Institute of Brewing & Distilling

The Diploma in Beverage Packaging (Beer)

Examination Syllabus 2011

THE DIPLOMA IN BEVERAGE PACKAGING (BEER)

BACKGROUND

The Mission Statement of the Institute of Brewing & Distilling (IBD) is:

> ”To be recognized as the world’s leading members organization for the advancement of education and training in the science and technology of brewing, distilling and related industries”.

Consistent with the achievement of this objective is the requirement for the means of assessing the levels of knowledge, understanding and competence of those educated and trained. The method of assessment is by examination and the IBD operates several levels of examination, with the Master Brewer as the highest level.

Currently, the most senior qualification in beer packaging is the IBD Diploma in Beverage Packaging (Beer). This is a measure of the level of a candidate’s knowledge and competence in the technical management of the packaging processes for beer.

To achieve the standard necessary, the examination process will measure the candidate’s theoretical knowledge of beer packaging technology. Typical candidates are team leaders or operational managers in brewery packaging departments.

The Institute awards successful candidates the use of the post-nominal, “Dipl. Pack.”.

INTRODUCTION

The IBD Diploma in Packaging Qualification has been designed to meet the ever changing needs of the brewing industry of which Packaging has become a key and expensive part. Packaging has to be carried out to give the best quality, at the lowest cost and with the best customer service delivery.

The course will only be available to members of the IBD

It would assist candidates if they have successfully completed the IBD General Certificate in Packaging (GCP), although this is **not** a requirement.

The core skills covered by this qualification are:

- An Understanding of Packaging and Packaging Components
- A Knowledge of Beer Preparation for Packaging and Packaging Operations
- An Understanding of Safety, Utilities and Environment
- A detailed Knowledge of Process Engineering
- An Appreciation of Brewing **or** Carbonated Soft Drinks Production.

The IBD Diploma in Packaging (Dipl. Pack.) programme will form a significant part of a candidate’s Continuing Professional Development. Since the examination syllabus is designed for Team Leaders and Packaging Managers in the Brewing Industry, it

requires the appropriate level of experience and knowledge in many aspects of technical operation of the beer packaging processes.

The programme is divided into 3 Modules, each consisting of 4 Units to be studied. Candidates must study all four units of Modules 1 and 3, plus units 2.1 and 2.2 of Module 2; candidates can choose to study **either** unit 2.3 **or** 2.4 and **either** unit 2.5 **or** Unit 2.6

Each unit is assessed by written examination, plus an assignment (assessed by written dissertation).

The units within the 3 modules are organized as follows:

Module	**Unit No.**	**Unit Titles**
M1	1.1	Packaging Theory and Materials
M1	1.2	Beer Preparation
M1	1.3	Planning and Line Design
M1	1.4	Small Pack Operations
M2	2.1	Quality
M2	2.2	Operations Management
	Either	
M2	2.3	Large Pack Operations - Keg
	Or	
	2.4	Large Pack Operations – Cask
M2	**Either**	
	2.5	Brewing
	Or	
	2.6	Carbonated Soft Drinks
M3	3.1	Resource Management
M3	3.2	Fluid Mechanics
M3	3.3	Heat Transfer
M3	3.4	Process Control

Progressive acquisition of the knowledge and competence required for each module builds up to a permanent personal record of achievement, yielding certificated qualifications in their own right through success in each module examination.

Each module Certificate will list the units included; this is especially relevant to Module 2, where candidates can select elective options.

The qualification of Diploma in Beverage Packaging is awarded following completion of all 3 Module examinations and entitles the use of the post-nominal – **Dipl. Pack.**

ADVICE TO CANDIDATES

It is a requirement that all candidates are sponsored by their employing organization, with a senior person nominated as the candidate's Sponsor. The role of the Sponsor is to support the candidate with resources and opportunities to carry out the full qualification programme, including the assignments.

It is recommended that all candidates acquire a Mentor for each module of the programme, since this will give the greatest opportunity for success in the examinations. An experienced Mentor, capable of giving general direction, support and assessment of progress through **all** modules would be ideal. Also, ideally, the Sponsor and Mentor should not be the same person, but this is not a requirement.

Combined with the need for relevant specialist tuition in many modular elements, the programme can be the ideal channel for technical development in beverage packaging.

The programme is modular, in order to allow the examinations to be sat when experience is fresh. During the course of the programme, all candidates are expected to keep up-to-date with the literature concerning novel plant and processing techniques across the whole syllabus, and to demonstrate this in the appropriate examination answers. Certain elements in the syllabus specify up-to-date knowledge.

QUALIFICATION FOR EXAMINATION

Qualification to sit the Dipl. Pack. examinations is membership of The Institute of Brewing & Distilling throughout the programme.

To attain the full Dipl. Pack. qualification, candidates must successfully complete all 3 Modules; the 3 Modules and their examinations may be attempted in any order.

There is no time limit between initial registration onto the programme and sitting one or all of the module examinations.

Studying for the Qualification is expected to take three years. However, candidates with the requisite level of experience and commitment could complete the qualification in two years.

EXAMINATION FORMAT

Assessment will be through achievement of learning outcomes via both assignments and written examinations for all Units within a Module.

The table above (page 3) shows how the Units are allocated to the three modules (M1, M2, M3). There will be an assignment given for each unit and the mark achieved will contribute to the overall mark for that unit.

Assignments will be work-based, where possible. This will enable candidates to prove through work that they have met their learning outcomes with the support of their mentor or sponsor. It is suggested that they submit a short draft plan of their assignment to their mentor or sponsor before they commence that assignment.
All assignments will be assessed by a written dissertation of typically 2500 - 3000 words.

If it is not possible for a candidate to carry out a work-based assignment due to lack of facilities (e.g. no kegging operation), then the assignment will be more theoretically based. If a theoretically based route is chosen this will need to be justified as the work-based method is preferred.
An assignment will be set for each unit. A framework and timetable for each assignment will be provided. Each assignment will be marked and moderated by the Board of Examiners.
Assignment dissertations must be submitted before a set date and candidates can **not** pass an individual unit unless an assignment is submitted.

Examinations for each unit of all 3 modules will consist of two written exams to be completed in 1 hour:

- Short Answer Paper: “short answers” and “multiple choice”, in order to ensure as complete a coverage of the unit syllabus as possible.

- Long Answer (Essay) Paper: choice of 1 from 2 questions.

Each module will be sat on separate days; 2 units (each consisting of short answer paper and “essay” paper, for I hour per unit) in the morning and 2 units in the afternoon.

Weighting of the marks for each unit will be as follows:

i. Short answers paper = 35%
ii. Written answers (1 from 2) = 35%
iii. Assignments = 30%

Candidates do **not** have to pass all units within a module in order to achieve a pass grade for that module; marks achieved for all units within a module are totalled to determine the grade achieved for that module.

However, failure to submit an adequate assignment dissertation for ANY unit will annul the results of that unit from the total marks for the relevant module and will require the candidate to repeat that unit assignment AND examination in the following (or subsequent) year, in order to achieve a pass grade for the module.
The IBD Board of Examiners reserves the right to judge whether a candidate’s dissertation constitutes an adequate submission.

RECOGNIZED PRIOR LEARNING (RPL) AND PORTFOLIO OF EVIDENCE (POE)

Students who have covered a unit to a required standard through prior learning may be exempt from that unit. Exemption will be granted upon the receipt of a Portfolio of Evidence, which, if required, may be tested by assignment**.**

Full details of Recognition of Prior Learning are given below, indicating those Units within modules for which exemptions may be allowed against prior learning.

The following table indicates where such exemptions may apply:

Unit No	Unit Title	RPL Exemption from Unit Standard
1.1	Packaging Theory and Materials	-
1.2	Beer Preparation	IBD Dipl. Brew.
1.3	Planning and Line Design	-
1.4	Small Pack Operations	-
2.1	Quality	-
2.2	Operations Management	-
2.3	Large Pack Operations - Keg	-
2.4	Large Pack Operations - Cask	-
2.5	Brewing	IBD GCB/ IBD Dipl. Brew.
2.6	Carbonated Soft Drinks	-
3.1	Resource Management	-
3.2	Fluid Mechanics	IBD Dipl. Brew.*/ Chemical or Mechanical Engineering B.Sc.
3.3	Heat Transfer	IBD Dipl. Brew*./ Chemical or Mechanical Engineering B.Sc.
3.4	Process Control	-

* Applies to fully qualified IBD Diploma Brewers, who attained grades A or B in Module 3 - PACKAGING TECHNOLOGY AND PROCESS TECHNOLOGY

Portfolio of Evidence

If a candidate does not have automatic exemption but has considerable experience in the area covered by a unit then that candidate can apply for RPL by submitting a Portfolio of Evidence (PoE) for that unit to the IBD BoE. The RPL process will require the candidate to complete the RPL application which will include detailing all relevant experience in a Portfolio of Evidence, validated by an appropriately qualified person (ideally from the sponsoring company). The IBD will then decide whether to award RPL and, if necessary, may set an assignment to test the PoE.

LEARNING MATERIAL

Learning material per Unit will be made available to all candidates as CD-ROM Revision Notes

Long Distance Learning (LDL) will also be available via the IBD LDL website, with IBD accredited tutors. Full details are available from the IBD Examinations Dept (see below).

Candidates will also be referred to a reading list, and as part of their assignments, will need to show referenced research using publications and the web.

REGISTRATION FOR EXAMINATIONS

The written examinations for Dipl. Pack. Modules 1 to 3 will take place in June of each year; individual unit dissertations must be submitted by the specified dates set by the IBD BoE.

Candidates must register with the IBD for Modules 1 to 3 before the 1st September of the previous year.

Registration fees and any special conditions are published regularly in the IBD's publications.

ISSUE OF CERTIFICATED QUALIFICATIONS

Success in each Module examination is individually Certificated as a self-standing Qualification, testifying to professional competence in technical management in that area of packaging operations.

The full Diploma in Beverage Packaging is awarded following successful completion of all 3 Module examinations.

EXAMINATION ENQUIRIES

Please address all enquiries and correspondence to:

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DIPLOMA IN PACKAGING

SYLLABUS SUMMARY

MODULE 1

Unit 1.1 Packaging Theory and Materials

Element
- 1.1.1 Theory
- 1.1.2 Materials

Unit 1.2 Beer Preparation

Element
- 1.2.1 Fundamentals of brewing practice
- 1.2.2 Beer filtration
- 1.2.3 Beer dilution, carbonation and bright beer handling
- 1.2.4 Theory and practice of sterile filtration and pasteurization

Unit 1.3 Planning and Line Design

Element
- 1.3.1 Capacity planning
- 1.3.2 Operational planning
- 1.3.3 Line design
- 1.3.4 Materials of construction

Unit 1.4 Small Pack Operations

Element
- 1.4.1 Fundamental considerations
- 1.4.2 Pre-filling operations
- 1.4.3 Theory and practice of filling technology
- 1.4.4 Container closing
- 1.4.5 Post-filling operations
- 1.4.6 Secondary packaging
- 1.4.7 Full line inspection procedures

MODULE 2

Unit 2.1 Quality

Element
- 2.1.1 Quality management
- 2.1.2 Food safety
- 2.1.3 Hygiene
- 2.1.4 Cleaning in place (CIP)
- 2.1.5 Product and package analysis

Unit 2.2 Operations Management

Element
- 2.2.1 Line operations
- 2.2.2 World class manufacturing
- 2.2.3 Finance
- 2.2.4 Purchasing

Unit 2.3 Large Pack Operations - Keg

Element
- 2.3.1 Fundamental considerations
- 2.3.2 Pre-filling operations
- 2.3.3 Theory and practice of keg filling
- 2.3.4 Post-filling operations
- 2.3.5 Draught beer dispense

Unit 2.4 Large Pack Operations - Cask

Element
- 2.4.1 Fundamental considerations
- 2.4.2 Pre-filling operations
- 2.4.3 Theory and practice of cask filling
- 2.4.4 Post-filling operations
- 2.4.5 Cask beer dispense

Unit 2.5 Brewing

Element
- 2.5.1 Sweet wort production
- 2.5.2 Wort boiling
- 2.5.3 Wort clarification, cooling and oxygenation
- 2.5.4 Fermentation and yeast management
- 2.5.5 Maturation, chilling and cold storage

Unit 2.6 Carbonated Soft Drinks

Element
- 2.6.1 Introduction to soft drinks
- 2.6.2 Raw materials and drink preparation
- 2.6.3 Production operations
- 2.6.4 Product integrity
- 2.6.5 Dispense
- 2.6.6 Product developments and adaptations

MODULE 3

Unit 3.1 Resource Management

Element
- 3.1.1 Environment
- 3.1.2 Health and Safety
- 3.1.3 Utilities
- 3.1.4 Maintenance

Unit 3.2 Fluid Mechanics

Element
- 3.2.1 Fluid Mechanics
- 3.2.2 Process Gases

Unit 3.3 Heat Transfer

Element
- 3.3.1 Principles of heat transfer
- 3.3.2 Steam
- 3.3.3 Refrigeration

Unit 3.4 Process Control

Element
- 3.4.1 Process and line control
- 3.4.2 Instrumentation

MODULE 1

Unit 1.1 Packaging Theory and Materials

1.1.1 Theory:

1.1.1.1 History and development of packaging:

- Evolution of small pack packaging (glass, cans and plastics) and large pack packaging (casks and kegs)
- Development of packaging from primitive functionality to a sophisticated marketing tool

1.1.1.2 Packaging principles:

- Definitions and examples of primary, secondary and tertiary packaging
- Technical and marketing functions of packaging
- Identification and specification of key components
- Environmental concerns and effects of packaging (see also 3.1.1.5)

1.1.2 Materials:

1.1.2.1 Glass bottles:

- Advantages and disadvantages of glass
- The different parts of the bottle including labelled diagrams
- Bottle manufacture:
  - Raw materials and cullet
  - Colour and how it is achieved
  - Principles of glass bottle making
- Bottle faults and testing
- Acceptance – positive release
- Palletization of bottles

1.1.2.2 Plastic bottles:

- Types of plastic bottles:
  - PET (polyethylene terephthalate)
  - PET multi-layer
  - PEN (polyethylene naphthalate)
  - PCR (post consumer recyclate)
- Technologies employed to make plastic bottles suitable for beer:
  - Mono-layer PEN
  - Blend of PET and PEN
  - Barrier coated monolayer PET (internal and external)
  - Multi-layer PET with barrier / scavenger in centre wall
- Advantages and disadvantages of the differing plastic bottles

- Principles of plastic bottle making:
  - Preforms
  - Stretch blow moulding

1.1.2.3 Emerging bottle formats:

- Aluminium
- Others

1.1.2.4 Crowns and caps:

- Types of closure:
  - Stainless steel
  - Electrolytic tin plate
  - Tin free steel
  - Pry-off / twist off
  - ROPP
- Crown manufacture:
  - Decoration
  - Forming
- Crown sealing materials:
  - PVC
  - PVC dry-blends
- Cap materials and manufacture

1.1.2.5 Cans and ends:

- Advantages and disadvantages of cans.
- Sizes of cans and ends including diameter measurement conventions
- Design criteria:
  - Cans
  - Ends
- Manufacture of cans:
  - Steel cans (three piece)
  - Steel and aluminium cans (two piece)
- Inspection of cans
- Palletization of cans
- Manufacture of ends
- Inspection of shells
- Manufacture of tabs
- Shell and tab assembly
- Inspection of ends
- End bagging and palletization

1.1.2.6 Paper and cardboard:

- Advantages and disadvantages of paper and cardboard
- Fundamentals of paper and cardboard manufacture
- Corrugated board
- Cardboard
- Paper and cardboard types

1.1.2.7 Plastics:

- Plastic films and other polymers:
  - Types of plastic films used in beverage packaging
  - Manufacture by blow-film extruders
  - Typical film properties, uses and specification values
- Plastic crates:
  - Materials of construction
  - Design
  - Manufacture (principles only)

1.1.2.8 Adhesives:

- History and development of adhesives
- Types of adhesives and materials:
- Principles of adhesion
- Hot melts
- Aqueous adhesives

1.1.2.9 Kegs, spears and casks:

- The different parts of kegs and casks including labelled diagrams
- Keg sizes (dimensions and capacities) and manual handling considerations
- Manufacture of kegs and casks:
  - Materials (stainless steel, aluminium, plastics)
  - Advantages and disadvantages of the differing materials
- Principal types of spears
- Spear safety
- For principles of spear operation see 2.3.6.1

Unit 1.2 Beer Preparation

1.2.1 Fundamentals of brewing practice:

1.2.1.1 Definition of beer and beer types:

- A generic, non-legalistic, definition of beer in terms of its typical ingredients and methods of production
- Characteristics which differentiate lagers, ales, stouts, low-alcohol and low carbohydrate beers

1.2.1.2 Raw materials:

- Malt
- Adjuncts
- Water
- Hops

1.2.1.3 Basic brewing process:

- Milling, mashing and conversion
- Wort separation, boiling, clarification and cooling
- Role of yeast in fermentation
- Fermentation process
- Yeast handling
- Beer maturation, conditioning and cold storage

1.2.1.4 Key beer properties:

- The key properties of beer and why they are important:
  - Alcohol content
  - Colour
  - Flavour
  - Foam formation and retention
  - CO_2 content
  - O_2 content (shelf life implications)
  - Particulate matter (haze)
  - Susceptibility to microbiological contamination

1.2.1.5 Basic principles of handling beer and maintaining key properties:

- Pipework systems and pumping (design principles, velocities for beer and CIP fluids)
- Storage in tanks

1.2.2 Beer filtration:

1.2.2.1 Purposes and principles of filtration:

- Purposes of rough, polishing and stabilizing filtration
- Principles of filtration:
  - Using filter powders
  - Using sheet filtration
  - Using cross-flow techniques
  - Using depth filtration

1.2.2.2 Rough beer filtration:

- The nature, function and available materials for pre-coat filter aid and main filter medium
- The basic principles of design and operation and the respective merits of:
  - Plate and frame
  - Leaf
  - Candle
  - Cross-flow
- The relevance of micro-organism concentrations in the beer presented to the filter and in the filtered beer
- Temperature control during filtration
- Filter performance as a function of time, pressure, filter medium dosing and beer solids concentration
- Safety considerations

1.2.3 Beer dilution, carbonation and bright beer handling:

1.2.3.1 De-aerated liquor (water) and beer dilution:

- High gravity brewing:
  - Principles and implications
  - Advantages and disadvantages
- Quality requirements for dilution liquor
- Basic principles and schematic diagrams for de-aerated liquor production (see also 3.1.3.1)
- Blending procedures and calculations

1.2.3.2 Purposes and principles of carbonation (see also 3.2.2):

- Purposes of carbonation:
- Qualitative principles of dissolving gas in a liquid and the positive influencing factors
- Carbonation equipment
- Location of carbonation points
- Dissolved gas adjustment:

1.2.3.3 Bright beer storage:

- Principles of bright beer storage:
  - Vessels
  - Filling, emptying and cleaning
  - Temperature control
  - Maintaining dissolved gas in solution
  - Residence time
- Positive release of beer for packaging

1.2.3.4 Maintaining beer quality up to the filler:

- Plant features and procedures to control:
  - Beer dilution
  - Variations in CO_2 levels
  - O_2 pick-up
  - Loss of foam potential

- Particulate matter in the beer
- Microbiological contamination risk
- Chemical contamination risk
- Techniques for monitoring the key parameters

1.2.4 Theory and practice of sterile filtration and pasteurization:

1.2.4.1 Sterile filtration theory, filter design and operation:

- Process specification:
  - Feedstock maximum microbiological and non-biological load
  - Filtrate maximum concentration
  - Product viscosity and flow characteristics
- Concept of Log Reduction Value (LRV)
- Simple calculations relating to filtration efficiency i.e. beta ratio
- Filtration mechanisms
- Principal concepts of filter media design
- Filter types including cross-flow filters
- Removal ratings:
  - Nominal
  - Absolute
- Filter flow characteristics
- Integrity testing
- Filter cleaning

1.2.4.2 Definition of pasteurization and pasteurization unit:

- Definition and aims of pasteurization and the difference between pasteurization and sterilisation
- The relationship between time and temperature on lethal rate
- Simple calculations estimating the magnitude of lethal rate changes with varying temperatures
- The effect of pasteurization on different organisms and the concept of thermal tolerance
- The definition of pasteurization unit (PU)
- Simple calculations on the relationship between pressure, temperature and CO_2 content of beer

1.2.4.3 Design, operation and control of a plate pasteurizer:

- Design, operation and control of a plate (flash) pasteurizer (including very basic heat transfer principles – covered fully in 3.3.1)
- Heat regeneration – saving heat and refrigeration energy
- Operating parameters and the importance of high quality instrumentation and control
- Overall pasteurizer system design and control
- Common faults, likely causes and remedies
- Principal effects on beer quality during pasteurization

1.2.4.4 Design, operation and control of a tunnel pasteurizer:

- Principles of design and operation:
  - Single / double deck
  - Materials of construction
  - Transport system
  - Spray system
  - Temperature balance
  - Heating methods and PU control
- Measurement of PUs including by travelling thermograph
- Chemical treatment of pasteurizer water
- Common faults, likely causes and remedies
- Principal effects on beer quality during pasteurization

Unit 1.3 Planning and Line Design

1.3.1 Capacity planning:

1.3.1.1 Forecasting demand:

- Market and category forecasting including where and when the data may be gathered
- Basic methods for forecasting demand / sales and quantitative analysis
- Restrictions or constraints on plans due to raw materials (including water), labour, transport, utilities, maintenance requirements etc

1.3.1.2 Strategic and tactical planning:

- The contrast between strategic planning (visionary, conceptual and directional) and tactical (short term, focused, operational, implementable and measurable)
- The key elements of strategic and tactical plans

1.3.2 Operational planning:

1.3.2.1 Line planning and scheduling:

- Customer demand and service levels:
  - Translating forecasts into plans and schedules
  - Setting, maintaining and meeting internal and external service level objectives
  - Measuring and reporting performance
- Short and medium term scheduling:
  - The principles for production and packaging scheduling
- The role of labour and shift patterns in planning and scheduling
- How major planned maintenance activities are accommodated e.g. annual overhauls, statutory inspections etc
- Recovery steps following plant breakdowns
- Planning systems

1.3.2.2 Planning and production constraints:

- Internal influences including: process times, plant efficiencies, line changeovers, scheduled cleaning and maintenance (daily, weekly, monthly), plant utilization and optimization, materials, labour (also see below), transport, utilities, planned downtime (e.g. team meetings, training)
- External influences including: customer demand and supply, market pressures, customer supplied items
- Calculations around planning and scheduling

1.3.3 Line design:

1.3.3.1 Line design theory:

- Principles of line design including:
  - Running time
  - Range of containers
  - Frequency of product / container changeovers
  - Planned downtime
  - Maintenance and engineering requirements
  - Seasonality
- Design constraints including:
  - Safety and environmental requirements
  - Plant layout, working environment and operation
  - Labour requirements and technology
  - Maintenance / overhaul regimes
  - Communications
- 'V' graph: Principles of designing for the critical machine
- Line layouts: Advantages and disadvantages of various formats
- Conveyor design, accumulation and line philosophy
- Calculations around line design

1.3.3.2 Manning philosophy:

- Line layout
- Manual versus automatic operation
- Company and customer operational requirements
- Culture and skills

1.3.3.3 Materials handling:

- Location(s) of internal / external warehouses
- Just-in-time (JIT) material deliveries, live-bed small pack container handling
- Fork lift truck / automated guided vehicle handling
- Proximity of storage locations to points of use
- Storage conditions for differing materials and finished product

1.3.3.4 Waste handling:

- Points at which waste is generated
- Categorisation of wastes for storage and disposal
- Storage of wastes: locations; storage containers; management
- Fate of wastes:
  - Return / re-use
  - Recycle
  - Controlled waste to landfill
  - General waste to landfill
  - Drain

1.3.4 Materials of construction:

1.3.4.1 Classification, properties and duties of materials:

- Material groupings:
  - Metals
  - Plastics and glass
  - Other materials (e.g. civil finishing)
- Properties:
  - Tensile and compressive strengths
  - Compatibility with process conditions
  - Ease of fabrication
  - Finishes
  - Availability and relative costs
  - Resistance to corrosion
- Duties:
  - Safety
  - Hygiene
  - Suitability for water, beer, CIP, process gases, air, refrigeration
  - Handling of materials, work-in-progress and finished product

1.3.4.2 Metals:

- Carbon and low alloy steels:
  - Mild steel and galvanised steel:
    - Properties
    - Advantages and disadvantages
    - Applications in packaging
    - Corrosion and its consequences (including prevention and mitigation measures)
  - Stainless steels:
    - Types (with approximate compositions)
    - Properties (e.g. passivity, thermal conductivity)
    - Relative costs
    - Advantages and disadvantages
    - Applications in packaging
    - Corrosion and its consequences (including prevention and mitigation measures): General; galvanic; erosion and cavitation; intergranular; pitting; crevice; microbiologically induced; stress.
- Other metals including aluminium, copper (and alloys), cast iron etc
  - Properties
  - Relative costs
  - Advantages and disadvantages
  - Applications in packaging
  - Corrosion and its consequences (including prevention / mitigation measures)

1.3.4.3 Plastics and glass:

- Classification of plastics
- Properties
- Advantages and disadvantages
- Applications in packaging

1.3.4.4 Civil finishes:

- General requirements:
  - Safety
  - Hygiene
  - Cleanability
  - Appearance
  - Durability
  - Maintainability
  - Cost vs benefits
- Specific requirements for wet and dry areas
- Common materials used

Unit 1.4 Small Pack Operations

1.4.1 Fundamental considerations:

1.4.1.1 Typical small pack line layouts:

- Schematic diagrams showing configuration of complete line with all key plant items and conveyoring
- Simple flow diagrams showing key plant items and product flow
- The relationships between the plant items

1.4.1.2 Influence of container design and specification (on filling performance):

- The benefits of container standardization vs product differentiation
- Container design in relation to conveying and handling within worms and starwheels
- Bottle appearance vs fill height control

1.4.2 Pre-filling operations:

1.4.2.1 Container reception, depalletizing and returnable bottle decrating:

- Handling of bottles, cans and crates / returnable packaging
- Depalletizing
- Decrating

1.4.2.2 Container preparation for filling (inspection covered in 1.4.7.2 and 1.4.7.3):

- Crate washing
- Bottle washing
- Bottle and can rinsing

1.4.3 Theory and practice of filling technology:

1.4.3.1 Filling theory and principles:

- Specific issues for beer:
  - Head retention
  - Damaging effects of oxygen
- Key issues for filler design and operation
- The filling cycle
- Fillers:
  - Mechanical
  - Electro-pneumatic
  - Volumetric

1.4.3.2 Glass bottle filling:

- Pre-evacuation
- Short tube and long tube filling
- Fill height control

- Burst bottle procedures (see also 1.4.7.2)
- Safety
- Common filling problems, reasons and remedies

1.4.3.3 PET bottle filling:

- CO_2 flushing
- Key differences with glass bottle filling
- Common filling problems, reasons and remedies

1.4.3.4 Can filling:

- CO_2 flushing
- Key differences with glass bottle filling
- Common filling problems, reasons and remedies

1.4.3.5 Sterile and aseptic filling:

- Reasons for sterile or aseptic filling (for treatment of beer prior to filling see 1.2.4)
- Primary materials preparation
- Filler enclosures
- Sterilizing the filler
- Process controls and procedures

1.4.3.6 Widget technology:

- Purpose of widgets and their development
- Widget theory and operating principles
- Types of widgets for cans and bottles
- Issues associated with widget technology

1.4.4 Container closing:

1.4.4.1 Crowning / capping:

- Expelling air from headspace
- Crowning operation
- Crown tolerances and integrity
- Roll on closures
- Common closing problems, reasons and remedies

1.4.4.2 Seaming:

- Expelling air from headspace
- Seaming operation
- Labelled section diagram of double seam showing important dimensions and standard descriptors
- Common seaming problems, reasons and remedies

1.4.5 Post-filling operations:

1.4.5.1 Pasteurizing: See 1.2.4.4

1.4.5.2 Drying / warming containers:

- Purposes and equipment for drying bottles and cans
- Bottle warmers

1.4.5.3 Container sleeving, labelling and coding:

- Sleeving:
  - Products, benefits and constraints
- Labelling:
  - Key reasons for labelling
  - Types of labelling
  - Paper and glue types
  - Labeller operation
  - Common labelling problems, reasons and remedies
- Coding:
  - Key reasons for coding
  - Types of coding
  - Coder operation
  - Common sleeving, labelling and coding problems, reasons and remedies

1.4.5.4 Secondary packaging (see 1.4.6)

1.4.5.5 Palletization:

- Principles and practices of palletization:
- Pallet condition
- Configuration of crates and packs
- Number of layers
- Measures to maximize pallet stability
- Stretchwrapping and labelling

1.4.5.6 Warehousing:

- Storage conditions
- Stock rotation

1.4.6 Secondary packaging:

1.4.6.1 Purposes and roles of secondary packaging:

- Containment and marketing function
- Collating, handling, storing and distributing of product
- For environmental concerns and effects of packaging see 1.1.1.2 and 3.1.1.5).

1.4.6.2 Materials (see also 1.1.2.5 and 1.1.2.7):

- Corrugated board
- Plastics
- Cardboard

1.4.6.3 Types of secondary packaging:

- Open tray; tray and shrink; shrink only
- Hi-cone; hi-cone in tray with or without shrink
- Case with or without dividers
- Carton
- Wrap around pack
- Cluster / basket pack
- Future trends

1.4.7 Full line inspection procedures:

1.4.7.1 Purposes and principles of inspection

1.4.7.2 Bottle:

- Empty crate and bottle sorting
- Crates
- Empty bottle sorting
- Empty bottle inspection (EBI)
- Fill level and crown inspection
- Filler and burst bottle management
- Label inspection
- Full beer inspection (FBI)
- Crates and pack inspection
- Rejectors
- Maintenance and cleaning of equipment, common faults and remedies

1.4.7.3 Cans and PET:

- Visual and minor faults at depalletization
- Vacuum bridge
- Empty can inspection
- Fill level inspection
- Pack inspection
- End of line inspection
- PET closure inspection
- Rejectors
- Maintenance and cleaning of equipment, common faults and remedies

MODULE 2

Unit 2.1 Quality

2.1.1 Quality management:

2.1.1.1 Quality assurance principles and practices:

- Concept and purpose of quality control
- Concept and purpose of quality assurance
- Principles of quality assurance
- Concept of right first time
- Total quality management
- Practical application of quality assurance principles

2.1.1.2 International standards:

- The structure and content of relevant national and international standards (e.g. ISO9000:2000 series)
- The sections of the standards, their purpose and content including:
  - quality policy
  - planning
  - implementation and operation
  - auditing
  - corrective action
  - management review

2.1.2 Food safety:

2.1.2.1 Food legislation:

- International and national regulations
- Requirements of regulations for labelling including:
  - Best before date
  - ABV
  - Health messages
  - Presence of potential allergens etc

2.1.2.2 Procedures and controls:

- Company policies and procedures
- Risk management
- Security in plants
- Concept of due diligence
- Contamination prevention

2.1.2.3 Hazard Analysis Critical Control Point (HACCP):

- Concept of a hazard in terms of food safety
- Key stages in a HACCP analysis
- Maintaining a HACCP system

2.1.3 Hygiene:

2.1.3.1 Microbial contamination:

- Definition of microbial contamination
- Typical micro-organisms
- Methods of detection and quantification of residual surface contamination

2.1.3.2 Preventing microbial contamination:

- Underlying principles
- Plant design
- Practical considerations

2.1.4 Cleaning in place (CIP):

2.1.4.1 CIP principles:

- Factors affecting the performance of cleaning systems:
- Composition of soil, scale and biofilm
- Microbiology of cleaning
- Safety requirements

2.1.4.2 Detergents and sterilizing agents:

- Detergent and sterilant chemistry
- Ingredients of caustic or alkali detergents
- Ingredients of acid detergents
- Ingredients of sterilants

2.1.4.3 Design and operation of CIP systems:

- Design principles
- CIP of vessels
- CIP of pipework systems and hoses
- Types of CIP systems
- Optimization of cleaning systems

2.1.5 Product and package analysis:

2.1.5.1 Interpretation of analytical data:

- Sampling error
- Accuracy and precision
- Repeatability (r)
- Reproducibility (R)
- Specification ranges (tolerances)

2.1.5.2 Relevance of inter-laboratory collaboration:

- Purpose of inter-laboratory collaboration
- Proficiency testing schemes

2.1.5.3 Analytical and on-line measurement techniques (where applicable):

- Original gravity
- Alcohol content
- Dissolved carbon dioxide
- Dissolved oxygen
- Dissolved nitrogen
- Colour
- Bitterness
- Specific gravity
- pH
- Invertase test
- In package shelf life measurement, actual and predictive
- In package volume including regulatory requirements
- Checking the crowning operation
- Measurement of can seams
- Foreign body detection
- Procedures following bottle breakage on the filler
- Full package checks

Unit 2.2 Operations Management

2.2.1 Line operations:

2.2.1.1 Operating practices:

- Organization including structure, operational philosophy (team, mixed team, self managing etc), roles and responsibilities
- Skill profiles; training needs; training and development
- Day to day practices:
  - Team / shift meetings
  - Performance management
  - Maintenance planning meetings
- Interface with other departments:
  - Bright beer
  - Warehouse
  - Engineering
  - Quality assurance (including laboratory)
- Cleaning: CIP and manual cleaning
- Maintenance:
  - Organization and planning of maintenance
  - Operational team tasks (including multi-skilling)
  - Specialist tasks (carried out by supplier or contractor)
  - Planned short or extended shut-downs

2.2.1.2 Measuring performance:

- Principles of performance measures and the impact on overall performance of plant efficiency and losses (including quality defects and time)
- Performance measures including:
  - Yield
  - Operating efficiency
  - Utilization
  - Mechanical efficiency
  - Mechanical effective utilization (MEU)
  - Overall equipment effectiveness (OEE)
- Efficiency calculations
- Time management:
  - Planned downtime
  - Unplanned downtime
- Changeovers: Practices; single minute exchange of die (SMED) principles
- For performance improvement see 3.1.4.5

2.2.2 World class manufacturing:

2.2.2.1 High performance work environments and cultures:

- Workplace environments and cultures for achieving high levels of performance including examples of differing approaches such as:
  - Kaizen (evolutionary process improvement)
  - Crosby (cultural change)

- Lean manufacturing (the continuous elimination of all waste resulting in a system of value added activity)
- Six Sigma (statistical technique)

- Examples of World Class Standards:
  - 5S (see 3.1.4.5)
  - Autonomous maintenance
  - Quality (ISO 9001) – see 2.1.2.1
  - Environmental (ISO 14001)
  - Safety (ISO 18001) – see 3.1.2.1
- Change management

2.2.2.2 Continuous improvement:

- The principles of continuous improvement, in particular improvement cycles e.g. Deming
- Techniques for problem solving
- Tools and techniques for measuring and reporting performance
- Techniques for communicating performance

2.2.3 Finance:

2.2.3.1 Basic revenue budgeting:

- Accounting principles and conventions
- Direct and indirect costs
- Fixed and variable costs
- Construction of departmental budgets

2.2.3.2 Management accounting:

- Annual budgets and period operating statements
- How actual performance is reported against the budgeted monthly or period figures
- The purpose of year-to-date figures
- Variance reporting:
  - The meaning of variance and the conventions for designating positive and negative variances

2.2.3.3 Project management:

- Project justification
- Project life cycle:
  - The key stages of the project life cycle from conception to final acceptance
  - The roles and responsibilities of individuals and groups at each stage and how they interact
- Control of time and cost:
  - Tools and techniques for controlling time and cost
  - The meaning of critical path
  - The likely effect on completion of delaying events and implementing a recovery strategy
  - The differing implications of project variations initiated by the customer or supplier

2.2.4 Purchasing:

2.2.4.1 Markets and suppliers:

- Preferred markets and excluded areas
- Policies and criteria for selecting suppliers and expectations of suppliers
- Ongoing partnering agreements
- Key principles of contracts and contract terms and conditions
- E-Commerce

2.2.4.2 Specifications and tenders:

- Material, product and service specifications including quality requirements
- Competitive tendering process – gathering information, drafting tender documents, evaluating offers

2.2.4.3 Contract management:

- Supplier meetings
- Performance improvement
- Value engineering

Unit 2.3 Large Pack Operations - Keg

2.3.1 Fundamental considerations:

2.3.1.1 Role and importance of keg beer:

- History and development of keg beer
- Advantages and disadvantages of keg beer

2.3.1.2 Typical keg line layouts:

- Schematic diagrams showing configuration of complete line with all key plant items and conveyoring
- Simple flow diagrams showing key plant items and product flow
- The relationships between the plant items

2.3.2 Pre-filling operations:

2.3.2.1 Container collation methods:

- Pallets (flat beds, belly)
- Locator boards
- Loose

2.3.2.2 De-unitizing:

- Traditional methods
- Robotic arms
- Pallet and locator board inspection

2.3.2.3 External keg washing and label removal:

- Overview and objectives of external keg washing
- Current design capabilities
- Typical washer configurations and operations
- Maintenance and cleaning of equipment, common faults and remedies

2.3.2.4 Keg orientation and spear torque tightness:

- Selective turning
- Spear torque tightness

2.3.3 Theory and practice of keg filling:

2.3.3.1 Filling theory and principles:

- Specific issues for beer:
  - Head retention
  - Damaging effects of oxygen
- The cleaning cycle:
  - Assuring keg hygiene
- Keg sterilization:
  - Steam properties

- Steam quality
- The filling cycle
- Key issues for combined cleaning / filling machine design and operation

2.3.3.2 Design and operation of cleaning / filling machines:

- Lane cleaning / filling machines including:
  - Typical machine layouts and configurations
  - Keg conveying
  - Dealing with damaged kegs
  - Keg size changes
  - Maintenance and cleaning of equipment, common faults and remedies
- Rotary cleaning / filling machines including:
  - Pre-cleaner machine layout
  - Cleaner machine layout
  - Filler machine layout
  - Keg conveying
  - Dealing with damaged kegs
  - Keg size changes
  - Maintenance and cleaning of equipment, common faults and remedies

2.3.3.3 Gases other than CO_2 as a top pressure:

- Nitrogen
- Mixed gas

2.3.4 Post-filling operations:

2.3.4.1 Labelling, coding and capping:

- Purpose of labels and caps
- Design and operation of labelling machines
- Design and operation of coding machines
- Design and operation of capping machines
- Common labeling, coding and capping problems

2.3.4.2 Keg tracking:

- Purposes of keg tracking
- Keg security
- Systems for tracking

2.3.4.3 Unitizing:

- Traditional methods
- Robotic arms

2.3.4.4 Warehousing:

- Storage conditions
- Stock rotation

2.3.4.5 Keg Inspection:

- Pre-filling
- Volume contents
- Labels
- Caps
- Leakers
- Dealing with rejects

2.3.5 Draught beer dispense:

2.3.5.1 Design and operation of dispense equipment:

- Spears (extractor tubes) and spear couplings:
  - Types
  - Components
- Beer pumps
- Beer lines
- Dispense taps
- Dispense problems
- Maximizing yield

2.3.5.2 Hygiene:

- Beer line cleaning:
  - Choice of detergent, concentration and temperature
  - Methodology
- Cellar hygiene
- Glass cleaning

2.3.5.3 Dissolved gas control:

- Safety
- Gas systems (with examples)
- Pressure reducing valves
- Product gas levels

2.3.5.4 Temperature control:

- Principles
- Cellar / store cooling
- Under bar cooling
- Line cooling

Unit 2.4 Large Pack Operations - Cask

2.4.1 Fundamental considerations:

2.4.1.1 Role and importance of cask beer:

- History of cask beer
- Advantages and disadvantages of cask beer

2.4.1.2 Beer treatment:

- Beer condition
- Beer fining
- Hop product addition

2.4.1.3 Typical cask line layouts:

- Schematic diagrams showing configuration of complete line with all key plant items and conveyoring
- Simple flow diagrams showing key plant items and product flow
- The relationships between the plant items

2.4.2 Pre-filling operations:

2.4.2.1 Container collation methods (similarities to keg see 2.3.2.1):

- Pallets (flat beds, belly)
- Locator boards
- Loose

2.4.2.2 De-unitizing (similarities to keg see 2.3.2.2):

- Traditional methods
- Robotic arms
- Pallet and locator board inspection

2.4.2.3 Shives, keystones, corks and spiles:

- Shive bush and shive
- Keystone bush and keystone
- Shive and keystone removal (manual and automatic) and insertion

2.4.2.4 External cask washing and label removal:

- Overview and objectives of external cask washing
- Current design capabilities
- Typical washer configurations and operations
- Maintenance and cleaning of equipment, common faults and remedies

2.4.2.5 Cask beer preparation:

- The purposes of warm maturation
  - Typical times and temperatures appropriate to different beer types
  - Changes during maturation that can affect beer flavour
  - The purposes and operating principles of cooling in vessel
- Clarification
  - The nature and action of auxiliary finings
  - The nature and action of isinglass finings
  - The operating principles of finings addition equipment
- Priming
  - Reasons for the addition of priming sugar

2.4.3 Theory and practice of cask filling:

2.4.3.1 Filling theory and principles:

- The cleaning cycle
- The filling cycle

2.4.3.2 Design and operation of cleaning and filling machines:

- Cleaning machines including:
  - Typical machine types, layouts and configurations
  - Cask conveying
  - Walking beam system (where relevant)
  - Cleaning and sterilizing
  - Cask size changes
  - Maintenance and cleaning of equipment, common faults and remedies
- Filling machines including:
  - Typical machine types, layouts and configurations:
    - Manual counter-pressure
    - Fully automated racking and shiving (FARAS)
  - Cask conveying
  - Monitoring cask filling
  - Full cask discharge
  - Dealing with damaged casks
  - Cask size changes
  - Maintenance and cleaning of equipment, common faults and remedies

2.4.4 Post-filling operations:

2.4.4.1 Addition of hops or hop products to cask

- Reasons for addition of hops or hop products
- Types of hops and hop products used

2.4.4.2 Labelling and coding:

- Purpose of labels
- Design and operation of labelling machines
- Design and operation of coding machines

- Common labelling and coding problems

2.4.4.3 Cask tracking:

- Purposes of cask tracking
- Cask security
- Systems for tracking

2.4.4.4 Unitizing:

- Traditional methods
- Robotic arms

2.4.4.5 Warehousing:

- Storage conditions
- Stock rotation

2.4.4.6 Cask Inspection:

- Pre-filling
- Volume contents
- Labels
- Leakers
- Dealing with rejects

2.4.5 Cask beer dispense:

2.4.5.1 Design and operation of dispense equipment:

- Bungs and spiles
- Cask taps:
  - Types
  - Components
- Beer engines
  - Types
  - Components
- Beer lines
- Dispense taps
- Dispense problems
- Maximizing yield

2.4.5.2 Hygiene:

- Beer line cleaning
  - Choice of detergent, concentration and temperature
  - Methodology
- Cellar hygiene
- Glass cleaning

2.4.5.3 Dissolved gas control:

- Beer quality (condition)
- Product gas levels

2.4.5.4 Temperature control:

- Principles
- Cellar / store cooling
- In-line cooling

Unit 2.5 Brewing

2.5.1 Sweet wort production:

2.5.1.1 Raw materials:

- Barley, malting and malt
- Adjuncts
- Water

2.5.1.2 Milling operation:

- Mills
- Grist
- Safety

2.5.1.3 Mashing and conversion:

- Process of conversion
- Mashing systems

2.5.1.4 Wort separation:

- Objectives of wort separation
- Wort separation systems
- Spent grain

2.5.2 Wort boiling:

2.5.2.1 Purposes of boiling wort

2.5.2.2 Kettle (copper) additions (in addition to hops / hop products):

- Liquid adjuncts
- Kettle (copper) finings

2.5.2.3 Hops and hop bitterness:

- Hops
- Hop products:
  - Hop extracts
  - Hop pellets
  - Pre-isomerised hop products

2.5.2.4 Wort boiling systems including:

- Kettles with internal heating elements
- Kettles with external heating elements
- Typical control parameters

2.5.3 Wort clarification, cooling and oxygenation:

2.5.3.1 Wort clarification:

- Composition of trub

- Systems for wort clarification

2.5.3.2 Wort cooling:

- Principles of operation of the plate heat exchanger
- Benefits of the plate heat exchanger

2.5.3.3 Wort oxygenation / aeration:

- Purpose of wort oxygenation / aeration
- Advantages and disadvantages of hot and cold aeration

2.5.4 Fermentation and yeast management:

2.5.4.1 Principles of fermentation:

- Types of yeast
- Yeast activity
- Fermentation process

2.5.4.2 Fermentation implications for beer flavour:

- Fermentation reaction
- Importance of by-products:
  - Esters
  - Higher alcohols
  - Diacetyl
  - Sulphur compounds
- Fermentation conditions and the achievement of consistent performance

2.5.4.3 Fermentation practice:

- Fermentation vessels:
  - For top cropping yeasts
  - For bottom cropping yeasts
- Fermentation control
- Safety

2.5.4.4 Yeast handling in the brewery:

- Yeast pitching
- Yeast cropping
- Yeast storage

2.5.4.5 Yeast propagation:

- Methods of long-term culture storage
- Yeast propagation principles

2.5.5 Maturation, chilling and cold storage:

2.5.5.1 Maturation:

- Purposes of maturation and cold storage:
  - Flavour maturation
  - Clarification
  - Stabilization
  - Conditioning

2.5.5.2 Maturation practice:

- Maturation systems including:
  - Unitanks
  - Transfer chilling between fermentation and maturation
  - Vessels with external cooling jackets
  - Vertical or horizontal vessels in a cold room

2.5.5.3 Additions to beer:

- Purposes of additions at the maturation stage including:
  - Increase sweetness (or additional fermentation)
  - Promote head stabilization
  - Adjust colour
  - Increase bitterness

Unit 2.6 Carbonated Soft Drinks

2.6.1 Introduction to soft drinks:

2.6.1.1 History and background, including overviews on:

- Raw materials
- The manufacturing process
- Quality control and recycling
- Safety and hazard prevention
- The future

2.6.1.2 Soft drink specific packaging materials:

- Objectives of packaging
- PET / RPET
- Cans
- Cartons
- Closures
- Labelling and sleeving

2.6.1.3 Line layouts:

- Differences with beer operations (see 1.3.3 and 1.4.1.1)
    - Measurement of carbonation
    - De-aeration
    - Proportioning
    - Carbonation & pasteurization
- Typical soft drink line layouts
    - PET including advantages of bloc lines
    - Cans & glass
    - Capping & closure systems
    - Factory design

2.6.2 Raw materials and drink preparation:

2.6.2.1 Ingredients, additives and flavourings:

- Regulations
- Sweeteners:
    - Bulk sweeteners
    - Intensive sweeteners
    - Shelf life
    - Synergy
- Acidulants
- Preservatives:
    - Sulphur dioxide
    - Benzoic acid
    - Sorbic acid
- Colours:
    - Artificial
    - Natural
    - Caramel

- Stabilizers:
  - Antioxidants
  - Cloudifier
  - Antifoam
- Flavourings:
  - Taste, smell
  - Raw materials and substances
  - Developing a flavor
  - Handling of flavours
  - Examples of formulations

2.6.2.2 Water preparation and uses:

- Types of water
- Treated water (see also 3.1.3.1)
- Water treatment processes
- Semi-treated water
- Treatment summary of various water types
- Water treatment process comparison
- Measurement of water alkalinity

2.6.2.3 Product preparation:

- Syrup production and services
- CO_2, water
- Proportioning principles
- De-aeration
- Carbonated product processing and filling equipment
- Types of proportioners and carbonators
- Beverage cooling

2.6.3 Production operations:

2.6.3.1 Filling of finished products:

- Differences with beer operations (see 1.4.3)
- Basic principles of filling soft drinks
- Major components of a filling machine
- Stages of the filling process
- Variables affecting fill levels
- Fill level detection
- Common filling problems and fault-finding
- Types of filling machines
- Use of sterile air / CO_2
- Carbonation levels - Non-sugar drinks vs sugar base

2.6.3.2 Filling syrup for dispense operations

- Bag-in-box manufacture
- Other types of packaging (e.g. kegs)

2.6.3.3 Labelling and coding (including promotions):

- Differences with beer operations
- Wraparound labeling
- Sleeving
- Labelling in production including bottle warmers, air knives
- Date-coding
- Future trends

2.6.3.4 Warehousing:

- Storage conditions
- Stock rotation

2.6.4 Product integrity:

2.6.4.1 Microbiological testing:

- Requirements and results

2.6.4.2 Analytical testing:

- Requirements and results

2.6.4.3 Full line inspection:

- Differences with beer operations

2.6.4.4 Legislative declarations:

- Ingredients / allergens / colours
- Nutrition labeling on soft drinks

2.6.5 Dispense

2.6.5.1 Design and operation of dispense equipment:

- Vending machines
- Use of planograms
- Dispense problems

2.6.5.2 On-premise hygiene & maintenance of dispense equipment

2.6.5.3 Dissolved gas control

2.6.5.4 Temperature control

2.6.6 Product developments and adaptations:

2.6.6.1 Bottled waters

2.6.6.2 Functional drinks

2.6.6.3 Energy drinks / isotonics

MODULE 3

Unit 3.1 Resource Management

3.1.1 Environment:

3.1.1.1 Sustainability and climate change:

- Sustainability:
  - The challenge of sustainable development to achieve economic, social and environmental objectives at the same time
  - The impact the packaging operation has on the environment as a user of energy, as a consumer of water and other natural resources and as a source, both directly and indirectly, of atmospheric emissions, trade effluent and packaging waste
- Climate change:
  - Greenhouse gases and their sources
- Sustainability guiding principles:
  - Compliance with legislation and regulation
  - The design, operation and maintenance of processes and plants to optimize the use of all resources and minimize the potential impact on the environment
  - Assessment of environmental impacts and setting of targets for continuous improvement
  - Minimization of the use of substances which may cause potential harm to the environment and the means of ensuring they are used and disposed of safely
  - The encouragement of a culture of awareness on sustainability issues amongst employees and how this is achieved
  - The procedures and management systems to implement the principles (including Environmental Management Systems and relevant international standards e.g. ISO14001)

3.1.1.2 Energy conservation:

- Principal energy consuming activities
- Relative amounts of these energies used in the main packaging processes
- The roles of natural gas (or other fossil fuel) as heat and electricity as power in providing energy for packaging
- Energy reduction strategies:
  - The importance of monitoring and targeting
  - Comparison of the environmental performance of existing process technologies with Best Available Techniques

3.1.1.3 Water conservation:

- The water supply chain for the packaging operation from taking water from the environment to returning waste water to the environment
- Principal water consuming activities
- The three distinct purposes for water in a packaging operation and the relative consumptions:
  - De-aerated water
  - Process water
  - Service water
- Water conservation strategies:
  - The importance of monitoring and targeting
  - Comparison of the environmental performance of existing process technologies with Best Available Techniques
  - The cost benefit hierarchy in achieving water savings including reduction in uncontrolled use (housekeeping), improved control (management), water reuse, water recycling and design improvements

3.1.1.4 Waste minimization:

- The sources of waste from packaging operations
- Waste storage and segregation
- Waste disposal and duty of care
- The pressure on landfill
- Waste recovery or disposal
- The nature of liquid effluents from packaging operations
- Best practice techniques for reducing effluent
- Options and systems for effluent treatment
- Charging mechanisms for effluent discharge and subsequent treatment
- Statutory controls to impose limits on the volume and condition of effluent being discharged

3.1.1.5 Packaging waste:

- The impact of packaging waste on household (consumer) recycling
- The effects of consumer pressure, market mechanisms, cost and legislation on packaging minimization and the reduction in landfill by encouraging / forcing the recycling of packaging materials

3.1.2 Health and Safety:

3.1.2.1 Fundamental considerations:

- Health and Safety in the food and drink industry
- Relevant national and local legislation and regulations
- Principle of duty of care

3.1.2.2 Management:

- Policy:
  - Examples of health and safety policies and their main elements
  - The importance of senior management commitment
- Organisation:
  - The way in which responsibility for health and safety is reflected in the organisational structure and how authority is delegated from the senior manager to his / her reports
  - Responsibilities of both managers and employees
  - The content and operation of a health and safety system to implement the health and safety policy including the purpose and operation of regular safety meetings, the use of safety representatives, safety tours etc
  - The role of accredited standards e.g. ISO18001
- Measuring and reviewing performance:
  - Ways in which brewery health and safety objectives are set and how these reflect the health and safety policy including how to make these objectives measurable
  - Monitoring and reporting of performance including the use of accident ratios, incidence rates etc
  - Relevance of auditing and management reviews
  - Communicating performance
  - Importance of continuous improvement
- Training:
  - Training needs of managers, team leaders, operatives and technicians
  - Difference between competence and awareness training (and where each might be appropriate)
  - Ways in which competence can be tested and possible action if an individual is found to be no longer competent
  - Importance of record keeping (e.g. training given and when; testing of competence etc)

3.1.2.3 Hazard identification and risk assessment:

- Techniques for assessing hazards and risks:
  - Difference between risk and hazard
  - Techniques for identification of hazards
  - Techniques for assessing risk including the use of risk grids
- Risk treatment:
  - Techniques and practices for treating risk including avoiding risk, reducing risk, transferring risk, retaining risk
  - Management programmes for reducing risk including occupational safety, health and hygiene, on-site transport risk management, fire prevention and control, public safety and liability
- Safe working practices:
  - The principles of safe working practices including procedures, training and the testing of competence
  - The most common practices such as safe working in confined spaces, working at height, hot work etc
  - Types and uses of Permits to Work

- Potential hazards with packaging machinery

3.1.2.4 Accident investigation:

- Systematic approach:
  - The key steps in accident investigation
- Gathering information:
  - The essential procedures including the gathering of general information about the accident, securing witness statements and compiling specific details to establish the precise circumstances
  - The importance of photographs and sketches
- Reporting:
  - Types of categorisation levels of accidents in terms of seriousness

3.1.3 Utilities:

3.1.3.1 Water:

- Principles and treatment plants for:
  - Water filtration
  - Water sterilization
  - Water softening / de-ionization
  - Water de-aeration
- Differentiation and typical uses of:
  - De-aerated water
  - Process water
  - Service water
- Points at which water is introduced into the process and the special water quality needed at these points
- *Legionella* in cooling tower water and service water and the health risks associated with the organism

3.1.3.2 Compressed air:

- Features and operation of common systems for the production of compressed air
- Principal types of compressor
- Main components of air distribution systems
- Quality requirements for the differing packaging applications and how these are achieved

3.1.3.3 Managing utilities:

- Typical packaging usage figures:
  - Electricity
  - Steam
  - Water
  - CO_2
  - N_2
  - Air
- Comparisons with “best in class” figures
- Estimating utility requirements

3.1.4 Maintenance:

3.1.4.1 Aims of maintenance:

- Sustaining the functionality of plant
- Minimizing downtime
- Providing a safe working environment
- Protecting product quality
- Proving due diligence
- Ensuring legal requirements are met
- Protecting the value of plant

3.1.4.2 Approaches to maintenance:

- No maintenance
- Breakdown (also known as corrective)
- Preventive (also known as planned or planned preventive)
- Predictive (includes condition based and risk based)
- Advantages and disadvantages of the differing approaches

3.1.4.3 Maintenance tasks:

- Types and variety of maintenance tasks in packaging including the keeping of records
- Systems of 'safe working practices' including permits to work, the use of personal protective equipment, interlocking guarding systems and competence training
- Differing skills requirements, accredited specialisms and multi-skilling
- Competence training and how experience is gained

3.1.4.4 Organization:

- Alternative organisational structures for packaging maintenance activities (ranging from separate maintenance departments to autonomous operational teams)
- Role of specialist contractors
- Planning of maintenance activities:
  - Basis for periodicity
  - Generation of work instructions
  - Plant history (record keeping)

3.1.4.5 Performance improvement:

- Principal performance initiatives:
  - Reliability Centred Maintenance (RCM):
  - Total Productive Maintenance (TPM):
  - Workplace Organisation (5S):
  - Single Minute Exchange of Die (SMED):
- Circumstances in which each of the performance improvement initiatives might be appropriate

Unit 3.2 Fluid Mechanics

3.2.1 Principles of fluid mechanics:

3.2.1.1 Forms of fluid and fluid energy:

- Newtonian and non-Newtonian fluids
- Definition of viscosity
- Mass flow and conservation of mass
- Components of fluid energy (pressure, kinetic and potential)
- Conservation of energy
- Principle of energy interchangeability, Bernoulli equation
- Concept of “head” as a measure of pressure
- Calculations in this area

3.2.1.2 Properties of moving fluids:

- Laminar and turbulent flow and their relevance in packaging
- Examples of laminar and turbulent flow in packaging
- Reynolds number (as a measure of turbulence)
- Velocity profiles in pipes
- Mean and maximum velocities
- Calculations in this area

3.2.1.3 Friction loss:

- Pressure loss in pipes, friction factors and pipe roughness
- Pressure losses in pipes using Moody diagram
- Pressure losses in fittings using the “equivalent pipe diameters” and “velocity heads” methods
- Identification of duty point on a pump curve by comparing with system curve
- Calculations in this area

3.2.1.4 Pumps:

- Centrifugal pumps:
  - Principles of operation
  - Impellor designs
  - Materials of construction for different applications
  - Hygienic considerations
  - Shaft sealing, flushing and control
  - Self priming pumps
  - Multistage pumps for high pressure applications
  - Pump characteristics
  - Effect of speed variation
  - Flow control and “soft start”
  - Typical applications
- Positive displacement pumps:
  - Principles of operation
  - Pump characteristics
  - Need for pressure relief
  - Pump types, including materials of construction
  - Hygienic considerations
  - Rotary pumps

- Reciprocating pumps
- Blending pumps
- CIP
- Flow control
- Typical applications

- Cavitation and net positive suction head (NPSH):
  - Causes and effects of cavitation
  - Factors which promote or hinder cavitation
- The terms NPSH required and NPSH available
- Particular problems in packaging and remedial techniques
- Calculations in this area

3.2.1.5 Valves:

- Design features, respective merits and applications of the following types of valve:
  - Butterfly
  - Ball
  - Gate
  - Non-return
  - Pressure and vacuum relief
  - Double seat (mix-proof)
  - Control valves (with various plug designs)
- Concept of double block and bleed for protection
- Sampling systems

3.2.2 Process Gases:

3.2.2.1 Gases used in packaging and dispense:

- Typical applications:
  - Blanketing / oxygen exclusion
  - Carbonation adjustment
  - Nitrogenation and use of CO_2 and N_2 mixtures

3.2.2.2 Gas laws:

- Equations relating to pressure, temperature, volume and density using the perfect gas laws:
  - Boyle's
  - Charles'
  - Gay Lussac's
- Concept of "Standard Conditions" (STP, NTP etc)
- Universal gas law and gas constant
- Concept of molar volume
- Dalton's law of partial pressures
- Calculations involving gas laws

3.2.2.3 Gas solubility:

- Concept of gas / liquid equilibrium, Henry's law (and as applied to gas mixtures)
- Dependence of gas / liquid solubility on temperature
- Molar fraction / molar ratio
- Effects of hydrostatic head

- Definition of supersaturation (how it occurs in beer, its effects on and threats to beer quality in the packaging operation, in the retail outlet and to the consumer)
- Calculations of equilibrium conditions of gas solubility for single gas and mixed gas systems

3.2.2.4 Gas dissolution:

- Principles of dissolving gases in liquids
- Typical equipment for measurement and control
- Dissolved gas adjustment (see also 1.2.3.2)
- Effects of pressure and temperature on carbonation level during storage of beer

3.2.2.5 Carbon Dioxide:

- Carbon dioxide recovery and pre-treatment
- Liquid CO_2 storage and vapourization methods
- Carbon dioxide specifications
- For carbonation see 1.2.3.2
- Health and safety aspects

3.2.2.6 Nitrogen:

- Nitrogen specifications
- Supply, storage and vapourization
- Awareness of on-site generation methods (pressure swing / membrane / cryogenic)
- Health and safety aspects

Unit 3.3 Heat Transfer

3.3.1 Principles of heat transfer:

3.3.1.1 Forms of heat energy:

- Definition of specific heat
- Concept of latent heat and exothermic heat as material properties
- Calculations of energy change associated with these forms of energy

3.3.1.2 Heat transfer mechanisms:

- Conduction:
  - Mechanism of conduction
  - Concept of thermal conductivity as a material property
  - Calculation of heat transfer through a slab of material (single and multi-layer systems with special consideration for thick circular sections such as insulated pipes i.e. log mean area or thickness)
- Convection:
  - Mechanisms of convection with the sub classifications of “natural” and “forced”
  - Concept of heat transfer across a film layer and the benefit of high turbulence
  - Concept of “film heat transfer coefficient” to be treated as a “conductivity factor”
  - Calculation methods and influence of velocity
  - The plate heat exchanger as an example of forced convection with high velocity / turbulence
  - Boiling and condensation heat transfer
  - Nucleate boiling and film boiling (including the effect of stainless steel surface properties - “wetability”)
- Radiation:
  - Basic Stefan-Boltzmann equation
  - Concept of emissivity
  - Areas where radiant heat transfer is relevant in packaging operations
  - Radiant heat loss reduction
- Overall heat transfer:
  - Heat transfer through multi-component barrier (e.g. across a plate heat exchanger plate with fouling layers, film coefficients and conductivity for the plate and fouling layers)
  - Calculation of the overall heat transfer coefficient “U value” and calculation of heat transfer in a typical composite system
  - Effects of fouling and scaling

3.3.1.3 Heat exchanger sizing:

- Concept of the heat balance and heat transfer across a temperature gradient

- Concept and calculation of log mean temperature difference (LMTD) and differences with “arithmetic mean”
- Co- and counter-current flow in a heat exchanger

3.3.1.4 Plate heat exchanger designs:

- Construction of a plate heat exchanger, its components and configuration
- Function of plate patterns
- Typical heat transfer coefficients
- Sealing gaskets and “grid” or “divider” plates
- Parallel and series passes to match flow and heat recovery requirements
- Importance of fouling / scaling problems
- CIP techniques
- Leakage protection
- Heat exchanger calculations (e.g. typical heat exchanger area, number of plates etc)
- Specific plate heat exchanger applications in packaging (e.g flash pasteurization) with process control and instrumentation arrangement.

3.3.1.5 Jacketed vessels:

- Heat transfer in jacketed vessels

3.3.1.6 Shell and tube heat exchangers:

- Shell and tube heat exchanger designs and configurations
- Applications in packaging

3.3.1.7 Insulation:

- Function of insulation
- Choice of materials based on temperature, duty, safety and environmental considerations
- Function of vapour barrier for cold duties
- Protection of stainless steel surfaces against possible chloride attack (see also 1.3.4.2)
- External protection of insulation material
- Multi-layer insulation systems

3.3.2 Steam:

3.3.2.1 Steam properties:

- Reasons for using steam
- Physical properties of water in its states:
  - Temperature-energy relationship as illustrated in the Mollier chart
  - Steam tables
  - Specific heat of liquid water
  - Latent heat of vapourization
  - Definition of terms describing steam quality and their position on the Mollier chart

- Clean steam
- Calculations involving change of energy to a steam system
- Calculations which utilize steam table data
- Calculations estimating steam quality

3.3.2.2 Steam raising and distribution:

- Boilers – general types and principles of operation
- Pipe sizes, arrangements and design velocities
- Insulation
- Steam traps
- Control valves, reducing valves, relief valves
- Legal requirements in having a properly designed, safe system with the correct protection measures

3.3.2.3 Steam applications:

- Pasteurizing
- Sterilizing

3.3.3 Refrigeration:

3.3.3.1 Refrigeration theory:

- Definition of refrigeration
- Concept of pressure / temperature equilibrium in relation to the vapour-compression refrigeration process
- Refrigeration cycle
- Function of evaporator, compressor, condenser, expansion valve

3.3.3.2 Refrigeration practice:

- Refrigeration cycle described on the Mollier chart (including terms superheated, sub-cooled, isenthalpic, isobaric)
- Coefficient of performance (COP)
- Calculation of performance using Mollier chart
- Typical manufacturers' performance curves
- Measures to improve output and COP
- Effects of "parasitic" loads

3.3.3.3 Principal plant items:

- Compressors:
  - Types of compressors
  - Advantages and disadvantages
  - Capacity ranges
  - Controllability

- Condensers:
  - Types of condensers
  - Advantages and disadvantages
  - Power requirements
  - Water requirements
  - *Legionella* precautions

- Evaporator and expansion devices:
  - Types of evaporators and expansion devices
  - Advantages and disadvantages
  - Controllability

3.3.3.4 Primary refrigerants:

- Description of purpose, design considerations and choice
- Safety and environmental:
  - Legislation
  - Global warming potential
  - Ozone depletion potential
- Types available:
  - CFC
  - HCFC
  - HFC
  - Hydrocarbons
  - Inorganic
- Significance of ASHRAE “R” designation
- Relative costs
- Physical and chemical properties, oil compatibility

3.3.3.5 Secondary refrigerants:

- Description of purpose, design considerations and choice
- Physical properties:
  - Freezing point
  - Viscosity
  - Flammability
- Chemical properties:
  - Compatibility with materials of construction
- Safety and environmental:
  - Leak protection
  - Pressure controls
  - Management controls

3.3.3.6 Refrigeration applications:

- Bright beer storage
- Pasteurization
- Cellar and dispense systems

Unit 3.4 Process Control

3.4.1 Process and line control:

3.4.1.1 Basic control elements:

- Definitions and descriptions of:
  - Sensors
  - Controllers
  - Actuators
  - The process

3.4.1.2 Basic on / off control:

- Descriptions of:
  - Timers
  - Thermostats
  - Pressure switches
  - Level switches
  - Proximity detectors
  - Position switches
  - Deadband

3.4.1.3 Sequence control:

- Description of Programmable Logic Controller (PLC)
- Examples of PLC applications

3.4.1.4 Aim of process control:

- Continuous or modulating control
- Feedback control
- Open loop and closed loop control
- Difference between continuous and on / off control

3.4.1.5 Principles of process control:

- Concepts of controlled, measured and manipulated variables
- Input to controller
- Function of set-point
- Characteristics of proportional output (P)
- Characteristics of integral output (I)
- Characteristics of derivative output (D)
- Combinations of outputs (P, P + I, P + I + D)
- The ideal controller response

3.4.1.6 Control arrangements:

- Control concepts:
  - Feed back
  - Feed forward
  - Cascade
  - Ratio
- Advantages and disadvantages of each
- Typical applications

3.4.1.7 Typical control systems:

- Descriptions of:
  - Self acting systems
  - Pneumatic
  - Electronic to pneumatic conversion
  - Electronic 4 ma to 20 ma analogue
  - Distributed digital systems

3.4.1.8 Actuation:

- Descriptions of:
  - Pneumatic, including function of positioner
  - Electrical
  - Electronic (e.g. variable speed drives)

3.4.1.9 Control system arrangements:

- Self-acting controllers
- Individual electronic analogue controls
- PLC for multiple sequence controls
- Small local computer control (for multiple process control loops)
- Large digital systems with distributed data highways incorporating:
  - Supervisory Control and Data Acquisition (SCADA)
  - Management Information Systems (MIS)
- Interlinking of systems
- Advantages and disadvantages of each
- Comparative costs (i.e. cost per loop)

3.4.2 Instrumentation:

3.4.2.1 Factors determining the choice of sensors:

- Food compatibility and special requirements
- Calibration and servicing requirements

3.4.2.2 Typical conventional sensors:

- Pressure
- Volume flow
- Temperature
- Mass flow
- Level
- Vessel contents

3.4.2.3 Typical analytical sensors:

- CO_2
- O_2
- Optical devices
- pH
- Density
- Alcohol content