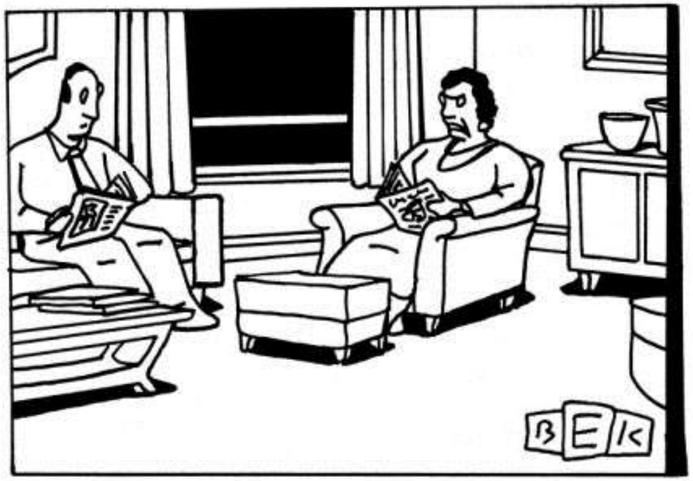
Design For Manufacturing

MAE 2250

Are you here?

A. Yes
B. No
C. Only physically (but not spiritually)
D. Only spiritually (only my clicker is here)
E. Whatever



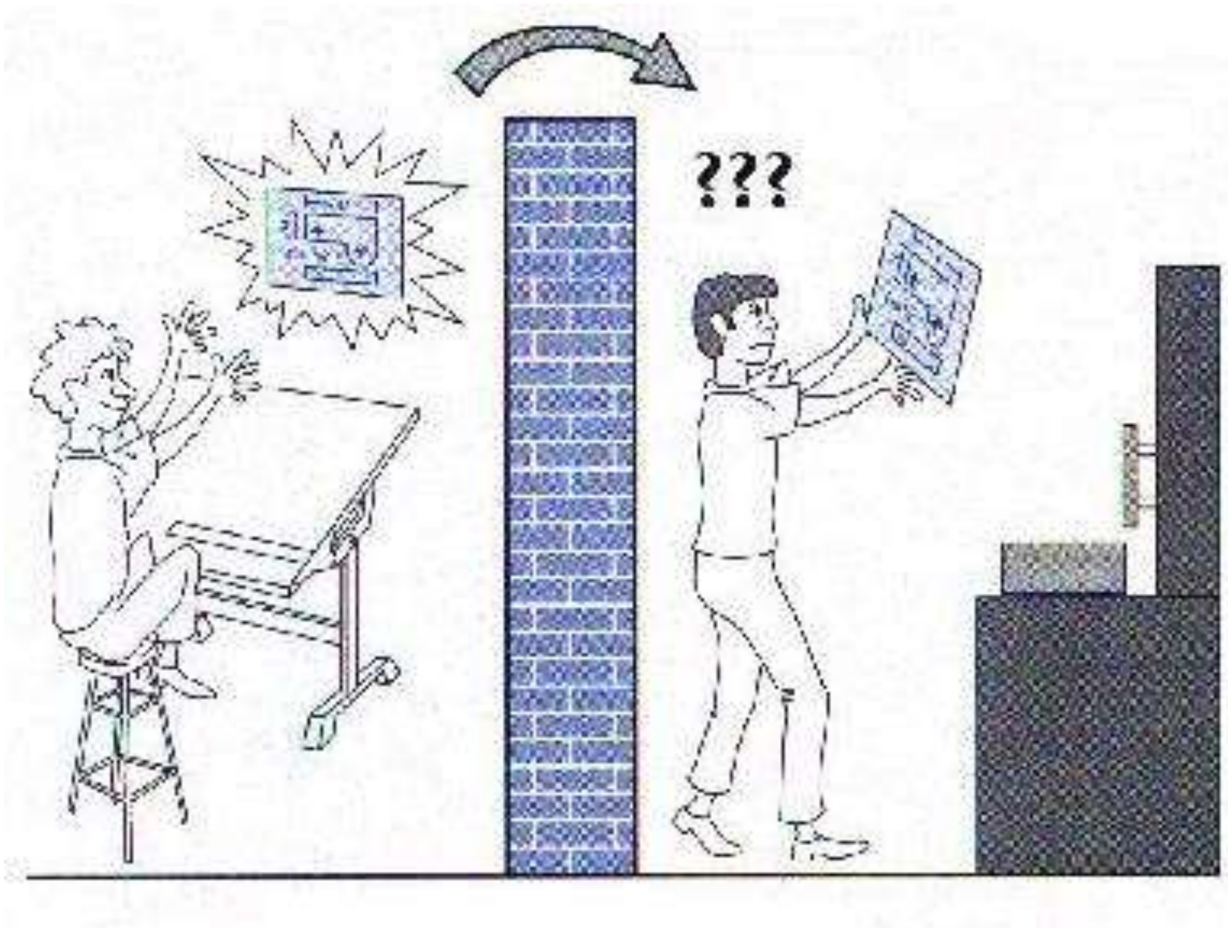
"If it's all random, why are you always here?"

Phases

- Phase 0: Planning
- Phase 1: Conceptual design
- Phase 2: System design
- Phase 3: Detail design
- Phase 4: Testing and refinement
- Phase 5: Production ramp-up

Iterate

Over The Wall



Two things hppened

- Manufacturing people were put on the design team
  - “Concurrent engineering”
- Manufacturing requirements were made very specific and became ‘needs’ themselves
  - The ‘new customers’

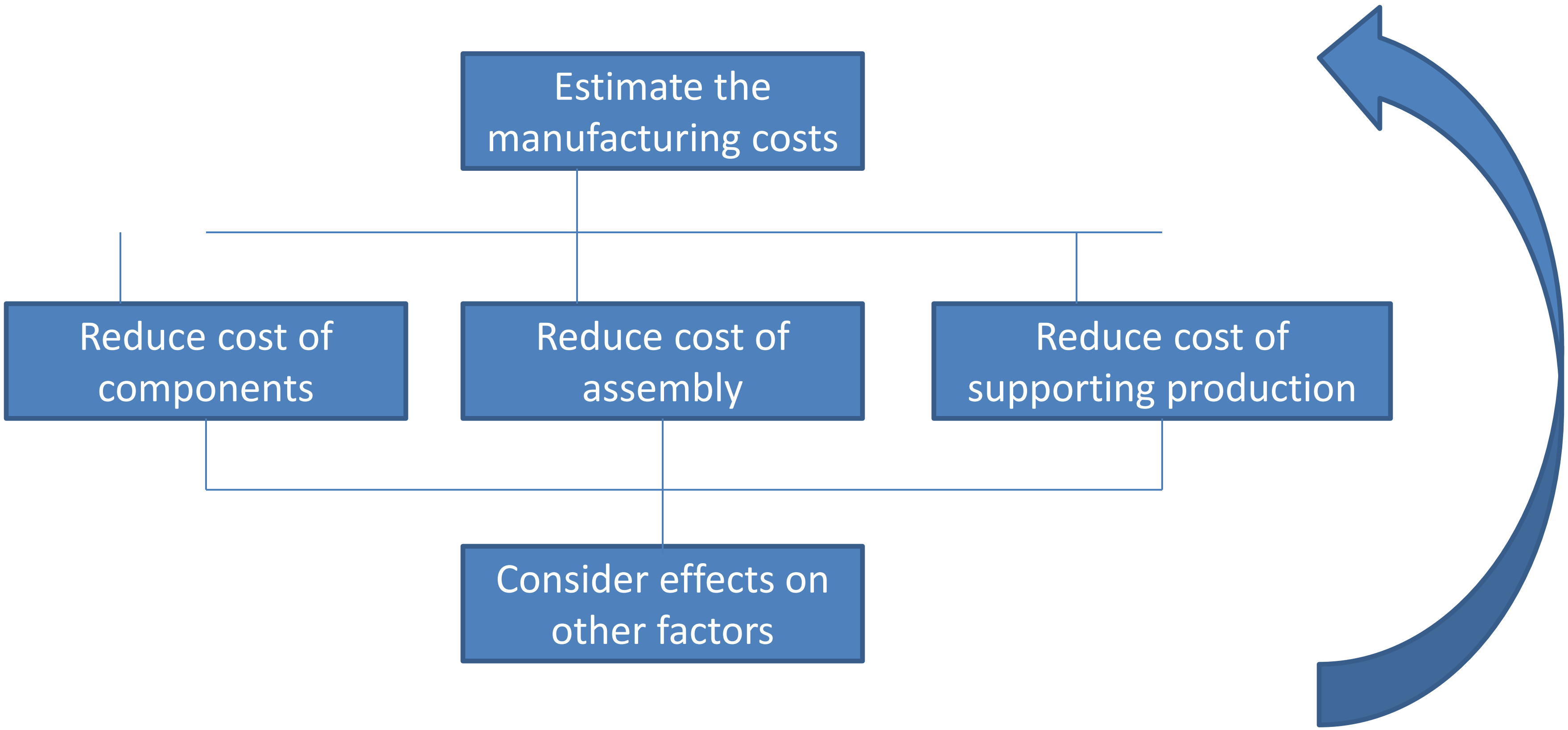
DFX

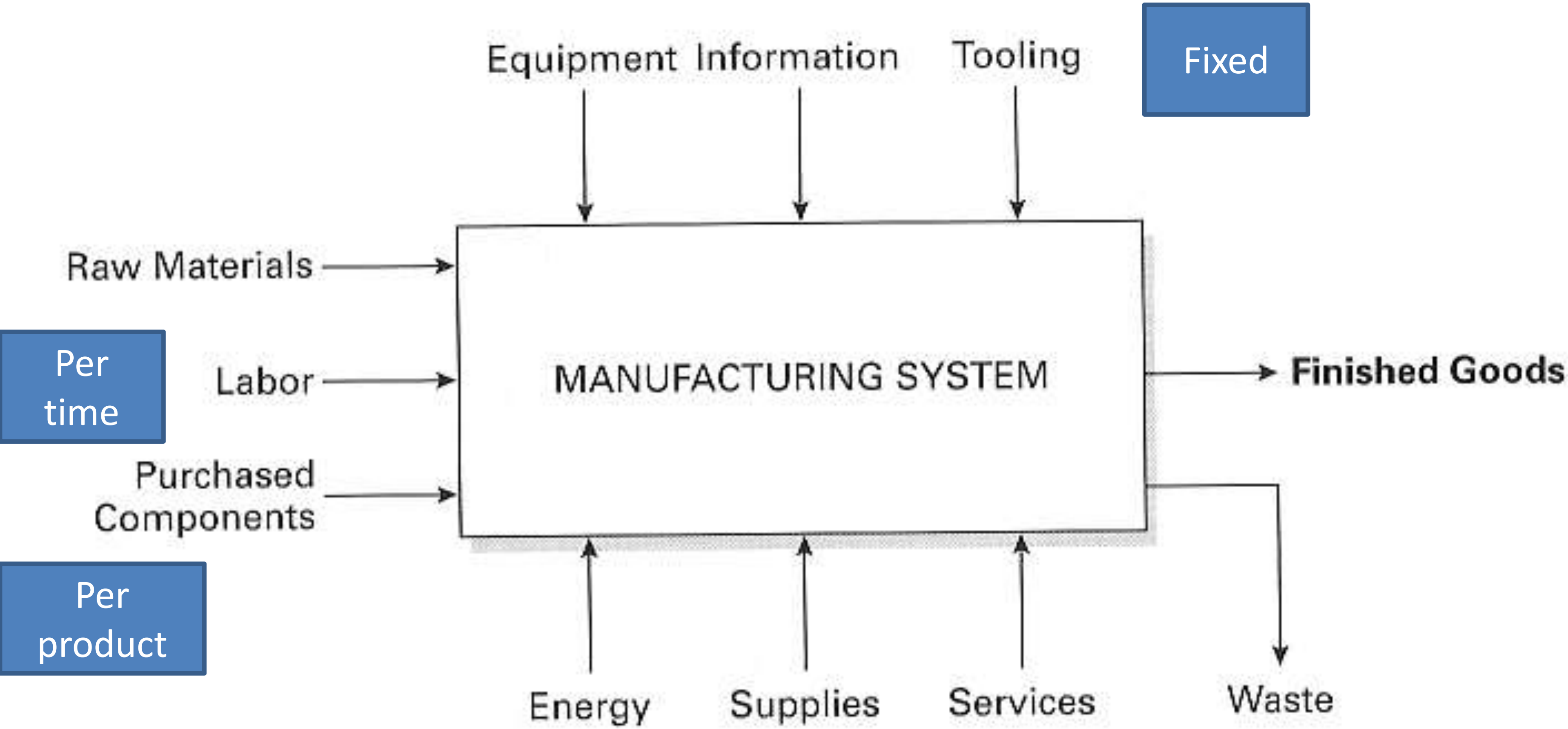
- The service people are customers: Design for servicability
- The environment is a customer, ‘Design for environment’
- Design for manufacturing (DFM)
- Design for Assembly (DFA)
- Design for X (DFX)

DFM

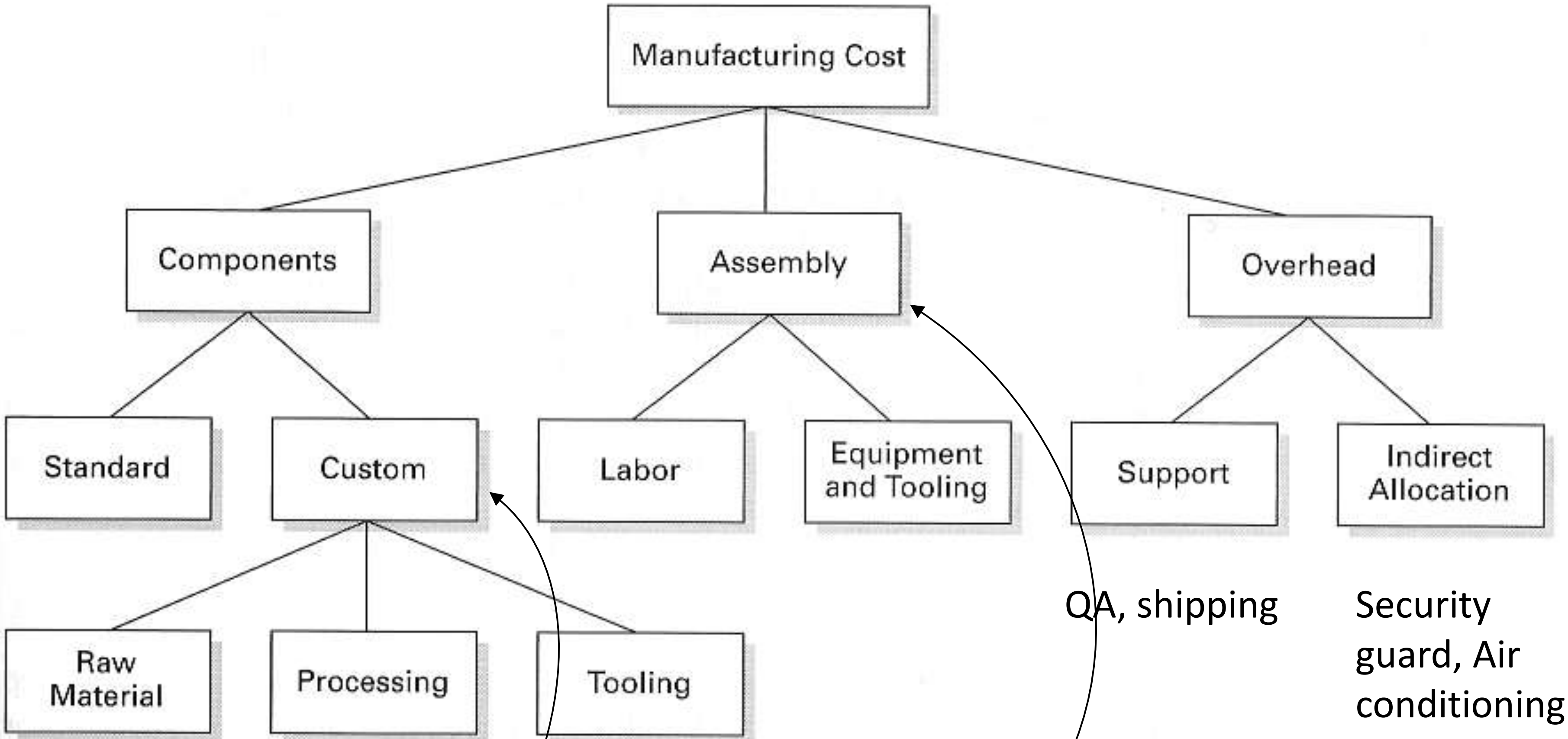
DFM is a means of addressing producibility issues early in the design cycle, and integrating manufacturing concerns and considerations into a design to obtain a more producible product

DFM Process


Estimate the manufacturing costs
Reduce cost of components
Reduce cost of assembly
Reduce cost of supporting production
Consider effects on other factors


Equipment
Information
Tooling
Fixed
Raw Materials
Per
time
Labor
Purchased
Components
Per
product
MANUFACTURING SYSTEM
Finished Goods
Energy
Supplies
Services
Waste

Categories



Custom approximates standard for high enough quantities (e.g. electric motor, > 100,000/year

Assembly is usually done by humans even for mass produced products, unless very very high quantities (>100,000)

Reducing cost of components

- Understand the limitations of the fabrication processes; do not exceed normal capabilities unless you really have to
  - Geometry (Making a square hole is hard)
  - Accuracy and tolerances of machining
  - Surface finish of casting

Understand cost drivers

- Welding cost is proportional to welding length, fixturing
- Machining cost is proportional to material removed, fixturing
- Injection molding? Thickness of part. Work with experts to find out details
- E.g. produce an tall open box by bending and welding. Where would you put bends and where welds?

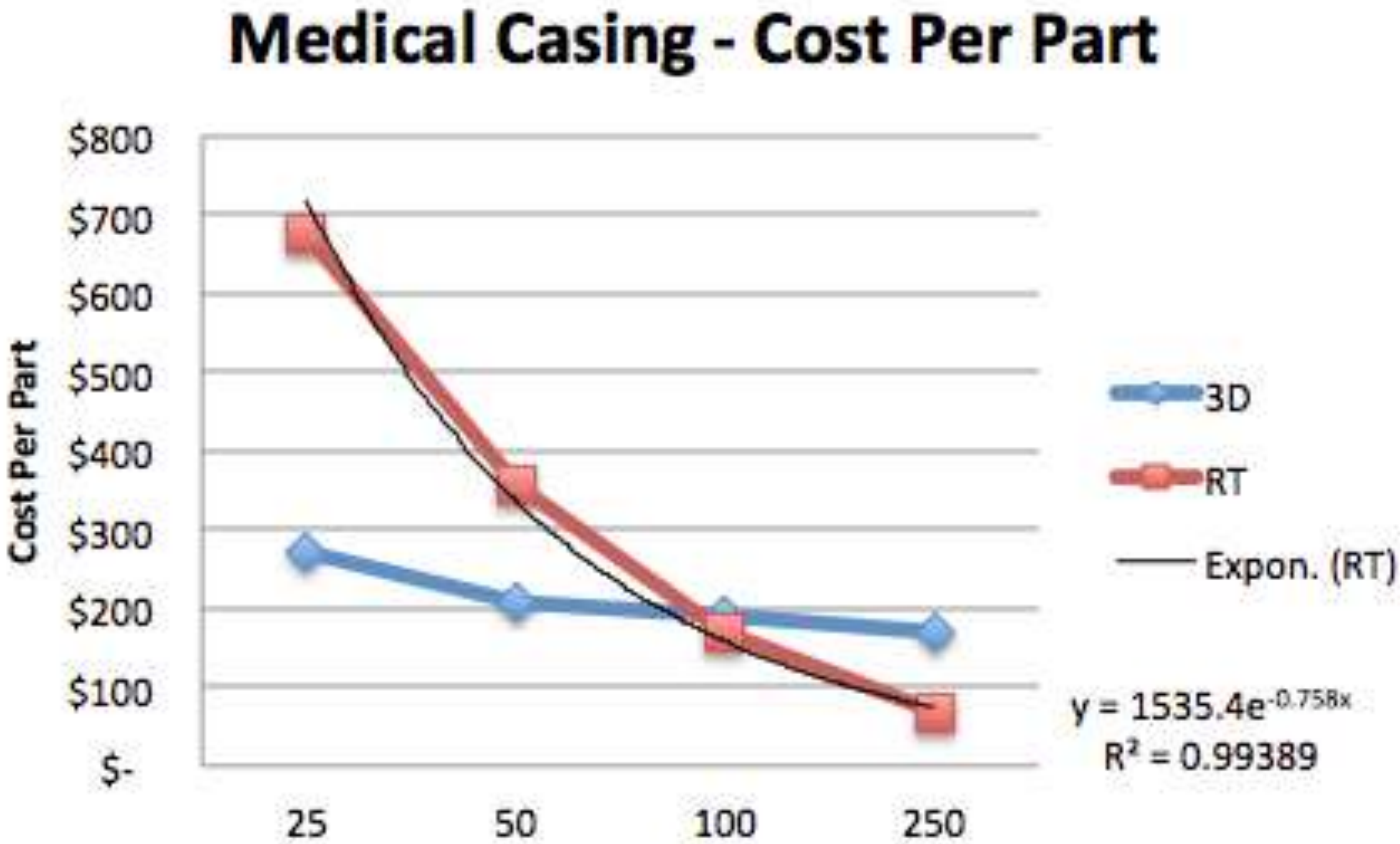
Redesign to eliminate process steps

- Use net-shape processes. Forging, casting and molding provide close to final shapes and eliminate machining steps
- E.g. Stamped piece: U shape with two holes. If holes are on base, can be stamped in one go. If holes are on flanges, needs two steps

Chose process with economy of scale

- Injection molding
- Machining
- Additive Manufacturing

Jeff Hanson, RedEye RPM



http://blog.3sourceful.com/post/45422603072/hedging-your-production-bets-with-3d-printing

Reducing Assembly costs

- DFA index: Theoretical minimum number of components x 3 seconds, divided by actual assembly time
  - Shorter actual assembly time → higher index
- Theoretical minimum
  - Do parts need to move with respect to each other? (ignore compliant mechanisms)
  - Must the parts be made of different materials?
  - Do the parts need to be separate fro access/maintenance reasons?

Integrate parts

- Fewer assembly steps (higher DFA)
- Reduced cost of tooling (e.g. fewer dies)
- More control over relative positioning
- Conflicts with modularity!

Integrate parts

- Fewer assembly steps (higher DFA)
- Reduced cost of tooling (e.g. fewer dies)
- More control over relative positioning
- Conflicts with modularity!

Consider customer assembly

- Assemble-it-yourself furniture
- Good also for packing and shipping
- Requires very careful and intuitive assembly plan

Reduce cost of supporting production

- Less equipment – flexible equipment
- “Just in time” production
- Frequent error proofing. Design your product so critical errors are self-evident.
  - E.g. design some notches and protrusions so that if parts are not assembled correctly, next part wont fit

Guidelines

- Heuristics (rules that are generally true)
  - have been developed for various manufacturing technologies.
- Some DFM guidelines
  - Guidelines for machining
  - Guidelines for assembly
  - Guidelines for injection molding
  - Guidelines for sheet metal processing
  - Guidelines for sheet die forming
  - Guidelines for casting
  - Guidelines for welding

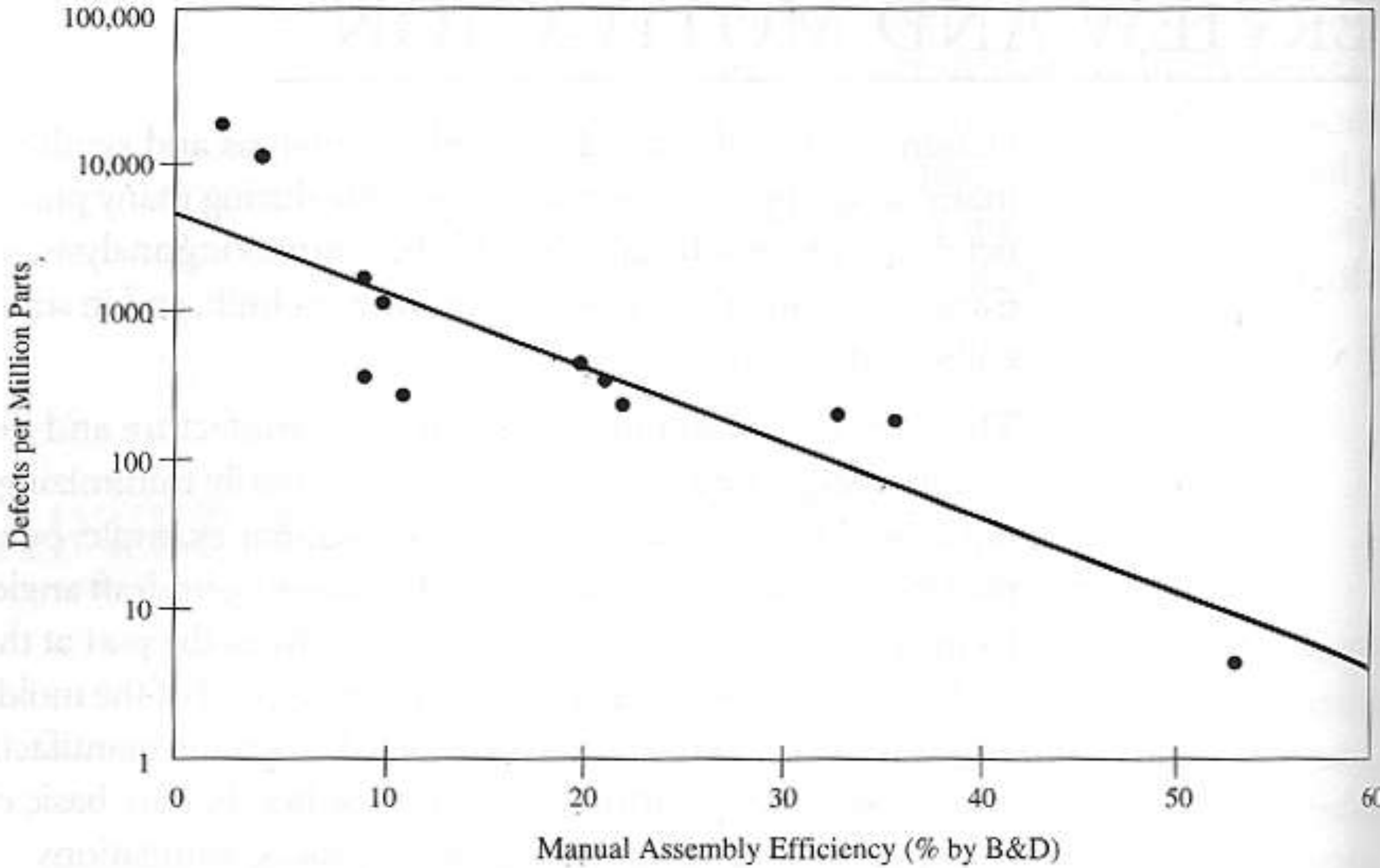
TABLE 14.1. DFA GUIDELINES

1. Minimize part count by incorporating multiple functions into single parts. (Iredale 1964)
2. Modularize multiple parts into single subassemblies. (Crow 1988)
3. Assemble in open space, not in confined spaces. Never bury important components. (Tipping 1965)
4. Make parts to identify how to orient them for insertion. (Tipping 1965)
5. Standardize to reduce part variety. (Tipping 1965)
6. Maximize part symmetry. (Iredale 1964; Paterson 1965)
7. Design in geometric or weight polar properties if nonsymmetric. (Tipping 1965)
8. Eliminate tangly parts. (Iredale 1964; Tipping 1965)
9. Color code parts that are different but shaped similarly.
10. Prevent nesting of parts. (Iredale 1964; Tipping 1965)
11. Provide orienting features on nonsymmetries. (Iredale 1964; Tipping 1965)
12. Design the mating features for easy insertion. (Iredale 1964; Tipping 1965; Baldwin 1966)
13. Provide alignment features. (Baldwin 1966)
14. Insert new parts into an assembly from above. (Tipping 1965)
15. Insert from the same direction or very few. Never require the assembly to be turned over. (Tipping 1965)
16. Eliminate fasteners. (Iredale 1964)
17. Place fasteners away from obstructions.
18. Deep channels should be sufficiently wide to provide access to fastening tools. No channel is best.
19. Providing flats for uniform fastening and fastening ease.
20. Proper spacing ensures allowance for a fastening tool.

DFA Goals

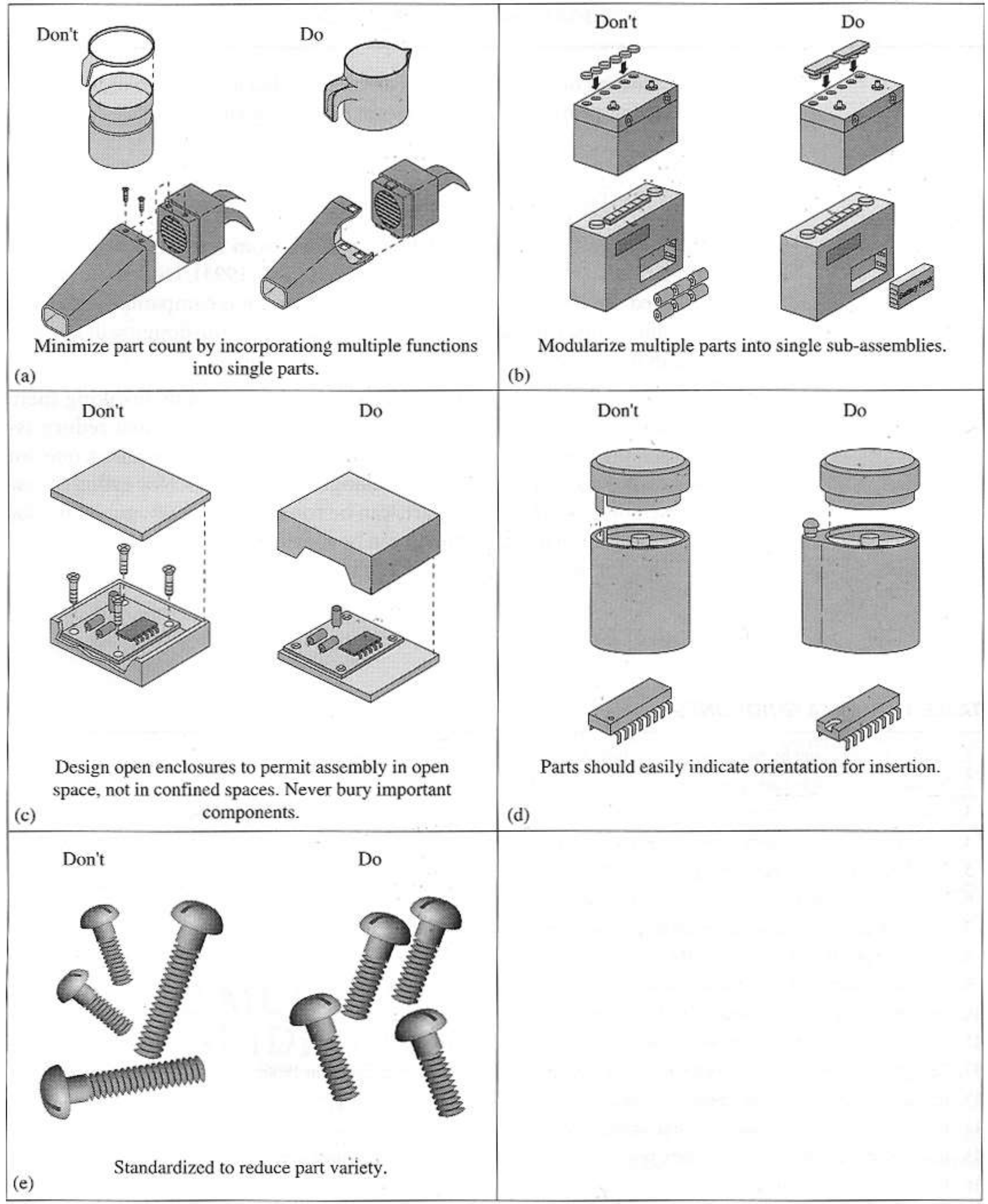
- Reducing costs
- Reducing time
- Reducing errors

In some projects (e.g. aerospace, cost is less important than time and error. In others, e.g. toys, cost is more important than error)



▼ ***Figure 14.2.***
Increase in reliability with application of DFA at Motorola (from Branan 1991).

Guidelines for assembly



(a) Minimize part count by incorporationg multiple functions into single parts.

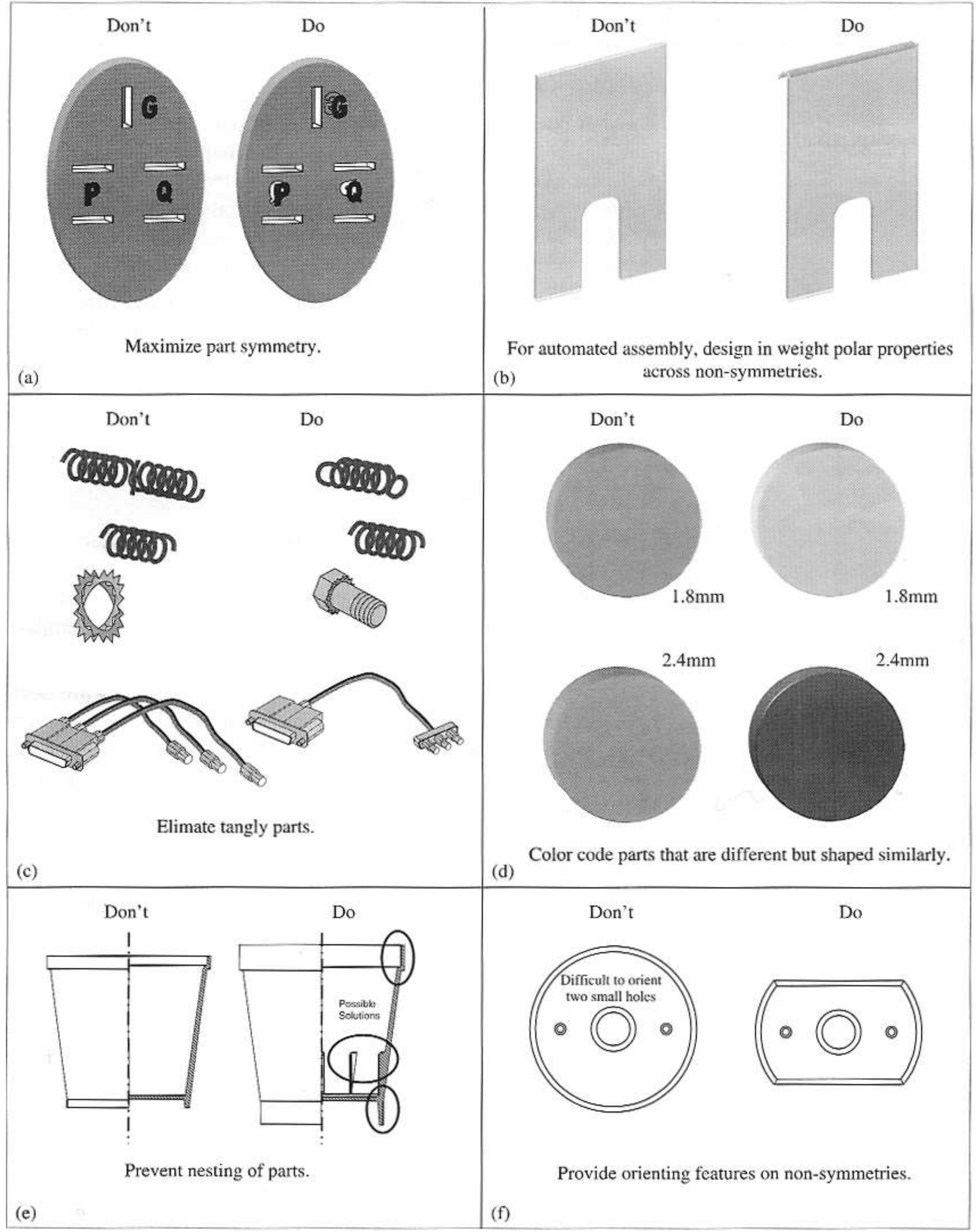
(b) Modularize multiple parts into single sub-assemblies.

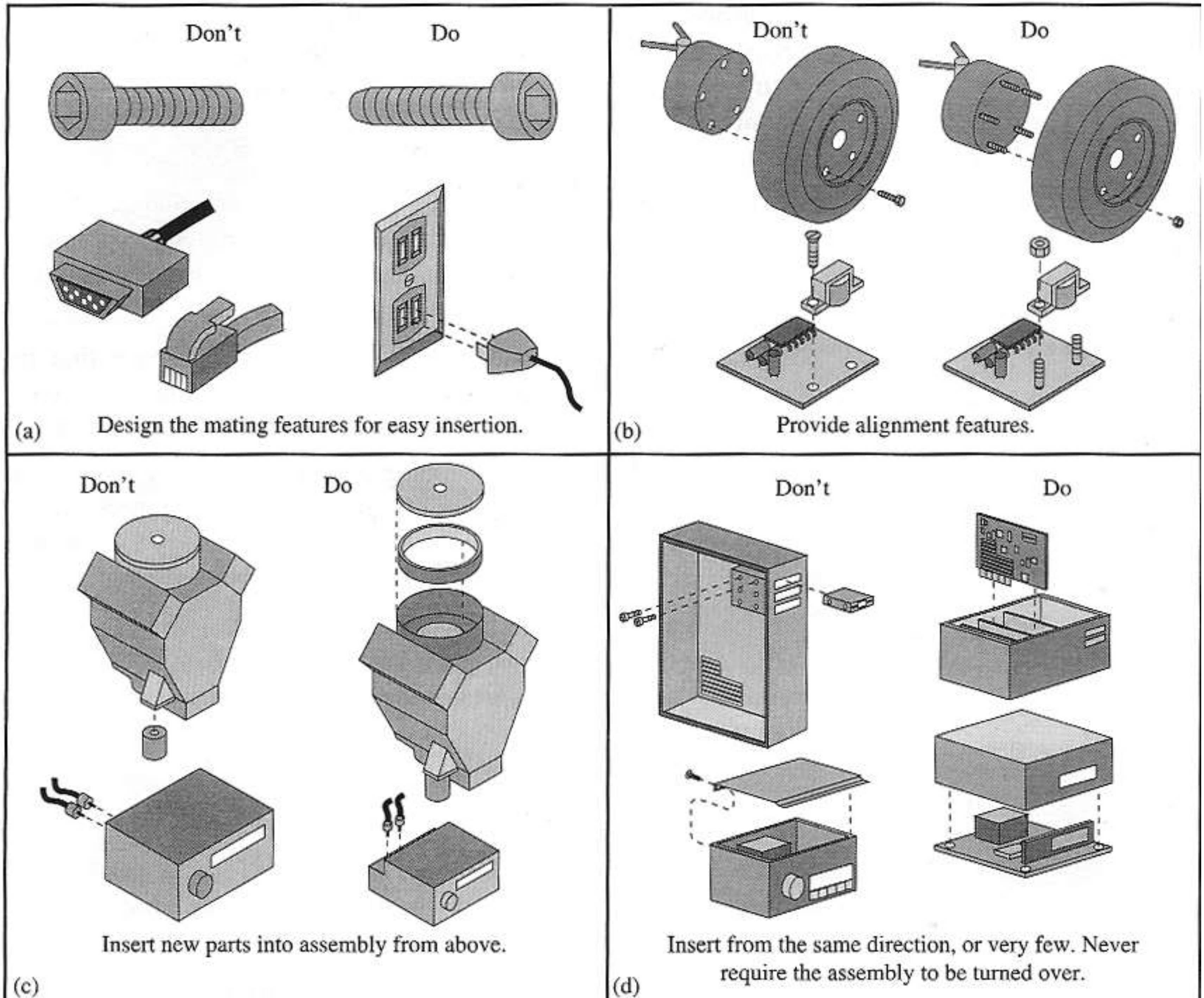
(c) Design open enclosures to permit assembly in open space, not in confined spaces. Never bury important components.

(d) Parts should easily indicate orientation for insertion.

(e) Standardized to reduce part variety.

Guidelines for assembly





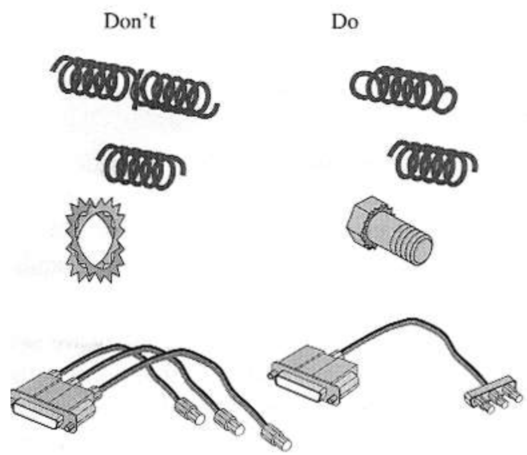
(a) Design the mating features for easy insertion.

(b) Provide alignment features.

(c) Insert new parts into assembly from above.

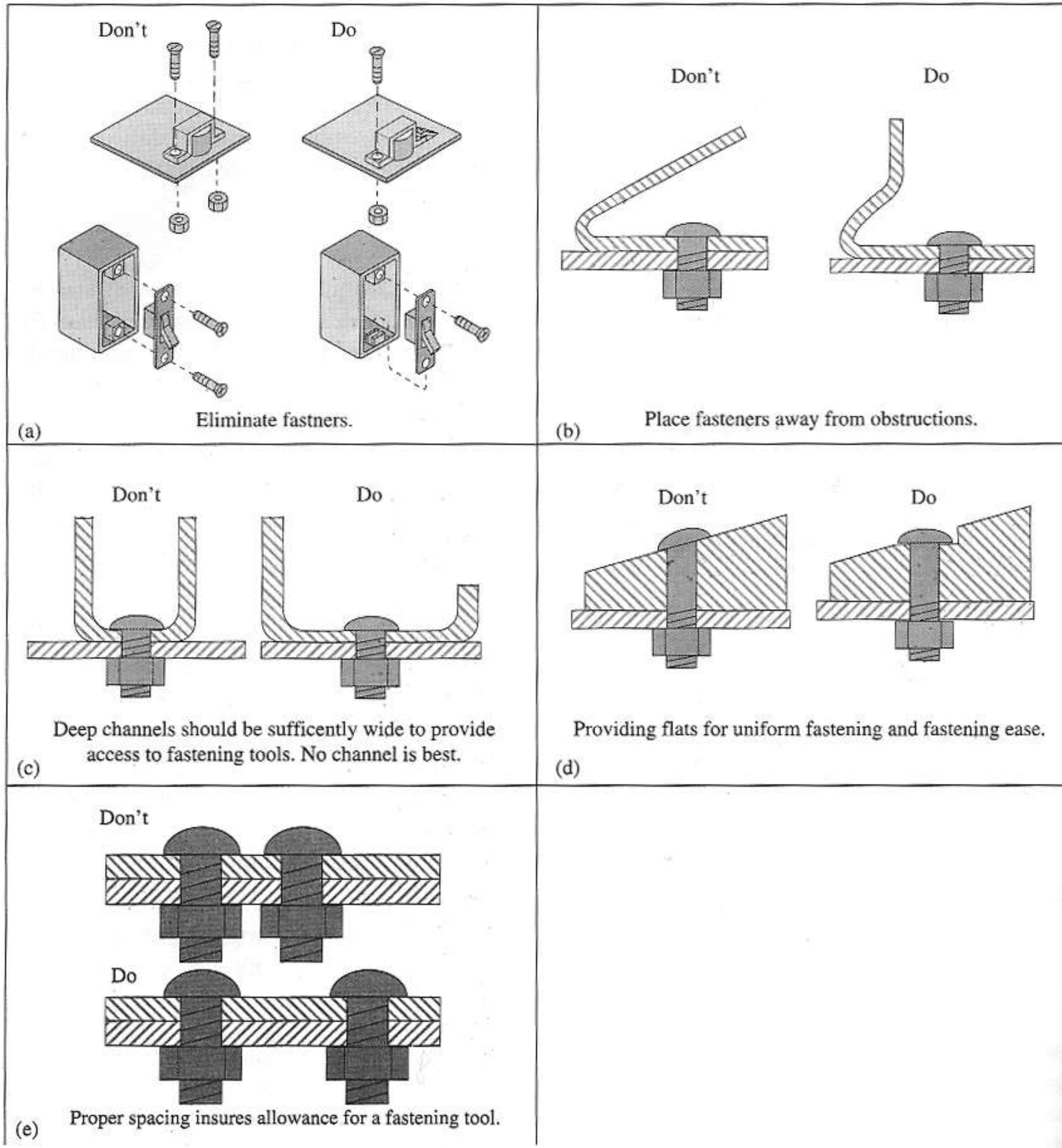
(d) Insert from the same direction, or very few. Never require the assembly to be turned over.

Design for robotic assembly

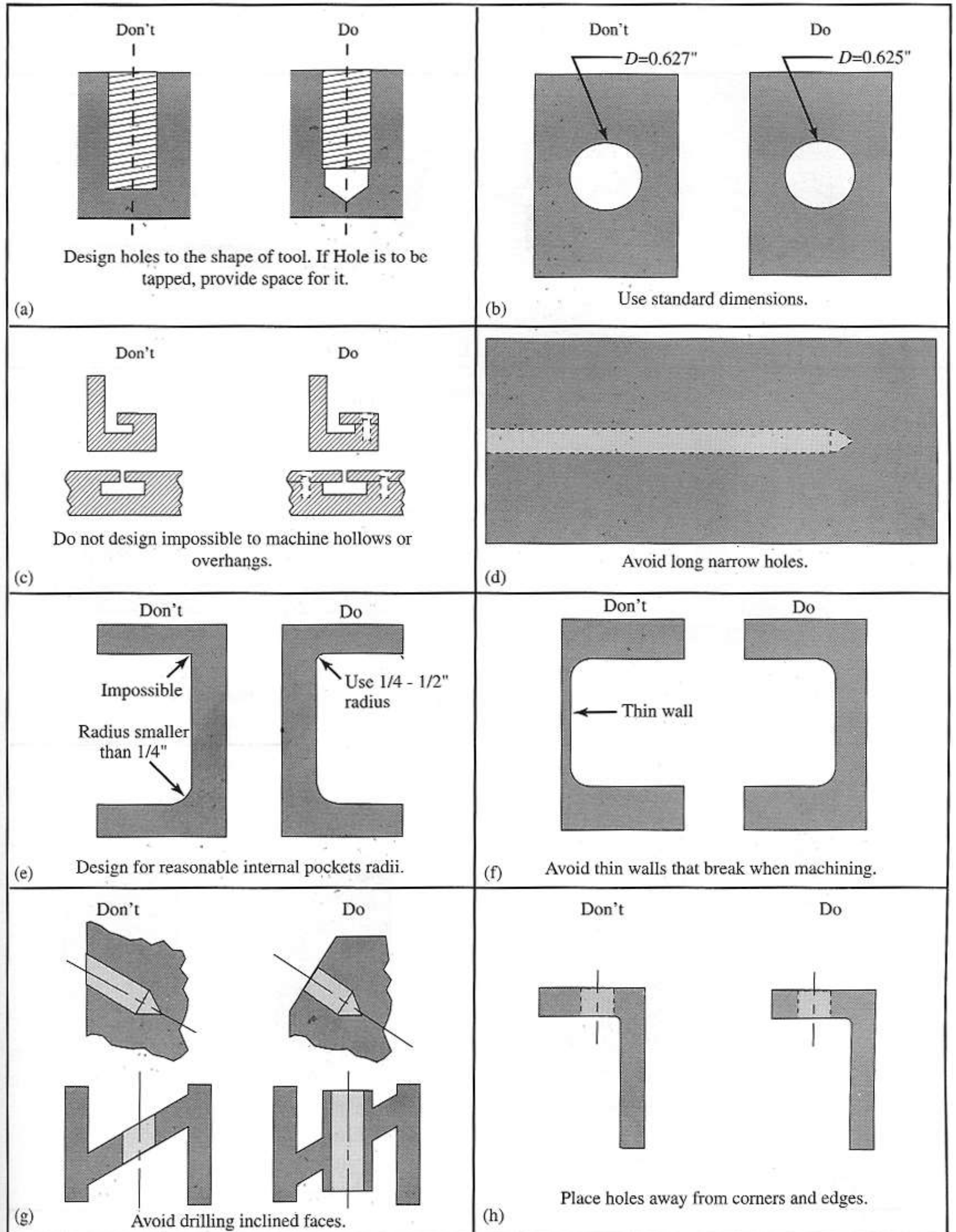


Elimate tangly parts.

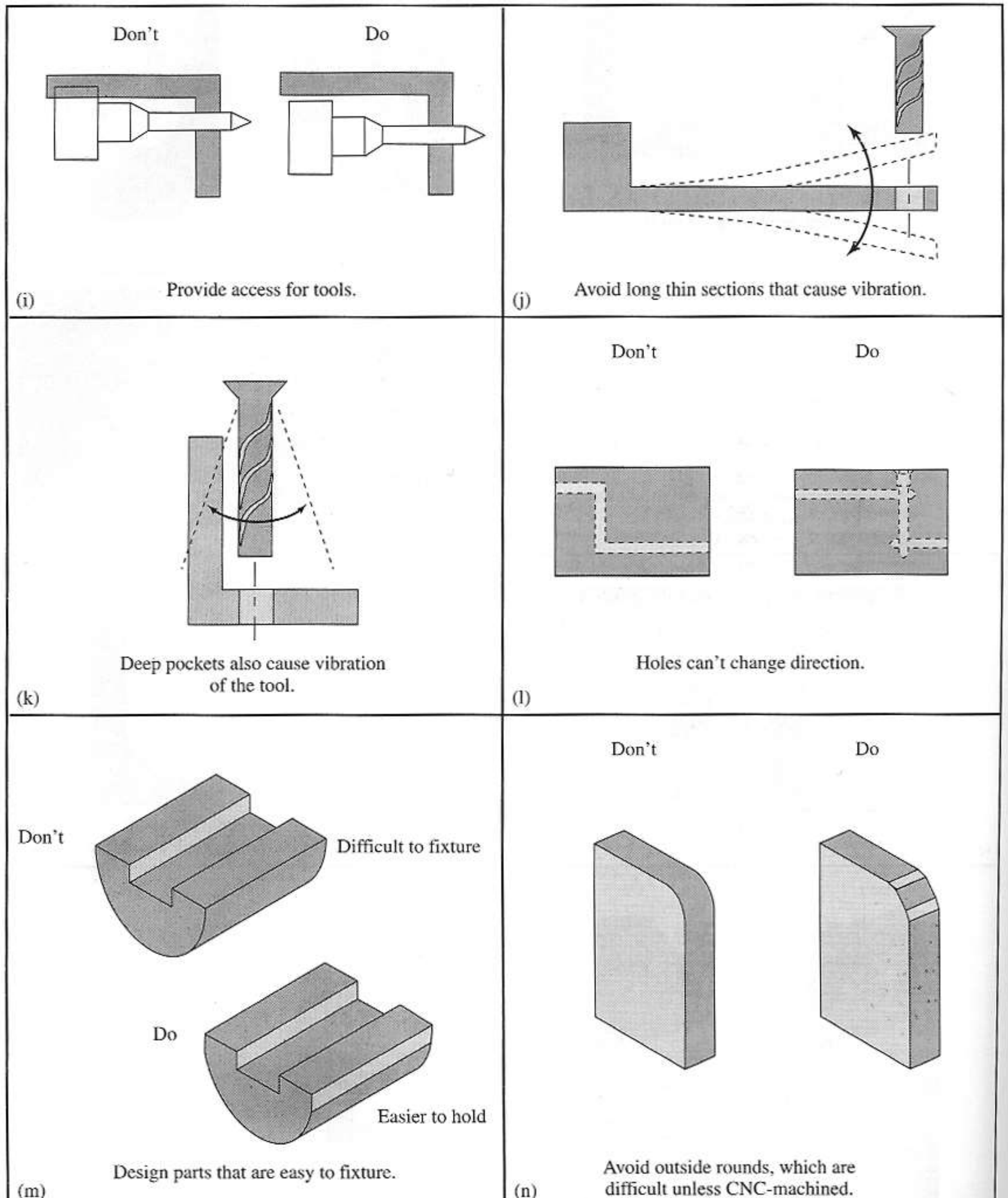
Guidelines for assembly



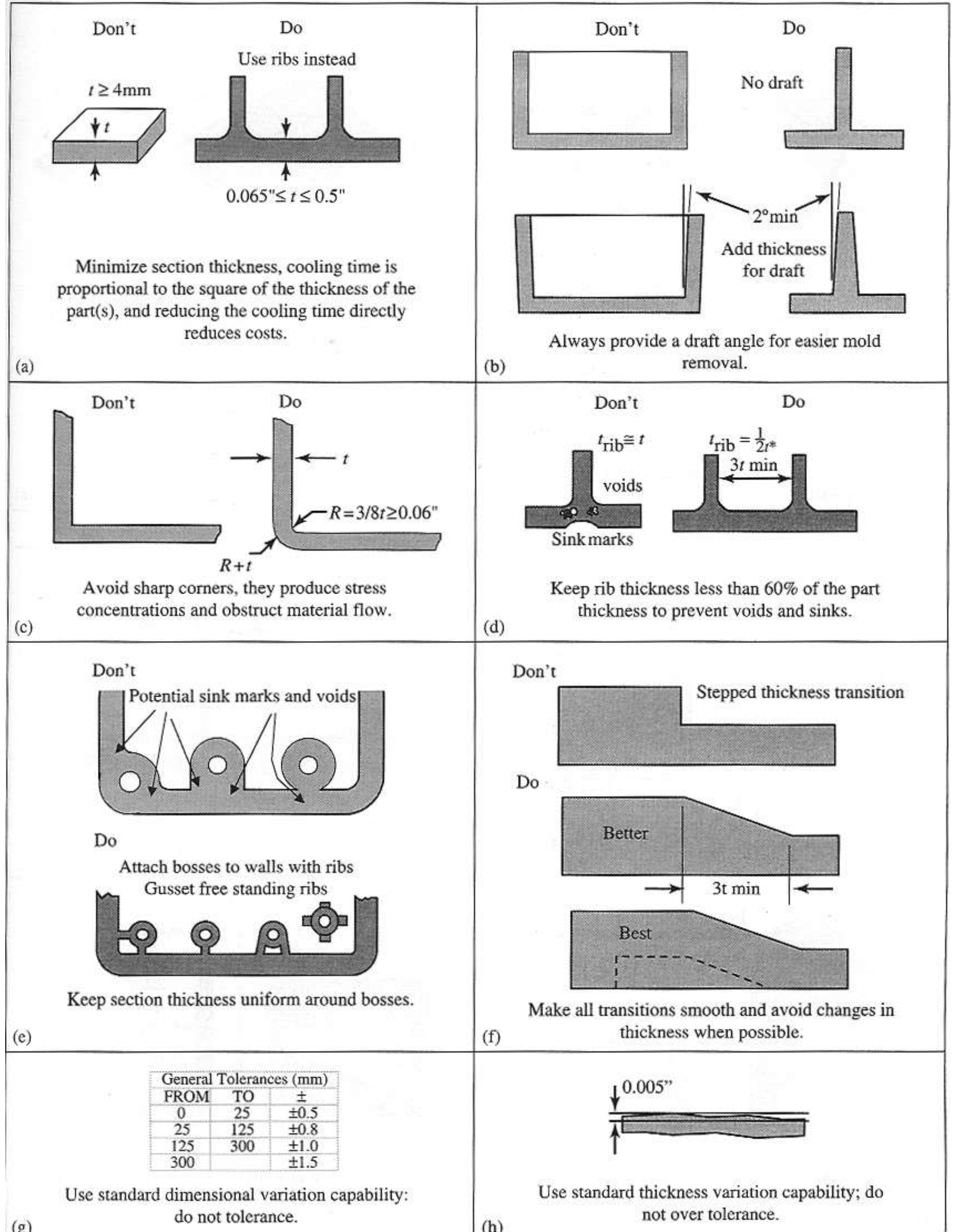
Guidelines for machining



Guidelines for machining

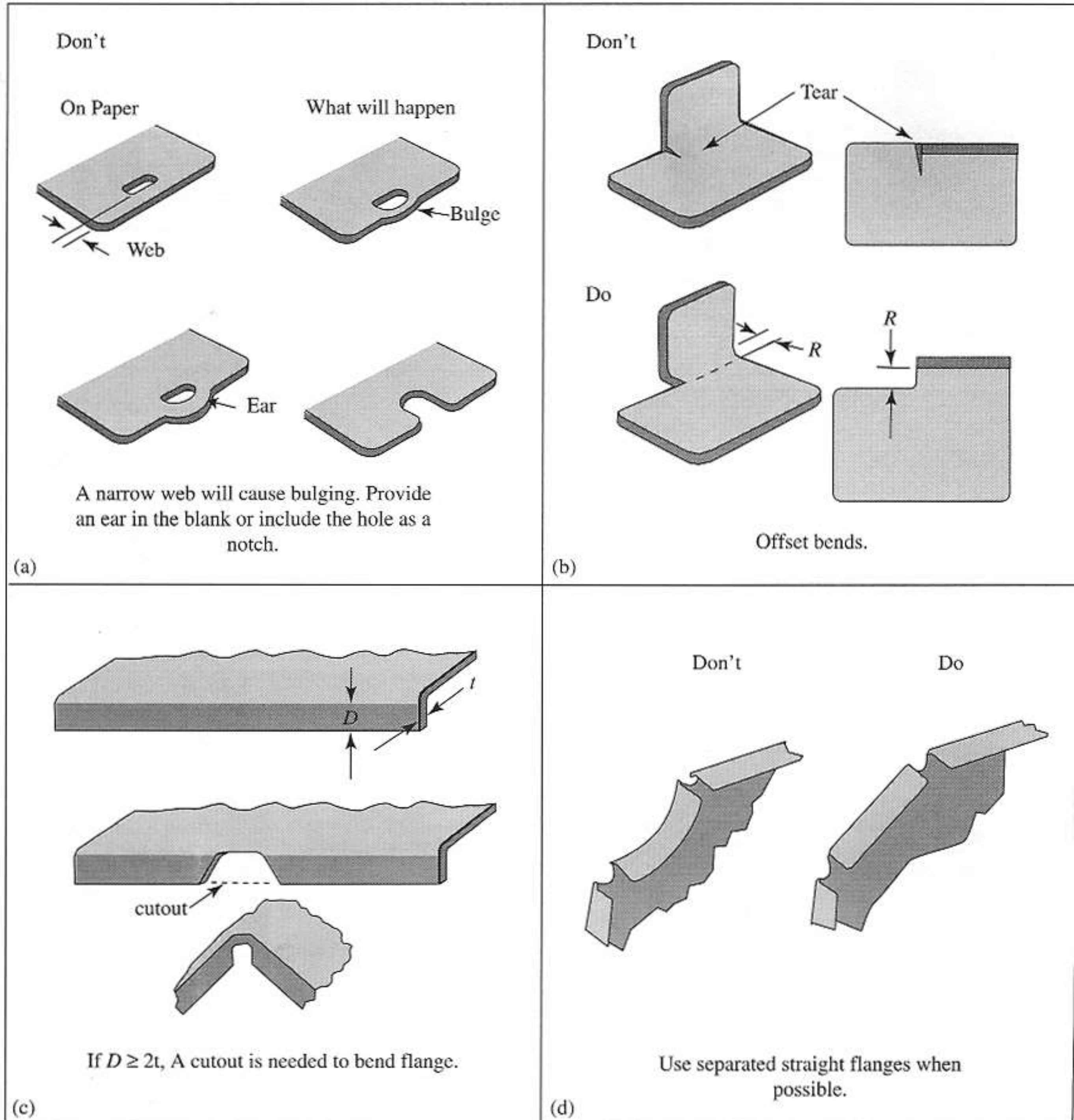


Guidelines for injection molding

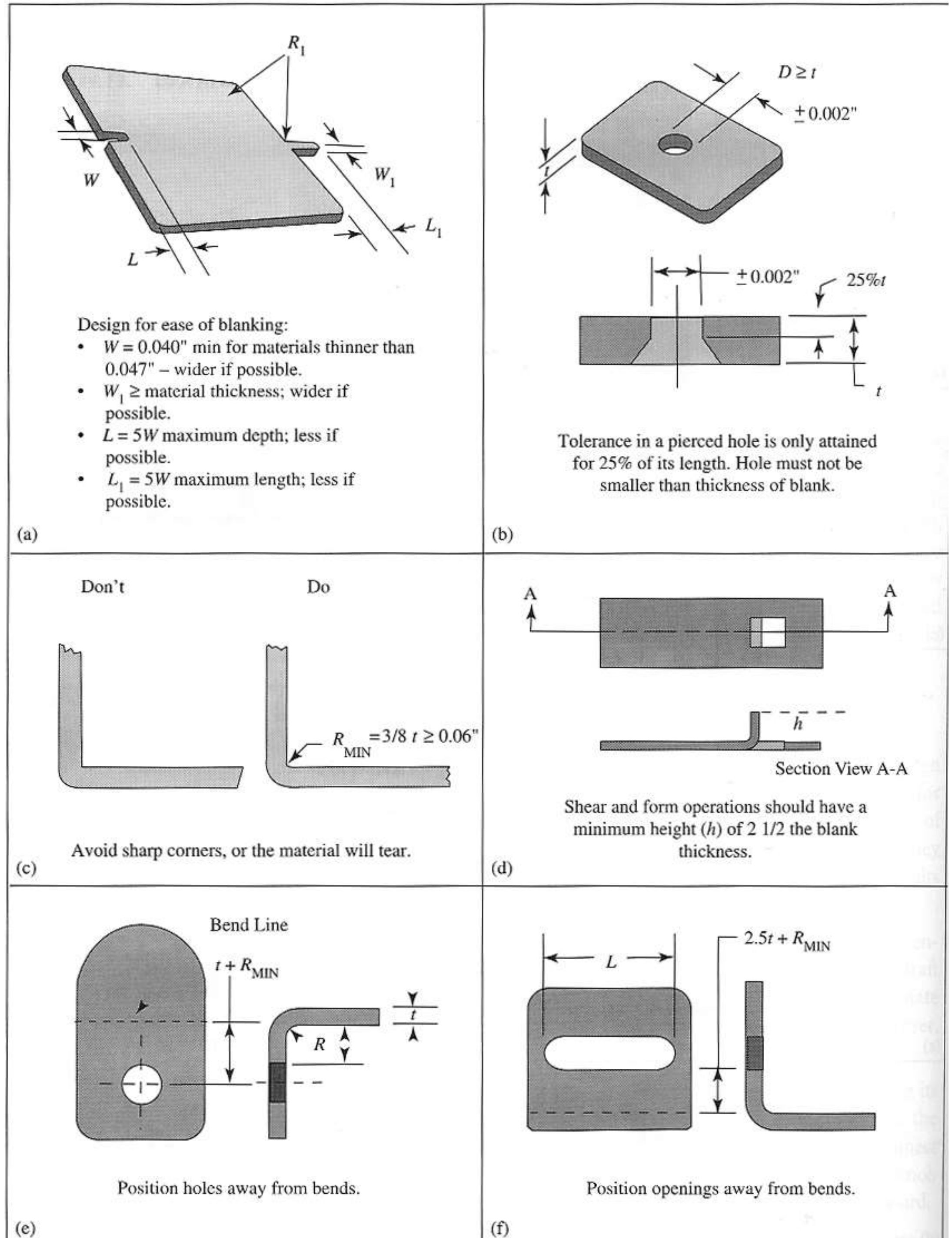


General Tolerances (mm)		
FROM	TO	±
0	25	±0.5
25	125	±0.8
125	300	±1.0
300		±1.5

Guidelines for sheet forming



Guidelines for sheet forming



Design for ease of blanking:

- $W = 0.040"$ min for materials thinner than $0.047"$ – wider if possible.
- $W_1 \geq$ material thickness; wider if possible.
- $L = 5W$ maximum depth; less if possible.
- $L_1 = 5W$ maximum length; less if possible.

(a)

Tolerance in a pierced hole is only attained for 25% of its length. Hole must not be smaller than thickness of blank.

(b)

Avoid sharp corners, or the material will tear.

(c)

Shear and form operations should have a minimum height (h) of 2 1/2 the blank thickness.

(d)

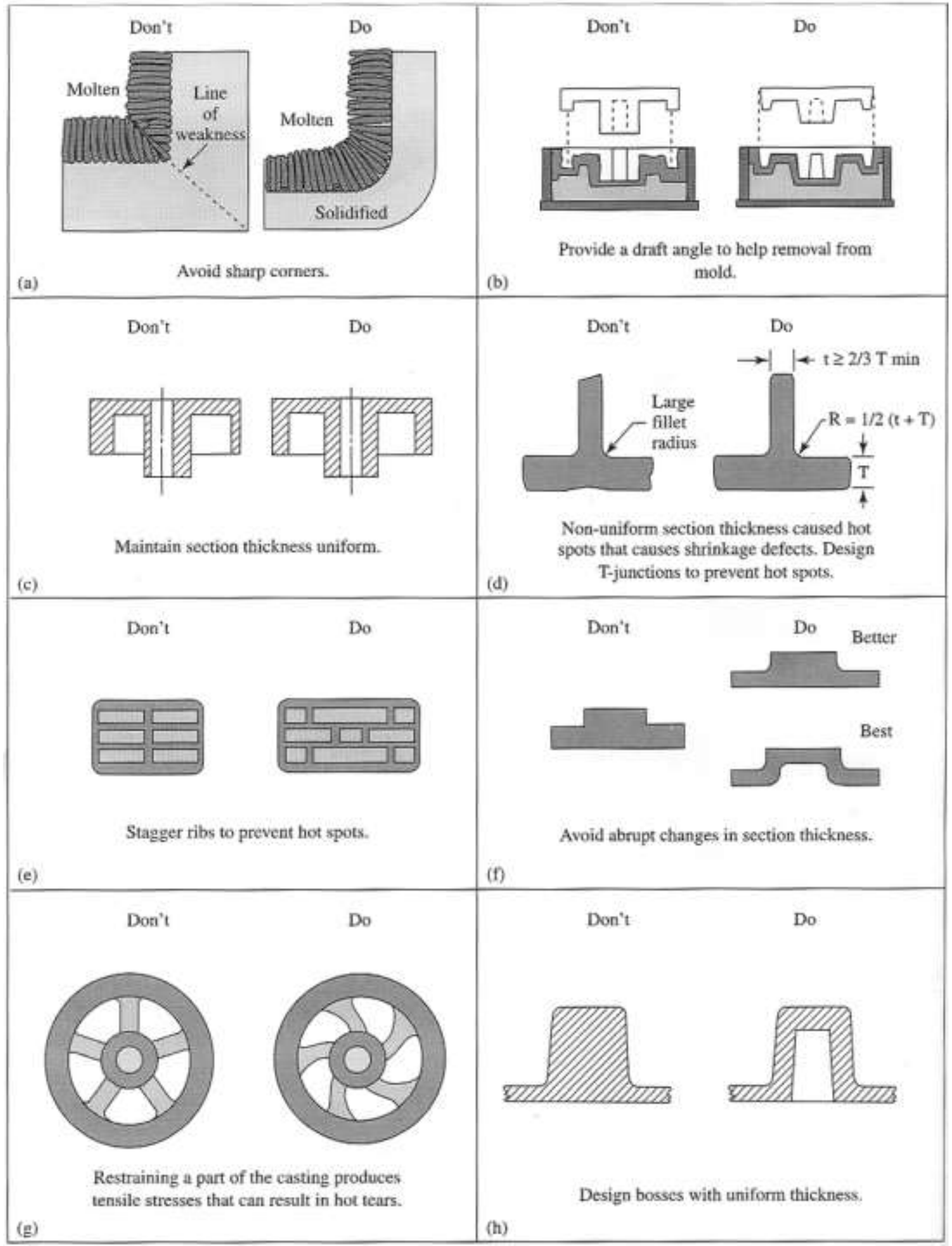
Position holes away from bends.

(e)

Position openings away from bends.

(f)

Guidelines for casting



Are you still here?

A. Yes
B. No
C. Only physically (but not spiritually)
D. Spiritually (only my clicker is here)
E. What-e-ver