# Design Rules for Machining
From "Product Design for Manufacture and Assembly"
by G. Boothroyd et al. (Dekker, 1994)

*Standardization*

1. Utilize standard components as much as possible.
2. Pre-shape the workpiece, if appropriate, by casting, forging, welding, etc.
3. Utilize standard pre-shaped workpieces, if possible.
4. Employ standard machined features whenever possible.

*Raw Material*

5. Choose raw materials that will result in minimum component cost (including cost of production and cost of raw material).
6. Utilize raw material in the standard forms supplied.

*Component Design*

**a.** General

7. Try to design the component so that it can be machined on one machine tool only.
8. Try to design the component so that machining is not needed on the unexposed surfaces of the workpiece when the component is gripped in the work-holding device.
9. Avoid machined features the company is not equipped to handle.
10. Design the component so that the workpiece, when gripped in the work-holding device, is sufficiently rigid to withstand the machining forces.
11. Verify that when features are to be machined, the tool, toolholder, work, and work-holding device will not interfere with one another.
12. Ensure that auxiliary holes or main bores are cylindrical and have L/D ratios that make it possible to machine them with standard drills or boring tools.
13. Ensure that auxiliary holes are parallel or normal to the workpiece axis or reference surface and related by a drilling pattern.
14. Ensure that the ends of blind holes are conical, and in the case of a tapped blind hole, that the thread does not continue to the bottom of the hole.
15. Avoid bent holes or dogleg holes.

**b.** Rotational Components

16. Try to ensure that cylindrical surfaces are concentric, and plane surfaces are normal to the component axis.
17. Try to ensure that the diameters of external features increase from the exposed face of the workpiece.

18. Try to ensure that the diameters of internal features decrease from the exposed face of the workpiece.
19. For internal corners on the component, specify radii equal to the radius of a standard rounded tool corner.
20. Avoid internal features for long components.
21. Avoid components with very large or very small L/D ratios.

**c.** Nonrotational Components

22. Provide a base for work holding and reference.
23. If possible, ensure that the exposed surfaces of the component consist of a series of mutually perpendicular plane surfaces parallel to and normal to the base.
24. Ensure that internal corners normal to the base have a radius equal to a standard tool radius. Also ensure that for machined pockets, the internal corners normal to the base have as large a radius as possible.
25. If possible, restrict plane-surface machining (slots, grooves, etc.) to one surface of the component.
26. Avoid cylindrical bores in long components.
27. Avoid machined surfaces on long components by using work material pre-formed to the cross section required.
28. Avoid extremely long or extremely thin components.
29. Ensure that, in flat or cubic components, main bores are normal to the base and consist of cylindrical surfaces decreasing in diameter from the exposed face of the workpiece.
30. Avoid blind bores in large cubic components.
31. Avoid internal machined features in cubic boxlike components.

***Assembly***

32. Ensure that assembly is possible.
33. Ensure that each operating machined surface on a component has a corresponding machined surface on the mating component.
34. Ensure that internal corners do not interfere with a corresponding external corner on the mating component.

***Accuracy and Surface Finish***

35. Specify the widest tolerances and roughest surface that will give the required performance for operating surfaces.
36. Ensure that surfaces to be finish-ground are raised and never intersect to form internal corners.