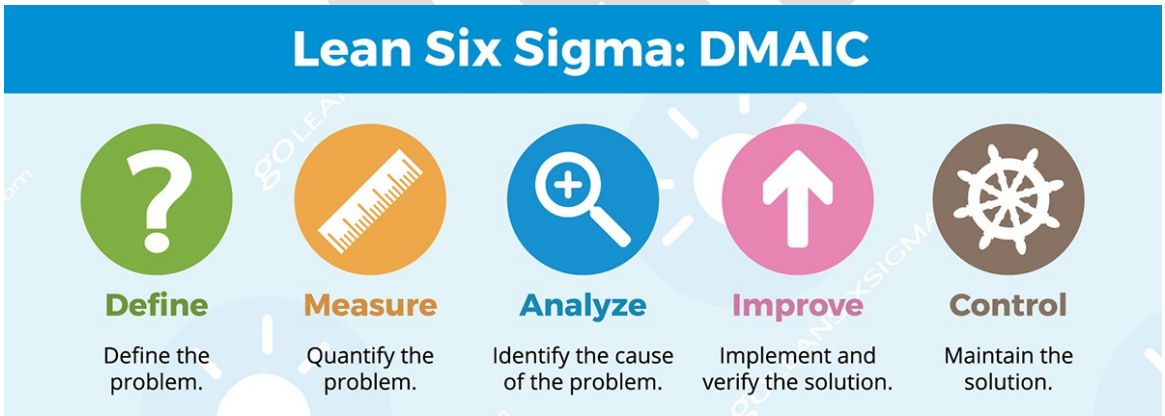
- Mentoring
- Job rotation
- Promotions
- Performance management and development
- Succession planning

Methodologies of Six Sigma:



DMAIC

DMAIC (define, measure, analyze, improve, control) is an approach to problem-solving defined by Motorola as part of the Six Sigma management philosophy.



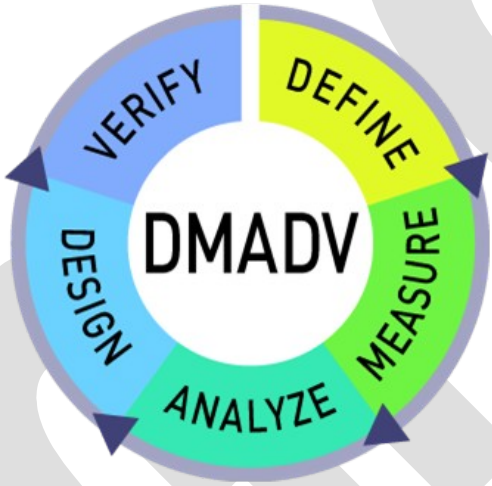
DMAIC: This method is used primarily for **improving existing business processes.** The letters stand for:

- **Define** the problem and the project goals
- **Measure** in detail the various aspects of the current process
- **Analyze** data to, among other things, find the root defects in a process
- **Improve** the process
- **Control** how the process is done in the future.

DMADV

DMADV: This method is typically used to ***create new processes and new products or services.*** *The letters stand for:*

- **Define** the project goals
- **Measure** critical components of the process and the product capabilities
- **Analyze** the data and develop various designs for the process, eventually picking the best one
- **Design** and test details of the process
- **Verify** the design by running simulations and a pilot program, and then handing over the process to the client



1.4 Statistical Process Control (SPC):

Statistical Process Control, commonly referred to as SPC, is a method for monitoring, controlling and, ideally, improving a process through statistical analysis.

SPC is a type of charting that tells us about the variation that exists in the systems that we are looking to improve.

S - Statistical, because we use some statistical concepts to help us understand processes

P - Process, because we deliver our work through processes. i.e. how we do things

C - Control, by this we mean predictable

Purpose

- Prevent rather than detect defects
- Indicate the need for corrective action
- Continuous monitoring of the printing process
- Direction for process improvement
- Quantitative proof of quality

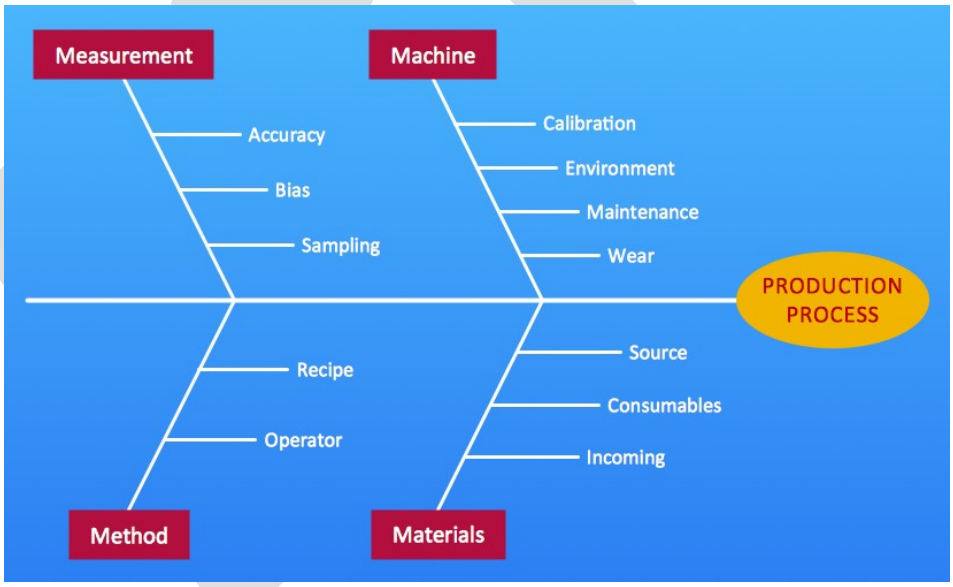
- Identify the sources of variation
- Determine process capability

Statistical Process Control (SPC) Tools:

1. Cause and effect diagram
2. Check sheet
3. Flow diagram
4. Pareto analysis
5. Histogram
6. Run chart
7. Control chart

1) Cause-and-Effect Diagrams (Ishikawa diagrams)

One analysis tool is the Cause-and-Effect (or Fishbone) diagram. These are also called "Ishikawa diagrams" because Kaoru Ishikawa developed them in 1943. They are called fishbone diagrams since they resemble one with the long spine and various connecting branches.



The fishbone chart organizes and displays the relationships between different causes for the effect that is being examined. This chart helps organize the brainstorming process. The major categories of causes are put on major branches connecting to the backbone, and various sub-causes are attached to the branches. A tree-like structure results, showing the many facets of the problem.

The method for using this chart is to put the problem to be solved at the head, then fill in the major branches. People, procedures, equipment and materials are commonly identified causes.

2) Check Sheet

A check sheet is a sheet or form used to record data. It is one of the simplest method for collecting data and determining trends. The recording can be used to determine the occurrence of events such as non-conformity.

It is a way of collecting and classifying data so that it can be easily presented or analyzed. It is particularly useful at the start of a problem-solving process for data gathering. It can also be used for monitoring performance once change has been implemented.

This is the logical point to start in most problem solving cycles to detect patterns and carry out further analysis.

Check Sheet

quality-management-tools.com

Date: _____

Employee Name: _____

Note: _____

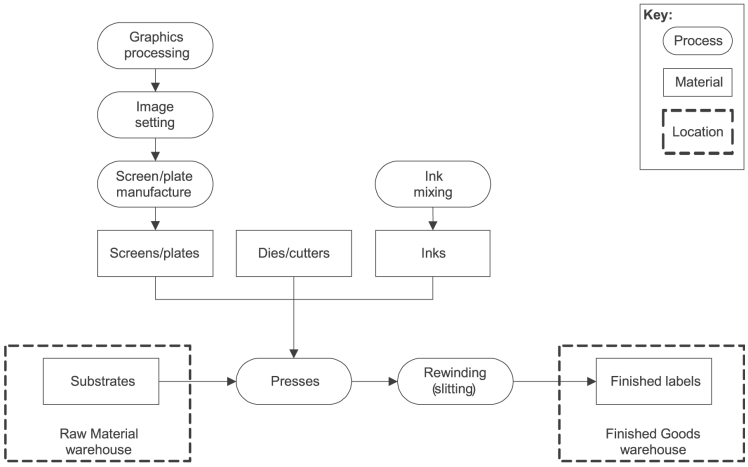
PROBLEM	FREQUENCY
List categories you want to measure such as problems, errors, defects, etc.	Add a check for the appropriate category as you collect your data.
Problem 1	II
Problem 2	III
Problem 3	I
Problem 4	IIII
Problem 5	~~IIII~~ III
Problem 6	~~IIII~~ I
Problem 7	II
Problem 8	I
Problem 9	II
Problem 10	IIII

Types of check sheet:

1. Production process distribution check sheet
2. Defective item check sheet
3. Defect location check sheet
4. Defect cause check sheet
5. Confirmation/inspection checklist

3) Flow diagram

Flow diagrams or charts (also known as Process map) are used to assist in systemically breaking down the organizational process into a step by step picture of each component. Symbols are used to indicate activities, decisions, beginning and ending points and the flow that the process takes.



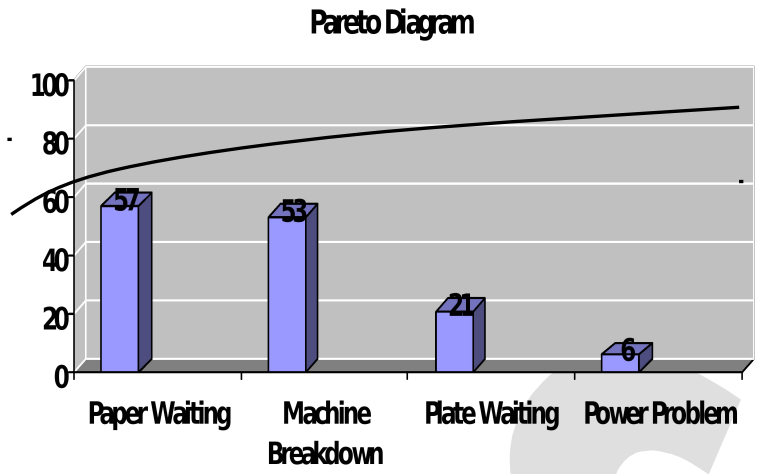
After a process has been identified for improvement and given high priority, it should then be broken down into specific steps and put on paper in a flowchart. This procedure alone can uncover some of the reasons a process is not working correctly. Other problems and hidden traps are often uncovered when working through this process.

Flowcharting also breaks the process down into its many sub-processes. Analyzing each of these separately minimizes the number of factors that contribute to variation in the process.

4) Pareto Analysis

Pareto analysis is developed around the basic concept that 80% of a specific effect is due to 20% of the cause (80-20 rule). The Pareto chart can be used to display categories of problems graphically so they can be properly prioritized.

Defect	Weekly Total	% Total	Cum. %
Paper waiting	57	41.61	41.61
Machine breakdown	53	38.69	80.30
Plate waiting	21	15.33	95.63
Power problem	6	4.37	100.00
TOTAL	137	100.00	-



There are often many aspects of a process or system that can be improved, such as the number of defective products, time allocation, or cost savings. A Pareto chart or diagram indicates which problem to tackle first by showing the proportion of the total problem that each of the smaller problems comprise. **This is based on the Pareto principle: 20% of the sources cause 80% of the problem.**

A Pareto chart is a vertical bar graph displaying rank in descending order of importance for the categories of problems, defects or opportunities. Generally, you gain more by working on the problem identified by the tallest bar than trying to deal with the smaller bars.

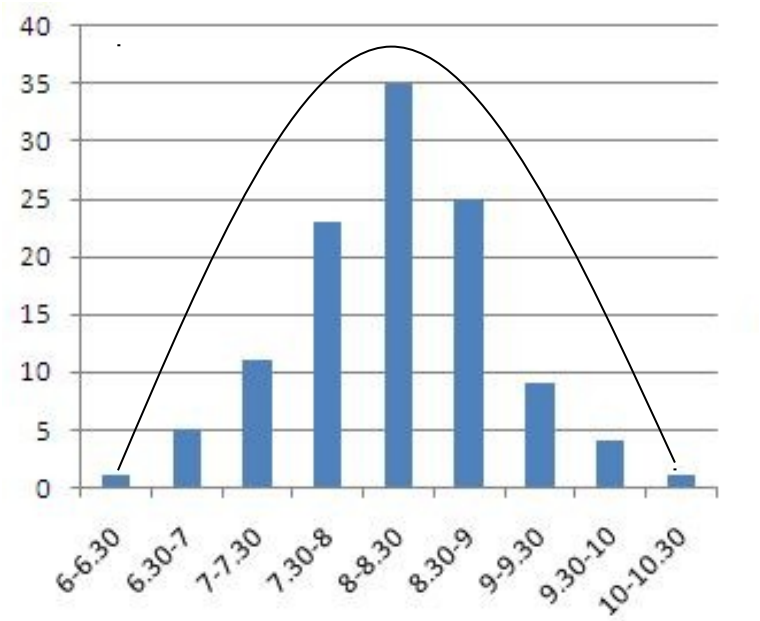
5) Histogram

Histogram is used for illustrating the frequency and the extent in the context of two variables. Histogram is a chart with columns. This represents the distribution by mean. If the histogram is normal, the graph takes the shape of a bell curve.

If it is not normal, it may take different shapes based on the condition of the distribution. Histogram can be used to measure something against another thing. Always, it should be two variables.

Now you can put the data from the check sheets into a histogram. A histogram is a snapshot of the variation of a product or the results of a process. It often forms the bell-shaped curve which is characteristic of a normal process.

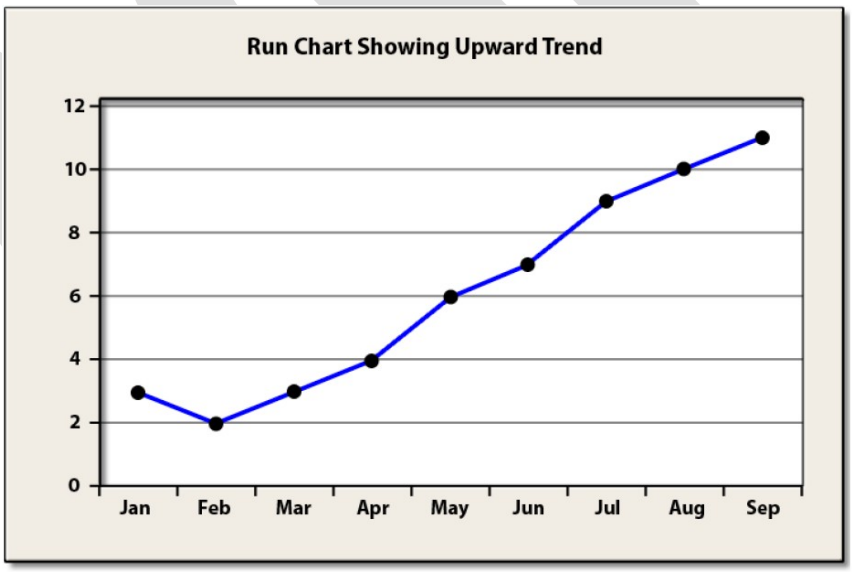
The histogram helps you analyze what is going on in the process and helps show the capability of a process, whether the data is falling inside the bell-shaped curve and within specifications.



6) Run Chart

Run charts visually display the variation in a process over time. The run chart displays an average line taken from the data and will have data points and lines connecting them. In this manner the user can readily see how each data point varies from the average.

Run charts can also be used in most of a printing company to plot events over time. Some of these areas include sales calls per month, completed jobs per week, estimates per week, ink density per job and customer complaints.



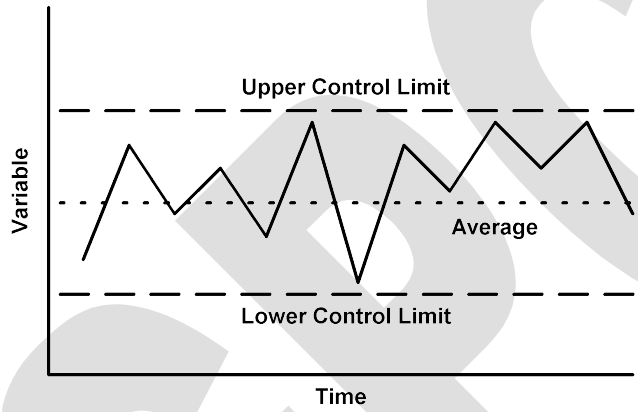
7) Control Chart

Control charts typically display the limits that statistical variability can explain as normal. If your process is performing within these limits, it is said to be in control; if not, it is out of control.

Control chart is the best tool for monitoring the performance of a process. These types of charts can be used for monitoring any processes related to function of the organization.

These charts allow you to identify the following conditions related to the process that has been monitored.

- Stability of the process
- Predictability of the process
- Identification of common cause of variation
- Special conditions where the monitoring party needs to react



1.5 Basic concepts and benefits of Kaizen:

1) Kaizen:

From the Japanese words “kai-” which means “change” and “-zen” which means “good.” The popular meaning from Toyota is “continuous improvement” or “small incremental improvements” of all areas of a company, not just manufacturing.

Kaizen works on the following basic principle - ***“Change is for good”.***

Kaizen is defined as a continuous effort by each and every employee (from the CEO to field staff) to ensure improvement of all processes and systems of a particular organization.

The purpose of Kaizen goes beyond simple productivity improvement. When done correctly, the process humanizes the workplace, eliminates overly hard work, and teaches people how to spot and eliminate waste in business processes.

The continuous cycle of Kaizen activity has seven phases:

1. Identify an opportunity
2. Analyze the process
3. Develop an optimal solution
4. Implement the solution
5. Study the results

6. Standardize the solution
7. Plan for the future

Kaizen generates small improvements as a result of coordinated continuous efforts by all employees. Kaizen events bring together a group of process owners and managers to map out an existing process and identify improvements that are within the scope of the participants.

Benefits of Kaizen:

- **Quality** – Bettering products, service, work environment, practice and processes.
- **Cost** – Reducing expenses and manpower, and use of material, energy and resources.
- **Delivery** – Cutting delivery time, movement and non-value-added activities
- **Management** – Improving procedures, training, morale, administration, planning, flow, information systems, documentation and reporting.
- **Safety** – Decreasing hazardous situations, unsafe working conditions, chances of resource depletion and damage to the environment.

2) LEAN:

Lean is about creating the most value for the customer while minimizing resources, time, energy and effort.

- Lean manufacturing or lean production, often simply "lean", is a systematic method for waste minimization ("Muda") within a manufacturing system without sacrificing productivity.
- Lean also takes into account waste created through overburden ("Muri") and waste created through unevenness in work loads ("Mura").
- Working from the perspective of the client who consumes a product or service, "value" is any action or process that a customer would be willing to pay for.

A lean approach to work is about:

- Understanding what's really going on at the place where value is created – commonly known as the gemba.
- Improving the processes by which products and services are created and delivered.
- Developing and empowering people through problem solving and coaching.
- Developing leaders and an effective management system.

Benefits of Lean:

- Improved quality
- Improved Visual Management
- Increased efficiency
- Manpower reductions
- Easier to manage
- Total Company Involvement
- Problem Elimination
- Reduced Space
- Safer Work Environment

- Improved employee morale

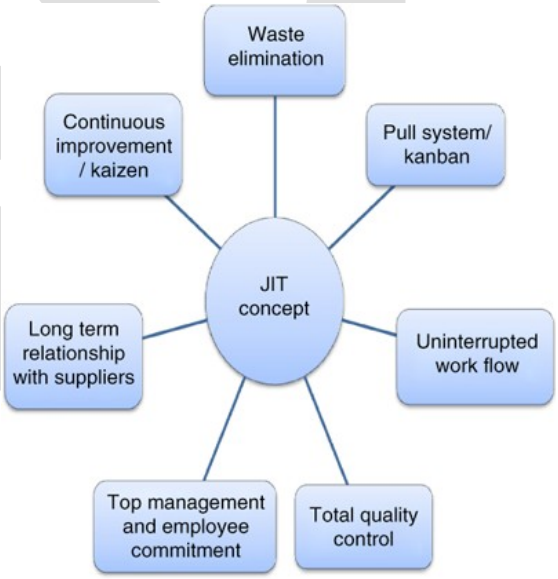
3) Just in Time:

Just-in-time (JIT) is an inventory strategy companies employ to increase efficiency and decrease waste by receiving goods only as they are needed in the production process, thereby reducing inventory costs. This method requires producers to forecast demand accurately.

In traditional manufacturing we try to predict what the customer will want and we will create a forecast (or guess) against which we will produce our products. This will typically result in long lead times through our processes, huge amounts of Work In Process (WIP) stocks and also large quantities of finished goods stocks that have not yet been ordered by our customers. This is what many now call “Just in Case” manufacturing.

A Just in Time system on the other hand will seek to use simple visual tools known as Kanbans to pull production through the processes according to what the customer actually takes. It massively reduces the amount of stock held and will reduce lead times by a significant amount, often from weeks to just a few hours or days.

- Its objective is to eliminate product inventories from the supply chain. As much a managerial philosophy as an inventory system,
- JIT encompasses all activities required to make a final product from design engineering onwards to the last manufacturing operation.
- JIT systems are fundamental to time based competition and rely on waste reduction, process simplification, setup time and batch size reduction, parallel (instead of sequential) processing, and shop floor layout redesign.



The benefits of a JIT system

The following are some of the many benefits that you could gain through the implementation of just in time:

1. Reduction in the order to payment timeline
2. Reduction in Inventory costs
3. Reduction in space required
4. Reduction in handling equipment and other costs
5. Lead time reductions
6. Reduced planning complexity
7. Improved Quality
8. Productivity increases
9. Problems are highlighted quicker
10. Employee empowerment

4) ***5S***

"5S" was invented in Japan, and stands for five (5) Japanese words that start with the letter 'S':

1. Seiri – Sort
2. Seiton - Set (in place)
3. Seiso - Shine
4. Seiketsu - Standardize
5. Shitsuke – Sustain

Japanese Term	English Equivalent	Meaning in Japanese Context
Seiri	Tidiness (Sort)	Throw away all rubbish and unrelated materials in the workplace
Seiton	Orderliness	Set everything in proper place for quick retrieval and storage
Seiso	Cleanliness	Clean the workplace; everyone should be a janitor
Seiketsu	Standardization	Standardize the way of maintaining cleanliness
Shitsuke	Discipline	Practice 'Five S' daily - make it a way of life; this also means 'commitment'

1) Sort

- Make work easier by eliminating obstacles.
- Reduce chances of being disturbed with unnecessary items.
- Evaluate necessary items with regard to cost or other factors.
- Remove all parts or tools that are not in use.
- Segregate unwanted material from the workplace.
- Define Red-Tag area to place unnecessary items that cannot immediately be disposed of. Dispose of these items when possible.
- Need fully skilled supervisor for checking on a regular basis.
- Waste removal.
- Make clear all working floor except using material.
- Sort bad and good things.
- Sort all items as per their parts.

2) Set in order

- Arrange all necessary items so that they can be easily selected for use.
- Prevent loss and waste of time by arranging work station in such a way that all tooling / equipment is in close proximity.
- Make it easy to find and pick up necessary items.
- Ensure first-in-first-out FIFO basis.
- Make workflow smooth and easy.
- All of the above work should be done on a regular basis.

- Place components according to their uses, with the frequently used components being nearest to the work place.

3) Shine

- Clean your workplace on daily basis completely or set cleaning frequency time to time
- Use cleaning as inspection.
- Prevent machinery and equipment deterioration.
- Keep workplace safe and easy to work.
- Keep workplace clean and pleasing to work in.
- When in place, anyone not familiar to the environment must be able to detect any problems within 50 feet in 5 sec.

4) Standardize

- Standardize the best practices in the work area.
- Maintain high standards in workplace organization at all times.
- Everything in its right place.
- Every process has a standard.
- Standardize color coding of usable items
- People know the process of that specific job

5) Sustain

- Not harmful to anyone.
- Also translates as "do without being told".
- Perform regular audits.
- Training and discipline.
- Training is goal-oriented process. Its resulting feedback is necessary monthly.
- Self-discipline
- To maintain proper order
- Ensure all defined standards are being implemented and heard.
- Follow the process, but also be open to improvement

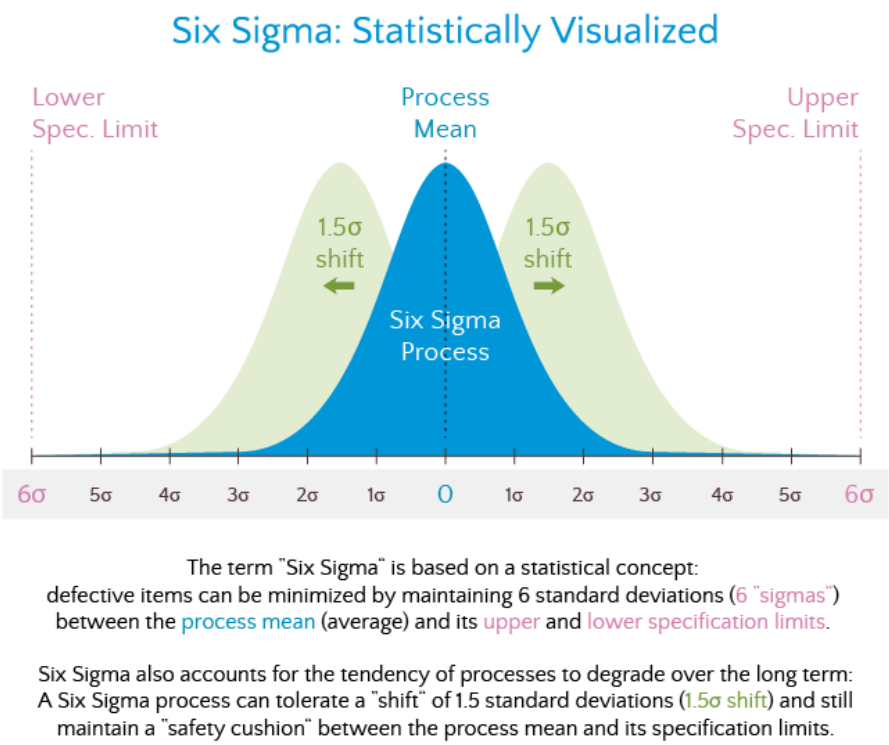
The key benefits of 5S are:

- Less Waste (Improved Efficiency)
- Reduced Space Used For Storage

- Improved Maintenance
- Improved Safety
- Better, More Committed Employees
- Improved Quality

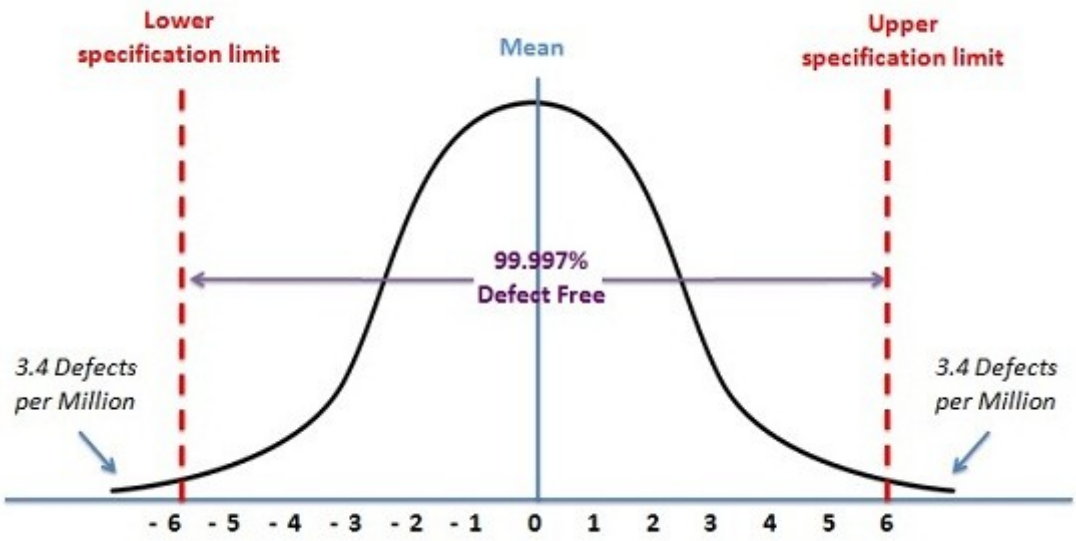
5) Six Sigma

- Six Sigma is a method that provides organizations tools to improve the capability of their business processes.
- This increase in performance and decrease in process variation lead to defect reduction and improvement in profits, employee morale, and quality of products or services.
- Six Sigma quality is a term generally used to indicate a process is well controlled (within process limits ±3s from the center line in a control chart, and requirements/tolerance limits ±6s from the center line).



Definition:

Six Sigma seeks to improve the quality of process outputs by identifying and removing the defects (errors) and minimizing variability in manufacturing and business processes.



Six Sigma Roles and Responsibilities

Sponsor	Senior executive who sponsors the overall Six Sigma initiative.
Leader	Senior-level executive who is responsible for implementing Six Sigma within the business.
Champion	Middle- or senior-level executive who sponsors a specific Six Sigma project, ensuring that resources are available and cross-functional issues are resolved.
Black Belt	• Full-time professional who acts as a team leader on Six Sigma projects. • Typically has four to five weeks of classroom training in methods, statistical tools and sometimes team skills.
Master Black Belt	• Highly experienced and successful Black Belt who has managed several projects and is an expert in Six Sigma methods/tools. • Responsible for coaching/mentoring/training Black Belts and for helping the Six Sigma leader and Champions keep the initiative on track.
Green Belt	• Part-time professional who participates on a Black Belt project team or leads smaller projects. • Typically has two weeks of classroom training in methods and basic statistical tools.
Team Member	Professional who has general awareness of Six Sigma (through no formal training) and who brings relevant experience or expertise to a particular project.
Process Owner	Professional responsible for the business process that is the target of a Six Sigma project.

Key Concepts of Six Sigma

- **Critical to Quality** − Attributes most important to the customer.
- **Defec**t − Failing to deliver what the customer wants.
- **Process Capability** − What your process can deliver.

- **Variation** − What the customer sees and feels.
- **Stable Operations** − Ensuring consistent, predictable processes to improve what the customer sees and feels.
- **Design for Six Sigma (DFSS)** − Designing to meet customer needs and process capability.

Benefits of Six Sigma

- Generates sustained success
- Sets a performance goal for everyone
- Enhances value to customers
- Accelerates the rate of improvement
- Promotes learning and cross-pollination
- Executes strategic change

Unit - I

2 Mark Question

1. What is TQM?

   TQM is a set of systematic activities carried out by the entire organization to effectively and efficiently achieve company objectives.

2. Define Quality.

   Meeting the requirements of the customer

3. What is JIT?

   Just-in-time (JIT) is an inventory strategy that strives to improve a business's return on investment by reducing in-process inventory and associated carrying costs.

4. What is Quality Assurance?

   Quality assurance refers to the processes and procedures that systematically monitor different aspects of a service or process.

5. What is process control?

   Process control refers to the methods that are used to control process variables when manufacturing a product.

6. Define Quality Control

   Quality control may be defined as group of techniques of the industrial management by means of which products of uniform acceptable quality are manufactured.

7. What is 5M?

   Men, Machine, Money, Method & Materials

8. What is Kaizen?

   'Continuous Improvement' is a policy of constantly introducing small incremental changes in a business in order to improve quality and/or efficiency.

9. What is TPM?

   Total productive maintenance (TPM) is the systematic execution of maintenance by all employees through small group activities.

10. What is 5s?

    Seiri, Seiton, Seiso, Seiketsu & Shitsuke

11. What is benchmarking?

    Benchmarking is the process of measuring your company's performance in each function and comparing that level of performance with the level of performance achieved by successful leaders.

12. What is Pareto analysis?

Pareto analysis is developed around the basic concept that 80% of a specific effect is due to 20% of the cause (80-20 rule).

13. Write other name for cause and effect diagram.

    Fishbone diagram or Ishikawa diagram

14. Define SPC.

    Statistical Process Control, commonly referred to as SPC, is a method for monitoring, controlling and, ideally, improving a process through statistical analysis.

15. Mention any two statistical process control tools?

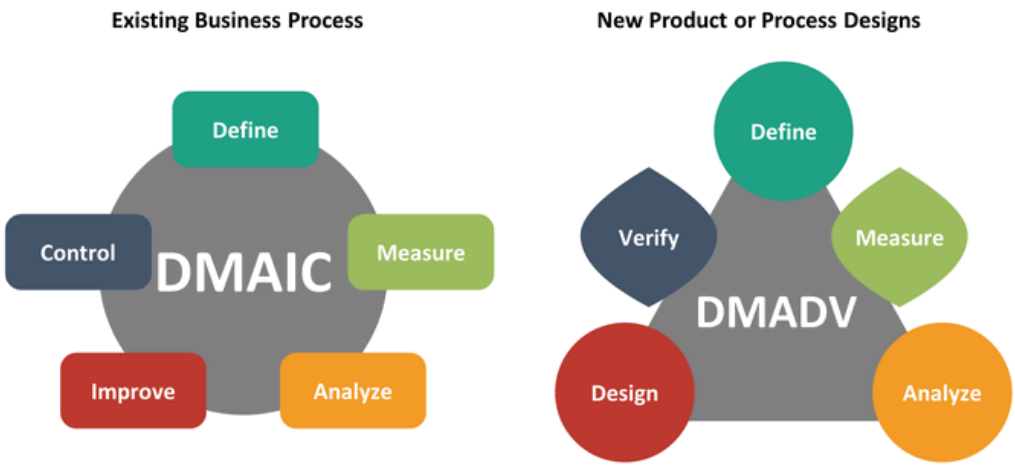
    Cause and effect diagram, Check sheet, Flow diagram, Pareto analysis

3 Mark Question

1. What do you mean by quality control Process?
   - Maintenance of standards of quality of manufactured goods.
   - A system for maintaining desired standards in a product or process by inspecting samples of the product.
2. State the purpose of TQM in print quality improvement?
   - The primary goal of a quality management system is to beat the competition.
   - Initiation of a quality management system in your business can identify waste, straighten out processes and hence reduce costs by decreasing inefficiencies.
   - It improves customer satisfaction, increases sales and furthers the goodwill of your business.
3. What are the basic elements of Quality Management?
   - Management support
   - Mission statement
   - Proper planning
   - Focus on customer
   - Empowerment of employees
   - Teamwork
   - Continuous improvement process
4. Explain the benefits of Lean.
   - Improved quality
   - Improved Visual Management

- Increased efficiency
- Manpower reductions
- Easier to manage
- Total Company Involvement
- Problem Elimination

5. Explain the use of kaizen in printing industry.
   - The purpose of Kaizen goes beyond simple productivity improvement.
   - When done correctly, the process humanizes the workplace, eliminates overly hard work, and teaches people how to spot and eliminate waste in business processes.
6. What is six sigma?
   - Six Sigma seeks to improve the quality of process outputs by identifying and removing the defects (errors) and minimizing variability in manufacturing and business processes.
   - This increase in performance and decrease in process variation lead to defect reduction and improvement in profits, employee morale, and quality of products or services.
7. What are the Methodologies of Six Sigma?



8. Explain the fishbone diagram.
   - The fishbone chart organizes and displays the relationships between different causes for the effect that is being examined.
   - This chart helps organize the brainstorming process.
   - A tree-like structure results, showing the many facets of the problem.

10 Mark Question

1. Explain in detail about elements of Quality control process system for graphics arts industry.
2. Explain in detail about DMAIC and DMADV.
3. Explain all the seven statistical control tools with diagram.
4. Explain Pareto charts and Histogram with neat diagram.
5. Explain in detail about Kaizen and its benefits.
6. Explain in detail six sigma concepts with their roles and responsibilities.
7. Write short notes on (i) LEAN (ii) JIT
8. Explain in detail 5S concepts adopted in printing industry

UNIT - II – MATERIAL INSPECTION AND TESTING

2.1 VISUAL INSPECTION

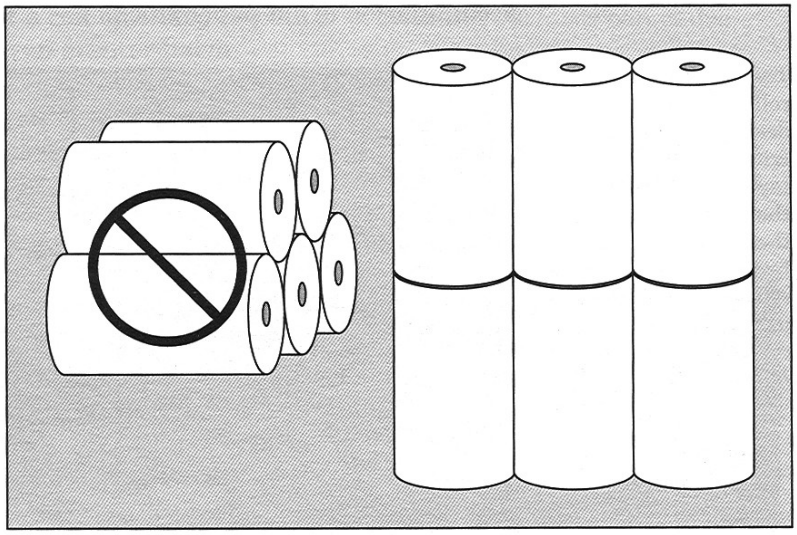
- Before accepting paper shipments, printers should inspect all paper for transit damage.
- They should also enter all damages and shortages on the carrier's delivery receipt and have the damage acknowledged by the carrier's agent.
- In addition, the printer should retain a signed copy of the inspection report and inform the paper manufacturer and shipper of any transit damage, such as that caused by improper loading or inadequate packaging.
- Before settling a damage complaint, the shipper or papermaker must have supporting evidence that damage occurred during shipment, not after being received by the printer.
- Photographs showing the conditions of paper before and after unloading are therefore helpful in substantiating damage claims and in reporting the damage.
- To be certain that photos of the damage are taken before the paper is moved
- Before the paper is placed in storage, all damaged wrapping should be repaired, taped, or, if necessary, replaced. In addition, broken skid bands should be replaced to maintain compactness and protect the paper.

Storage and Handling of Substrates and Chemicals

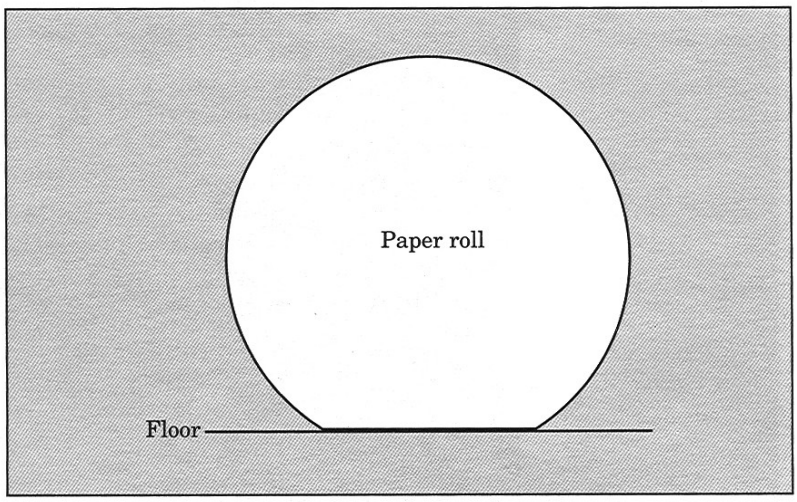
1. Handlers should use proper procedures to minimize damage to rolls, skids, and cartons during unloading and storage.
2. Rolls are particularly susceptible to costly handling damage. *Bumping, tipping, or dropping* a roll only a few inches can flatten it or cause it to become starred or bruised at its edges.
3. The floors on which rolls are stored and moved about should be clean and free of sharp objects like *nails, stones, and splintered wood.*
4. Rolling paper rolls *over rough floors or sharp objects* can damage the outside layers.
5. Nicks, gouges, and other results of improper roll handling may render large portions of the roll unusable. Correcting this damage may require the removal of large slabs of paper.
6. Rolls should be stored on their ends, because rolls stored on their sides will become flat and out of round.
7. If rolls are stored on their ends in too many tiers, however, the excessive weight can flare the ends of the rolls as the bottom.
8. The material should never be stored on the floor but always on a pallet, don´t place it close to a radiator or air conditioning device.

9. Most environments with air conditioning systems provide the proper mix of temperature and humidity. If you are in an environment that is not air conditioned, follow these guidelines:
    - Minimum temperature of 50°F/10°C with 15 percent relative humidity
    - Maximum temperature of 81°F/27.2°C with 85 percent relative humidity

Rolls should be stored on their ends. They will become flat if stored on their sides.



Storing rolls of paper on their sides can cause them to become out-of-round.



Proper Storage of Paper:

Good storage significantly prolongs the preservation of paper materials and includes:

1. A cool (room temperature or below), relatively dry (about 35% relative humidity), clean, and stable environment (avoid attics, basements, and other locations with high risk of leaks and environmental extremes)
2. Minimal exposure to all kinds of light; no exposure to direct or intense light
3. Distance from radiators and vents
4. Supportive protective enclosures
5. Unfolded and flat or rolled storage for oversized papers

6. Individual/isolated storage of acidic papers to prevent acids from migrating into the other works on paper

Chemical Storage:

1. Control your inventory – only keep minimum amounts – don't squirrel chemicals
2. Label shelves and cupboards with the segregation scheme so that chemicals can be put away in the right place quickly
3. Remove all cardboard and other packing from storage area
4. Keep the outside of containers scrupulously clean and the area tidy
5. Ensure the store area is lockable and kept locked
6. Do not store liquids above solids in case of contamination in the event of a breakage
7. Never store flammable liquids in fridges/freezers unless they have been modified (i.e. spark proof)
8. Do not store containers on the floor

Product documentation

- Technical data sheets (TDS) give detailed technical description and area of use
- Safety data sheets (SDS) include important information about health, safety and environmental (HSE) aspects
- Application guides include information about surface preparation, application details, curing times etc.

What is a Material Safety Data Sheet (MSDS)?

- A Material Safety Data Sheet (MSDS) is a document that contains information on the potential hazards (health, fire, reactivity and environmental) and how to work safely with the chemical product.
- It is an essential starting point for the development of a complete health and safety program.
- It also contains information on the use, storage, handling and emergency procedures all related to the hazards of the material.
- It is intended to tell what the hazards of the product are, how to use the product safely, what to expect if the recommendations are not followed, what to do if accidents occur, how to recognize symptoms of overexposure, and what to do if such incidents occur.

What is Technical Data Sheet (TDS)?

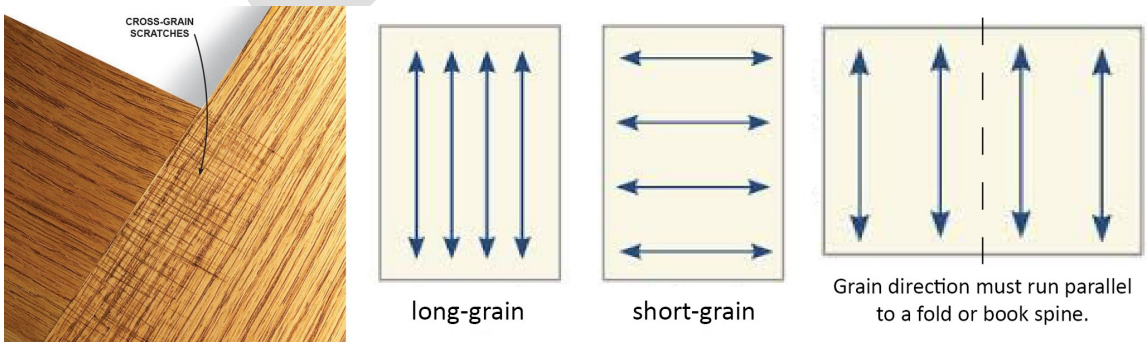
- A datasheet is usually used for technical communication to describe technical characteristics of an item or product.

- It can be published by the manufacturer to help people choose products or to help use the products.
- By contrast, a technical specification is an explicit set of requirements to be satisfied by a material, product, or service.
- Technical Data Sheets (TDS) provide detailed specifications for our products, including:
  - ❖ Smart advantages
  - ❖ Product characteristics
  - ❖ Directions for use
  - ❖ Precautions in use

2.2 TESTING PROCEDURE FOR PAPER AND BOARD

1) Paper Grain Direction:

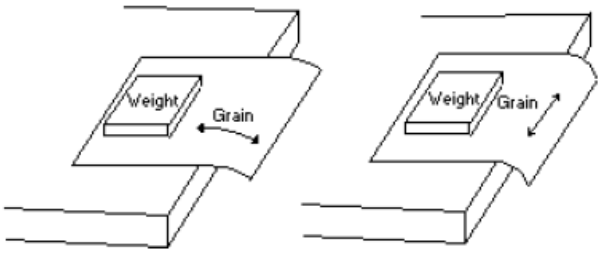
- The grain of the paper refers ***to the direction of the fibers in a sheet of paper.***
- **Long grain paper** refers to paper in which the fibers run in the same direction as the longest measurement of the paper. On rolls of paper for web presses, the grain runs along the length of the web.
- **Short grain paper** refers to paper in which the fibers run in the same direction as the shortest measurement of the paper.
- When paper is torn, it will tear easier and straighter when torn parallel with the grain.
- It will also fold easier parallel to the grain and produce a cleaner fold than if folded across the grain.
- Laser printers require long grain paper for the best results.
- Short grain paper may not feed properly into a laser printer and the heat produced by a laser printer may result in the sheets curling as they come out of the printer.



TESTING OF PAPER GRAIN DIRECTION FOR THE PAPER SAMPLE

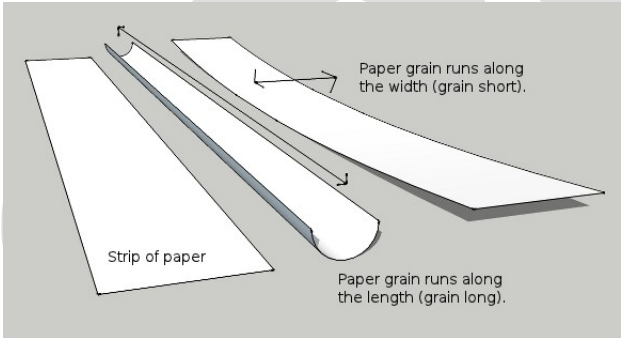
1. The Droop Test

- Place a sheet of paper at the edge of the table and observe the degree to which it droops over the edge
- It will droop more if the paper grain runs parallel to table edge.



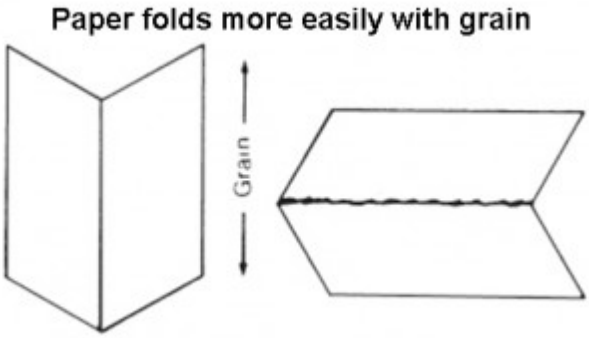
2. Wet Test

- Slightly wet one side of the paper with a mister or damp sponge
- The paper will curl in the direction of the grain
- Once the paper has dried it will be relaxed and easy to work with



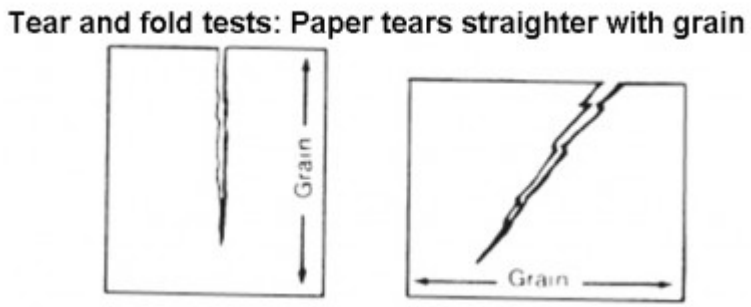
3. Resistance Test

- Turn a piece of paper back onto itself and feel the degree of resistance against your hand
- Do this in both directions
- With the grain – slight resistance
- Against the grain – strong resistance



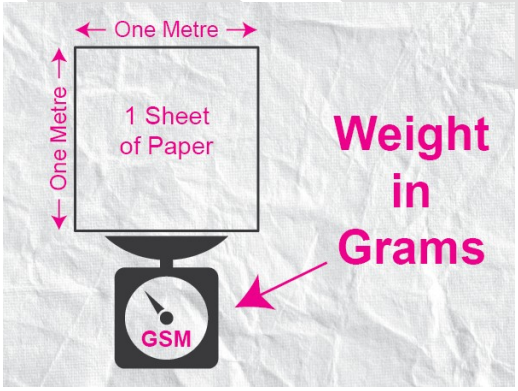
4. Tear Test

- Use a piece of newspaper and tear it in one direction
- Tear it in the other direction
- With the grain the tear will be clean
- Against the grain the tear will be ragged



2) GSM

- **Paper is measured in GSM.** This stands for 'Grams per Square Meter' and means exactly that ie how many grams a single sheet of paper weighs measuring 1m x 1m.
- If you weight a sheet of paper that is 1 metre x 1 metre in size, the weight of that sheet in grams is the GSM value of that paper type.
- **GSM stands for Grammes per Square Metre** - and is how the quality of paper is measured.
- The term GSM refers to the substance weight of paper, relating to an area of paper that remains constant, irrespective of sheet size, expressed as grams per square metre.



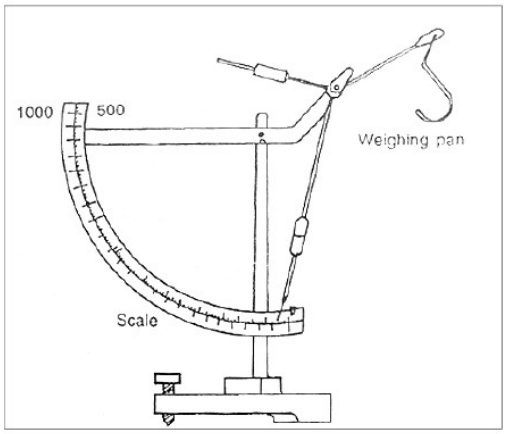
- GSM Tester / Substance Indicator measures and directly indicates substance of paper and paper boards in terms of grams per sq.meter.

Calculate Basis Weight From Grammage

Basis Weight

- The basis weight of a paper is the designated fixed weight of 500 sheets, measured in pounds, in that paper's basic sheet size.

- It is important to note that the "basic sheet size" is not the same for all types of paper.
- Basis weight is very important for paper production, productivity and quality of paper.
- If the basis weight fluctuates then it will be hamper the quality of the paper such as bad formation, uneven drying and calendaring, calendar cutting, bad mother roll development, blackish etc.



GSM tester

- Moreover cutter machine have to face problem for bad mother roll development.
- So it is very important for a papermaker to controlling basis weight.

Caliper

- Caliper refers to the thickness of a sheet of paper expressed in thousandth of an inch. This measurement is taken with a micro meter.
- Normally, paper caliper should not have more than a + or - 5% variance within a sheet. Generally, the relation between caliper and basis weight the greater the caliper (the thicker the paper), the greater the paper weight.

Equivalent Weight

- While different paper types have different basic sizes, papers can still be compared by using equivalent weight.

1) WEIGHT IN KG OF A GIVEN NUMBER OF SHEETS

$$\textbf{Weight} = \frac{L \times Swd \times Gsm \times Ns}{1000}$$

L = Length of sheet in metres

Swd = Width of sheet in metres

Gsm = g/m² of paper

Ns = Number of sheets

$$\textbf{Basis Weight in Pounds} = \frac{\text{Grams per sq. meter} \times \text{Basic Size}}{1406.5}$$

Example:

Calculate 90 GSM Offset Paper to Basis Weight of 25" x 38" size in pounds

$$\frac{90 \text{ gsm} \times (25 \times 38)}{1406.5} = 60.8\#$$

2) GRAMMAGE OF A SHEET OF PAPER IN G/M2

$$\textbf{Grammage} = \frac{W \times 1000}{L \times Swd \times Ns}$$

W = Weight in kg

L = Length of sheet in metres

Swd = Width of sheet in metres

Ns = Number of sheets

3) NUMBER OF SHEETS FOR A JOB

Total = Npj x Cr x (100 + %overs) / Nps x 100

Npj = Number of printed pages of job

Cr = Copies required

Nps = Number of printed pages per sheet

4) Calculate the GSM from reel

Substance in gsm = (Weight of reel in kgs * 1,00,000) / (Length of paper on meter * reel width in cms)

Example:

Calculate the GSM weight of paper for the given details.

Weight of reel in kgs = 25

Length of paper in meter = 30

Reel width in cms = 15

Solution:

Apply formula:

*Substance in gsm = (Weight of reel in kgs * 100000)/(Length of paper on meter * reel width in cms)*

*Substance in gsm = (25*100000)/ (30 *15)*

Substance in gsm = 2500000/450 = 5555.555555555556

Substance in gsm = 5555.555555555556 (gsm)

3) Bulk

Bulk expresses the specific volume of a material. Bulk is the inverse of density.

Bulk = 1 / density = (cm^2/g)

- In the paper trade bulk is a more commonly used measure than density to indicating the "compactness" of paper.
- Bulk can be calculated by dividing the thickness of a sheet by its basis weight.

- Decrease in bulk or in other words increase in density makes the sheet smoother, glossier, less opaque, darker, lower in strength etc.
- In some connections, bulk is used to express the thickness of paper or board according to the following equation:

$$\textbf{Bulk (cubic centimeter/g)} = \frac{\textbf{Thickness (mm) x 1000}}{\textbf{Basis Weight (g/m2).}}$$

Bulk x basis weight = thickness

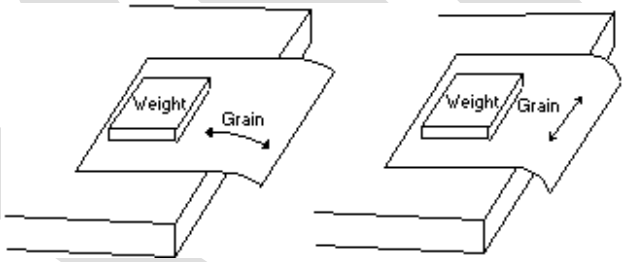
For example:

Bulk	Basis weight	Thickness
1.3	100 gsm	130 microns
1.6	80 gsm	130 microns

This is done particularly when choosing bookprinting paper and packaging.

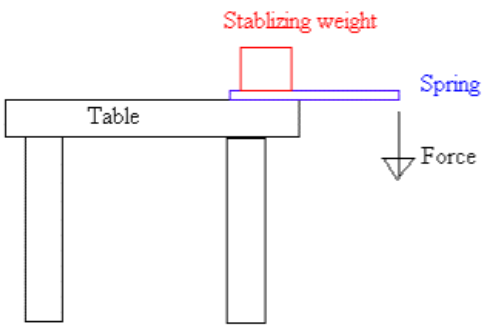
4) Stiffness

- ***Paper stiffness is the ability for a sheet of paper to resist bending.***
- Stiffness is influenced by the thickness and basis weight of the sheet.
- Stiffness can vary from machine direction (MD) to cross machine direction (CMD).
- Paper stiffness is typically stiffer across the grain due to the resistance of the paper fibers to bend across themselves.



Measuring Paper Stiffness

Stiffness can be measured using number of different testing devices. A common device is the **Gurly stiffness tester.**



- The Gurly testeer uses its own units and is governed by the TAPPI T 543 paper standard.
- This procedure determines the bending resistance of paper, paperboard, and other materials by measuring the force required to bend a specimen under controlled conditions.
- The instrument described allows for a wide variation in specimen length and width, and in applied force.
- This procedure is not recommended for soft or limp materials such as tissue, toweling and newsprint, or for materials with a pronounced degree of curl.

Relationship with other properties

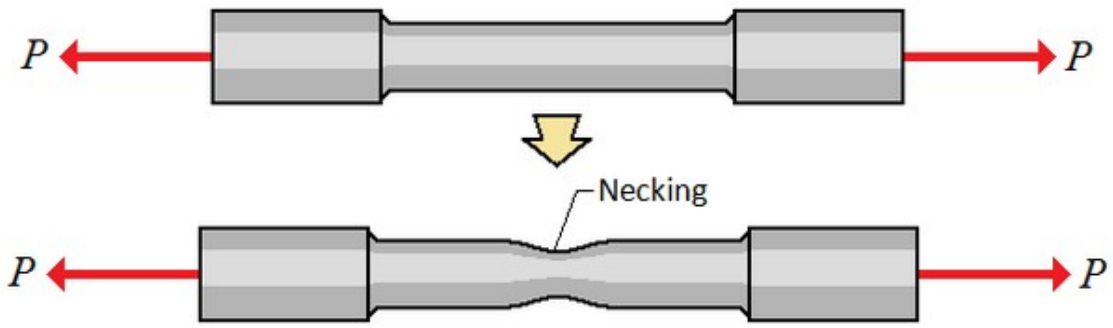
- The inter relationship of stiffness, grain direction and runnability.
- The stiffness of the paper affects its feeding ability and its ability to avoid distortion due to the pull of the ink during the printing process.

Applications:

- The stiffness is important to the converting operations for forms and envelopes.
- Adequate stiffness is essential for file folders, index cards, and posters, which must support their own weight, and for the rapid transporting of tab card, checks, and documents through their processing equipment.
- High stiffness is important paperboard used to make cartons and containers.
- Low stiffness required for paper tissue, toweling, and napkin for the easy opening and turning of pages in a book, and for music paper.

5) Tensile strength

The ability of the paper to withstand the stress and strain applied to it before breaking down and pulling apart.



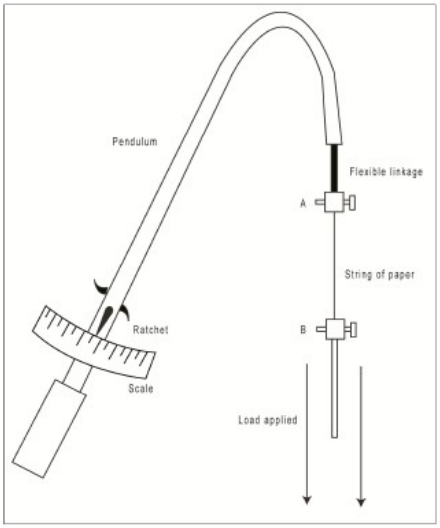
- The tensile force required to produce a rupture in a strip of paperboard, measured in MD &CD, expressed in N/m.
- Tensile strength is indicative of fiber strength, fiber bonding and fiber length.

- Tensile strength can be used as a potential indicator of resistance to web breaking during printing or converting.

Measuring Paper tensile strength

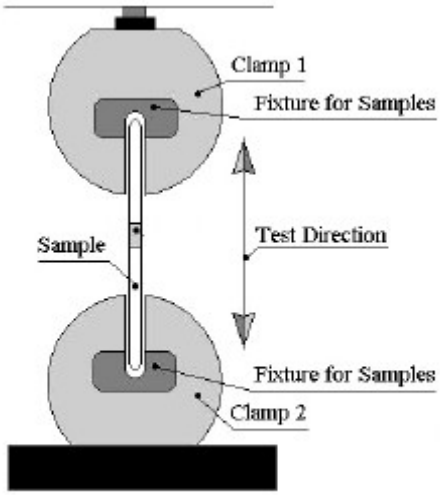
Tensile strength and elongation are measured with either of two types of testers.

- **The pendulum type of tester** applies a gradually increasing tension to a paper strip of specified width and length between two jaws.
- One jaw is moved downward and the other swings a pendulum away from its plumb, or starting position, by the pulling force of the paper strip.
- As the pendulum is pulled upward, an increased tension is applied to the paper strip until it breaks a number of strips are tested and their values averaged for each direction.



Principle of tensile tester

- Tensile breaking strength may be reported in different units: kilograms per 15-mm-width strip, pounds per inch -width strip, or kilonewtons per meter.
- The second type **of tester strains, or elongates, the** paper at a constant rate between a fixed lower clamp and an upper one that moves upward at a constant rate.
- There are four types of tensile strength tester apparatus used in paper industry such as rigid crosshead type, inclined plane type, hydraulic type and spring type.



Tensile tester

Tensile index and its calculation

Tensile index is defined with tensile strength divided by basis weight and express as Nm/g.

Tensile Strength = N/m

Basis Weight = g/m2

Hence, Tensile index (TI) = (N/m)/(g/m2) = Nm/g

Relationship with other properties

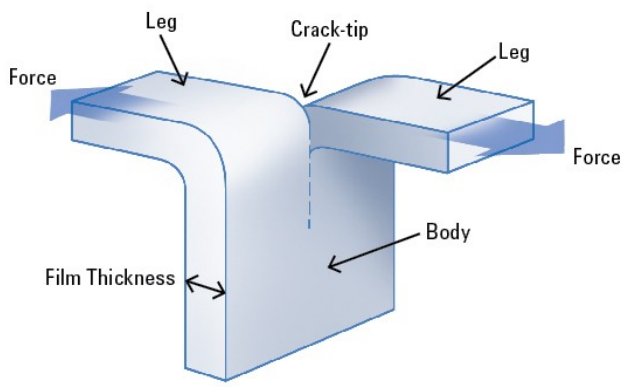
- Tensile strength is used to find out how resistant paper is to a web break.
- The strength, length and bonding of fiber, degree of fiber refining and the direction of the fiber are the main sources of the tensile strength of paper.
- It is also depends on the quality and quantity of fillers used.
- Tensile strength is influenced by refining, wet-pressing on the paper machine, fiber length, furnish, basis weight, and moisture content.
- Increased refining, greater wet-pressing, higher basis weight, and increased fiber length raise tensile strength.
- Increasing the percentage of filler lowers tensile strength.

Applications:

- It is a significant factor for many applications as like printing, converter and packaging papers.
- Tensile strength is an indicator of durability for papers like wrapping bag, creasing, gummed tape, cable wrap, and twisting.
- It relates to the stresses applied to paper as it is pulled through sheetfed presses by the grippers, to web travel, to breaks in printing and converting, and to the deleaving and perforation strength of business forms.

6) Tearing Resistance

Paper's ability to resist tearing while going through various stages of production such as printing, folding, book binding and miscellaneous bindery operations.



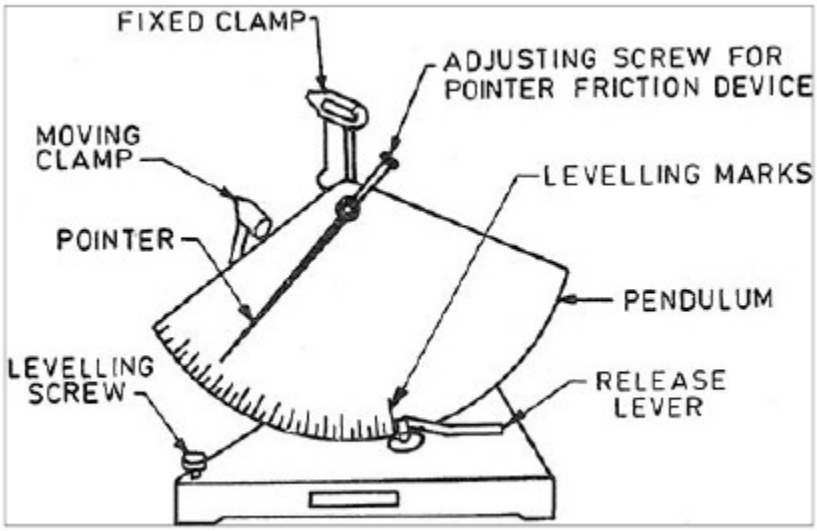
- The tear strength of paper means the resistance of a paper sheet to tearing force that it is subjected to.
- It is measured in both machine direction (MD) & cross direction (CD) and expressed as mN (mili Newton).
- Machine direction means the direction of the paper web which is running on the machine during paper making.
- On the other hand cross direction means the direction, which is perpendicular to the paper sheet that is running on the machine during paper making.

Types of instruments

There are two types of instruments are used for tear strength measurement, for example **Elmendorf & Trouser tear device**. Elmendorf tear test are used most commonly.

Elmendorf Tear Strength Tester

The Elmendorf Tearing Testers are accurate, low-cost and high quality falling pendulum tear testing Instruments with analog and digital display for the determination of the average force required to propagate a single-rip tongue-type tear starting from a cut in paper.



Tear strength tester

- Lift the pendulum up to a certain height to give it an initial potential energy.
- The pendulum tears the specimen while swinging down.
- Computer calculates the decreased energy caused by tearing to obtain the required force for tearing.

Factor of the tear strength of paper

- Tearing resistance depends on the degree of fiber refining, related to inter fiber bonding, the fiber strength, the fiber length, the quality and quantity of fillers used.
- Among of them fiber length and fiber bonding are most important factor.

- Longer fibers increase the tear strength because it is able to distribute the stress over more fibers and more bonds, whereas short fibers concentrated the stress in a smaller region.
- The direction of the fiber is another important parameter for tear strength.
- It is larger in lateral direction of the fiber than in longitudinal direction.
- Appropriate refining is increased the tearing strength, whereas insufficient and extra refining decreased. It is also decreased by the uses of more filler.

Tear factor and its calculation

Tear factor is calculated as tear strength per unit basis weight and expressed as mN/g/m2 or dm2 . Tearing factor = Tearing strength/grammage

If the tearing strength = x mN

basis weight = y g/m2

Then the tear factor = x/y mN* m2/g or 100*x/y dm2

Applications

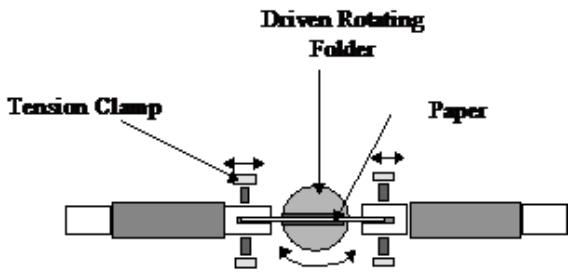
- The tearing strength property is significant factor for many applications involving cover papers, wrapping, toughness of packaging papers, bond papers, envelope papers, printer and converter.

7) Folding Endurance

- ***A paper property that refers to the ability of a paper to be folded repeatedly without tearing.***
- The number of folds it can withstand before it breaks is its folding endurance.
- Folding endurance varies according to grain direction, and is greater against the grain.

Types of instruments

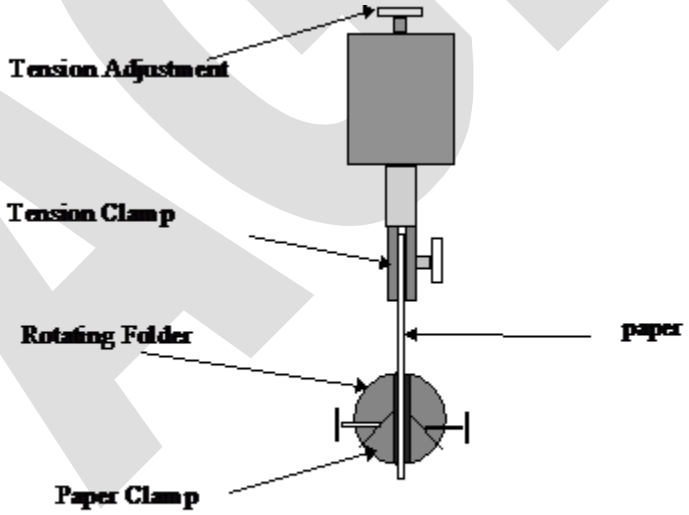
- In the Schopper method, a metal blade repeatedly folds a strip of paper back and forth between several rollers until it breaks.
- In the MIT method, an oscillating folding head repeatedly folds a paper sample back and forth until it breaks.
- The MIT method allows greater variability in the paper samples, and the tension can be adjusted based on the thickness of the sample.



Shopper Fold Apparatus

In the **Schopper method,** a metal blade repeatedly folds a strip of paper back and forth between several rollers until it breaks.

- In the schopper method a strip of paper is held under tension while a slotted reciprocating blade catches the strip in its middle and folds it back and forth between four rollers, folding it first toward one side, then toward the other side.
- The number of double folds the paper withstands before breaking is its folding endurance.
- In the **MIT method** a strip is clamped under tension between a spring-loaded jaw and an oscillating folding head.
- As the folding head oscillates an exact number of degrees on each side of its starting position, the paper is alternately folded toward each of its two sides.



MIT Fold Tester

Factor of the Folding Endurance of paper

- Folding endurance is enhanced by increased paper fiber refining, being a function of the interlacing of the bonds between the paper fibers.

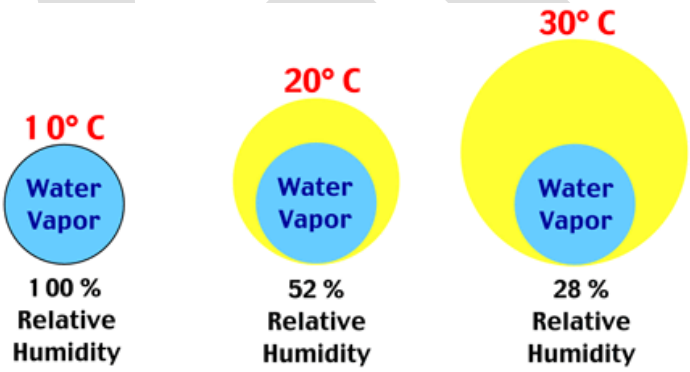
- Non-fibrous additives such as fillers, sizing, and coatings to the papermaking furnish or finished paper surface reduce folding endurance.
- Moisture loss also considerably decreases folding endurance.

Applications

- It is important for printing grades where the paper is subjected to multiple folds like in books, maps, or pamphlets.
- Fold test is also important for carton, box boards, ammonia print paper, and cover paper etc.
- Folding endurance is a requirement in Bond, Ledger, Currency, Map, Blue Print and Record Papers.

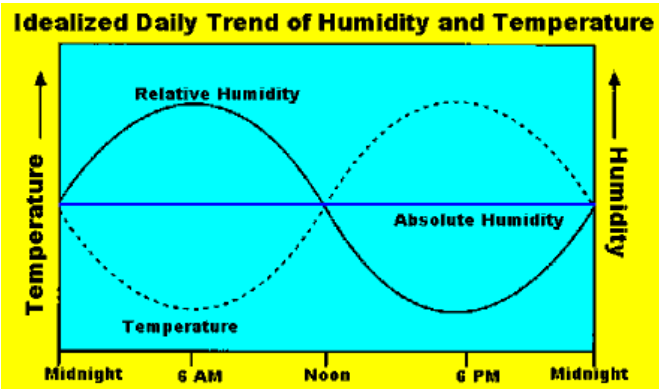
8) Relative Humidity (RH)

- A measure of the amount of water vapor present in the air expressed as a percentage of the total amount of water vapor the air could hold at the same temperature and pressure.
- Relative humidity is an important consideration in printing and in papermaking, as paper's hygroscopic tendency makes it absorb and lose water readily, which affects several paper properties, not the least of which is its dimensional stability.
- ***Most paper is manufactured at 35:50% relative humidity.***



- Many pressrooms have humidity control, and maintain the relative humidity within that range, to prevent as much water loss or gain as possible, so the paper remains flat before, during, and after printing.
- When printing jobs that require more than one pass through the press (such as multi-color work), paper should have a relative humidity 5:8% higher than the relative humidity of the room, so that its rate of moisture loss to the atmosphere will be offset by its rate of water absorption from the press dampening system.
- In some pressrooms, varying levels of humidification—adding moisture to the atmosphere—or dehumidification—removing moisture from the atmosphere—may

have to be performed to ensure that paper and pressroom are of congruent moisture content.

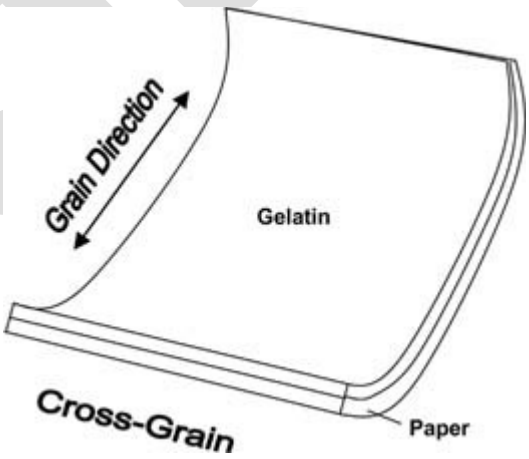


Testing for Relative Humidity

The amount of water vapor in the air at any given time is usually less than that required to saturate the air. The relative humidity is the percent of saturation humidity, generally calculated in relation to saturated vapor density.

$$\text{Relative Humidity} = \frac{\text{actual vapor density}}{\text{saturation vapor density}} \times 100\%$$

A device to measure relative humidity is called a **hygrometer**. The simplest hygrometer - a sling **psychrometer** - consists of two thermometers mounted together with a handle attached on a chain. One thermometer is ordinary. The other has a cloth wick over its bulb and is called a wet-bulb thermometer.



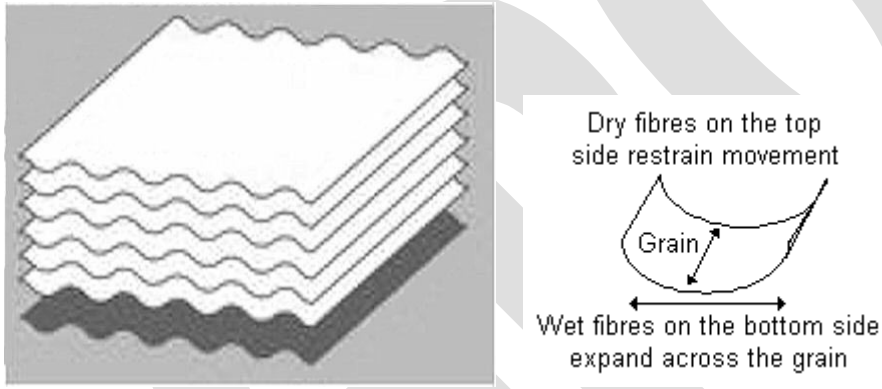
9) Moisture Content

- The amount of water contained in paper expressed as a percentage of the paper's total weight.
- The primary constituents of paper, fibers of cellulose, have a strong affinity for water, and will gain (or lose) it readily, depending on the amount of moisture in the air, or the relative humidity of the surrounding environment.

- This hygroscopic characteristic of paper makes it dimensionally unstable, as the length and/or width of a paper can change depending on how much water the paper has gained or lost.
- The moisture content of paper also affects its various mechanical, surface, and electrical properties, and contributes to the qualities of printability and runnability in the various printing processes.

The impact of moisture on cellulose fibre

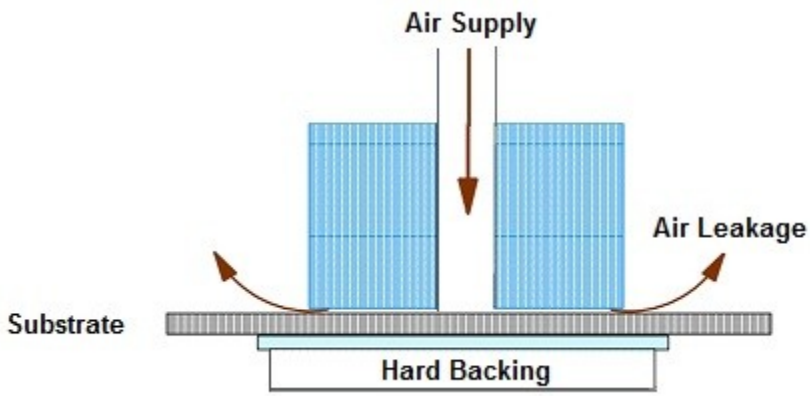
1. The cellulose fibre that exist in paper and board is influenced by the moisture in the air of its surroundings.
2. If for example the surrounding air is more dry than the board then the board will evaporate moisture, which makes the fibres shrink and you end up with a sheet that swell in the middle, so called “curl”.



3. If on the other hand the air is more moist than the board then the fibres will take on the moisture which causes the fibres to swell and you end up with a ”wavy” sheet.
4. The fibres will be more affected cross direction than along the grain. If the fibres either swell or shrink, then it is not possible to condition them back to their original dimension.

10) Smoothness

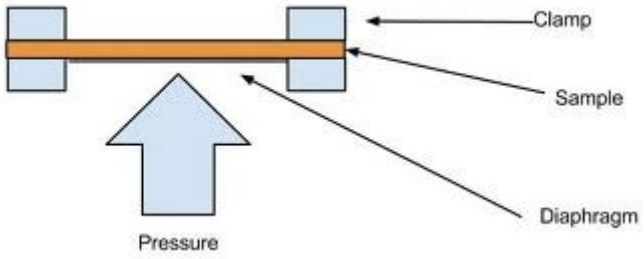
- ***Measure of the evenness or lack of contour of a paper's surface.***
- In terms of basic printability, a surface as free as possible of irregularities is desirable, but smoothness is also a function of the interrelationship of other paper properties, and varies with assorted manufacturing processes.
- Smoothness tends to be characterized by a wild formation, which is dependent on the degree of fiber refining, the extent of wet pressing, the extent of calendering and supercalendering, the use of coatings, and the desired paper finish.
- A measure of paper smoothness is made using **an air leak tester,** which determines the time it takes for a volume of air to seep between a smooth glass plate and the paper sample.



- One way is to measure smoothness as the time it takes, in seconds, for a given volume of air to leak between a smooth glass test plate And the paper surface under a specified air pressure.
- Smoothness can also be measured using a **Bekk Smoothness Tester or a Gurley Smoothness Tester**. More rapid measurements can be made with a Sheffield Smoothness Gauge or a Bendtsen Smoothness Tester.

11) Bursting Strength

- ***The bursting strength of a material gives the value of the maximum pressure that can be applied to the packaging materials before it ruptures.***
- The bursting strength of the material is directly proportional to its GSM.

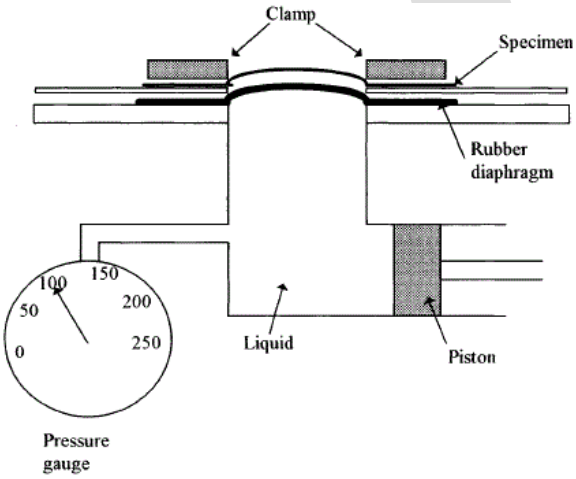


- The complete expression for Bursting Strength can be given as:

Bursting Strength (Kg / cm2) = Bursting Factor x GSM (gm / m2) / 1000

- Bursting factor is constant for different materials.
- Bursting strength is a function of various processes performed in the papermaking process.
- The increased use of fillers decreases bursting strength, while the increased use of longer fibers and surface sizing increases a paper's bursting strength.
- Bursting strength is measured utilizing a rubber diaphragm that is expanded hydraulically against the paper sample.

- A bursting test is also known as **a Mullen test or pop test**, and a minimum bursting strength is required for cartons used for shipping. Bursting strength has little application to printing papers.
- In a Mullen test (also called a pop test), the paper sample is placed between two ring-like clamps in a device called a Mullen tester, and hydraulic pressure is used to inflate a rubber diaphragm, which expands against the sample stretching it.
- The measure of the total hydraulic pressure expanding the diaphram at the time the sample ruptures (usually expressed in either pounds per square inch or kilopascals) is its bursting strength.
- Mullen tests are typically performed on papers and boards designed for use in packaging, bags, and envelopes. It is rarely performed on printing or writing papers.



12) Water Absorption Tester - COBB Tester

- The Water Absorption Tester - COBB Tester is used for determining **the water absorption of paper.**
- The method describes a procedure for determining the quantity of water absorbed by nonbibulous paper, paperboard, and corrugated fiberboard in a specified time under standardized conditions.

Purpose of Cobb Sizing Test

- Cobb Sizing Tester determined the amount of water or any liquid absorbed by the paper, corrugated fiberboard, and paperboard in a given period of time under some conditions.
- Water absorptiveness is a function of various characteristics of paper or board such as porosity, sizing, etc.
- The high Cobb value of the papers and cardboards indicates the ability of the materials to retain or absorb the moisture.

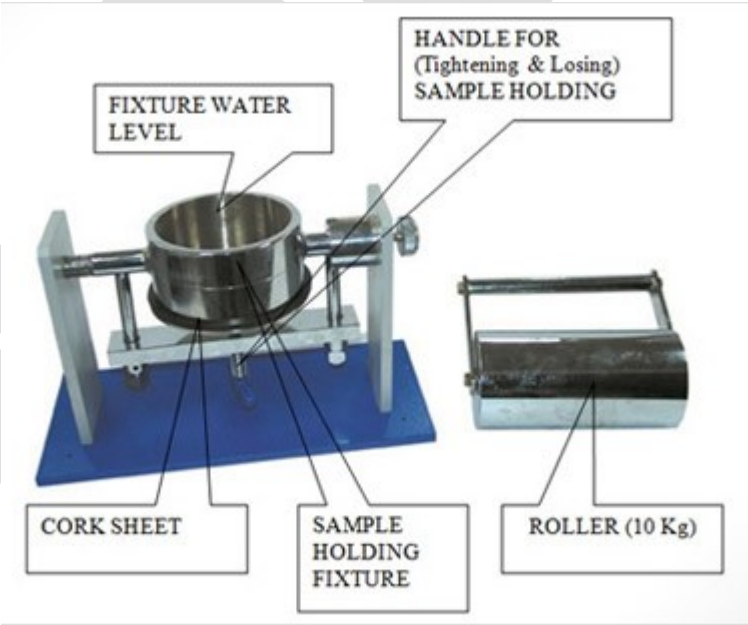
- The test includes examining of the quantity of water absorbed in a particular period of time usually 60 or 180 seconds. by non-bibulous paper having a thickness of 0.1 mm.
- **Water absorbency is quoted in g/m2.**

Standard Operating Procedure of Cobb Sizing Tester

- Easy operation.
- The dry specimen is weighed and placed under a vertical cylinder with an internal cross-section of 100 cm².
- Specimen and cylinder rest on a rubber mat supported on a steel plate.
- Approx. 100 ml of water is poured into the cylinder.
- After a precisely defined time the water is poured out and excess water is removed from the specimen using blotting paper and a roller.
- The specimen is weighed while wet and the amount of water absorbed by 1 m² of specimen material is calculated.

Formula to Calculate COBB value

Cobb Value = Weight of the sample after testing – Weight of the sample before testing



<u>2.3 Dampening solution testing methods:</u>

1) pH -

pH is the measure of acidity or alkalinity of a solution.

The most fundamental acid-base reaction is the dissociation of water:

$$H_2O \longleftrightarrow H^+ + OH^-$$

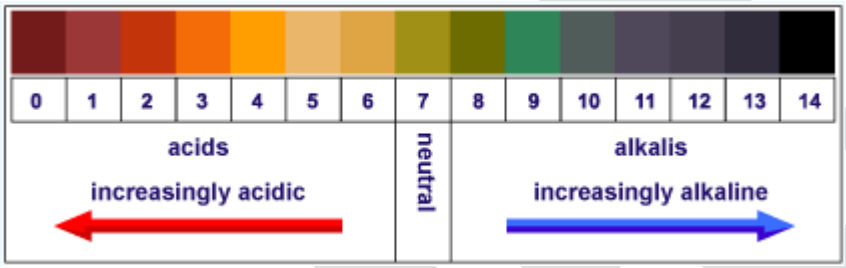
In this reaction, water breaks apart to form a hydrogen ion (H+) and a hydroxyl ion (OH-).

1. [H+] is the molar concentration of hydrogen
2. [OH- is the molar concentration of hydroxide

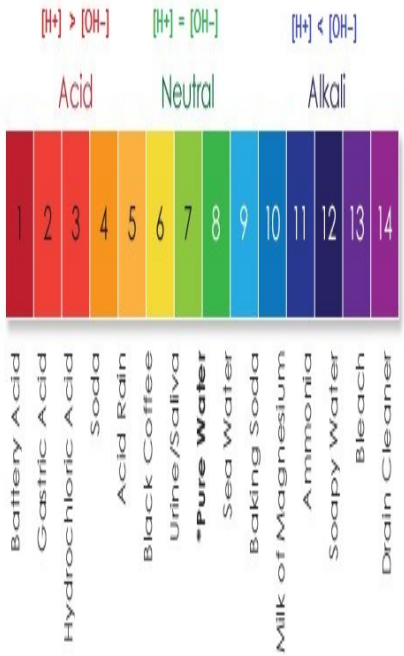
Water actually behaves both like an acid and a base. The acidity or basicity of a substance is defined most typically by the pH value, defined as below:

$$pH = -\log[H^+]$$

- Also, pH is measured in the fountain solutions that are used when printing the paper on the press.
- Measured on a scale of 0 to 14, pH7 being neutral, pH above that is alkaline and below that is acidic.



- The measure of the acidity or alkalinity of a material or solution.
- Maintenance of fountain solution at optimum pH is vital to high-grade, trouble free offset printing.
- 7 is neutral, below 7 is acid, above 7 is alkaline.
- Acid allows the highest quality printing - 4.8 to 5.3 (±2) pH is typically a good range for sheetfed printing.
- The acid side of the table allows gum to adhere to the plate better.



Principle of pH Meter

- pH meter basically works on the fact that interface of two liquids produces a electric potential which can be measured.
- In other words when a liquid inside an enclosure made of glass is placed inside a solution other than that liquid, there exists an electrochemical potential between the two liquids.

pH meter Components:

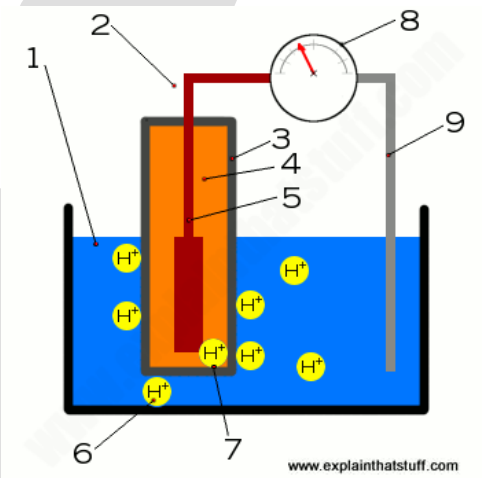
It is basically an electrode consisting of 4 components:

1. **A measuring electrode:** It generates the voltage used to measure pH of the unknown solution.

2. **A Reference Electrode:** It is used to provide a stable zero voltage connection to the complete the whole circuit.
3. **Preamplifier:** It is a signal conditioning device and converts the high impedance pH electrode signal to a low impedance signal.
4. **Transmitter or Analyzer:** It is used to display the sensor's electrical signal and consists of a temperature sensor to compensate for the change in temperature.

Working of pH meter:

- When you dip the two electrodes into the blue test solution, some of the hydrogen ions move toward the outer surface of the glass electrode and replace some of the metal ions inside it, while some of the metal ions move from the glass electrode into the blue solution.



- This ion-swapping process is called **ion exchange**, and it's the key to how a glass electrode works.
- Ion-swapping also takes place on the inside surface of the glass electrode from the orange solution.
- The two solutions on either side of the glass have different acidity, so a different amount of ion-swapping takes place on the two sides of the glass.
- This creates a different degree of hydrogen-ion activity on the two surfaces of the glass, which means a different amount of electrical charge builds up on them.
- This charge difference means a tiny voltage (sometimes called a potential difference, typically a few tens or hundreds of millivolts) appears between the two sides of the glass, which produces a difference in voltage between the silver electrode (5) and the reference electrode (8) that shows up as a measurement on the meter.

Dampening solution that is too acidic has the following effects:

- The printing layer of the plate is fretted resulting in sharp pointed halftone dots.
- The useful life of the plate is impaired.
- Ink drying is delayed. In extreme cases, ink does not dry at all.

The effects of alkaline solutions are:

- High dot increase
- Tendency towards scumming and emulgating
- Inks with metallic pigments will oxydate resulting in blunt quality in printing

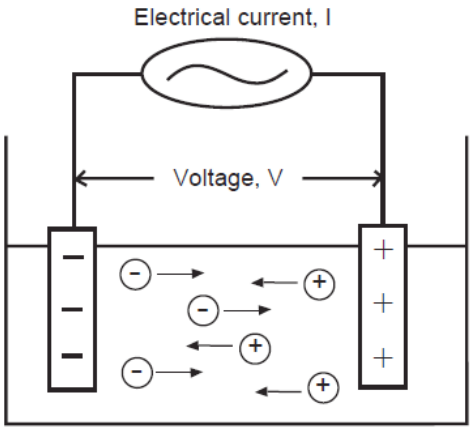
2) Conductivity of a Dampening Solution:

- **Conductivity unit = µS/cm**
- ***Conductivity describes how electricity is conducted through a liquid; impurities in the dampening solution allow conductivity to increase.***
- In water or any solution the degree of conductivity is determined by the amount of minerals and other ions present.
- Conductivity is measured on a linear scale, which is represented by the inverse of resistance. The units of measure are **micromhos.**
- When considering fountain solutions, most conductivities fall in the **1000 to 3000 micromhos** range.
- There are several variables that influence conductivity. Organic solvents such as isopropyl alcohol will reduce the actual conductivity reading.
- A 25 to 30 percent isopropyl alcohol solution can cut the conductivity in half.
- Temperature also influences conductivity. As the temperature goes up, the conductivity goes up, as temperature decreases, so does the conductivity.
- A good rule of thumb, is for every 10° F change in temperature, conductivity will change by 100 micromhos.
- Conductivity should be determined using a “freshly prepared dampening solution”, so that this measure can then serve as a “benchmark” when the dampening solution is later exchanged.
- When the conductivity in the dampening solution has climbed by approx. 1000 µs/cm, this should be taken as a signal that it is time to change the dampening solution.
- In order to guard against printing problems, it is recommended that the dampening solution be renewed every 14 days.

HOW A CONDUCTIVITY METER WORKS

- To measure conductivity we use a machine called a ***conductivity meter.***
- The actual amount of electricity that a given water solution will conduct changes with how far apart the electrodes are and what temperature the water is.
- The meter has a probe with two electrodes, usually 1 centimeter apart.
- The meter is equipped with a probe, usually handheld, for field or on-site measurements.
- After the probe is placed in the liquid to be measured, the meter applies voltage between two electrodes inside the probe.

- Electrical resistance from the solution causes a drop in voltage, which is read by the meter.
- The meter converts this reading to milli- or micromhos or milli- or microSiemens per centimeter.
- This value indicates the total dissolved solids. Total dissolved solids is the amount of solids that can pass through a glass-fiber filter.



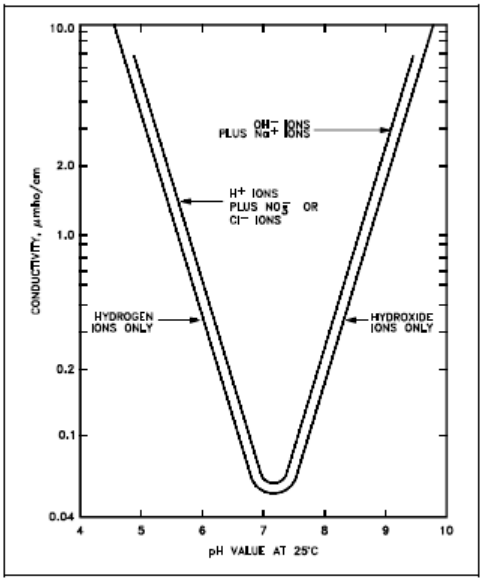


Figure 5 Theoretical Conductivity as a Function of pH

2.4 Ink Testing Methods:

1) Draw Down Test:

- A means of evaluating the color mixing of a printing ink by depositing a layer of the mixed ink on the surface of a substrate using a smooth-edged knife.

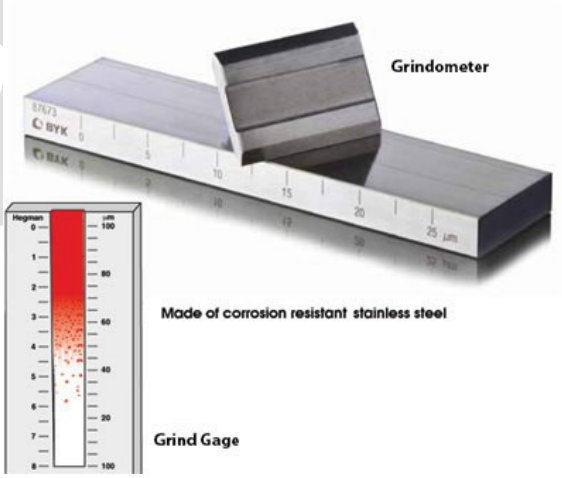
- Drawdown is one of three basic tests used to determine the accuracy of color matching and mixing processes, the compatibility of the various inks combined, the performance of the ink on the substrate, and the drying characteristics of the ink.

- Drawdowns allow easy evaluation of wettability, opacity, color match, gloss, tack strength, drying weight, dye uniformity, degree of pigment dispersion, and other attributes.
- A drawdown is a sample spread of ink that your print provider presses onto a paper.
- For offset printed jobs the drawdown is the best way to see exactly how the ink will look on a given paper.
- There are machines that will create the drawdown, but many shops still just hand roll the ink onto the paper.
- The drawdown is the only truly effective way of seeing how ink will look on a given stock of paper. A drawdown just shows a single ink on a sheet.

- But, perhaps you are ordering a large run, and the paper or ink you are using is a concern. In those instances you might want to ask for a draw-down.

2) Fineness of ink grind – (Grind Gauge)

- Fineness of ink grind is an important parameter that describes the quality of dispersion of the pigments in the ink.
- A grindometer is used to test the fineness of the pigment particles. The lower the particle size the better is the dispersion of the ink.
- The grinding quality of solid materials in coatings, pigment, ink, pharmaceutical or food formulation is essential for optimal dispersion.



- Sheen high precision grindometers are made of hardened stainless steel, for long term durability and reliability.
- Fineness of the ink depends on the wet level of pigment from vehicle, ink mixing, and rolling grind.
- The fineness of the ink will influence the ink rheology, fluidity and stability, printability, is a very important quality spec.

- The bad fineness and big size of solid particle will case clogging in offset printing and gravure printing, it will destroy the plate and scraper.
- And due to non-uniform dispersion of the pigment, the intensity of the color of the ink can not be fully realized. It will influence the ink tinning strength, dry and gloss.

Test Procedure:

- The test consists of placing a small volume of product on the deep end and drawing it with a straight scraper toward the shallow end.
- The position on the scale where oversize particles and their tracks appear can be rated for determination of dispersion.

1) VISCOSITY

- ***Viscosity is a measure of a liquid's ability to resist flow.***
- A thick liquid that does not flow easily has high-viscosity; a thin liquid that readily flows has low-viscosity.
- The viscosity of ink strongly affects how it behaves on the press and is ultimately transferred to the sheet.

Impact of Viscosity

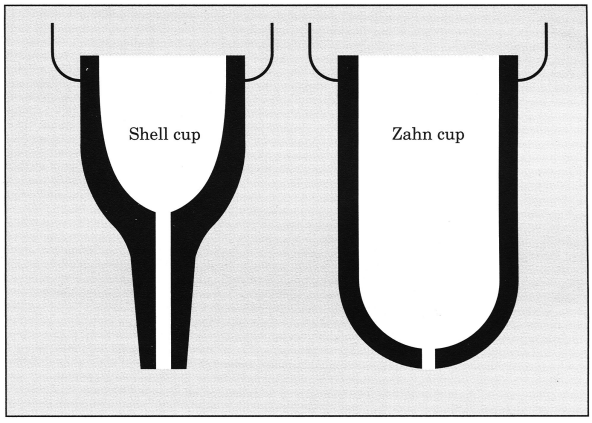
- Throughout a press run, the properties of the ink's viscosity can have several effects, on ink absorption, colour strength and drying.
- Highly viscous inks can be problematic as a result from the amount of tackiness it has; higher ink tack causes difficult image transfer to the substrate.
- With low viscosity, inks become more mobile and tend to flow on the printed substrate; this will often result in issues such as a growth in size of halftone dots,

Working Principle of Viscometer

Efflux Cups

- Essentially, an efflux cup is a container with a hole at the bottom.

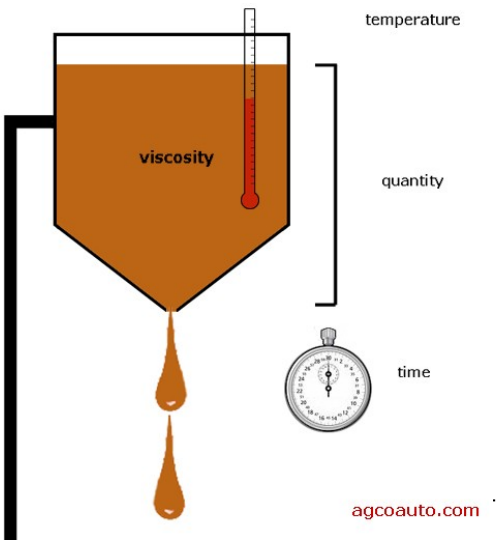
- The cup is lowered into the ink to be measured, then lifted out.
- When the hole is above the surface of the ink reservoir, a stopwatch is started, and the time it takes a fixed quantity to flow out of the hole can be measured.
- Efflux cups come in a variety of shapes and sizes, such as a **Ford Cup, a Zahn Cup, a Shell Cup, and a GRI Hiccup.**
- Each configuration of cup comes with a set of different hole sizes, suitable for inks with a range of viscosities.
- For example, a thicker, more viscous ink requires a larger hole than a thinner, less viscous ink.
- Several different readings should be taken for the same ink and averaged, as long as each reading is within ±0.5 second of each other.



- Shell cups are more accurate than Zahn cups and can detect smaller changes in viscosity.
- Shell cups are also slightly easier to use, as the moment at which ink flow stops is usually clearly apparent.
- Both Shell and Zahn cups are manufactured in a number of sizes. Cups should be selected that will empty within 20-40 seconds.

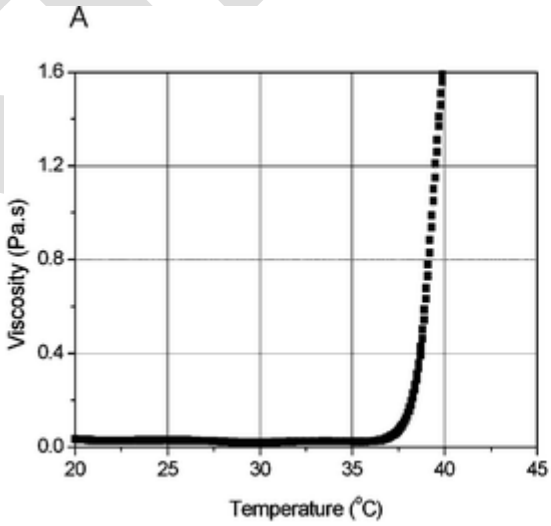
Viscosity Test Procedure

1. Use a clean efflux cup of appropriate size and an accurate stopwatch.
2. Be sure ink is warmed to working temperature.
3. Stir ink well, or circulate ink through the delivery system.
4. Lower the cup into the ink at an angle, allowing the cup to fill without trapping ink.



5. Hold the submerged cup in one hand and the timer in the other. Simultaneously, lift the cup vertically out of the ink and start the timer.
6. Watch the ink flow out of the bottom of the cup. When a break occurs in the stream of ink, stop the timer.
7. Read and record the elapsed time in seconds.
8. Clean the cup.
9. If the ink viscosity needs adjustment, add fresh ink to raise viscosity or dilutent to lower viscosity. Add slowly and in small amounts.
10. Allow sufficient mixing time before testing viscosity again to confirm that it is correct.

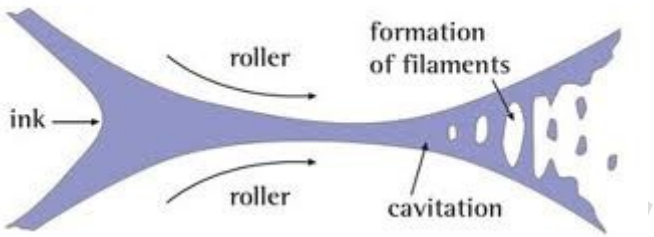
Effect of Temperature on Viscosity



- Fluctuations in temperature can have a drastic impact on the viscosity of ink.
- For example, a temperature increase of 5.5°C can reduce the viscosity of a printing ink by 50 percent or more.
- Colour changes on paper can occur over the course of a press run if the ink is not at its optimum temperature.
- A cold ink, which will be higher in viscosity than an ink at the proper temperature, is also more likely of promoting picking, where ink pulls fibres from the press sheet, resulting in wasted sheets.

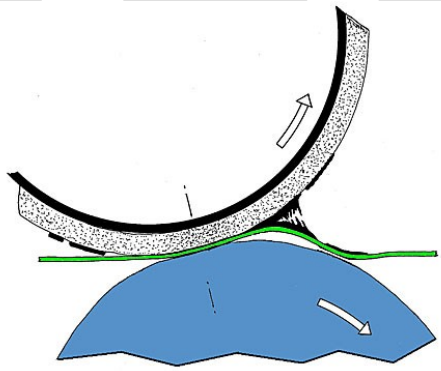
4) Tack

- Tack refers to the stickiness of ink or the force required in splitting an ink film from one surface to another.
- Proper ink tack needs to be achieved in order for the ink film to transfer from the ink train to the printing units and onto the printed substrate.



Impact of Tack

- In offset lithography, inks are formulated to have a high degree of tack to avoid emulsification by the dampening solution.
- The vehicles used during ink formulation determine ink tack and viscosity.
- Offset inks should be as tacky as possible without picking the surface of the paper.
- It should also be noted that to some extreme, picking caused by high tack inks might even tear the substrate.
- To achieve proper ink trap in multi-colour printing, the first ink should have the highest tack value that won't disrupt the substrate surface when printing.

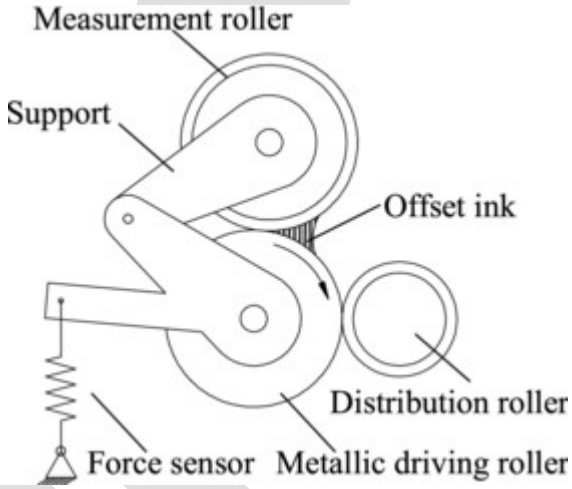


- The succeeding inks should have progressively less tack.
- Increased or insufficient ink tack also influences the reproduction of solids, sharp lines and may cause improper dot gain.
- Ink tack can be influenced by several factors: ink viscosity, press speed and ink film thickness.
- In flexographic and rotogravure printing, low-viscosity inks are used to accommodate high press speeds.
- If high-viscosity ink is used on a high-speed press, it will result in high ink tack and can cause picking.

- By maintaining optimal press speed and roller temperature, ink tack can be controlled.

Working Principle of Inkometer

- A device used to measure the tack, or stickiness, of a printing ink by means of determining the torque produced by a series of rotating inked rollers.
- Inkometers are frequently used to compare and contrast the tack of various inks to be used in wet multi-color printing processes, where the tack of the first ink printed must exceed that of the ink printed on top of it.
- An Inkometer is also called **a Tackoscope.**



- The ink tack commonly is measured on an “Inkometer” by means of a torque measurement.
- The configuration involves two rubber rollers with a brass roller in between.
- Speeds of the Inkometer are set to approximate the printing process.
- That is, typically 800 rpm for sheet-fed and 1,200 rpm for web offset. Temperature is set at 90 deg F.
- Tack is measured 1 min after inks are distributed evenly on the rollers.
- Ink stabilities or “ink length” are compared at 10 min. Typically, sheet-fed inks have tacks of 15, whereas those of web offset inks are 10.
- High quality process printing requires good trapping of the ink colors with predictable trapping to attain the desired colors.

2.5 Introduction to light viewing booth - different light sources in light booth

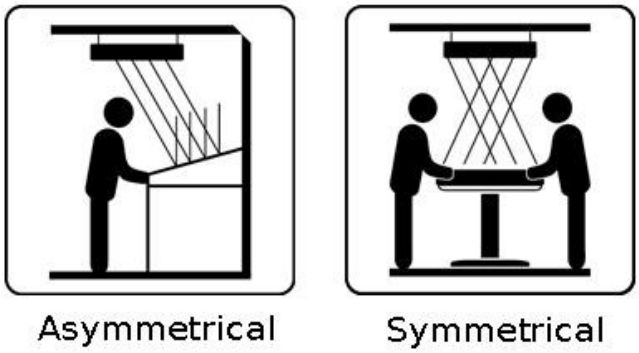
Industry Standard Viewing Conditions

- The Standard, **ISO 3664:2009**, is entitled “Viewing Conditions - Graphic Technology and Photography”.
- This international technical Standard does not specify any lamp, viewer, or fixture.

- Essentially, the Standard specifies five elements:
    1. Light quality
    2. Light intensity
    3. Light evenness
    4. Illuminating/viewing geometry and
    5. Environmental conditions.

ISO 3664:2009 Viewing Conditions

1. **Color Quality:** D50 light, which represents natural daylight, is used to maintain compliance with the standard. Use only ISO 3664:2009 compliant lamps.
2. **Light Intensity:** Color decisions should be under light that is between 1750 and 2250 lux, with 2000 lux being optimum.
3. **Evenness:** Evenness is ensured by measuring illuminance at several evenly distributed points on the viewing surface. Illumination should be at least 1200 lux (60% of 2000) intensity at all points on the viewing surface.
4. **Surround:** ISO 3664:2009 specifies that the surround and backing shall be neutral and matte. Munsell N8/ neutral gray paint is used by GTI Graphic Technology, Inc.
5. **Geometry:** The light source, image, and the observer's eyes need to be positioned to minimize glare. The standard does not specify lighting geometry, but states it should be minimized.



Common light sources:

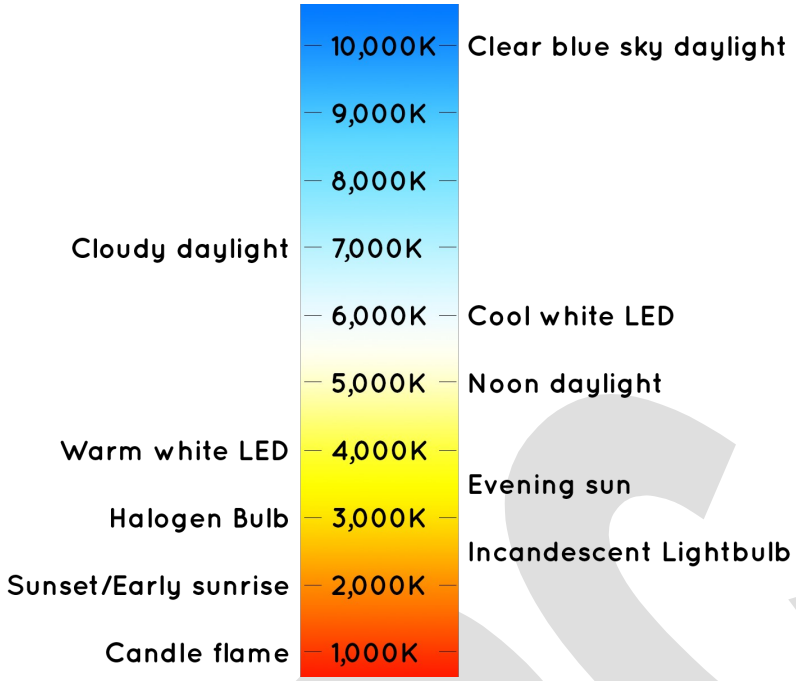
- **D65 (6500K)**
    - A light bluish colored light source used in color matching applications of paints, plastics, textiles, inks, automotive, and other manufactured products.
    - It accentuates blue and subdues green and red.

- D65 is commonly used as a primary light source in color measurement instrumentation.

- **D50 (5000K)**
  - A near white light source used for visual evaluation in printing, packaging, photographic, and other graphic art industries.
  - It has similar amounts of red, green, and blue energy.
  - It neither accentuates nor subdues color, a prime requirement when viewing press sheets and original images (i.e., photographs) since they usually have many colors within the product to be evaluated.

- **LED**
  - As more retail, office, and home environments switch to LED lighting it is becoming increasingly necessary to evaluate color in LED viewing conditions.
  - As a result, it is difficult to ensure consistency of color temperature from lamp-to-lamp, batch-to-batch, and manufacturer- to-manufacturer.
  - LED lamps are best utilized as an optional light source to gauge how the product may appear in an environment illuminated by a similar LED source.

LEDCube D65 D50 A


10,000K
Clear blue sky daylight
9,000K
8,000K
Cloudy daylight
7,000K
6,000K
Cool white LED
5,000K
Noon daylight
Warm white LED
4,000K
Evening sun
Halogen Bulb
3,000K
Incandescent Lightbulb
Sunset/Early sunrise
2,000K
Candle flame
1,000K

Unit - II

2 Mark Question

1. What is pH?

   The degree of acidity or alkalinity of the paper or solution

2. What is GSM?

   Paper is measured in GSM. This stands for 'Grams per Square Meter' and means exactly that ie how many grams a single sheet of paper weighs measuring 1m x 1m.

3. What is RH?

   The level of moisture in the air

4. What is viscosity?

   The degree to which ink resists flow when it is under force, such as in the roller train of a printing press.

5. What is tack?

   The stickiness of ink required to adhere properly to the type of substrate being printed on.

6. What is Bulk?

   Bulk expresses the specific volume of a material. Bulk is the inverse of density.

7. Name instrument measure the humidity.

   Hygrometers or psychrometers

8. Mention name of the instrument measure tear strength.

   Elmendorf Tear Strength Tester

9. Define stiffness

   Paper stiffness is the ability for a sheet of paper to resist bending.

10. Name two paper testing instruments.

    Mullen tester, GSM tester, stiffness tester, tensile strength tester.

11. Define COBB Test.

    The method describes a procedure for determining the quantity of water absorbed by nonbibulous paper, paperboard, and corrugated fiberboard in a specified time under standardized conditions.

12. What is the optimum value of pH to be maintained in fountain solution?

    4.5 to 5.5

13. Mention the uses of grind gauge?

A grindometer is used to test the fineness of the pigment particles. The lower the particle size the better is the dispersion of the ink.

14. What is conductivity?

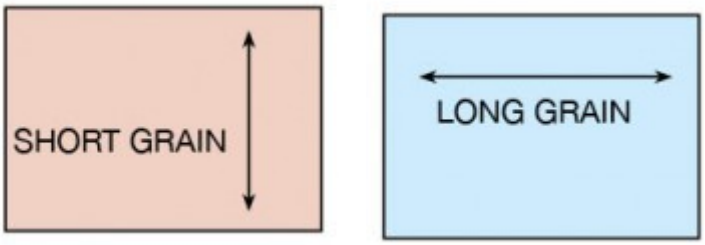
Conductivity describes how electricity is conducted through a liquid; impurities in the dampening solution allow conductivity to increase

15. What are the common light sources?

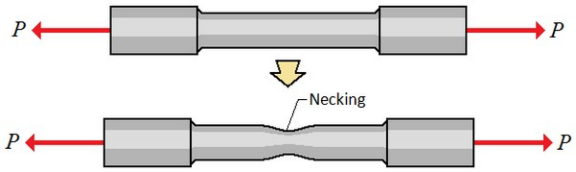
D50, D65 ,LED

3 Mark Question

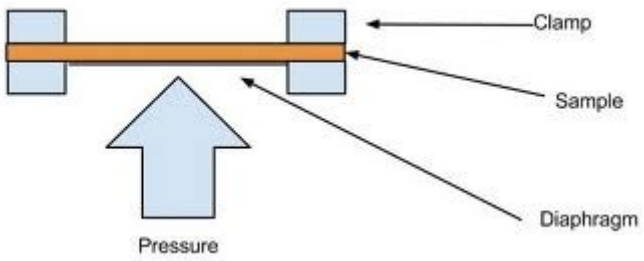
1. What is purpose of inspection?
   - Before accepting paper shipments, printers should inspect all paper for transit damage.
   - They should also enter all damages and shortages on the carrier's delivery receipt and have the damage acknowledged by the carrier's agent.
   - In addition, the printer should retain a signed copy of the inspection report and inform the paper manufacturer and shipper of any transit damage, such as that caused by improper loading or inadequate packaging.
2. What do you mean by proper handling of paper?
   - Handlers should use proper procedures to minimize damage to rolls, skids, and cartons during unloading and storage.
   - Rolls are particularly susceptible to costly handling damage. Bumping, tipping, or dropping a roll only a few inches can flatten it or cause it to become starred or bruised at its edges.
3. Write short notes on paper grain direction.
   - The grain of the paper refers to the direction of **the fibers in a sheet of paper.**
   - **Long grain** paper refers to paper in which the fibers run in the same direction as the longest measurement of the paper.
   - **Short grain** paper refers to paper in which the fibers run in the same direction as the shortest measurement of the paper.



4. What is tensile strength of paper?
   - The ability of the paper to withstand the stress and strain applied to it before breaking down and pulling apart.



   - The tensile force required to produce a rupture in a strip of paperboard, measured in MD &CD, expressed in N/m.
   - Tensile strength is indicative of fiber strength, fiber bonding and fiber length.
   - Tensile strength can be used as a potential indicator of resistance to web breaking during printing or converting.
5. Why do we test folding endurance for packaging materials?
   - A paper property that refers to the ability of a paper to be folded repeatedly without tearing.
   - The number of folds it can withstand before it breaks is its folding endurance.
   - Folding endurance varies according to grain direction, and is greater against the grain.
6. What is Bursting Strength of paper and how it is tested?
   - The bursting strength of a material gives the value of the maximum pressure that can be applied to the packaging materials before it ruptures.
   - The bursting strength of the material is directly proportional to its GSM.



7. Explain the relation between pH and Conductivity.
   - pH measures the concentration H+ ion only, whereas
   - Conductivity measures the concentrations of all active ions present in the solution

- Therefore, pH by itself does not specify the conductivity of the solution, because it does not tell you anything about the presence of other ions that affect the solution conductivity.

8. Explain the use of Drawdown test.
   - Drawdown is one of three basic tests used to determine the accuracy of color matching and mixing processes, the compatibility of the various inks combined, the performance of the ink on the substrate, and the drying characteristics of the ink.
   - Drawdowns allow easy evaluation of wettability, opacity, color match, gloss, tack strength, drying weight, dye uniformity, degree of pigment dispersion, and other attributes.
9. What are the Industry Standard Viewing Conditions?
   1. Light quality
   2. Light intensity
   3. Light evenness
   4. Illuminating/viewing geometry and
   5. Environmental conditions.
10. Calculate 90 GSM Offset Paper to Basis Weight of 25" x 38" size in pounds.

Basis Weight in Pounds = <u>Grams per sq. meter x Basic Size</u>
1406.5

$$\frac{90 \text{ gsm} \times (25 \times 38)}{1406.5} = 60.8 \text{ pounds}$$

<u>10 Mark Question</u>

1. Explain the storage and handling of substrates and chemicals and Maintenance of data sheets of materials.
2. What is Grain direction? and Discuss the testing methods of paper grain direction for the paper sample in the printing industry.
3. Explain in detail about any one dampening solution testing methods with neat sketch.
4. Explain the procedure for testing of ink viscosity by using viscometer with neat sketch.
5. Discuss about importance of tensile strength for incoming materials in packaging industry?
6. What is tack? and explain in detail how to measure it with neat sketch.
7. Explain about tearing resistance tester and folding endurance tester in detail.

8. State the various paper and board property and explain any one in detail with neat diagram?
9. Explain in detail about working principle of pH meter with neat diagram.
10. State various ink tests and explain any one in detail with neat diagram?
11. Write short notes on:

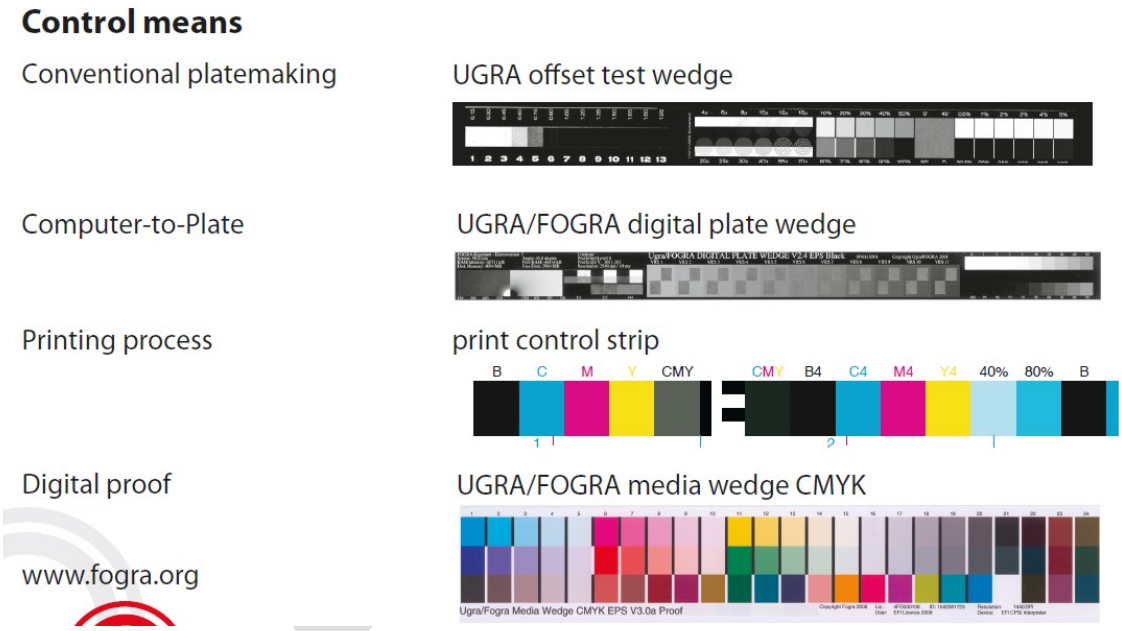
    a) GSM b) RH c) MSDS d) Smoothness
12. Explain in detail about Industry Standard Viewing Conditions and Common light sources used in printing industry.

UNIT - III – PROCESS CONTROL

3.1 QUALITY CONTROL TARGETS

The Quality and Process Control Product Line has been divided into five categories:

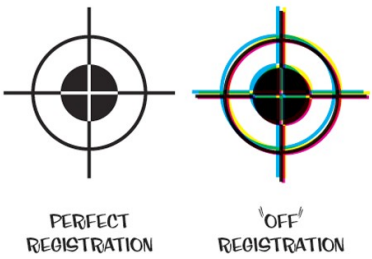
- **Quality Control Devices** include light indicators, color vision testing products, color correction products for photographers, color tolerance tests, and images to check color consistency.
- **Process Control Targets** include control wedges for imagesetters and platesetters, proof control devices and scales, and digital PostScript control targets.
- **Color Control Bars** include single and dual-tiered color bars in multiple lengths that contain neutral-gray patches, solids, tints, total area coverage patches, RGB overprint patches and Star Targets.
- **Test Forms** include measurement forms for sheetfed, web, and digital printing as well as diagnostic forms in sizes from 8.5”x11” to large format.
- **Custom Products** include special “made to order” color bars, test forms, targets, or film-based products with your company’s logo.



1) Registration mark

- ***Registration marks in printing are alignment marks made at the surface of a paper before printing. This lines help in ensuring that the paper to be printed is properly aligned.***
- You may have the most accurate CtP, the best and newest offset press, however, you are still covering absorbent paper with ink and water and squeezing under pressure in

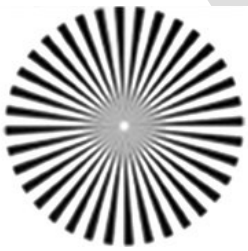
the press. The result is that there will always be a chance of misregistration in the presswork.



- The little circle with a cross through it is printed using every colour of the four-colour printing process.
- If they're being printed accurately, they should overlap precisely so the mark looks entirely black.
- Therefore if any of the colours are slightly offset (out of register) then they'll be displayed, showing the job isn't being printed correctly.
- In multicolor printing, when all the layers of inks are in perfect register, one is not aware of the individual ink layers, only the image created by their combination.
- However, if one or more of the individual ink layers begins to move out of register, the image begins to appear softer, with lower detail definition.

2) Star target

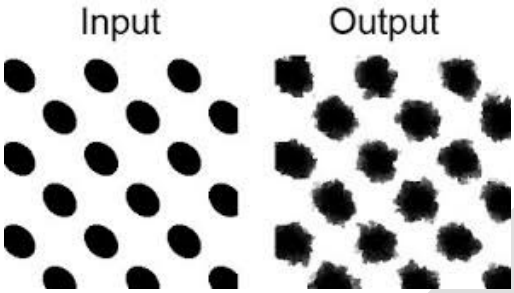
- ***The star target appears along with the color bar and helps the pressman detect any irregularity in the ink spread.***
- The star target consists of a circle formed of alternating positive and negative pie-shaped wedges tapering toward the center at a known angle.
- Having many stars across the field of view allows the best focus across the field of view to be determined while simultaneously analyzing horizontal and vertical information at a variety of resolutions.



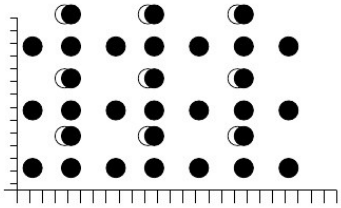
The GATF Star Targets

Slur targets are used to check for movement of the plate or sheet. The GATF Star Target is used to detect slur, as well as dot gain, and image doubling and spreading.

- **Slurring and doubling** are print defects that occur when halftone dots and type blur as a result of a slight second contact or movement between press cylinders or the paper and blanket.
- **Doubling** is normally due to incorrect setting or worn grippers, allowing movement from unit to unit.
- **Slurring** is excessive squeezing of the halftone dot, this is normally movement between plate and blanket or blanket and paper. Both can be lateral and circumferential.



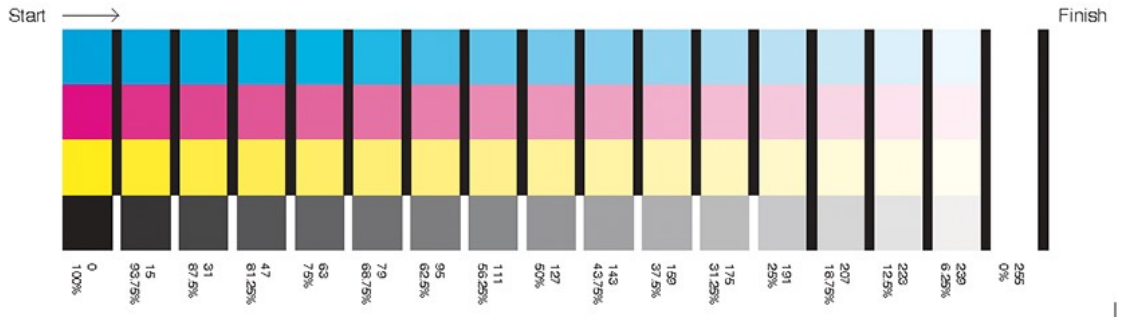
Doubling:



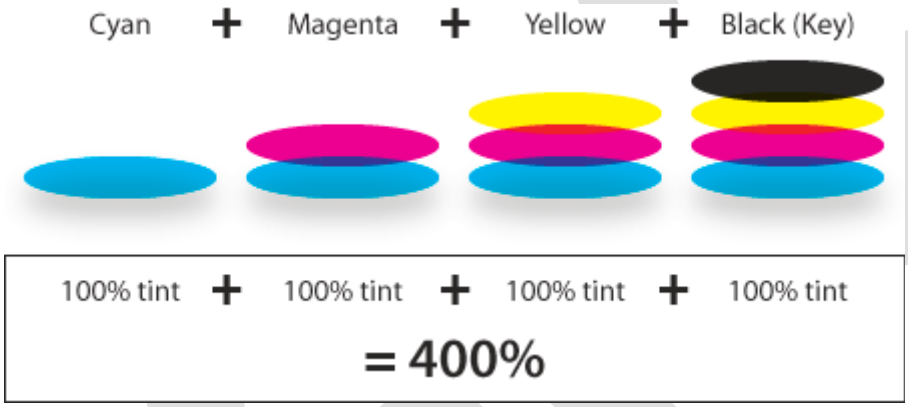
- The Star Target amplifies the effect of gain, slur, doubling, paper movement, so that small distortions in print can be easily seen by the operator. The indicator is visual; there is no way to quantify the result.

3) Ink coverage target

- ***The amount of ink printed on a sheet. Generally indicated by percentage***
- Each CMYK pixel is created using a percentage of each ink color.
- The more percentages are used to create the color of a pixel, the darker the pixel will get and the higher the ink coverage for that pixel will become**. The ink coverage is the total percentage of ink of a pixel.**
- There is one thing you need to know about ink coverage: you can have too much of it.
- If you want to create a dark color, like a very dark red, you might choose to create this color using 80% cyan, 100% Magenta, 80% yellow and 100% black. This would add up to a total ink coverage of 360%.
- This value is too high meaning too much ink is used for this pixel. It may cause it to spread, blend with neighbouring pixels and eventually smear
- To avoid this, you should use a maximum ink coverage of 330%. This is an absolute maximum. To be on the safe side, using 300% as a maximum target ink coverage is smart.



- The amount of ink that may be printed in a single pass depends on the number of inks set up for the job.
- Most jobs are printed in CMYK process colors and therefore can range to 400% ink coverage (see graphic below).

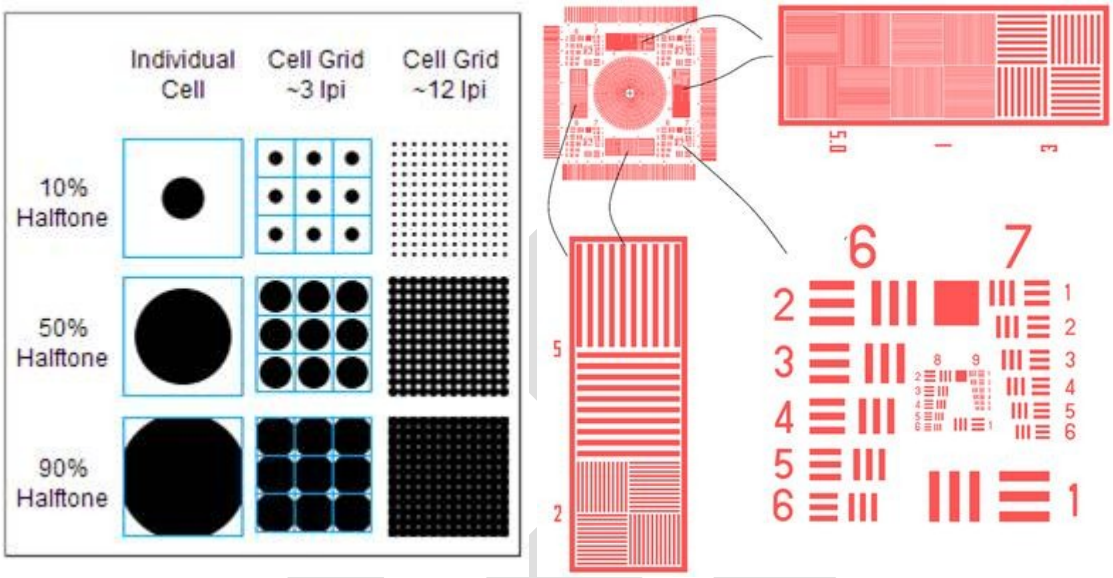


- Two other considerations of ink coverage are drying time (the speed at which a print press can run as each printed sheet is laid on top of the other) and the volume of ink used.
- Both have cost implications, usually for larger print runs, but could also impinge on the speed of turn-around from the printers.

4) Line resolution target

- ***The Line Resolution Target is an effective tool used for monitoring daily performance of film or plate-making.***
- It is used to determine proper exposure, processing, tone reproduction, exposure latitude, and resolving power of both positive and negative working light sensitive systems. It helps to quickly evaluate an unknown film or plate.
- A transparent screen which has been etched with fine lines. It is used to convert a picture or photograph into a halftone dot pattern so that it can be printed.
- Lines per inch (LPI) is a measurement of printing resolution. A line consists of halftones that is built up by physical ink dots made by the printer device to create different tones.

- Specifically LPI is a measure of how close together the lines in a halftone grid are. The quality of printer device or screen determines how high the LPI will be. High LPI indicates greater detail and sharpness.
- Because halftone images are printed as a series of dots, the higher the LPI number, the more dense the dots can be, resulting in a finer resolution.
- Newspapers are typically printed in a resolution of 85 lpi, while magazines may use 133 lpi or higher. Because the naked eye can distinguish halftone dots up to about 120 lpi, you are more likely to notice the dots in newspaper print than in magazines.



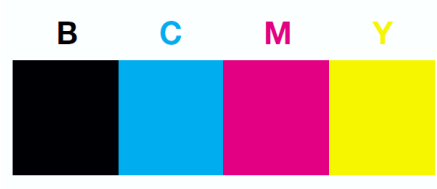
3.2 Print control Patches (Print control strip)

- Print Control Strips in offset printing are used to help printer controlling color thru whole process of printing and at the end we have a quality printed product.
- This control strips are usually put across the edge of the printed sheet containing various test elements for each of the four colors.
- They are used by proofers and press operators to control the trapping, ink density, dot gain, print contrast and CIE lab.
- These test strips, called **print control strips or color bars,** are available commercially from FOGRA, BRUNNER, etc. and consist of strips of film containing the various test elements for each of the four colors.
- In some cases six color versions are available when special colors might be used.

- Print control strip – the most important control tool mean for printing

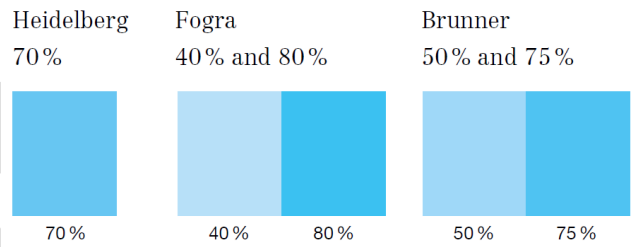
1) Solid patches

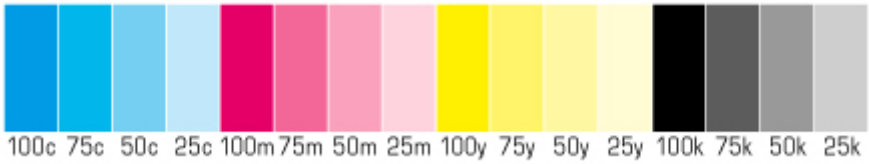
- In each ink zone there is a solid for every colour.
- Solids enable the uniformity of the inking to be checked across the entire image width.
- Solid patches enable the uniformity of the inking to be checked.
- It is advisable to use one solid field per printing ink spaced at the distance of the ink fountain zone width (32. 5 mm for Heidelberg).
- This makes it possible to use solid fields for the automatic calorimetric control of solids.



2) Halftone patches

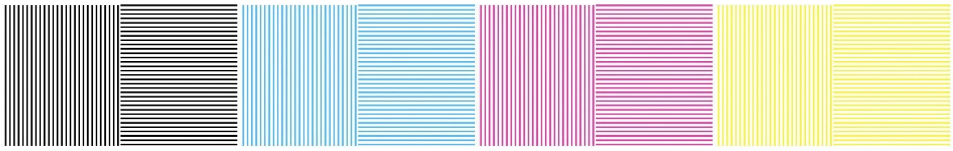
- **FOGRA:** These patches contain circular dots of 40% and 80% halftone value with a screen value of 150lpi. They are especially designed for measuring dot gain and print contrast.
- **Brunner:** Uses a 50% fine halftone dot at 150lpi. The patches also check positive and negative highlight dots down to a size of 0.5%.
- These targets are used to monitor the way the dot is printed. For example, if the original had a dot area of 50% and the resulting printed dot area was 70%, the dot gain would be 20%.





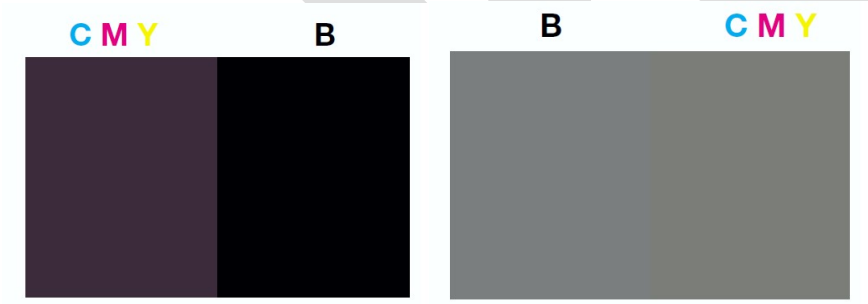
3) Slur/doubling patches

- Slur targets may consist of either radial or horizontal and vertical lines that blend together if slurring is occurring on the press.
- The direction of the blending indicates if the slur is lateral or longitudinal.
- Uses screen angles of 30 degrees right and 30 degrees left. Allows dot gain to be shown visually with slur and doubling.



4) Grey balance patches

- Balance patches consisting of the three color halftones at about 50% dot are used to visually check color balance.
- Given correct solid density and a normal dot gain approximately 15% the CMY halftone field gives a neutral gray.
- This corresponds in line to the black halftone patch on its left.
- In solid patches, the superimposition of cyan, magenta and yellow must result in an approximately neutral black.
- For purposes of comparison, a black solid field is printed next to the overprint field.
- Colour balance patches are also used for the automatic gray balance control of cyan, magenta and yellow.

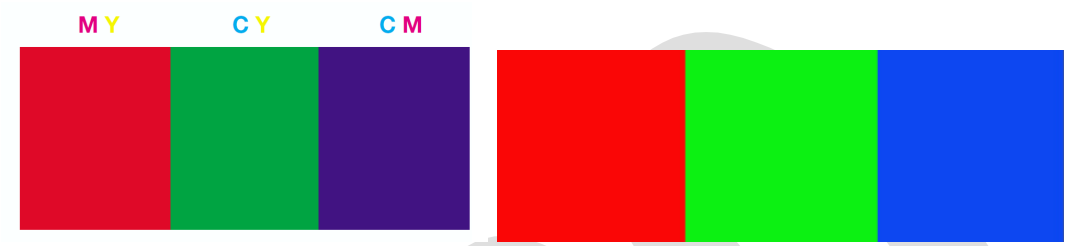


Offset CMY Gray Balance				Black Tint Equivalent
C	M	Y	K	K
25%	18%	18%	0%	25% (Quartertone)
40%	30%	30%	0%	50% (Midtone)

5) Solid overprint patches

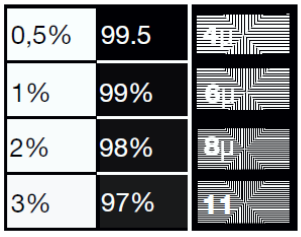
- The four-colour print control strip contains measuring patches for assessing the ink trapping in two- and three-colour overprinting.
- These elements are designed for the visual and densitometric assessment of the ink trapping performance.

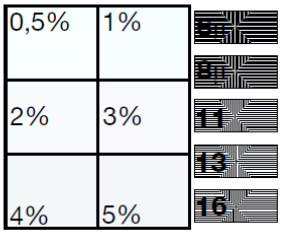
- Printing targets have solids are overprinted on top of each other, yellow on magenta, yellow on cyan, magenta on cyan.
- It monitor each ink will adhere to the previous ink that was printed rather than lifting it from the paper.
- These patches, together with patches of the component single colors, are then measured with a densitometer and a calculation is made to give a percentage trap figure. This is then a measure of how well the inks are “sticking” to each other.



6) Plate exposure control patches

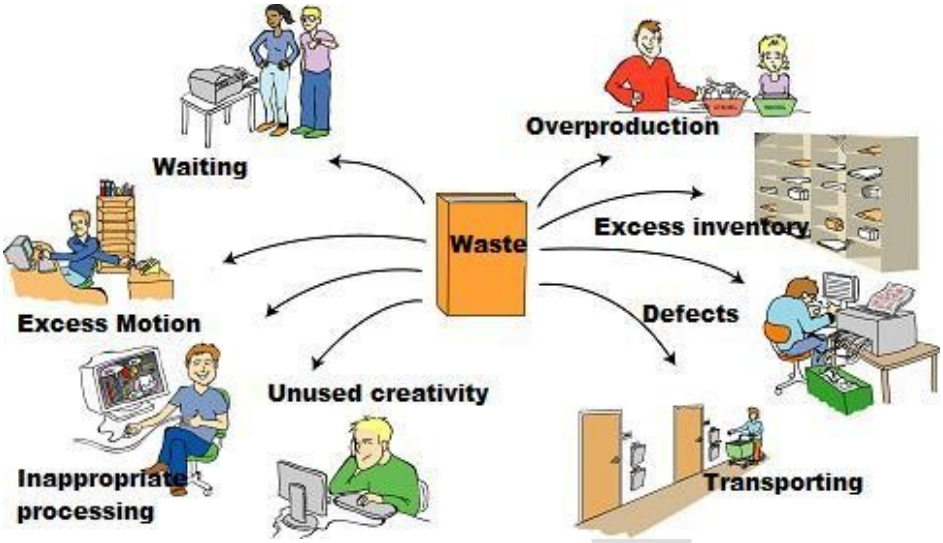
- The plate exposure target usually consists of very small patterns such as microlines and/or microdots, these are graduated in size ranging from six to thirty microns.
- By examining the plate and finding the limit of reproduction of these micro elements, usually about ten microns, the vacuum frame drawdown time and the plate exposure duration and uniformity can be monitored.





3.3 WASTAGE MINIMIZATION

1. Reduction of waste from over production
2. Inventory
3. Defects
4. Waiting time and delay
5. Accumulation of work in process
6. Transport (logistic)
7. Motions



1. Reduction of waste from over production:

- ***Producing more than is needed.***
- Any resources expended unnecessarily are considered waste, and producing product when it is not needed is a common waste in manufacturing.
- This can occur due to poor production planning and control, or it may result from improper incentive systems that reward overproduction.

2. Inventory:

- ***All idle resources are wasteful, and inventory is one of the most common.***
- Raw materials, Work in Progress (WIP) and Finished Goods inventories require significant capital investments, but add no value to the product.
- Some may argue that having product on hand so it can ship immediately adds value to the customer.
- Short lead times add value, but holding inventory does not.
- The goal of lean is to achieve the value desired, such as short lead times, without any waste, such as high inventory levels.

3. Waiting time and delay:

- ***Whenever materials, people or machines are sitting idle.***
- Waiting occurs when queues are built within processes, or when the time required for workers or machines to conduct a value added process is out of sync with each other.
- In these situations, one of the resources is waiting, and waste is occurring.
- Ideally, every resource would be put to productive use 100% of the time it is required.
- Any time a resource spends idle represents lost capacity and productivity, and increases lead time to the customer.

4. Transportation: *(logistic)*

- Material movement that does not move the product to the customer.
- The definitions of waste and value vary within the lean community.
- There are some who consider all transportation costs as waste.
- Others consider some transportation as value added since a product is more valuable to a customer once it is delivered to the customer.
- Regardless of the view on transportation, minimizing transport costs is a goal of lean.

5. Accumulation of work in process:

- ***Excessive processing includes any activity that provides no additional value to a product or service.***
- Often, excessive processing occurs when an individual processing operation can be combined with other processes or can be eliminated all together.
- For example, packaging processes do not add any value to a product.

6. Motion:

- ***Any movement, of people, machines or materials that does not add value to a product.***
- The elimination of motion was one the major drivers that led to the development of cellular manufacturing techniques.
- With these techniques, production is completed in a small work cell combining multiple operations with little to no movement between each operation, and without excess motion expended by the worker.

7. Defects:

- ***Poor quality drives up costs both in wasted materials and labor.***
- Lean manufacturing draws heavily on total quality techniques and seeks to ensure every activity delivers value.
- Defects disrupt this process, causing materials and labor to be lost.
- More recently, reducing waste and eliminating defects have taken a major step forward with the development of six sigma techniques.
- Six sigma tools compliment the lean framework, and many practitioners describe the combination as Lean Six Sigma.

3.4 Process control charts - recording, monitoring and controlling procedure.

- The control chart is a graph used to study how a process changes over time. Data are plotted in time order.

- A control chart always has a central line for the average, an upper line for the upper control limit and a lower line for the lower control limit. These lines are determined from historical data.
- By comparing current data to these lines, you can draw conclusions about whether the process variation is consistent (in control) or is unpredictable (out of control, affected by special causes of variation).

8 steps to Creating an X-bar and R Control Chart

1. Determine Sample Plan

Determine the sample size, n, and frequency of sampling. Consider the cost of sampling, required resources, and balance with minimizing time (and produced units) between measurements. Of course, more samples and more frequent measurements is better statistically.

2. Collect initial set of samples

Shewhart recommended 100 individual units in 25 samples of 4 each. Basically, we want enough samples to create reasonable estimates of the mean values of $\ddot{X}$ and R. Keep the data in time sequence following the time of the sample selection, which should be in the same order of manufacture.

3. Calculate $\ddot{X}$

Calculate the average for each set of samples. This is the $\ddot{X}$ for each sample.

$$\bar{X} = \frac{\sum X_i}{n} = \frac{X_1 + X_2 + \ldots X_n}{n}$$

where n is the subgroup size.

4. Calculate R

Calculate the range of each set of samples. This is the difference between the largest and smallest value in the sample.

$$R = Xmax - Xmin$$

5. Calculate X double bar

Calculate the average of the $\ddot{X}$'s. This is the centerline of the $\ddot{X}$ control chart.

Calculate the overall process average (Xdbar):

$$\bar{\bar{X}} = \frac{\sum \bar{X}_i}{k} = \frac{\bar{X}_1 + \bar{X}_2 + \ldots \bar{X}_k}{k}$$

6. Calculate $\bar{R}$

Calculate the average of the R values. This is the centerline of the R control chart.

Calculate the average range (Rbar):

$$\bar{R} = \frac{\sum R_i}{k} = \frac{R_1 + R_2 + \ldots R_k}{k}$$

7. Calculate Control Limits

Calculate the control limits for the R chart. The upper control limit is given by UCLr. The lower control limit is given by LCLr.

$$UCLr = D_4 \bar{R}$$

$$LCLr = D_3 \bar{R}$$

Calculate the control limits for the X chart. The upper control limit is given by UCLx. The lower control limit is given by LCLx.

$$UCLx = \bar{\bar{X}} + A_2 \bar{R}$$

$$LCLx = \bar{\bar{X}} - A_2 \bar{R}$$

where A2, D4, D3, are control chart constants that depend on subgroup size.

Example of x-bar and R charts: Step 2. Determine Control Limit Formulas and Necessary Tabled Values

$\bar{x}$ Chart Control Limits

$$UCL = \bar{\bar{x}} + A_2 \bar{R}$$

$$LCL = \bar{\bar{x}} - A_2 \bar{R}$$

R Chart Control Limits

$$UCL = D_4 \bar{R}$$

$$LCL = D_3 \bar{R}$$

n	A2	D3	D4
2	1.88	0	3.27
3	1.02	0	2.57
4	0.73	0	2.28
5	0.58	0	2.11
6	0.48	0	2.00
7	0.42	0.08	1.92
8	0.37	0.14	1.86
9	0.34	0.18	1.82
10	0.31	0.22	1.78
11	0.29	0.26	1.74

8. Plot the data

With the control limits in place, gather samples, and plot the data. Look for special or assignable causes and adjust the process as necessary to maintain a stable and in control process.

X-BAR AND R CHART: EXAMPLE

The following is an example of how the control limits are computed for an x-bar and R chart. Note that at least 25 sample subgroups should used to get an accurate measure of the process variation. The subgroup sample size used here is 3, but it can range from 2 to about 10–12 and is typically around 5.

	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5
	11.1	10.1	9.8	11.3	11.2
	9.2	11.2	10.2	10.1	9.4
	11.3	9.9	9.9	10.1	8.9
x-bar	10.5	10.4	10.0	10.5	9.8
R	2.1	1.3	0.4	1.2	2.3

R Chart

$$\text{Centerline} = \bar{R} = \frac{2.1 + 1.3 + 0.4 + 1.2 + 2.3}{5} = \frac{7.3}{5} = 1.46$$

$$\text{Upper Control Limit} = UCL = D_4(\bar{R}) = 2.57(1.46) = 3.75$$

$$\text{Lower Control Limit} = LCL = D_3(\bar{R}) = 0(1.46) = 0$$

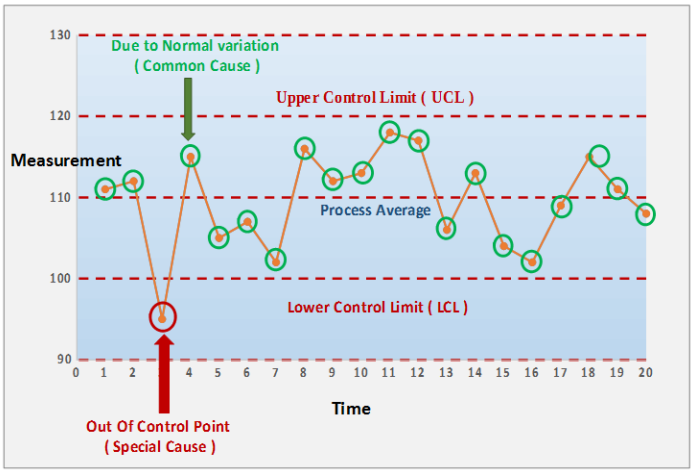
x-bar Chart

$$\text{Centerline} = \bar{\bar{x}} = \frac{10.5 + 10.4 + 10.0 + 10.5 + 9.8}{5} = 10.24$$

$$\text{Upper Control Limit} = \bar{\bar{x}} + A_2(\bar{R}) = 10.24 + 1.02(1.46) = 11.73$$

$$\text{Lower Control Limit} = \bar{\bar{x}} - A_2(\bar{R}) = 10.24 - 1.02(1.46) = 8.75$$

where A2, D4, D3, are control chart constants that depend on subgroup size.



Process Control Controlling Procedure

- Depending on the user, the results of a scanned or measured color can be displayed in a customized way.
- Machine operators just measure a color bar and software shows an understandable view that visualizes the overall quality of the print.
- The parameters are presented in such a way that the printer intuitional understands what to do to optimize the print quality.
- At the same time all data is centrally stored in the database for further process analysis or for a customer job quality report
- Quality Assurance managers and color specialists can review all aspects of color via the Gamut, Dot gain, Spot, and Trending views without remeasuring the printed samples.
- Software examines all aspects of color from Spectral Curve, CIE-Lab, Dot Gain, Spectral Gray Balance, Solid Ink Densities, and Overprints for Process, Spot, and Extended Gamut Colors.
- By clicking on a specific job, color or ink zone, the color specialist can analyze all aspects of any measured color.


FL001 / Flexo job test
2014-Jul-16 15:27
Measurement 3 of 19
Ok sheet:
Currently displayed
Job mode:
Production
0% / 89%
Score
Job score
Measured
(?/Colorware admin)
Overview
Tune
Solids
TVI
Other
Previous delta-E
Current delta-E
L
M
R
Solids
TVI 80%
TVI 70%
TVI 60%
TVI 50%
TVI 40%
Measurement Score trend
(3/19)
Remarks for this measurement
Jobs
Overview
Gamut
Trends
Import
Devices
Measure

Unit - III

2 Mark Question

1. Name two quality control targets.

   Registration mark, star target, ink coverage target & line resolution target

2. What is Grey balance?

   The superimposition of cyan, magenta and yellow must result in an approximately neutral black compared with normal solid black.

3. What is the purpose of minimize the wastage?

   Help to protect the environment, its saves money, create safer working conditions for employee and protects human health and environment.

4. Define slurring/doubling.

   It is an error in the printed product of offset printing which manifests itself through changes in geometry of the image elements.

5. What is star target?

   The star target appears along with the color bar and helps the pressman detect any irregularity in the ink spread.

6. Mention any two name of color control bar.

   FOGRA, BRUNNER, Heidelberg

7. Mention any two factors affect print result.

   Rolling and printing pressure, blankets and underlays, dampening & printing inks and additives.

8. What is the use of process control chart?

   The control chart is a graph used to study how a process changes over time. Data are plotted in time order.

9. What is meant by line resolution target?

   The Line Resolution Target is an effective tool used for monitoring daily performance of film or plate-making.

10. Mention the formula for the X bar.

$$\bar{X} = \frac{\sum X_i}{n} = \frac{X_1 + X_2 + \ldots X_n}{n}$$

11. Calculate Total Ink Coverage for 80% cyan, 60% Magenta, 70% yellow and 35% black.

    TIC = %C+%M+%Y+%B

    = 80 + 60+ 70+ 35

    = 245%

12. What is meant by accumulation of work in process?

Excessive processing includes any activity that provides no additional value to a product or service.

3 Mark Question

1. List down the quality control products for prepress operations.

Quality Control Devices include light indicators, color vision testing products, color correction products for photographers, color tolerance tests, and images to check color consistency.

2. Explain Registration Mark.

Registration marks in printing are alignment marks made at the surface of a paper before printing. This lines help in ensuring that the paper to be printed is properly aligned.

3. List down the patches in color control bar.

Control patches – Solid patches, Halftone, Slur/Doubling, Gray Balance, Solid overprint and Plate exposure control patches.

4. What is LPI?

Lines per inch (LPI) is a measurement of printing resolution. A line consists of halftones that is built up by physical ink dots made by the printer device to create different tones

5. Why we use solid overprint patches in Print control strip?
   - The four-colour print control strip contains measuring patches for assessing the ink trapping in two- and three-colour overprinting.
   - These elements are designed for the visual and densitometric assessment of the ink trapping performance.
   - Printing targets have solids are overprinted on top of each other, yellow on magenta, yellow on cyan, magenta on cyan.
6. How will reduce of waste from over production?
   - Producing more than is needed.
   - Any resources expended unnecessarily are considered waste, and producing product when it is not needed is a common waste in manufacturing.
   - This can occur due to poor production planning and control, or it may result from improper incentive systems that reward overproduction.
7. Mention the formula for control limits for X bar chart and R chart.

$\bar{x}$ Chart Control Limits	R Chart Control Limits
$UCL = \bar{\bar{x}} + A_2\bar{R}$	$UCL = D_4\bar{R}$
$LCL = \bar{\bar{x}} - A_2\bar{R}$	$LCL = D_3\bar{R}$

8. What are the uses of print control patches?

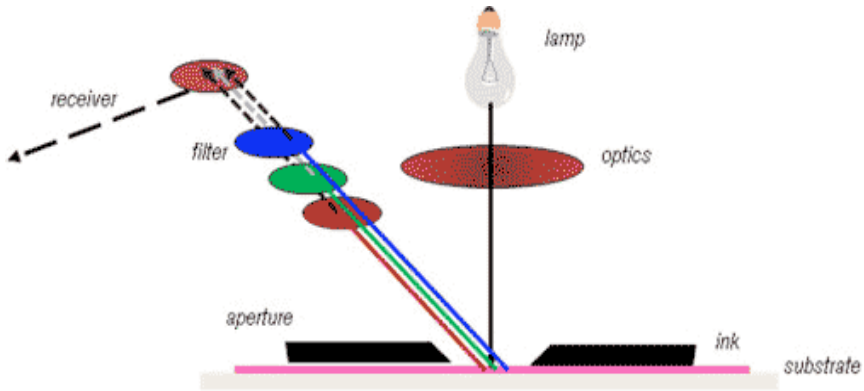
- Print Control Strips in offset printing are used to help printer controlling color thru whole process of printing and at the end we have a quality printed product.
- This control strips are usually put across the edge of the printed sheet containing various test elements for each of the four colors.
- They are used by proofers and press operators to control the trapping, ink density, dot gain, print contrast and CIE lab.

10 Mark Question

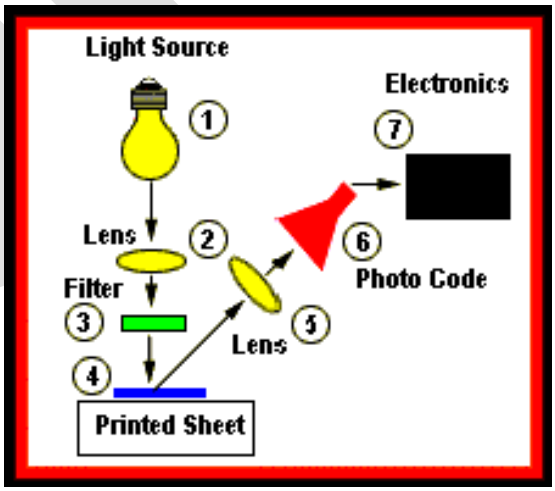
1. Explain in detail any two quality control targets with neat diagram.
2. Explain about print control strip in four color printing with neat diagram
3. Explain in detail about wastage minimization in printing industry.
4. Describe the process control charts controlling procedure with neat diagram.
5. Discuss in detail steps to Creating an X-bar and R Control Chart with example.
6. Write short notes on 1) Registration mark 2) Star target 3) SID 4) Dot gain.

UNIT - IV – CALIBRATION OF INSTRUMENTS AND PROFILE

4.1 DENSITOMETERS



- A densitometer is a device that measures the degree of darkness (the optical density) of a photographic or semitransparent material (film) or of a reflecting surface (paper).
- A densitometer does not measure color but measures density.
- In print work, density is caused by the light-stopping ability of the pigments in the printing ink that are deposited on the paper by the printing process.
- Densitometers are widely used in the graphics industry to help control color in each step of the printing process.



Types of Densitometers

- Reflection
- Transmission
- Combination

Uses for Densitometers

- Densitometers used for process control of density, dot gain (TVI), dot area, print characteristics, print contrast, CIE Lab value and ink trap.

Working principle of a reflection densitometer

1. Within a densitometer the light passes through the optical system bundled from a stabilized **light source** on the printed surface.
2. The amount light absorbed depends on the ink density and pigmenting of the ink.
3. The non-absorbed light penetrates the translucent (transparent) ink layer and is weakened.

4. The remainder is re-emitted by the surface of the material, i.e. diffusely reflected or scattered A part of this scattered light passes through the ink layer and is weakened again.

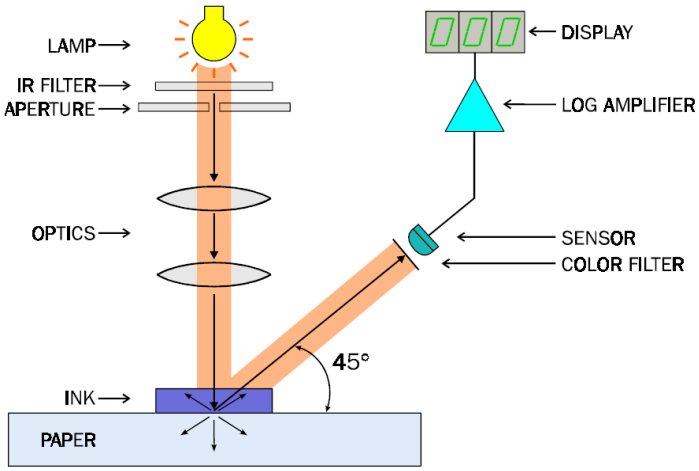
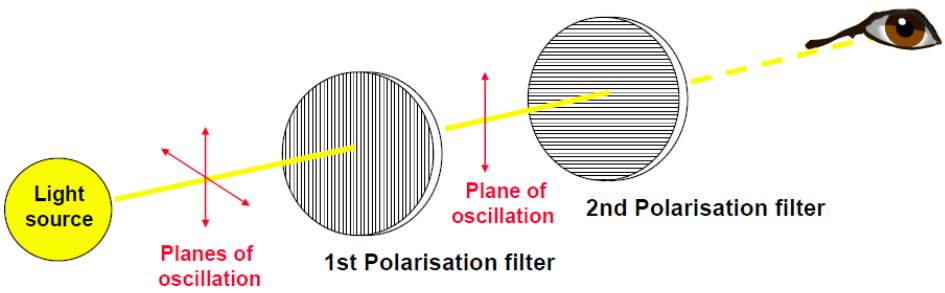


Figure 3: Components of a Reflection

5. **A lens system** captures the light rays coming from the ink layer and sends them to a photodiode.
6. The light striking **the photodiode** is converted into electric energy.
7. The electronics compares this current with a reference value.
8. The difference between the measured current and the reference value forms the basis for calculating the absorption behavior of the measured ink layer.

Basic other components

1. **Polarisation filters** serve to prevent differences in the measured values obtained from a shining wet surface and from the surface of a dry ink.

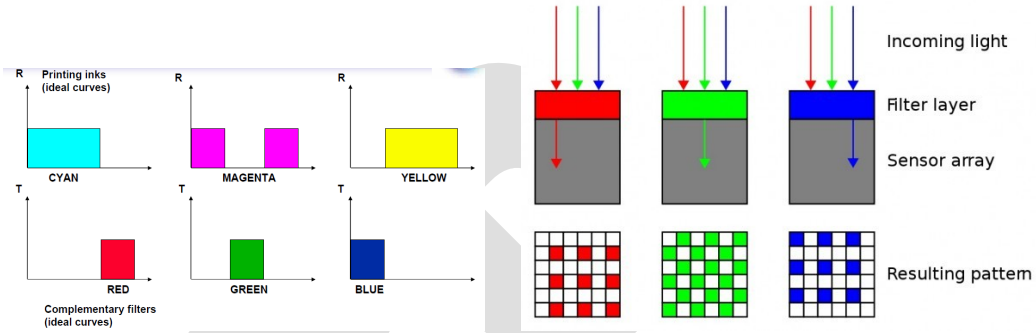


During the drying process, the ink adapts to the irregular structure of the paper surface, and the reflection effect decreases. If a given ink is measured first in wet and then in dry condition, different readings will result.

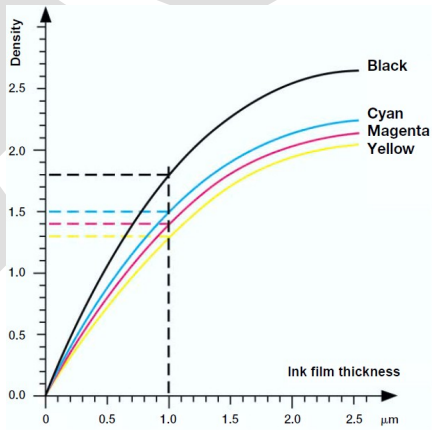
In order to eliminate this effect, two crossed linear polarisation filters are inserted in the path of the rays. Polarisation filters allow the light of only one particular vibration direction to pass, while blocking all light waves which are vibrating in other directions.

2. **Colour filters** are inserted for measurements of colours. The colour filters in a densitometer are tuned to the absorption performance of cyan, magenta and yellow.

Printing inks	Filter colour
cyan	red
magenta	green
yellow	blue



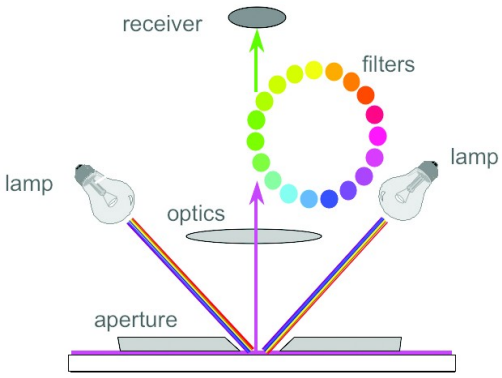
- In our example a red filter is used which allows only red light to pass, whereas blue and green are blocked.
- The density of a given ink mainly depends on the pigmentation, its concentration and its ink film thickness.
- The diagram illustrates the correlation between ink film thickness and ink density for the four process colours in offset printing.

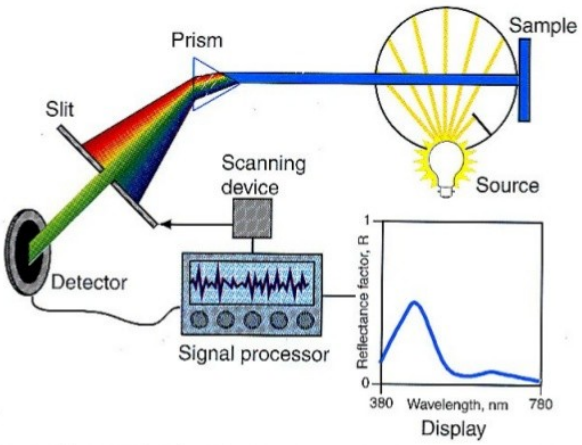


4.2 SPECTROPHOTOMETERS

- ***A spectrophotometer is a device for measuring light intensity by measuring the wavelength of light.***

- The most common application of spectrophotometers in the printing industry is the measurement of light absorption.

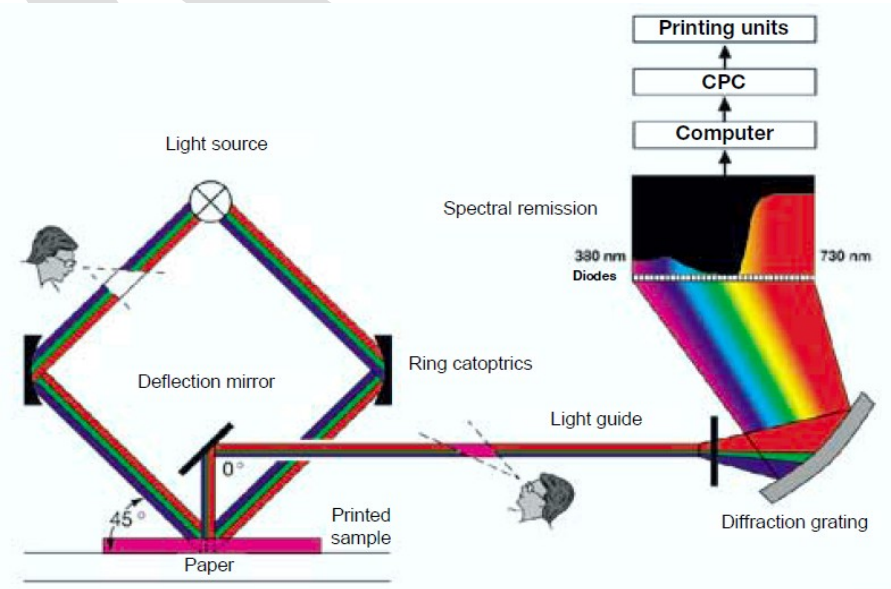




A scanning spectrophotometer using a prism to disperse the light.

Working principle of Spectrophotometers:

1. Place the spectro on the sample and click the button to measure.
2. The spectro projects a light onto the sample's surface.
3. The sample absorbs some of the light and reflects the rest into a set of filters.
4. The spectrophotometer measures that reflected light at many different points to capture the fingerprint, or signature, of the sample and presents it as a reflectance curve.
5. The reflectance curves of samples can be compared to the reflectance curves of standards to determine even the most minute color differences.
6. This is how manufacturers determine whether the color they're producing is on target.



Basic components:

1) Light source

- Two kinds of lamps, a **Deuterium** for measurement in the **ultraviolet range** and a **tungsten lamp** for measurement in the **visible and near-infrared ranges**, are used as the light sources of a spectrophotometer.
- The **standard illuminants A, C, D50 or D65** and the standard **observers 2° and 10°** can be used.

Spectroscope

- A spectroscope plays a role in selecting a monochromatic light from a light source (white light).
- Spectroscopes include **Filter type, Prism type, and Grating (**diffraction grating) type.

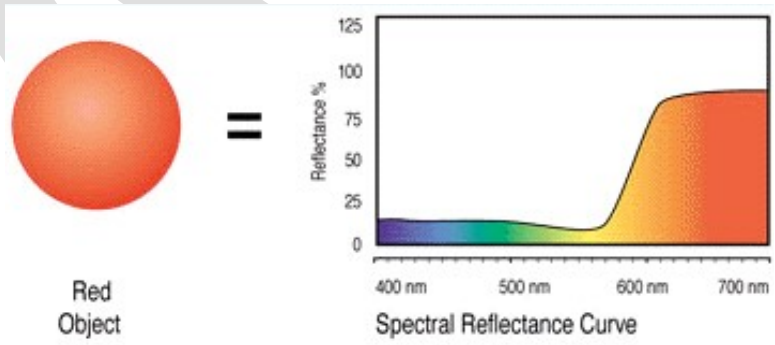
Optics

- A container that contains a sample is usually called **"cell";** two types are available, **glass and quartz cells**.
- A glass cell used for measurement in the visible range of 340 nm or more.
- A quartz cell used for the measurement in the ultraviolet range due to its high price.

Detector

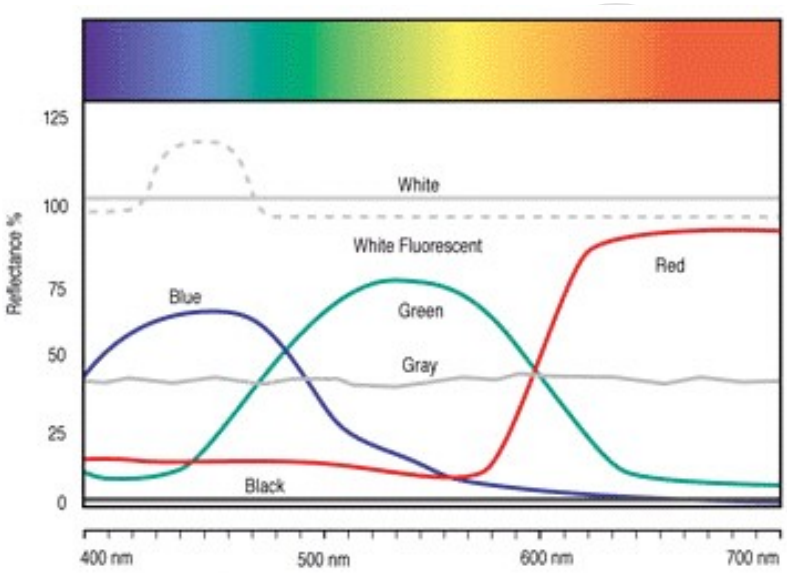
- A detector used to convert the light transmitted from a sample into an electric signal.
- **Optical semiconductor, Types of photomultiplier**, etc. are available.

REFLECTANCE CURVES



- A spectrophotometer produces a reflectance curve that can indicate the color being measured. White light contains all the colors of the rainbow in the visible spectrum.
- When white light falls upon an opaque object, the object interacts with that light.

- If the object appears red it is because the object absorbed most of the white light selectively, reflecting only the red portion, which is observed by the eye.
- Likewise, if an opaque object is green, it absorbs all of the white light except the green portion.
- White objects produce a reflectance curve which is essentially flat at nearly 100 percent (reflecting all wavelengths), and black objects produce a curve which is essentially flat at nearly 0 percent (absorbing all wavelengths).

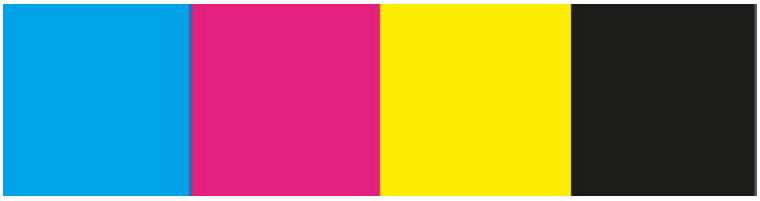


Spectral Reflectance Curves

4.3 Analysis of Print Attributes

1) Solid Ink Density (SID)

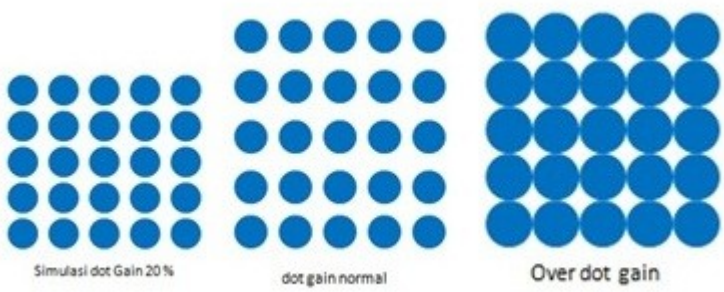
- ***Density is the ability of a material to absorb light. Generally, the darker a process color is to the eye, the higher the density.***
- Solid ink density is the measurement of a solid printed patch on the paper, including the paper density.
- Density is caused by the light-stopping ability of the pigments in the printing ink that are deposited on the paper by the printing process.
- **Densitometers** are widely used in the graphics industry to help control color in each step of the printing process.
- Density measurements of solid ink patches are used to monitor the ink film thickness applied during a press run.
- In comparing two printed sheets, density readings should be within .05 units, when measured on a densitometer, for meaningful print quality assessment.



- Dot gain, print contrast and apparent trap are directly affected by this solid ink density. Generally, these values will vary as the solid ink density changes.
- The readings of a solid area, are referred to as solid density. It is measured on a print control strip, which is printed on the sheet at right angles to the print direction.
- The solid density value allows a regular ink film thickness to be checked and maintained (within a certain tolerance) throughout the whole sheet width and print-run.
- Therefore, for most press operators, the minimum requirement for a color contains solid patches of the inks that will be printing since solid ink density is the only thing on press that an operator can adjust while the press is running.
- Those solid patches are then repeated over the width of the press sheet so that each ink zone is represented by at least one complete set of patches - containing one patch for each color being printed.

2) Dot gain

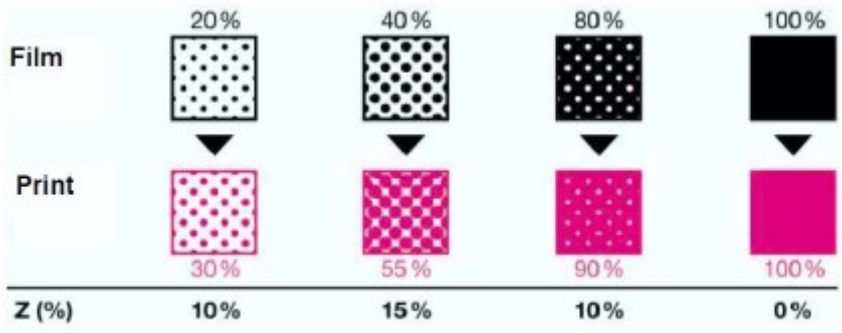
- When halftone dots print larger on the press than what they originally were on the plate or film, resulting in a loss of detail and lower contrast in the image.
- Dot gain occurs on every job to some degree.
- It is predictable to a point and can be compensated for when film and plates are produced Dot gain often occurs in long press runs, due to plates and/or pressure settings wearing or changing through out the run.



- **Dot gain is the difference between the halftone values in the screen film and in print.**

- The dot gain Z (%) is obtained from the difference between the measured halftone value in print FD and the known halftone value in film FF.

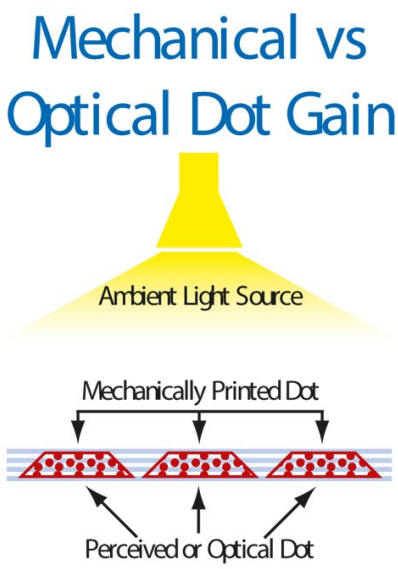
$$Z\ (\%) = F_D - F_F$$



- The major component of dot gain is Optical Dot Gain, by which light scatters in the printing substrate.
- Dot gain may also be contributed by dot spreading, press gain, slurring, or doubling.
- **Mechanical Dot Gain** - An aspect of Dot Gain associated with physical increase in the area coverage of a halftone dot when printed, compared to the area of the dot on the imagesetter film.
- **Optical Dot Gain** - Contribution to dot gain caused by light scattering and absorption in the substrate, and absorption of light on the underside of a printed dot, thereby increasing the density in those areas.

Here are some other factors that cause dot gain:

1. Ink and water balance.
2. Blanket construction or other properties.
3. Blanket height.
4. Roller settings.
5. Bearer pressure settings.
6. Plate wear.
7. Ink temperature.
8. Piling.



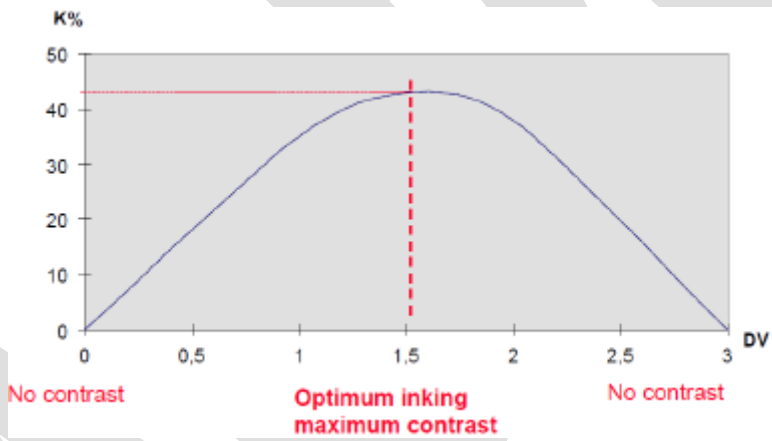
3) Print Contrast

- ***A method of evaluating and optimizing the density of the ink deposited on the substrate during printing.***

- Print contrast is calculated by measuring the ink density of a solid area and the ink density in a 75% tint.
- The relative print contrast is also calculated from the readings of the solid ink density Ds and the screen (or tint) ink density Dt.
- The Dt value here is best measured in the three-quarter tone (ie 75% of tint). The print contrast is calculated according to the formula:

$$K(\%) = \frac{Ds - Dt \times 100}{Ds}$$

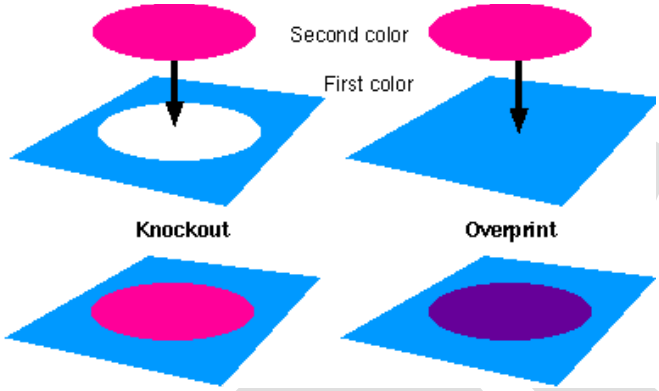
- A print should have a contrast as high as possible. This means that the solids should have a high ink density, but the screen should still print open (optimum halftone value difference).
- When the inking is increased and the ink density of the dots rises, the contrast is increased.



- However, the increase in ink feed is only practicable up to a certain limit. Above that limit the dots tend to exhibit gain and, especially in three-quarter tone, to fill in.
- This reduces the portion of paper white, and the contrast decreases again.
- If the contrast value deteriorates during a production run in spite of constant ink value in solid DV, this may be a sign that the blankets need washing.
- If the solid density is correct, the contrast value can be used to assess various factors which influence the print result such as
    - Rolling and printing pressure,
    - Blankets and underlays,
    - Dampening Solution,
    - Printing inks and additives.

4) Ink Trapping

- ***It indicates how well an ink is accepted when printed onto another ink as compared to when it is printed onto the printing stock.***
- The term trapping refers to the action of printing an ink film on top of another ink film, as in process color printing.



- Proper trapping results in well printed materials, while poor trapping results in successive inks that do not adhere properly and bead or rub off readily.
- A distinction has to be made between **wet-on-dry and wet-on-wet printing**.
- Wet trapping refers to trapping performed in wet multi-color printing, where one ink is laid down on top of a previously printed, still-wet ink. If the second ink has greater tack than the first ink, poor trapping will occur.
- Dry trapping is a multi-color printing process in which one ink is laid down on top of a dry ink.

$$\% \ Ink\ Trap = \frac{D3 - D1}{D2} \times 100$$

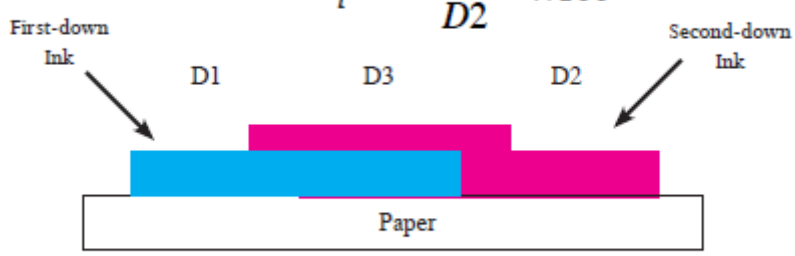


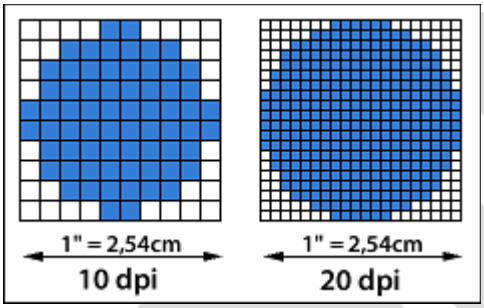
Figure 1. Density-based ink trapping formula

- The ink tack affects wet-on-wet ink trapping.
- The color of the overprint changes as a function of ink sequence.

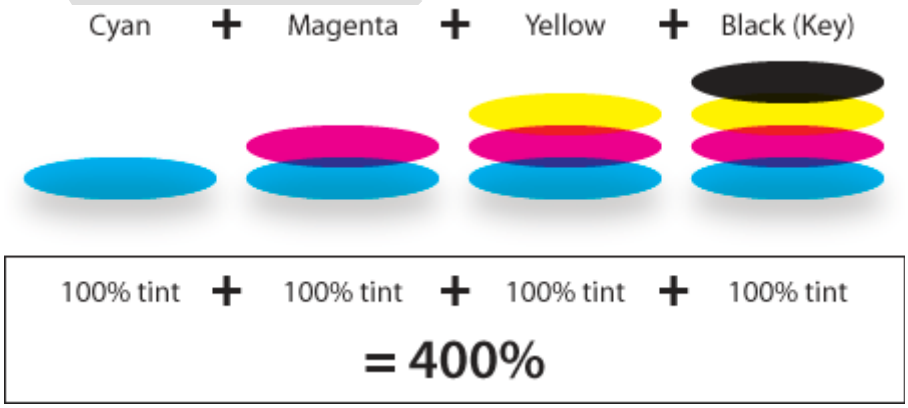
- When ink sequences are altered between black ink (high tack) and yellow ink (low tack), the 'black over yellow' overprint results in less darkness than the 'yellow over black' overprint.

5) Dot Area

- ***The size of a halftone dot, expressed as a percentage of the total surface area, which can range from 0% (no dot) in highlights to 100% (solid ink density) in shadows.***



- By carefully measuring the dot area in various regions of an image at various stages in the reproduction of an image, dot densities can remain consistent.
- In digital halftoning, dots (in this case called cells) comprise much smaller printer spots which, depending on the resolution of the output device, can be used to create dots of various sizes and densities.
- Varying the number of spots that make up a halftone cell can work to fine-tune the dot densities by increasing the number of shades of gray available as the number of spots in a cell is increased.
- The amount of ink layered on a page (colors printed on top of each other as in 4-color process printing) is **the Total Ink Coverage (TIC) or Total Area Coverage (TAC)** for a document.

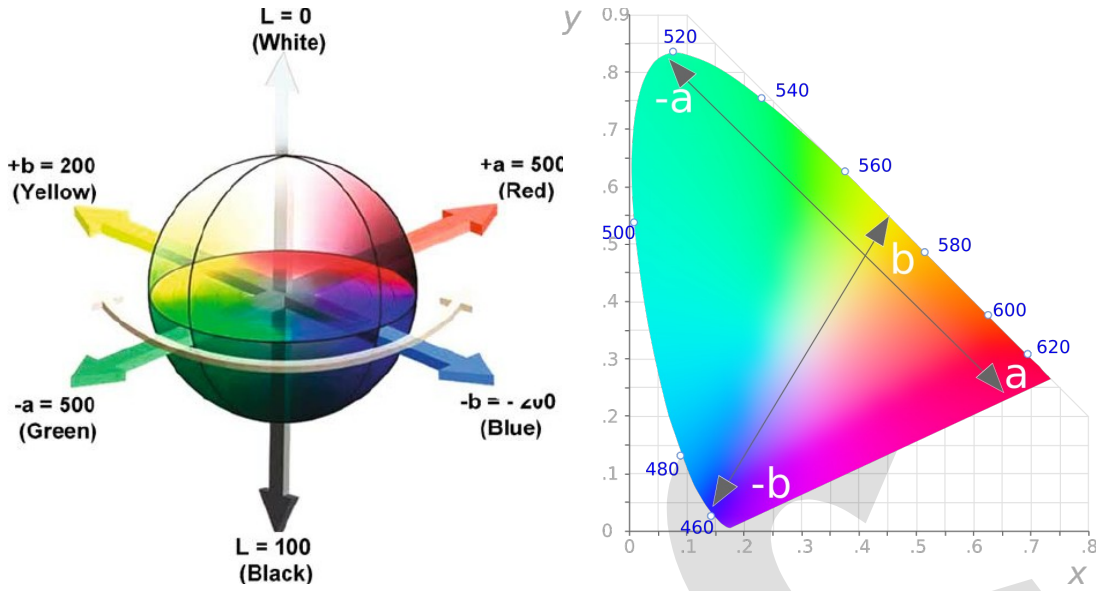


- **The printing method and type of paper** are two key factors in determining the maximum ink coverage that is acceptable.

- TIC is the sum of the cyan, magenta, yellow, and black (CMYK) values for any part of an image. For example,
- C40 M30 Y20 K15 is 40+30+20+15 = 105% TIC.
- C50 M50 Y50 K100 would be 250% TIC.
- If the maximum TIC for a specific printing method and type of paper is exceeded the layers of ink added last in the print run may not adhere properly to the underlying layers of ink resulting in inaccurate colors, slow ink-drying with possible rub-off of ink, wrinkling of the paper, and ink bleeding through the paper.
- Too much ink can result in photos with muddy colors or dirty brown instead of a nice neutral black or a loss of detail in the shadows from the excessive ink.

CIE Lab

- CIE - International Commission of Illumination. This is the organization responsible for setting the world-wide color measurement standards.
- An organization called CIE (Commission Internationale de l'Eclairage) determined standard values that are used worldwide to measure color.
- CIELab is the color space that ICC Profiles and CMMs often use as an intermediary space when converting colors.
- So a monitor to printer match translates colors from the monitor's space (RGB) into Lab and then into the printer's color space
- The values used by CIE are called L*, a* and b* and the color measurement method is called CIELAB.
  - ❖ L* represents the difference between light (where L*=100) and dark (where L*=0).
  - ❖ a* represents the difference between green (-a*) and red (+a*), and
  - ❖ b* represents the difference between yellow (+b*) and blue (-b*).
- Each colour is then a measure of their a*, b* and L* values, giving a definitive point of reference on the colour space.
- This space gives a precise value with each value having a specific point on the space, creating that particular hue of colour.
- CIE LAB is standard measurement tool to measure the difference (Delta E) between the colours represented (displayed) and the deviation from the true colour location on the CIELAB space.



Colour difference - Delta E

- Even if two colors look the same to one person, slight differences may be found when evaluated with a color measurement instrument.
- If the color of a sample does not match the standard, customer satisfaction is compromised and the amount of rework and costs increase.
- ***Color difference can be defined as the numerical comparison of a sample's color to the standard.***
- It indicates the differences in absolute color coordinates and is referred to as Delta (Δ).
- These formulas calculate the difference between two colors to identify inconsistencies and help users control the color of their products more effectively.

The colour differences are calculated using the following formula:

$$\Delta L^* = L^*_{act} - L^*_{ref}$$

$$\Delta a^* = a^*_{act} - a^*_{ref}$$

$$\Delta b^* = b^*_{act} - b^*_{ref}$$

$$\Delta E^*_{ab} = \sqrt{\Delta L^{*2} + \Delta a^{*2} + \Delta b^{*2}}$$

- To begin, the sample color and the standard color should be measured and the values for each measurement saved.

- The color differences between the sample and standard are calculated using the resulting colorimetric values.

ΔE between 0 and 1	In general, this deviation cannot be perceived.
ΔE between 1 and 2	Very small deviation; only perceivable by an experienced eye.
ΔE between 2 and 3.5	Medium deviation; perceivable even by an unexperienced eye.
ΔE between 3.5 and 5	Large deviation
ΔE exceeding 5	Massive deviation

4.4 CTP calibration and Linearization process

What is CTP?

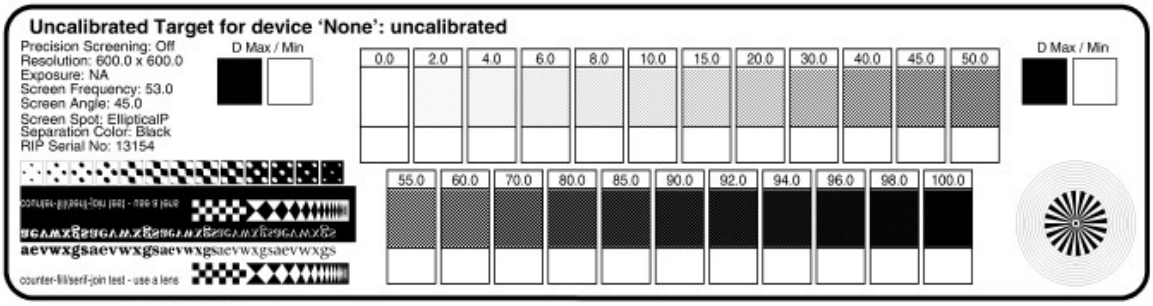
- CTP (Computer to Plate) is a streamlined process of print production.
- Streamlined in that takes a finalized file from a computer and outputs it directly to a plate.
- The plates are made from a variety of materials ranging from aluminum to polyester.
- Once the plate is imaged, it can be used on the press.

Calibration:

- To ensure the correct reproduction of images, all devices such as the monitor, color printer, proofer and imaging unit should be coordinated such that the fixed numerical values for CMYK can be represented correctly.
- Here, imagesetters have to be linearized and inking characteristics of the presses have to be matched to the real ink consumption.

Calibrating a Platesetter (CTP Device) with the Harlequin RIP

1. Calibrate your plate densitometer using the instructions or manual provided with your densitometer.



2. Start the RTI RIP-Kit. Go to RTI RIP-Kit / Page Setup Manager in the menu and edit the page setup you would like to calibrate. While in the page setup change the page setup to positive by unchecking Negative and Mirrorprint. Click OK to exit the page setup and OK once more to exit the Page Setup Manager.

3. Go to Output / Print Calibration in the RIP menu. Select (or highlight) your page setup on the right hand side of the window.
4. Controlling Exposure with the RIP: If you are going to be controlling the exposure within the RTI Harlequin RIP, enter the values for the exposure sweep at the bottom of the window.
5. Using the plate densitometer take density readings from the target(s). Once you have found the exposure setting that meets these criteria you will need to take the dot percentage readings from that exposure target.

6. Go to Output / Calibration Manager and click 'New' to create a new calibration set. Change Measurement to: Positive % Dot (default). Enter the dot percentage values and then OK out of the Calibration Manager window.
7. Go to RTI RIP-Kit / Page Setup Manager and edit the page setup used to print the targets. Under the calibration section of the page setup select the newly created calibration. Enter the exposure from the selected exposure sheet into the page setup. Click OK to exit the page setup and OK again to exit out of the Page Setup Manager.
8. Go to Output / Print Calibration and select your page setup. Next, click Print Calibrated Target. Check the values from the calibration using the plate densitometer. The values should not be off more than 1 to 2%. To change the RIP back to outputting negative plates, you will need to follow the last two steps listed below.
9. In the Calibration Manager, edit the calibration set from 'Uncalibrated' and check 'Using Negative Media'.
10. In the Page Setup Manager, edit the page setup used to print the calibration and check Negative and Mirrorprint.

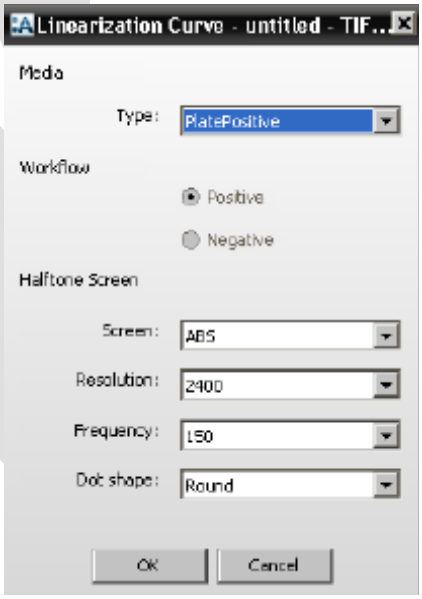
Linearization

- A linearization curve is applied to an output device in order to make that device linear, i.e. 50% dot equals 50% on film or plate.
- The curve is applied to all separations as a whole, which means that you cannot make a linearization curve per separation.
- If your output device is already linear, there is no need to create a linearization curve.

Creating a Linearization Curve

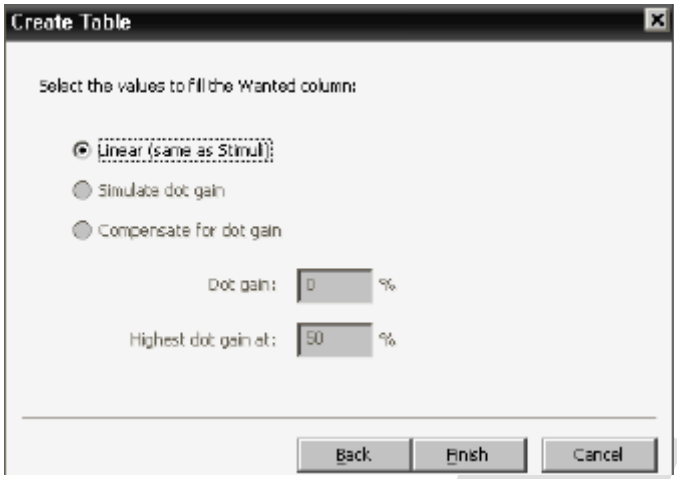
To create a linearization curve

1. In the System Overview window click the TIFF Platesetter.
2. Double-click the Linearization Curves Resource.
3. Click New.
4. In the Linearization Curve window set the following:
   - …Media Type: PlatePositive
   - …Screen: ABS
   - …Resolution: 2400 dpi
   - …Frequency: 150 lpi
   - …Dot Shape: Round

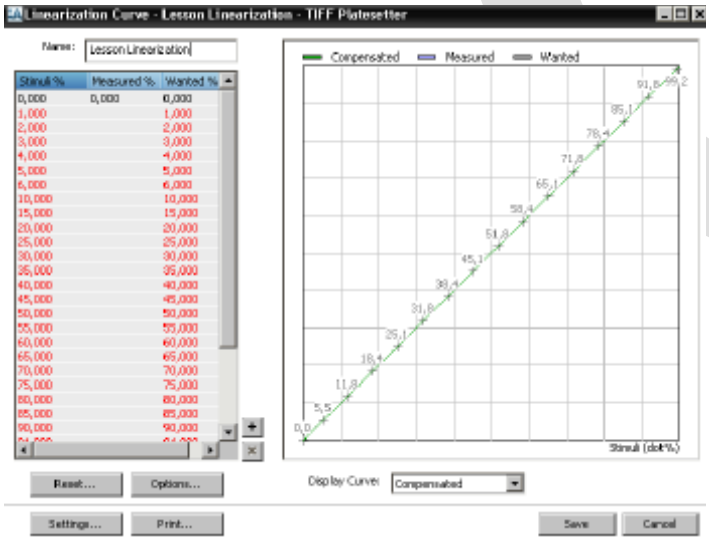


5. Click OK.
6. In the Create Table window ensure that Manually is selected and click Next.
7. In the Create Table window ensure that the Standard 31 value is selected. This defines the number of measured steps for the curve.
8. Click Next.

   In the Create Table window you will see that the dot gain choices are disabled and that the only option for a linearization curve is Linear: The dot gain choices are only available if you create a calibration or simulation curve.



9. Click Finish.



10. Type the name Lesson Linearization in the Name box and click Save.

    You have now created a linearization curve that is visible in the Linearization Curves window.

11. Close the Linearization Curves window.

Unit - IV

2 Mark Question

1. Name any two instruments used to find density of the ink.

   Densitometer, Spectrophotometer

2. What are the uses of densitometers?

   Densitometers are used for process control of density, dot gain (TVI), dot area, and ink trap. Densitometer readings will different for different types of substrates.

3. Why polarisation filter used in densitometer?

   Polarisation filters serve to prevent differences in the measured values obtained from a shining wet surface and from the surface of a dry ink.

4. Define spectrophotometer.

   A spectrophotometer is a device for measuring light intensity by measuring the wavelength of light.

5. Define Delta E.

   The colour difference is a measure of the distance between two colour locations in the colour space

6. What is print contrast?

   A method of evaluating and optimizing the density of the ink deposited on the substrate during printing.

7. What is TIC?

   The amount of ink layered on a page (colors printed on top of each other as in 4-color process printing) is the Total Ink Coverage

8. What is SID?

   Solid ink density is the measurement of a solid printed patch on the paper, including the paper density.

9. What is CMS?

   Color management system defines the colors which can be reproduced by each device and determines and corrects colors that deviate from device to device.

10. Expand ICC profile.

    International Color Consortium profile

11. What is color profile?

    A color profile is a file that describes the color characteristics of a specific device while it's in a particular state.

12. Define calibration.

    To ensure the correct reproduction of images, all devices such as the monitor, color printer, proofer and imaging unit should be coordinated such that the fixed numerical values for CMYK can be represented correctly.

3 Mark Question

1. What are the basic components of densitometer?
   - Polarisation filters
   - Colour filters
   - light source
   - A lens system
   - photodiode
2. State the advantages of spectrophotometer.
   - A spectrophotometer is a device for measuring light intensity by measuring the wavelength of light.
   - The most common application of spectrophotometers in the printing industry is the measurement of light absorption.
3. Explain purpose of color filter.

   Colour filters are inserted for measurements of colours. The colour filters in a densitometer are tuned to the absorption performance of cyan, magenta and yellow.

Printing inks	Filter colour
cyan	red
magenta	green
yellow	blue

4. Explain reflectance curve.
   - A spectrophotometer produces a reflectance curve that can indicate the color being measured. White light contains all the colors of the rainbow in the visible spectrum.
   - When white light falls upon an opaque object, the object interacts with that light.
   - If the object appears red it is because the object absorbed most of the white light selectively, reflecting only the red portion, which is observed by the eye.
5. Explain briefly about Dot Area
   - The size of a halftone dot, expressed as a percentage of the total surface area, which can range from 0% (no dot) in highlights to 100% (solid ink density) in shadows.
   - In digital halftoning, dots (in this case called cells) comprise much smaller printer spots which, depending on the resolution of the output device, can be used to create dots of various sizes and densities.
6. .Explain briefly about Dot gain.
   - When halftone dots print larger on the press than what they originally were on the plate or film, resulting in a loss of detail and lower contrast in the image.

- It is predictable to a point and can be compensated for when film and plates are produced Dot gain often occurs in long press runs, due to plates and/or pressure settings wearing or changing through out the run.

7. What is print contrast?
   - A method of evaluating and optimizing the density of the ink deposited on the substrate during printing.
   - The Dt value here is best measured in the three-quarter tone (ie 75% of tint). The print contrast is calculated according to the formula:

$$K(\%) = \frac{Ds - Dt \times 100}{Ds}$$

8. Write short notes on wet ink trapping.

Wet trapping refers to trapping performed in wet multi-color printing, where one ink is laid down on top of a previously printed, still-wet ink. If the second ink has greater tack than the first ink, poor trapping will occur.

9. Explain Delta E.
   - Color difference can be defined as the numerical comparison of a sample's color to the standard.
   - It indicates the differences in absolute color coordinates and is referred to as Delta (Δ).
10. Define Linearization.

- A linearization curve is applied to an output device in order to make that device linear, i.e. 50% dot equals 50% on film or plate.
- The curve is applied to all separations as a whole, which means that you cannot make a linearization curve per separation.
- If your output device is already linear, there is no need to create a linearization curve.

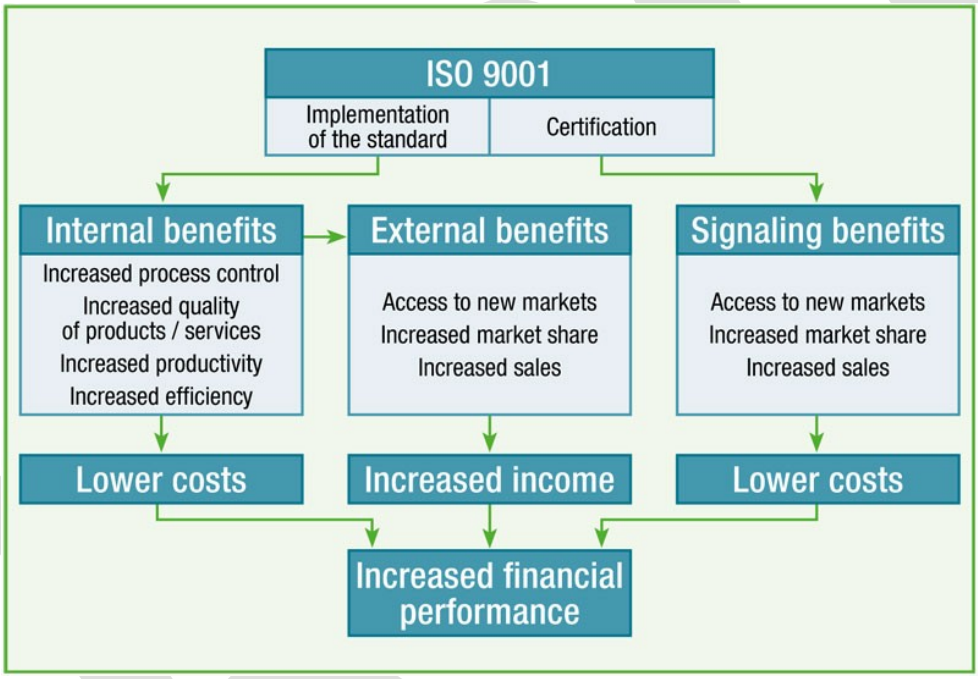
10 Mark Question

1. Explain in detail about working principle of densitometer with neat diagram.
2. Explain the working principles of spectrophotometer with neat sketch.
3. Explain in detail about various analysis of print attributes applied to maintain quality in printing.
4. Explain in detail about CIE Lab with neat diagram.
5. Explain in detail CTP calibration and Linearization process with neat sketch.

UNIT - V – IMPLEMENTATION OF ISO FOR PRINT QUALITY

5.1 INTRODUCTION - ISO 9001

- ***ISO 9000 is a series of standards, developed and published by the International Organization for Standardization (ISO), that define, establish, and maintain an effective quality assurance system for manufacturing and service industries.***
- ISO 9001:2008 Quality Management System certification enables you to demonstrate your commitment to quality and customer satisfaction, as well as continuously improving your company's operations. The internationally recognized quality management system standard is the preferred solution for organizations worldwide..



Background

In November 2008 the International Organization for Standardization (ISO) introduced a revised Quality Management standard based on the same process model as the 2000 revision, with an emphasis on measuring customer satisfaction. The current version continues to emphasize compatibility with ISO 14001 - Environmental Management Systems.

The ISO 9000:2000 revision had five goals:

- Meet stakeholder needs
- Be usable by all sizes of organizations
- Be usable by all sectors
- Be simple and clearly understood

- Connect quality management system to business processes

ISO 9001:2008	ISO 9001:2015
0. Introduction	0. Introduction
1. Scope	1. Scope
2. Normative Reference	2. Normative Reference
3. Terms and Definitions	3. Terms and Definitions
4. Quality Management Systems	4. Context of the organisation
5. Management Responsibility	5. Leadership
	6. Planning
6. Resource Management	7. Support
7. Product Realisation	8. Operation
8. Measurement, Analysis and Improvement	9. Performance Evaluation
	10. Improvement

Key Benefits of ISO 9001:2008

What it does:

- Establishes and streamlines processes through complete documentation
- Improves and establishes training processes
- Defines roles and responsibilities
- Greatly increases operational efficiency
- Increases ability to troubleshoot
- Develops and builds relationships that help to retain existing customers
- Provides advantages over competitors that aren't certified ISO 9001:2008
- Builds opportunities for global commerce with international recognition
- Improves customer relations
- Improves relationships with suppliers due to clear, concise production standards· Provides basis for consistent and fact-based decision making
- Carefully planned improvements, based on documentation and analysis
- Provides for regular audits/reviews of performance

Steps involved in ISO9001 certification

The steps involved in any ISO9001 certification project are the following:

1. **Gap Analysis:** Assessment of existing quality management practices vis-a-vis ISO9001 requirements.
2. **Orientation Training:** Top/Senior Management orientation on ISO9001 requirements and action plans.
3. **System Documentation:** Preparation of quality manuals and design of quality record formats.

4. **System Implementation:** Implementation of quality system as per the quality manuals.
5. **Company-wide Training:** Training on ISO9001 clauses, Statistical Quality Control Techniques, Housekeeping (Japanese 5-S), and Quality Audit.
6. **Internal Quality Audits:** Periodic assessment of quality system implementation and corrective actions.
7. **Pre assessment:** Initial audit by Certifying agency, and, implementation of corrective actions.
8. **Final Assessment:** Certification audit by the Certifying agency and recommendation for certification.

ISO philosophy

ISO Philosophy
• Say what you do • Do what you say • Document what you do • Check the results • Correct the difference

ISO 9001 series of standards

ISO 9000 series is comprised of the following international standards:

1. ISO 8402 - Quality management and quality assurance vocabulary
2. ISO 9000 - Guidelines for selection and use
3. ISO 9001 - Model for quality assurance: design, development, production, installation and servicing
4. ISO 9002 - Model for quality assurance: production, installation and servicing
5. ISO 9003 - Model for quality assurance: final inspection and test
6. ISO 9004 - Quality management and quality system elements
7. ISO 10011 - Guidelines for auditing quality systems
8. ISO 10012 - Requirements for measuring equipment
9. ISO 10013 - Guidelines for quality manuals.

BS ISO/IEC 15504
The concepts of process assessment and its use in process improvement and process capability determination

ISO/IEC TS 17021-4:2013
Conformity assessment - Requirements for bodies providing audit and certification of management systems

ISO 19011:2011
Guidelines for auditing management systems.

ISO/IEC 17065
Conformity assessment — Requirements for bodies certifying products, processes, and services.

ISO 10006:2006
Quality management systems - Guidelines for quality management in projects

ISO 14000 Series
14001: Environmental Management Systems
14004: EMS General Guidelines
14010: Guidelines for Auditing of an EMS14012: Auditing - Qualification Criteria

ISO 20121:2012
specifies requirements for an event sustainability management system for any type of event or event-related activity and provides guidance on conforming to those requirements

ISO 21500:2012
Guidance on Project Management

ISO 9000 Series
ISO 9001:2008 - sets out the requirements of a quality management system

ISO 9000:2005 - covers the basic concepts and language

ISO 9004:2009 - focuses on how to make a quality management system more efficient and effective

ISO 19011:2011 - sets out guidance on internal and external audits of quality management systems.

ISO standards for printing process(ISO 12647)

- The ISO 12647 specifications includes standard process control aim points and tolerances for various printing methods and processes.
- Standardizing production means that a number of production parameters need to be clearly defined, along with a specific tolerance on each.
- In the case of ISO 12647 these definitions include:
    - the color and transparency of printing inks
    - definitions of paper types
    - solid tones, which are described with CIELAB values
    - tone value increases (TVI), per paper type and color

Components of ISO12647

The ISO 12647 standard is split up in different parts, which each have a different number. Because the standard covers various printing methods, a printer only needs to implement a part of the full specifications.

- **ISO 12647-1:2005** describes the parameters and measurements methods. Essentially 12647-1 provides the basis for the subsequent **print related settings**.
- **ISO 12647-2:2004** defines the process control settings for **offset lithography**.
- **ISO 12647-3:2005** defines the process control settings for newspaper printing, more specifically **coldset offset lithography on newsprint**

- **ISO 12647-4:2005** defines the process control settings for publication **gravure printing**, which is used for high volume magazines, catalogues, etc.
- **ISO 12647-5:2001** defines the process control settings for **screen printing**.
- **ISO 12647-6:2006** defines the process control settings for **flexographic printing**.
- **ISO 12647-7** is still being work on. It will cover off-press **proofing processes**.

ISO standard for Graphic Industry

- ISO 12637 Graphic technology - Vocabulary
  - ISO 12637-1:2006 Part 1: Fundamental terms
  - ISO 12637-2:2008 Part 2: Prepress terms
  - ISO 12637-3:2009 Part 3: Printing terms
  - ISO 12637-4:2008 Part 4: Postpress terms
- ISO 12639:2004 Graphic technology – Prepress digital data exchange – Tag image file format for image technology (TIFF/IT)
- ISO 12640 Graphic technology - Prepress digital data exchange
  - ISO 12640-1:1997 Part 1: CMYK standard colour image data (CMYK/SCID)
  - ISO 12640-2:2004 Part 2: XYZ/sRGB encoded standard colour image data (XYZ/SCID)
  - ISO 12640-3:2007 Part 3: CIELAB standard colour image data (CIELAB/SCID)
  - ISO 12640-4:2011 Part 4: Wide gamut display-referred standard colour image data [Adobe RGB (1998)/SCID]
  - ISO 12640-5:2013 Part 5: Scene-referred standard colour image data (RIMM/SCID)
- ISO 12641:1997 Graphic technology – Prepress digital data exchange – Colour targets for input scanner calibration
  - ISO 12641-1:2016 Part 1: Colour targets for input scanner calibration
- ISO 12642 Graphic technology - Input data for characterization of four-colour process printing
  - ISO 12642-1:2011 Part 1: Initial data set
  - ISO 12642-2:2006 Part 2: Expanded data set
- ISO/PAS 15339 Graphic technology - Printing from digital data across multiple technologies
- ISO/TR 15847:2008 Graphic technology - Graphical symbols for printing press systems and finishing systems, including related auxiliary equipment

- ISO 15930 Graphic technology – Prepress digital data exchange using PDF
- ISO 16612 Graphic technology - Variable printing data exchange
- ISO 16613 Graphic technology - Variable content replacement
- ISO 16684 Graphic technology - Extensible metadata platform (XMP) specification
- ISO 16760:2014 Graphic technology - Prepress data exchange - Preparation and visualization of RGB images to be used in RGB-based graphics arts workflows
- ISO 17972 Graphic technology - Colour data exchange format
- ISO/TR 19300:2015 Graphic technology – Guidelines for the use of standards for print media production
- ISO 19445:2016 Graphic technology - Metadata for graphic arts workflow - XMP metadata for image and document proofing
- ISO 28178:2009 Graphic technology - Exchange format for colour and process control data using XML or ASCII text

OSHASTANDARDS:

- The Occupational Safety and Health Act of 1970 (OSHAct) was passed to prevent workers from being killed or seriously harmed at work.
- The law requires that employers provide their employees with working conditions that are free of known dangers.
- The Act created the Occupational Safety and Health Administration (OSHA), which sets and enforces protective workplace safety and health standards.
- OSHA also provides information, training and assistance to workers and employers.

Some OSHA standards related Printing Industry

1910.0147 The control of hazardous energy (lockout/tagout).

1910.1200 Hazard Communication.

1910.0219 Mechanical power-transmission apparatus.

1910.0212 General requirements for all machines.

1910.0178 Powered industrial trucks.

WHAT IS ISO 14001:2015?

- ISO 14001 is the international standard that specifies requirements for an effective environmental management system (EMS).
- It provides a framework that an organization can follow, rather than establishing environmental performance requirements.

ISO 14000 family of standards

ISO 14001 is the most popular standard of the ISO 14000 family, which also includes standards such as the following:

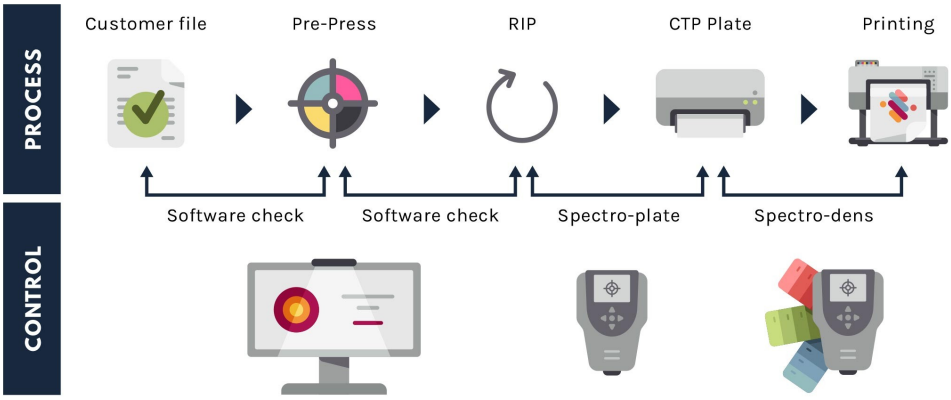
1. ISO 14004 – General guidelines on principles, systems and support techniques
2. ISO 14006 – Guidelines for incorporating ecodesign
3. ISO 14015 – Environmental assessment of sites and organizations (EASO)
4. ISO 14020 – Environmental labels and declarations
5. ISO 14031 – Environmental performance evaluation
6. ISO 14040 – Life cycle assessment
7. ISO 14050 – Vocabulary
8. ISO 14063 – Environmental communication
9. ISO 14064 – Greenhouse gases
10. ISO 19011 – Guidelines for auditing management systems

Benefits of working with a standard like ISO 12647-2

Adhering to the ISO 12647 specs can offer the following advantages to a printer:

- Savings on paper and ink as well as make-ready time
- Improved process stability
- Better quality and consistency
- Meeting the expectation level of print-buyers. There are large corporations and governments that insist that their printed matter is produced by a company that is ISO 12647 certified.
- Better matching between proofs and prints

5.2 Press Calibration to ISO-12647-2 standard



- Press Calibration is the whole process of bringing the printing press to a certain standard (e.g. ISO12647-2).
- Given a specific paper and ink combination, the correct ink layer thickness has to be determined and the corresponding CTP curves have to be calculated.

- This process is often done for a specific print test form.
- With PressView you can easily do a Press Calibration. You will have all the information of your printing press to help you through the standardization process.

Standardized Printing

Standardized Printing is the key for short makeready times at the press and a controlled proof to press match even for proofs delivered from different clients.

For successful implementation at a printers`site following steps are necessary

Step 1. Choosing the appropriate standard / specification for the complete print production (data, proofs, press calibration)

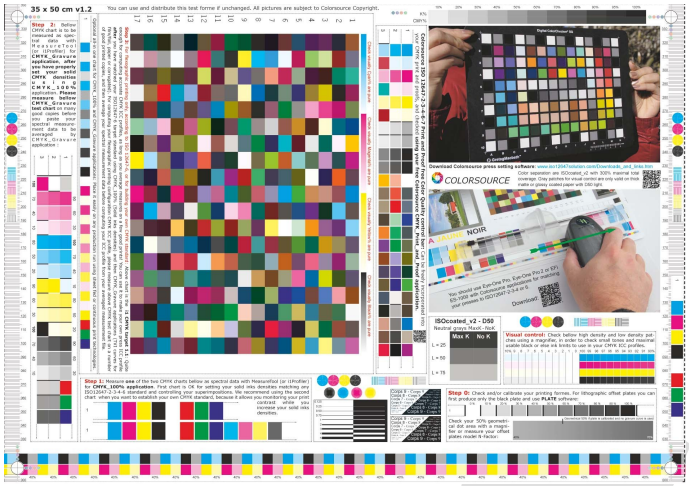
- The worldwide most referenced standard for printing is ISO 12647-2. Based on this ISO standard several specifications for data, proofs and press calibration have been developed. These are e.g. PSO Process Standard Offset Printing from bvdm / FOGRA / UGRA, Pass2Press vom PPA in UK or 3DAP in Australia.
- In the US GRACoL / SWOP and G7 are common specification for data, proofs and printing being partly compatible to ISO 12647

Step 2. Communication with clients about standards for data delivery

- A clear communication with clients about standards for data delivery is an important premise for a smooth workflow from separation via PDF and proof to press.
- The key is not only to specify that “print ready CMYK data” should be delivered, but to the most 2-5 CMYK standards for paper types used in printing.
- If the clients are not sure about whether they use the correct profiles for data creation, it is mandatory that the final color OK of the data needs proof for the correct printing standard.

Step 3. Implementation of standardized in-house proofing

- In-house proofing must be set up to the same standards as communicated for data delivery.
- It is necessary for a complete color management chain from clients’ data to proof, but it is also crucial if in-house proofs from the printer should match the proofs from the clients.
- The in-house proofing system should include a vendor independent control strip and a solution to measure this control with a spectrophotometer for internal verification of proofs.



Step 4. Implementation of verification for incoming proofs

- The printer has to communicate to his clients that delivered proofs must refer to standards and contain a vendor independent control wedge.
- This way a control of incoming proofs with the same solution which is used for the verification of in-house proofs is possible.

Step 5. Optimizing CtP and press performance

- Only if steps 1-3 are successfully implemented, Ctp and press performance optimization will lead to short makeready times and results which match the expectations of the client for every press run.
- The natural partners for optimizing CtP and press performance are the vendors of the CtP system and the press. The implementation of this optimization steps should at least include:
  - ❖ a written agreement that the final print result should match the chosen specification
  - ❖ a defined procedure for in-house controlling of the platemaking process after CtP calibration
  - ❖ a final press run which delivers a good visual match from the press to the controlled inhouse proof
  - ❖ a defined procedure for monitoring press performance after calibration

For the highest quality it is possible to work with an organization which certifies the printer for all steps (data handling, in-house proofing, proof verification, CtP and press performance) according the chosen specification. Such specifications are more and more demanded by industrial print buyers.

5.3 Implementation Process of ISO standards in printing organization

- Implementing ISO 9001 is primarily a process of organizing, training, and documentation.

- Depending on the present level of your company's procedures and level of documentation and system's complexity, the process can take from several months to several years, with a typical registration cycle taking from twelve to eighteen months.

Phase I - Management commitment

- In phase I, the company's top management becomes committed to pursuing ISO 9001.
- This involves training top managers as to what ISO 9001 is, how much it will cost, why it should be pursued, and what will be their role in the process.
- Top management's primary role is to allocate resources, set goals, review progress, and develop an awareness throughout the organization.

Phase II - Training and organization

- Phase II of the implementation is to develop a structure and a system that will support the certification process.
- It will be necessary to involve employees at all levels and from all functions of the organization in the process.
- Various leaders, such as department heads, must be trained in the methods of documentation and standard operating procedure (SOP) development.

Phase III - Documentation

- In phase III of the implementation, the actual SOP development begins.
- The outcome of this process is typically a four-tiered system of documentation consisting of a quality manual.
- **The first tier** is a set of company policies concerning quality.
- **The second tier** is process specifications that document what should be done and who will do it.
- **The third tier** is the development of work instructions.
- **The fourth tier** consists of quality records indicating that a procedure has been carried out and includes a calibration log and completed purchase orders as examples of this process.
- The following diagram illustrates the four-tiered quality system documentation typically associated with ISO 9001:

Phase IV - Third-party audit

- The final stage is phase IV, in which an outside auditor (registrar) is brought in for an ISO 9001 quality audit.
- It is beneficial to have a pre-audit done by the third-party auditor.
- The auditor will evaluate your ISO system pointing out its weaknesses and strengths.
- During the official audit, the auditor will look at your documentation developed in the previous phases and then go out into the plant and observe what the people are actually doing.
- If the procedure says that each plate will have a UGRA scale burned on it and be checked for proper exposure, the auditor will simply check if the platemaker is doing this and if the records are there to support that it is being done on the prescribed basis.
- If all procedures are found to be followed, the printer will be issued a certificate that the company is in conformance with ISO 9001.
- This assumes that the system itself meets all of the required elements of the standard.

Maintaining of ISO certification

Surveillance audits take place within 12 months of the Stage 2 audit and then at least annually thereafter:

- Client and ISO Certification communicate any changes to the business and the certification procedure since the last audit
- Certification programmes and audit teams are agreed with the client
- Surveillance audit takes place and any improvement actions are raised

- Once any improvement actions are satisfied, ISO Certification reviews the ISO 9001 audit file

Renewal process of ISO certification

Re-certification activities include any actions required before the expiry of an existing ISO 9001 Certification (every 3 years):

- Client and ISO Certification communicate any changes to the business and the certification procedure since the last audit
- Certification programmes and audit teams are agreed with the client
- Re-certification audit takes place and any improvement actions are raised with the client
- Once any improvement actions are satisfied, ISO Certification reviews the ISO 9001 audit file
- ISO 9001 Certification is granted for a further 3 year cycle

5.4 Benefits of ISO Implementation

Some of the benefits to your organisation:

- Provides senior management with an efficient management process
- Sets out areas of responsibility across the organization
- Mandatory if you want to tender for some public sector work
- Communicates a positive message to staff and customers
- Identifies and encourages more efficient and time saving processes
- Highlights deficiencies
- Reduces your costs
- Provides continuous assessment and improvement
- Marketing opportunities

Some of the benefits to your customers:

- Improved quality and service
- Delivery on time
- Right first time attitude
- Fewer returned products and complaints
- Independent audit demonstrates commitment to quality

5.4 Customer Satisfaction

- ***Customer satisfaction is a measurement of how pleased customers are with a particular product or service.***
- Satisfied customers are likely to make repeat purchases and often refer others.

Typical areas addressed in the surveys include:

- Quality of product
- Value of product relative to price - a function of quality and price
- Time issues, such as product availability, availability of sales assistance, time waiting at checkout, and delivery time
- Atmosphere of store, such as cleanliness, organization, and enjoyable shopping environment

Case Studies of ISO Certified Print Industry

Casey Press is a hypothetical, but typical, commercial printer founded in the 1950s and built from scratch to its present state. The company has annual sales of $7 million, primarily in the highly competitive four-color commercial market.

Recently several complaints from customers have surfaced. These have included complaints about color consistency, poor folding on some brochures, and a couple of late deliveries.

In the old days, the owner and president, Ms. Casey, would have thought of these as isolated incidents, but recently she has been doing some reading about quality management and wondered if the problem might be more systemic in nature. These readings have included the following information:

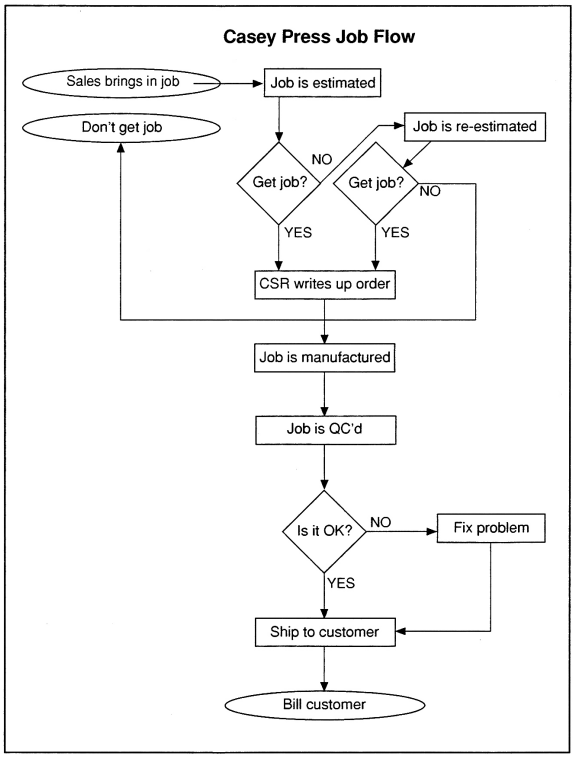
- Most customers don't complain; they just leave and you never find out why.
- It's not enough to satisfy customers; if you want them to be loyal, then they must be delighted.
- 85% of quality is the responsibility of management.
- If you want to improve quality, it's best to take a planned, scientific approach.

Having read this, Casey decided to do a little investigating. The first thing she did was to conduct a customer survey of all of the customers who had come to the company in the past but not in the previous year.

Asking why they hadn't returned in the past year, Casey found out the following from those who returned the survey:

1. 10% had gone out of business.
2. 25% had found somebody to do their printing cheaper.
3. 15% had found somebody to do their printing more quickly.

4. 30% had experienced quality problems with Casey Press and had therefore gone elsewhere.
5. 20% had gone to other printers, but couldn't explain why.



Casey's first reaction to this information was typical: disbelief, having believed that Casey Press was price, schedule, and quality competitive.

Apparently she had been mistaken, but how could she improve costs, on-time delivery, and quality at the same time.

This seemed an impossible task until she came across something called the Deming Chain Reaction, which said that by improving and focusing on quality you would be able to reduce waste and in turn reduce costs, improve pricing flexibility, improve turnaround time, and -therefore improve customer satisfaction.

Casey became convinced that this was the answer to her dilemma, so she sat down with the employees at the plant and began working on improving quality. Our tools will give you a picture of some of the things that were found, and done, to improve quality.

Flow charting at Casey Press.

- At Casey Press, a crossfunctional team of employees came up with a flow chart for the rough overall flow of the process as a job flows through from start to finish.
- This exercise proved beneficial, because for the first time all of the employees had to agree on the actual way in which they did things.
- They also discovered many things that could be improved.
- Interestingly enough, the group noticed that not everyone did the same things the same way, even though they all had the same goal in mind. .

Brainstorming at Casey Press.

You will recall that the employees at Casey Press were going to brainstorm about the many possible causes of job problems.

This is exactly what they did. First, they stated the problem clearly and wrote the problem in a statement on the flip chart for all to read and see:

- Lack of attention to detail
- Equipment in poor condition
- Lack of understanding of what the customer wants
- Press operators not trained

- Equipment not capable
- No measuring equipment for QC
- Use of poor materials (ink and paper)
- Hickeys
- Excessive makeready times on press
- Static electricity in prepress department

These were then organized into a fishbone diagram according to the six M's:

Man	• Lack of attention to detail • Lack of understanding of what the customer wants
Machine	• Equipment in poor condition • Equipment not capable
Material	• Use of poor materials (ink and Paper)
Milieu	• Hickeys • Static electricity in prepress department
Measurement	• No measuring equipment for QC
Methods	• Press operator not trained • Excessive makeready times on press

Remember that these are only a few of the ideas the group came up with. In reality, a group might come up with fifty or more items in a brainstorming session like this. If the group comes up with a huge list, the group can use the multivoting technique to narrow the list down to a more manageable number. These were:

- Print the wrong PMS color
- Charge the wrong amount for the job
- Deliver the job later than promised
- Deliver the job to the billing (not shipping) address, if different
- Print the job out of register
- Plugging in the shadows on critical halftones
- Color variation not controlled

Now that the team had developed a list of likely causes of quality problems and customer dissatisfaction, it was ready to go into the mode of collecting data so that the issue could then be analyzed with less subjectivity.

Unit - V

2 Mark Question

1. What is ISO 9001?

   International Organization for Standardization (ISO) defined establish, and maintain an effective quality assurance system for manufacturing and service industries.

2. Write any two benefits of ISO?

   Increases productivity, Maximizes quality, Increases revenue, Improves employee morale and satisfaction

3. State two management responsibility in implementation of ISO for print quality.

   Top management's primary role is to allocate resources, set goals, review progress, and develop an awareness throughout the organization.

4. What is audit?

   An audit is an evidence gathering process. Audit evidence is used to evaluate how well audit criteria are being met.

5. What is the purpose of audit?

   The basic purpose of audits and ISO certification is to improve the business through standardization and controlled processes.

6. Define customer satisfaction

   Customer satisfaction is a measurement of how pleased customers are with a particular product or service. Satisfied customers are likely to make repeat purchases and often refer others.

7. What is documentation?

   Preparation of quality manuals and design of quality record formats.

8. What will be audited in ISO?

   The organization quality system meets the criteria of the standard.

9. What is ISO 14001:2015?

   - ISO 14001 is the international standard that specifies requirements for an effective environmental management system (EMS).
   - It provides a framework that an organization can follow, rather than establishing environmental performance requirements.

10. Define Quality manual.

The quality manual is a series of policy statements for each of the elements of the ISO 9001 quality standard.

3 Mark Question

1. What is ISO standard for printing industry?
   - ISO 12647-1 Parameters & Measurement methods
   - ISO 12647-2 Offset Lithographic processes
   - ISO 12647-3 Coldset Offset Lithography on Newsprint
   - ISO 12647-4 Publication Gravure
   - ISO 12647-5 Screen Printing
   - ISO 12647-6 Flexo Printing
   - ISO 12647-7 Proofing process from digital data
   - ISO 12647-8 Digital Printing
2. What are the ISO 9000 goals?
   - Meet stakeholder needs
   - Be usable by all sizes of organizations
   - Be usable by all sectors
   - Be simple and clearly understood
   - Connect quality management system to business processes
3. What are the benefits of ISO implementation in print industry?
   - Provides senior management with an efficient management process
   - Sets out areas of responsibility across the organization
   - Mandatory if you want to tender for some public sector work
   - Communicates a positive message to staff and customers
4. State few area customer satisfaction of implementation of ISO for print quality.
   - Quality of product
   - Value of product relative to price - a function of quality and price
   - Time issues, such as product availability, availability of sales assistance, time waiting at checkout, and delivery time
   - Atmosphere of store, such as cleanliness, organization, and enjoyable shopping environment
5. Mention about ISO 14000 and OSHA standards for industry.
   - 1910.0147 The control of hazardous energy (lockout/tagout).

- 1910.1200 Hazard Communication.
- 1910.0219 Mechanical power-transmission apparatus.
- 1910.0212 General requirements for all machines.
- 1910.0178 Powered industrial trucks.

6. What is the renewal process of ISO certification?

Re-certification activities include any actions required before the expiry of an existing ISO 9001 Certification (every 3 years):

- Client and ISO Certification communicate any changes to the business and the certification procedure since the last audit
- Certification programmes and audit teams are agreed with the client
- Re-certification audit takes place and any improvement actions are raised with the client
- Once any improvement actions are satisfied, ISO Certification reviews the ISO 9001 audit file
- ISO 9001 Certification is granted for a further 3 year cycle

7. What is ISO standard for Graphic Industry?

- ISO 12637 Graphic technology - Vocabulary
  - ❖ ISO 12637-1:2006 Part 1: Fundamental terms
  - ❖ ISO 12637-2:2008 Part 2: Prepress terms
  - ❖ ISO 12637-3:2009 Part 3: Printing terms
  - ❖ ISO 12637-4:2008 Part 4: Postpress terms

10 Mark Question

1. Explain in detail about ISO 9001 standards for printing industry.
2. Describe in detail about steps involved in ISO 9001 Certification.
3. Explain in detail about press calibration to ISO-12647-2 standard.
4. Explain in detail about the implementing of ISO for print quality.
5. Discuss in detail the customer satisfaction in implementing ISO for print Quality.
6. Discuss any one of the case studies of ISO implemented print media industry.
