Principles of Motion Economy

Principles concerning the economy of movements which have been developed from direct experimentation and form a good basis for the development of improved methods at the workplace. They are classified as three main types:

A. Use of human body,
B. Arrangement of the workplace,
C. Design of tools and equipment.

The Four Principles of Motion Economy

1. Reduce the Number of Motions
   - Eliminate or reduce the number of motions
2. Perform Motions Simultaneously
   - Design improvements in the methods and tools which allow both hands to be used at the same time
3. Shorten Motion Distances
   - Reduce - walking, reaching, stretching, squatting and turning, etc.
4. Make Motion Easier
   - Work should be smooth and rhythmical, reduce fatigue and promote safety

A: Use of human body.

When possible –

1. The two hands should begin and complete their movements at the same time.
2. The two hands should not be idle at the same time except during periods of rest.
3. Motion of arms should be symmetrical and in opposite directions and should be made simultaneously.
4. Hand and body motion should be made at the lowest classification at which it is possible to work satisfactorily.
5. Momentum should be employed to help the worker, but should be reduced to a minimum whenever it has to be overcome by muscular effort
6. Continuous curved movements are to be preferred to straight-line motion involving sudden and sharp changes in direction.
7. Free-swinging movements are faster, easier and more accurate than restricted or controlled movements.
8. Rhythm is essential to the smooth and automatic performance of a repetitive operation.
9. Work should be arranged so that eye movements are confined to a comfortable area, without the need for frequent changes of focus.

Classification of movements

<table>
<thead>
<tr>
<th>Class</th>
<th>Pivot</th>
<th>Body parts moved</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Knuckle</td>
<td>Fingers</td>
</tr>
<tr>
<td>2</td>
<td>Wrist</td>
<td>Hand + above</td>
</tr>
<tr>
<td>3</td>
<td>Elbow</td>
<td>Forearm + above</td>
</tr>
<tr>
<td>4</td>
<td>Shoulder</td>
<td>Upper arm + above</td>
</tr>
<tr>
<td>5</td>
<td>Trunk</td>
<td>Torso + above</td>
</tr>
</tbody>
</table>
B: Arrangement of the workplace,

1. Definite and fixed station should be provided for all tools and materials to permit habit formation.
2. Tools and materials should be pre-positioned to reduce searching.
3. Gravity feed, bins and containers should be used to deliver the materials as close to the point of use as possible.
4. Tools, materials and controls should be located within the maximum working area and as near to the worker as possible.
5. Materials and tools should be arranged to permit the best sequence of motions.
6. The color of workplace should contrast with that of the work and thus reduce eye fatigue.
7. “Drop deliveries” or ejectors should be used wherever possible so that the operator does not have to use his hands to dispose of the finished work.
8. Provision should be made for adequate lighting, and a chair of the type and height to permit good posture should be provided.
9. The height of the workplace and seat should be arranged to allow alternative standing and sitting.

C: Design of tools and equipment.

1. The hand should be relieved of all work of holding the work-piece where this can be done by a jig, fixture or foot-operated device.
2. Two or more tools should be combined wherever possible.
3. Where each finger performs specific movements, the load should be distributed in accordance with the inherent capacities of the fingers.
4. Handles such as those on cranks and large screwdrivers should be designed so as to permit as much of the surface of the hand as possible to come in contact with the handle.
5. Levers, crossbars and hand-wheels should be so placed that the operator can use them with the least change in body position and the greatest “mechanical advantage.”

Summary: Through the pioneer work of Gilbreth, Ralph M. Barnes and other investigators, certain rules for motion economy and efficiency have been developed. Some of the more important of these principles are the following:

1. The movements of the two hands should be balanced and the two hands should begin and end their motions simultaneously (refer Figure 1).
2. The hands should be doing productive work and should not be idle at the same time except during rest periods.
3. Motions of the hands should be made in opposite and symmetrical direction and at the same time (refer Figure 2).
4. The work should be arranged to permit it to be performed with an easy and natural rhythm.
5. Momentum and ballistic-type movements should be employed wherever possible in order to reduce muscular effort.
6. There should be a definite location for all tools and materials, and they should be located in front of and close to the worker.
7. Bins or other devices should be used to deliver the materials close to the point of use.
8. The workplace should be designed to ensure adequate illumination, proper workplace height, and provision for alternate standing and sitting by the operator.
9. Wherever possible, jigs, fixtures, or other mechanical devices should be used to relieve the hands of unnecessary work.
10. Tools should be prepositioned wherever possible in order to facilitate grasping them.
11. Object should be handled, and information recorded. Only once

**Figure 1**

**Figure 2**

**Elimination**

1. Eliminate possible job, steps, or motion
2. Eliminate irregularities in a job so as to facilitate automaticity
3. Eliminate the use of hand as holding device
4. Eliminate awkward or abnormal motion
5. Eliminate the use of muscle to maintain a fixed position
6. Eliminate muscular force by using power tools, power feeds, etc.
7. Eliminate overcoming of momentum
8. Eliminate danger
9. Eliminate idle time unless needed for rest
Figure 3. Min and Max Working Area of an Operator

- Hinge Point
  - All distances are from hinge points

**Figure 49. Normal and maximum working areas**

**A. Normal working area**
(finger, wrist and elbow movements)

**B. Maximum working area**
(shoulder movements)