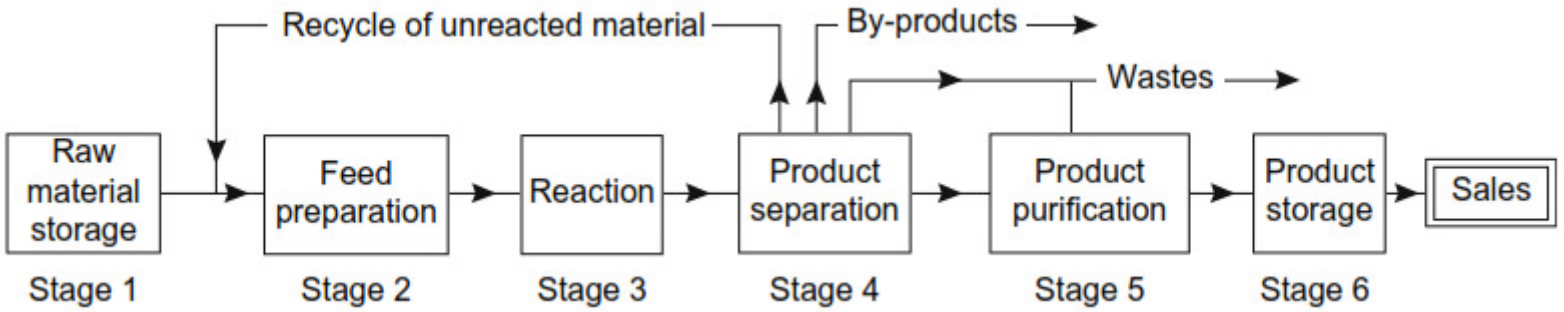
The Anatomy of Chemical Manufacturing Process

The basic components of a typical chemical process (a representative general process)

Stage 6. Product storage: Some inventory of finished product must be held to match production with sales.



Stage 5. Purification: Before sale, the main product will often need purification to meet the product specifications.

In addition to the main process stages, provision must be made for the supply of the services (utilities) needed, such as process water, cooling water, compressed air and steam. Facilities are also needed for maintenance, fire fighting, offices and other accommodation, and laboratories.

that promote the production of the desired product, almost inevitably, some by-products will also be formed, either through the reaction stoichiometry, by sidereactions, or from reactions of impurities present in the feed.

Continuous Processes

- Continuous processes are designed to operate 24 hours a day, 7 days a week, throughout the year.
- Some down time will be allowed for maintenance and, for some processes, catalyst regeneration.
- The plant attainment or operating rate is the percentage of the available hours in a year that the plant operates, and is usually between 90% and 95%.

$$\text{Attainment } \% = \frac{\text{hours operated}}{8760} \times 100$$

- Continuous processes will usually be more economical for large scale production.

Batch Processes

- Batch processes are designed to operate intermittently, with some, or all, of the process units being frequently shut down and started up.
- Batch processes are used when some flexibility is wanted in production rate or product specifications.
- Batch processing usually only makes sense for products that have high value and are produced in small quantities.

  Batch plants are commonly used for:

  - Food products
  - Pharmaceutical products such as drugs, vaccines and hormones
  - Personal care products
  - Specialty chemicals

  Even in these sectors, continuous production is favored if the process is well understood, the production volume is large and the market is competitive.
- It is quite common for batch plants to use a combination of batch and continuous operations. For example, a batch reactor may be used to feed a continuous distillation column.

The advantages of batch processing

1. Batch processing allows production of multiple different products or different product grades in the same equipment.

2. In a batch plant, the integrity of a batch is preserved as it moves from operation to operation. This can be very useful for quality control purposes.

3. The production rate of batch plants is very flexible, as there are no turn-down issues when operating at low output.

4. Batch plants are easier to clean and maintain sterile operation.

5. Batch processes are easier to scale up from chemist's recipes.

6. Batch plants have low capital for small production volumes. The same piece of equipment can often be used for several unit operations.

The drawbacks of batch processing

1. The scale of production is limited.

2. It is difficult to achieve economies of scale by going to high production rates.

3. Batch-to-batch quality can vary, leading to high production of waste products or off-spec product.

4. Recycle and heat recovery are harder, making batch plants less energy efficient and more likely to produce waste by-products.

5. Asset utilization is lower for batch plants as the plant almost inevitably is idle part of the time.

6. The fixed costs of production are much higher for batch plants on a $/unit mass of product basis.

The Organization of a Chemical Engineering Project

Phase 1: Process design

- covers the steps from the initial selection of the process to be used, through to the issuing of the process flow-sheets;
- includes the selection, specification and chemical engineering design of equipment.

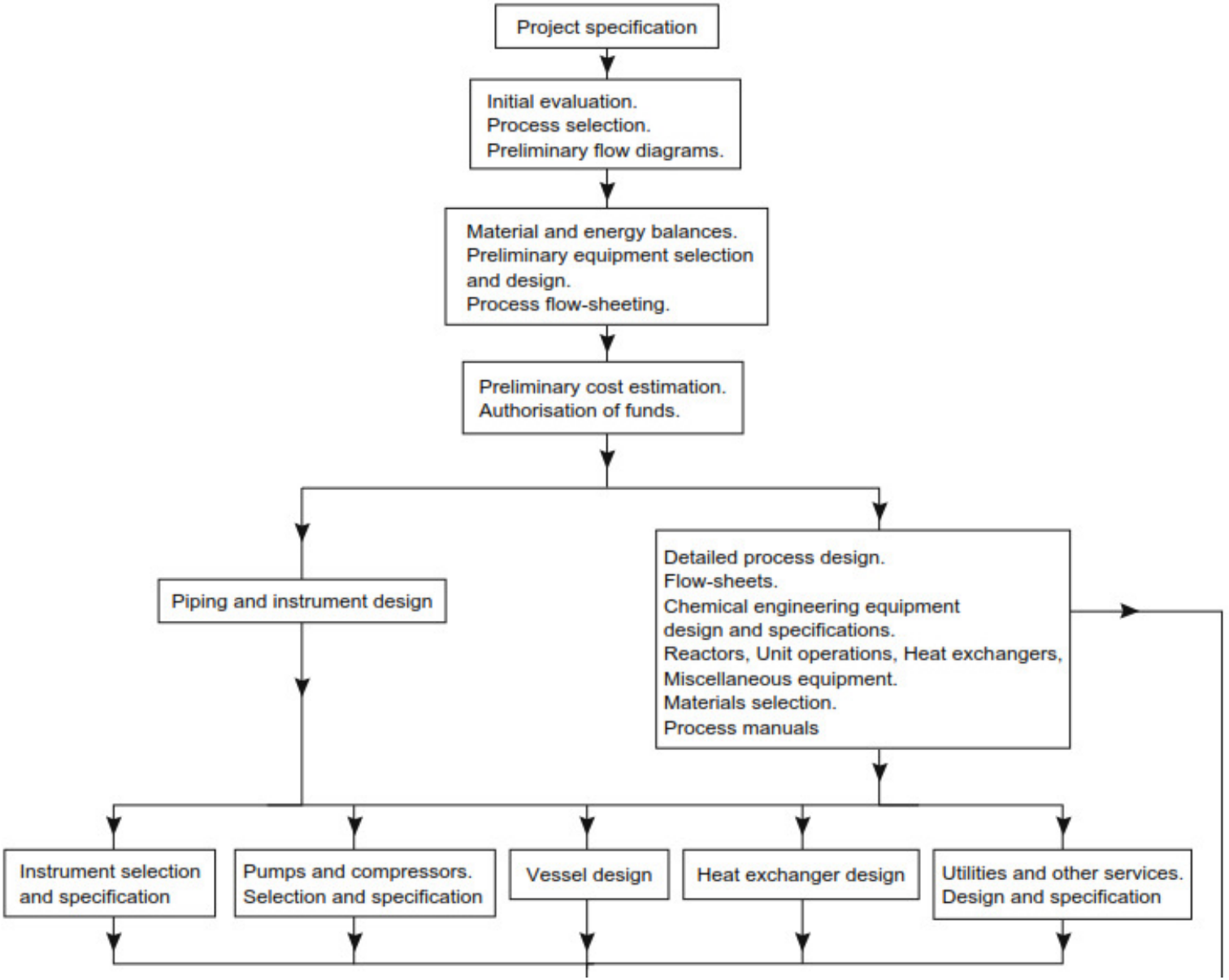
In a typical organization, this phase is the responsibility of the Process Design Group, and the work is mainly done by chemical engineers.

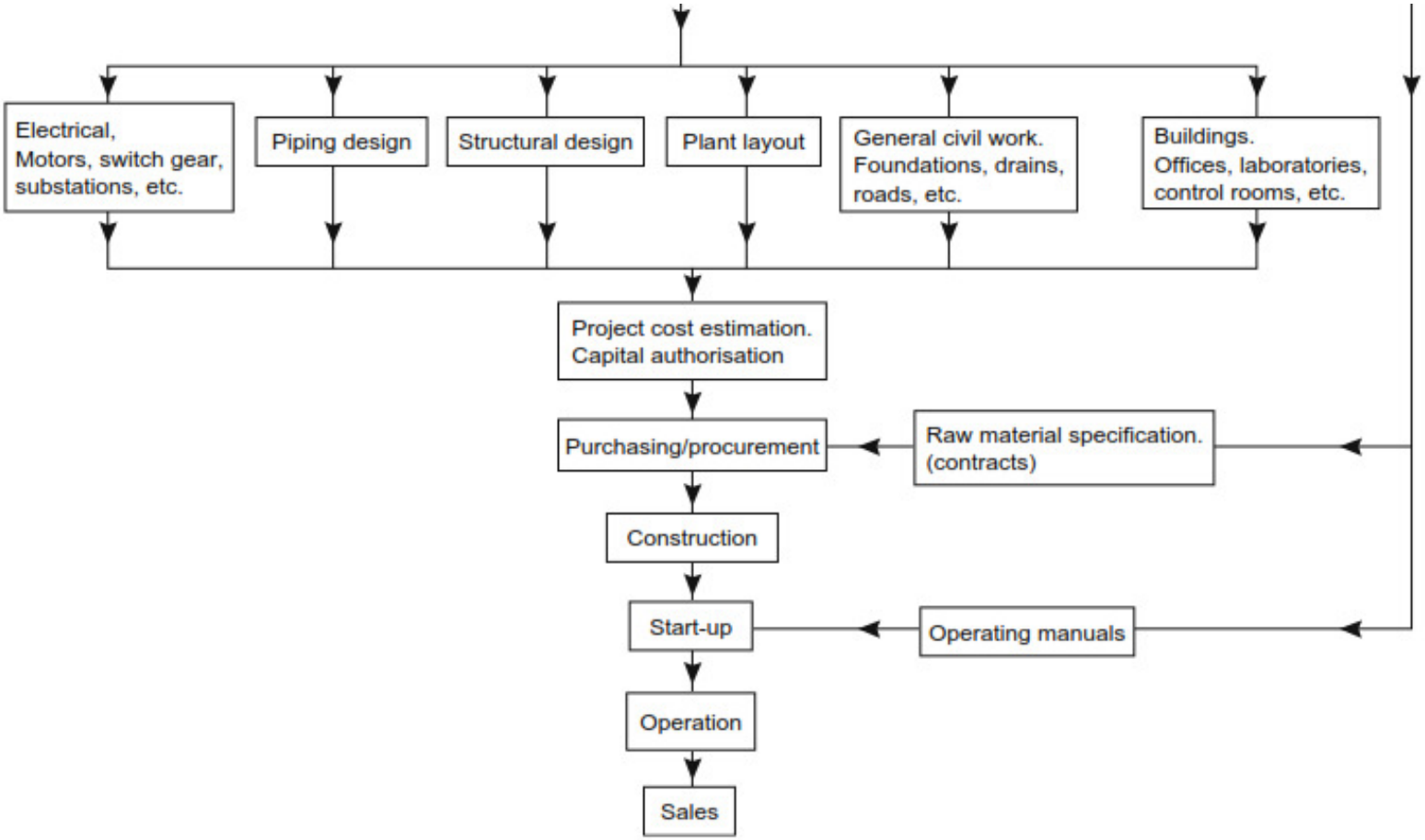
Phase 2: Plant design

- Includes the detailed mechanical design of equipment, the structural, civil and electrical design, and the specification and design of the ancillary services.

These activities will be the responsibility of specialist design groups, having expertise in the whole range of engineering disciplines.

Other specialist groups will be responsible for cost estimation, and the purchase and procurement of equipment and materials.


Project specification
Initial evaluation.
Process selection.
Preliminary flow diagrams.
Material and energy balances.
Preliminary equipment selection
and design.
Process flow-sheeting.
Preliminary cost estimation.
Authorisation of funds.
Piping and instrument design
Detailed process design.
Flow-sheets.
Chemical engineering equipment
design and specifications.
Reactors, Unit operations, Heat exchangers,
Miscellaneous equipment.
Materials selection.
Process manuals
Instrument selection
and specification
Pumps and compressors.
Selection and specification
Vessel design
Heat exchanger design
Utilities and other services.
Design and specification


Electrical,
Motors, switch gear,
substations, etc.
Piping design
Structural design
Plant layout
General civil work.
Foundations, drains,
roads, etc.
Buildings.
Offices, laboratories,
control rooms, etc.
Project cost estimation.
Capital authorisation
Purchasing/procurement
Raw material specification.
(contracts)
Construction
Start-up
Operating manuals
Operation
Sales