

3.1 cGMP: objectives and policies

Current good manufacturing practice, cGMP, is the part of quality assurance that ensures products are consistently produced and controlled to the quality standards appropriate to their intended use. The word current is important: expectations rise as knowledge and technology improve, and a practice that passed inspection ten years ago may not pass today.

The objectives of cGMP are that:

- Every batch is made by defined, written procedures, by trained people, in suitable premises with suitable equipment.
- Materials are correct, tested and traceable; every step is documented as it happens, so any batch can be reconstructed from its records.
- Contamination and cross contamination are prevented; mix ups between products and labels are impossible by design.
- Deviations are recorded, investigated and corrected; complaints and recalls can be executed completely.

The policy instruments that deliver these objectives include the quality management system and its manuals, standard operating procedures (SOPs) for every operation, batch manufacturing and packaging records, training programmes, self inspection and audit, vendor qualification, and change control. Schedule M in India, WHO GMP, EU GMP and US FDA 21 CFR 210/211 are the written forms of the same policy. cGMP is a cost, but it is cheaper than recalls, regulatory action and loss of trust.

3.2 Layout of buildings

Plant layout is a GMP tool. A well laid out building separates flows so that materials, people, products and waste do not cross in ways that risk contamination or mix up. Principles include:

- **Logical unidirectional flow:** raw materials enter at dispensing, move through production stages to packing and the finished goods store, without back tracking.
- **Separation of areas:** dispensing, granulation, compression, coating and packing each in defined rooms; special segregation for potent, sensitising or beta lactam products, which need dedicated or strictly controlled facilities.
- **Cleanliness grades:** sterile manufacture uses graded cleanrooms (Grades A to D in EU terms) with airlocks and pressure differentials; oral solid areas use controlled, clean conditions with dust extraction.
- **Construction details:** smooth, impervious, easily cleaned walls, floors and ceilings; no cracks or open joints; drains designed against backflow; adequate lighting and ventilation; insect and rodent proofing.
- **Supporting areas:** quality control laboratories, wash areas, tool rooms, change rooms and rest areas placed so that they serve production without disturbing it.

3.3 Services and utilities

Services are the hidden systems that keep production in its validated environment:

- **HVAC (heating, ventilation and air conditioning):** controls temperature, humidity, air changes, filtration through HEPA filters and pressure differentials between rooms, so dust and microbes are kept out of cleaner areas.
- **Water systems:** purified water and Water for Injection are produced, stored and distributed in validated loops, tested chemically and microbiologically; water is the most used raw material and the most common source of contamination.
- **Compressed air and gases:** filtered, oil free and dry where they contact product.
- **Steam and power:** clean steam for sterilisation, stable power and backup for critical equipment.

Each service is qualified, monitored with defined alert and action limits, and maintained on schedule; a failed HVAC or water system stops production just as surely as a failed machine.

3.4 Equipment and their maintenance

Production equipment must be designed so it can be cleaned, does not react with or shed into the product, and can be operated and maintained safely: food grade contact materials such as stainless steel 316L, smooth welded surfaces, and no dead spaces where product can lodge. Equipment is identified with status labels (clean, in use, under maintenance), used within its qualified range, and recorded in log books.

Maintenance is planned, not improvised. Preventive maintenance schedules cover lubrication, calibration, replacement of worn parts and inspection at defined intervals, done so production plans are not disturbed; breakdown maintenance is documented and its impact on product assessed. After any significant maintenance, the equipment returns to use through cleaning, and where needed requalification, before GMP production resumes.

3.5 Production management and production organization

Production management is the planning, organising and controlling of manufacturing so that the right products are made, in the right quantity, at the right time and cost, and to the right quality. The production organisation is usually headed by a production manager or head of production, with section heads for each dosage form area, shift in charges, supervisors and operators, working with the quality assurance and quality control departments, which are independent of production. Independence of quality from production is a GMP requirement, because the department that makes a product must not be the only judge of whether it may be sold.

The core activities are setting production plans from sales forecasts and orders, scheduling machines and people, ensuring materials and documents are ready before a batch starts, monitoring output and yields, and reviewing batch records for release.

3.6 Materials management, handling and transportation

Materials management covers procurement, receipt, storage, issue and control of raw materials and packaging materials. On receipt, materials are quarantined, sampled and tested by quality control, and released or rejected before use. Stores are organised so that approved, quarantined and rejected materials cannot be mixed (status labelling and segregated areas), stock rotates by first expiry first out, and storage conditions of temperature and humidity are monitored.

Handling and transportation inside and outside the plant must protect the material: clean covered containers, protection from weather and contamination during transport, validated cold chain for temperature sensitive products, and complete documentation so every movement is traceable from supplier

to finished batch.

3.7 Inventory management and control

Inventory is money sitting on shelves: too much blocks capital and risks expiry, too little stops production. Inventory control balances the two. Standard tools include:

- **ABC analysis:** materials are ranked by annual usage value. A items (few, high value) get tight control and frequent review; C items (many, low value) get simple control.
- **VED analysis:** vital, essential and desirable classification by criticality to production, combined with ABC for stocking policy.
- **Economic order quantity (EOQ):** the order size that minimises the sum of ordering cost and holding cost.
- **Safety stock and reorder level:** buffer stock held against supply delay, and the stock level at which a fresh order is placed, calculated from consumption rate and lead time.
- **Perpetual inventory records:** stock cards or computerised systems updated with every receipt and issue, verified by periodic physical counting.

3.8 Production planning and control

Production planning and control (PPC) converts demand into a feasible manufacturing programme. Its steps are routing (the sequence of operations for a product), scheduling (when each batch runs on which equipment), loading (matching work to machine and manpower capacity), and follow up (tracking progress, expediting delayed work, and rescheduling when deviations occur). Good PPC keeps equipment utilised without overloading it, keeps work in progress low, and protects delivery dates. In a GMP plant, PPC must also respect cleaning and changeover times, campaign rules and validation status: a plan that ignores a mandatory cleaning between products is not a plan, it is a deviation waiting to happen.

3.9 Sales forecasting, budget and cost control

Sales forecasting estimates future demand from past sales, market trends, seasonality and planned promotions; it drives the production plan, material procurement and manpower planning. Errors in forecast become either stock outs or expired stock, so forecasting is a shared duty of sales, production and planning.

A budget is the financial expression of the plan: expected sales, production costs (materials, labour, overheads), and capital spending for a period. Cost control compares actual costs with the budget and with standard costs, investigates variances, and acts on them, for example by reducing wastage of materials, improving yields, controlling overtime and energy use, and negotiating purchase prices. Yield reconciliation of every batch is where budget control and GMP meet: unexplained loss is both a cost problem and a quality signal.

3.10 Industrial and personnel relations

Industrial relations is the relationship between management, workers and their unions. In a pharmaceutical plant, good relations are a quality issue as well as a human one: trained, stable and motivated staff make fewer errors. The essentials are clear communication, fair wages and working conditions under the applicable labour laws, grievance handling procedures, worker participation through committees, and disciplined but respectful supervision. Personnel management in the GMP sense adds: defined job descriptions, training on SOPs and hygiene before a person works in production, documented training

records, health checks for staff in sterile and production areas, and strict gowning and hygiene discipline. A person who does not understand why a rule exists will break it under pressure; training is therefore a cGMP activity, not an optional extra.

3.11 Concept of total quality management

Total quality management (TQM) is a management philosophy in which quality is the responsibility of every person in the organisation, and the goal is continuous improvement of processes to achieve complete customer satisfaction. Its main ideas are:

- **Customer focus:** the patient and the prescriber are the final customers; internal departments treat the next process step as their customer too.
- **Continuous improvement (kaizen):** small, constant improvements by everyone, rather than occasional large changes.
- **Employee involvement:** quality circles and suggestion schemes use the knowledge of the people who run the process.
- **Process approach and data based decisions:** problems are solved by measuring and analysing the process, using the statistical tools of Unit 5 of this subject.
- **Prevention over inspection:** building quality into the product and process rather than testing it in at the end.

TQM contains GMP rather than replacing it: GMP gives the non-negotiable legal floor of quality, and TQM adds the culture and the improvement engine on top of it.