

## CHAPTER 3

### Fabrication parts manufacturing

There are numerous ways to classify industrial system, but the majority of manufacturing operations may be categorized as *product shop* or *process shop*. Both classifications imply certain characteristics regarding the production facility layout and the product type.

A product shop is frequently referred to as a production line or flow shop, where machines or workstations are arranged so that products follow a logical sequence of operations in a straight path from start to finish. Production is usually limited to a small range of products requiring similar or identical manufacturing operations.

A process shop is also called a *job* or *intermittent* shop, and is structured to allow production of a wide variety of different products with different requirements. Typically, similar machines or workstations are grouped together to facilitate this diverse production activity.

Some air conditioner manufacturing plants may be job shops and may also separated this job shop production into two main work areas : one is the *Fabrication section* and another is the *Assembly section*. The fabrication section is responsible to produce steel-sheet components for assembly with purchased parts at the assembly section.

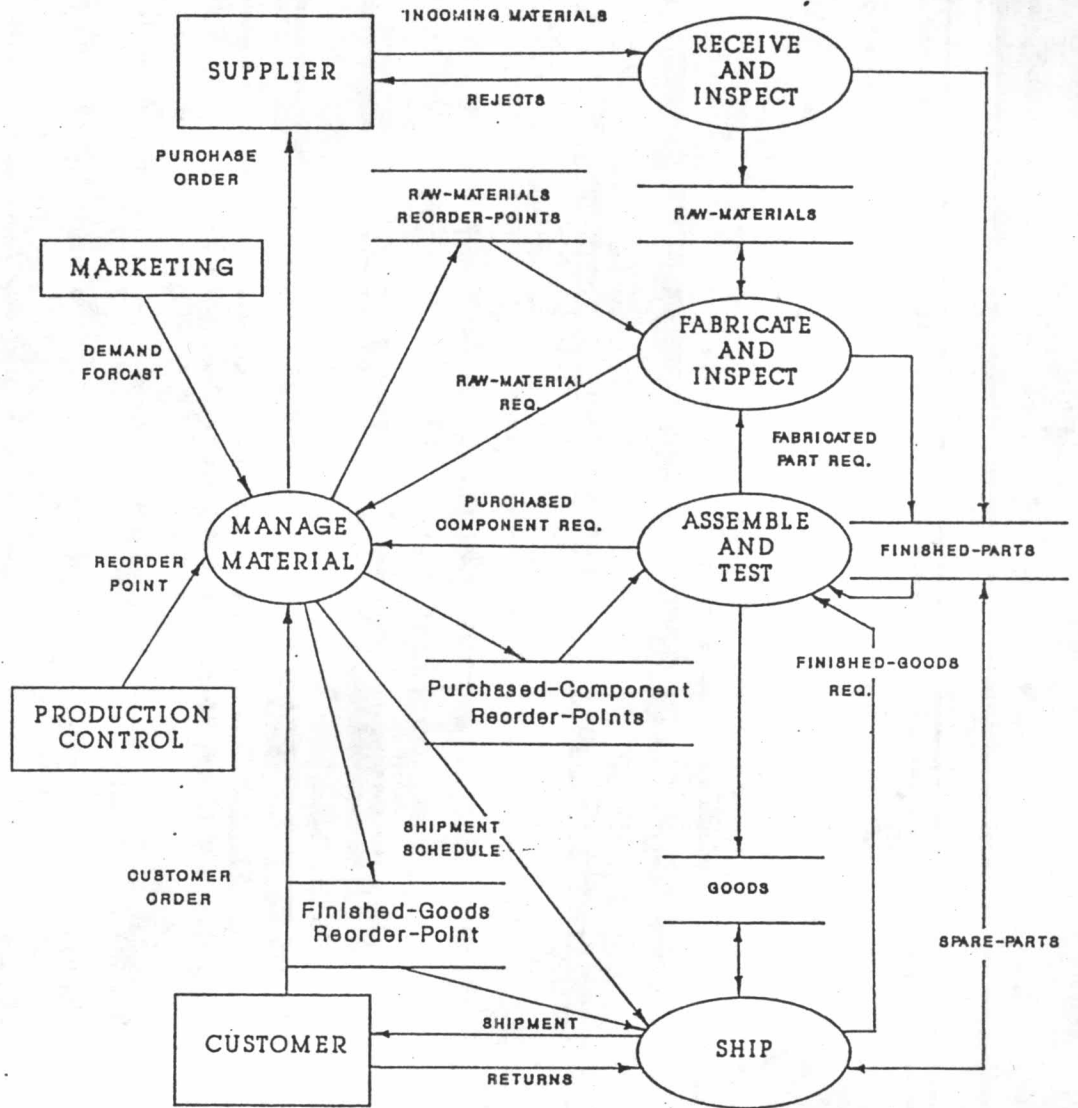


Figure 3.1 Material flow in manufacturing.

### Material flow

Figure 3.1 represents closed loop of material flows in the air conditioner manufacturing plant. Galvanized steel sheets, plastic parts, copper tubes, compressors, and motor are sample of materials purchased from suppliers.

### Production process in fabrication section

The Process starts at shearing raw sheet metal to required size and quantity, then proceeding to the next operations for notching, punching, bending (a small number of components also need spot welding or rolling). After bending the components are phosphate treated and powder coated and moved to assembly. The processes described above may be presented as a diagram like Figure 3.2.

Due to the wide variety of components produced and the presence of multiple machines at each workstation, there are many possible process routings on the shop floor. Figure 3.3 shows all possible routes to manufacture components. Rectangular boxes represent a particular machine while arrows show directions of process progression.

As illustrated with Figure 3.2, manufacturing progresses from the operations of shear, notch, punch, and bend to many possible routes. Approximately 50 per cent of the parts must pass through all operations.

Blank plate shearing is the first stage to manufacture a workpiece. Standard 4 feet x 8 feet rectangular plates are shear to size in the quantities required depending on each job order. Both hot dip (HD) and electro galvanized (EG) plates with thicknesses of 1.0,

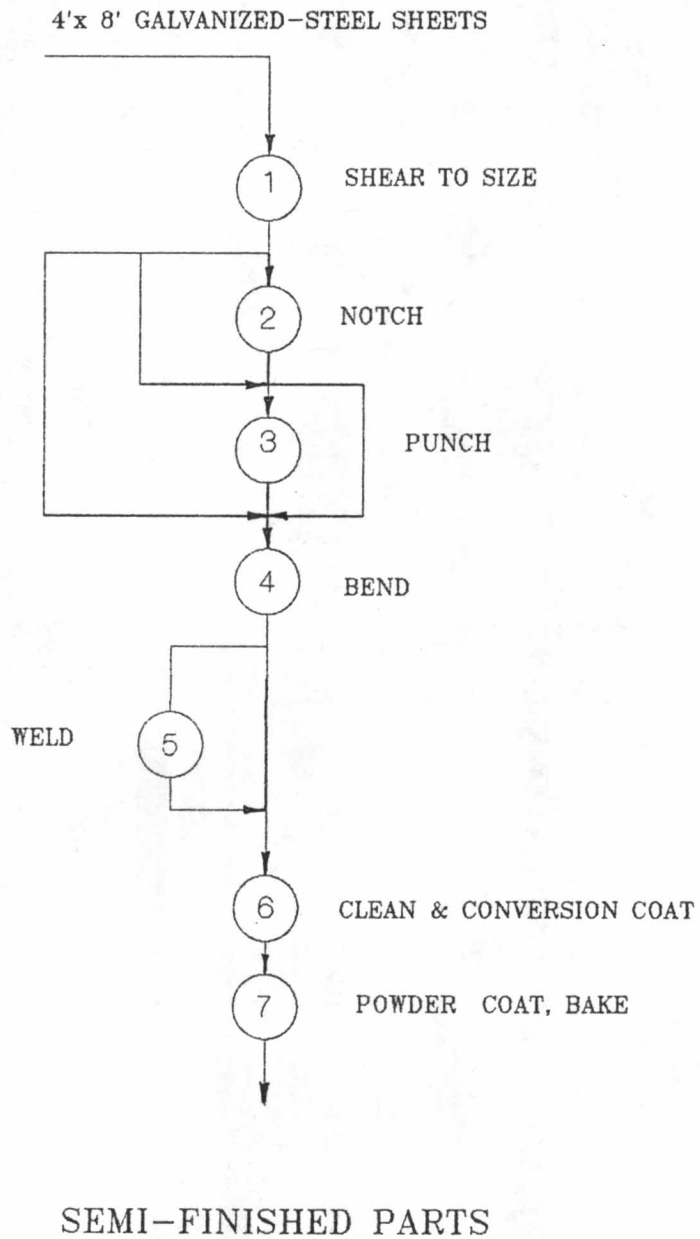


Figure 3.2. Operation outline of a sheet-metal component.

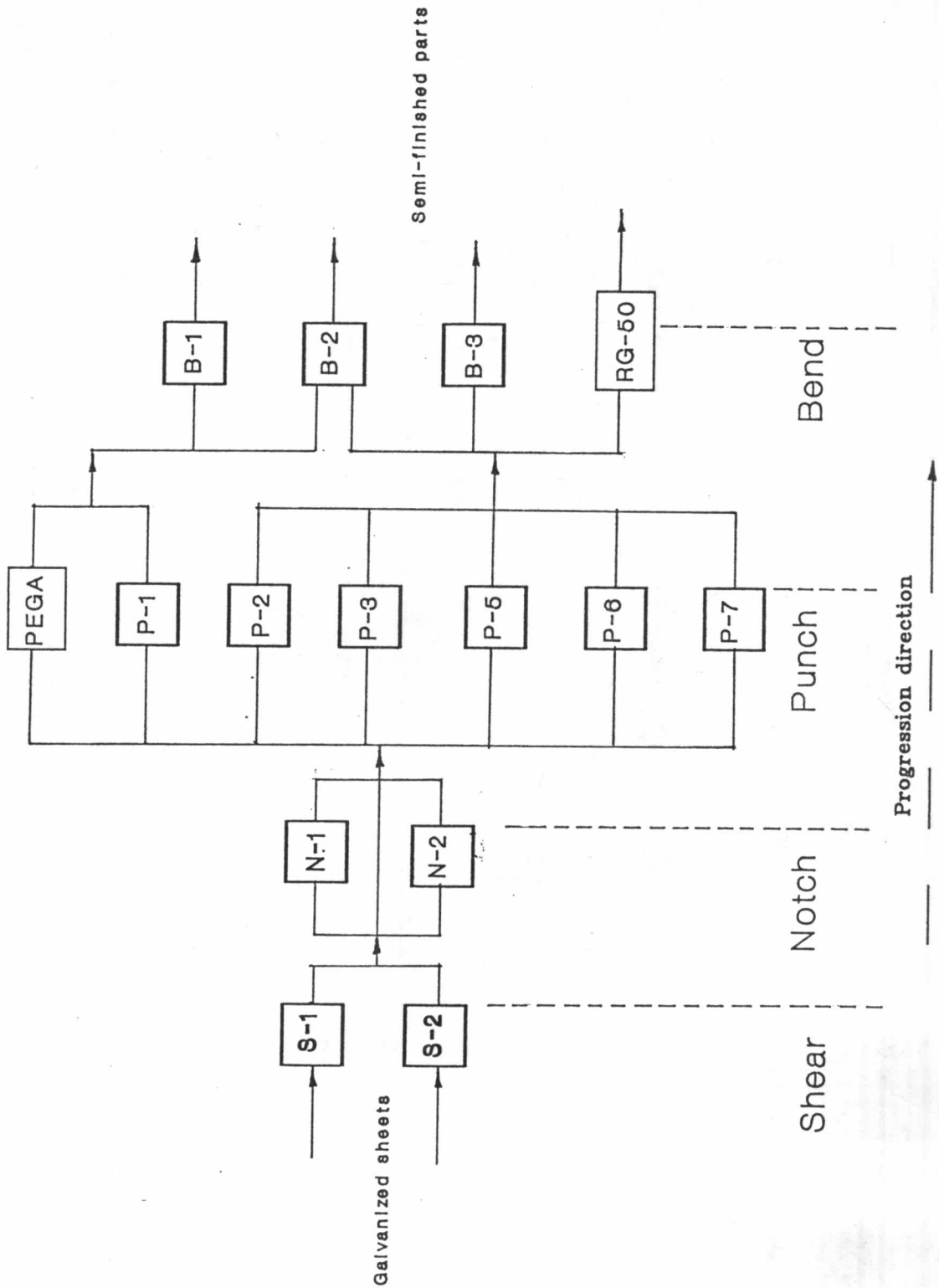


Figure 3.3. All possible routes to manufacture components.

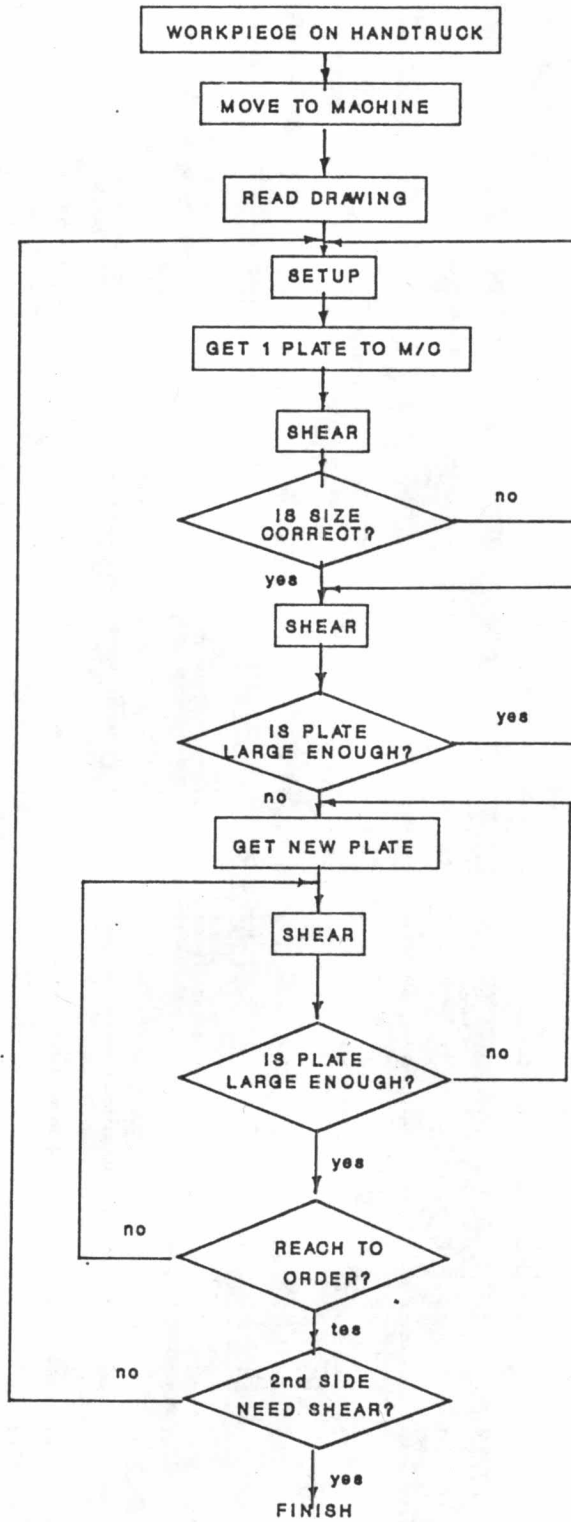


Figure 3.4. Standard blank shearing procedure.

1.2, 1.6, 2.0, and 3.0 millimetre are used to produce workpieces. The flow diagram of the standard blank shearing procedure is shown in Figure 3.4.

After shearing the workpieces are stacked on metal hand trucks and moved to the next operation. The adjacent operation may be notching or punching depending on workpiece design. Standard procedures for punching and bending are shown as Figure 3.5 and 3.6 respectively.

The manufacturing process sequence has been recorded on the flow process chart (Figure 3.7). Times were not included in the chart due to the variations of process routings and lot size quantities.

After powder coating, the components are brought to the designated assembly section. Figure 3.8 shows an example operation process chart in assembly sections.

### Products

In general, air-conditioners are classified according to the following :

a) *Package unit*, is an air-conditioner unit in which the condensing unit and fan coil unit are integrated to one package. This product type may be sub-classified as *window type* or *large package type*. The package unit has the advantages of *complete factory testing*, ease of handling and installation, when compared with the other types.

b) *Split system*, is an air-conditioner unit which splits the condensing unit and fan coil and the fan coil is installed in the building interior. Condensing units consist of the motor compressor, the condensor coil, and the condensor fan. Fan coil units (or indoor

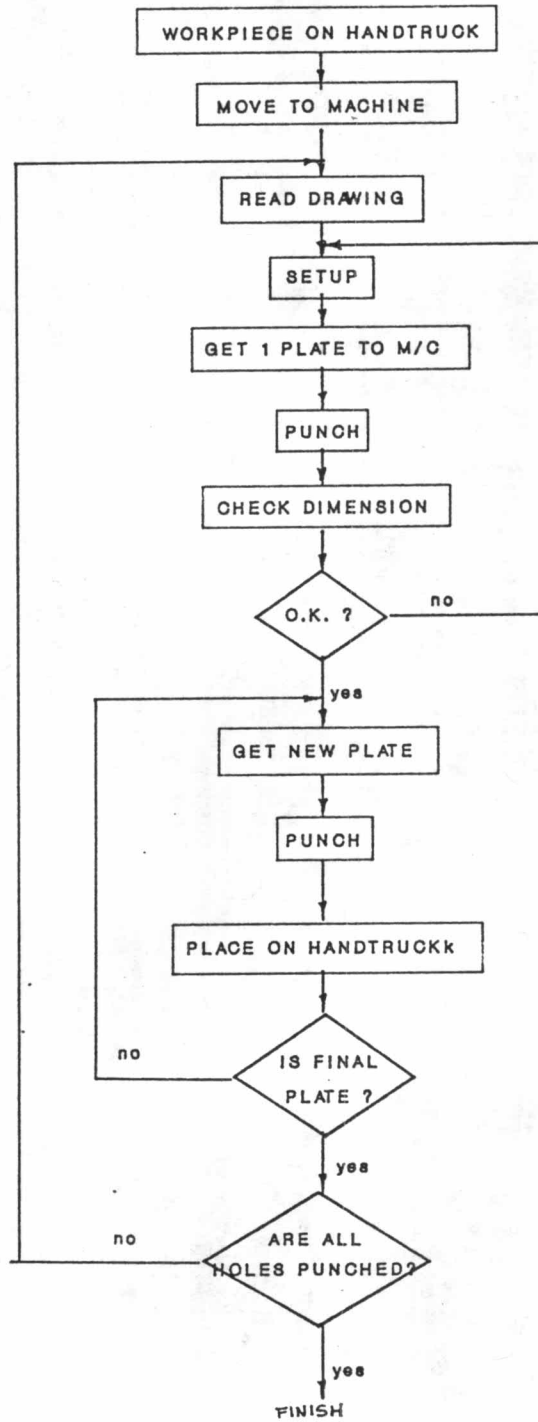


Figure 3.5. Standard punching procedure.



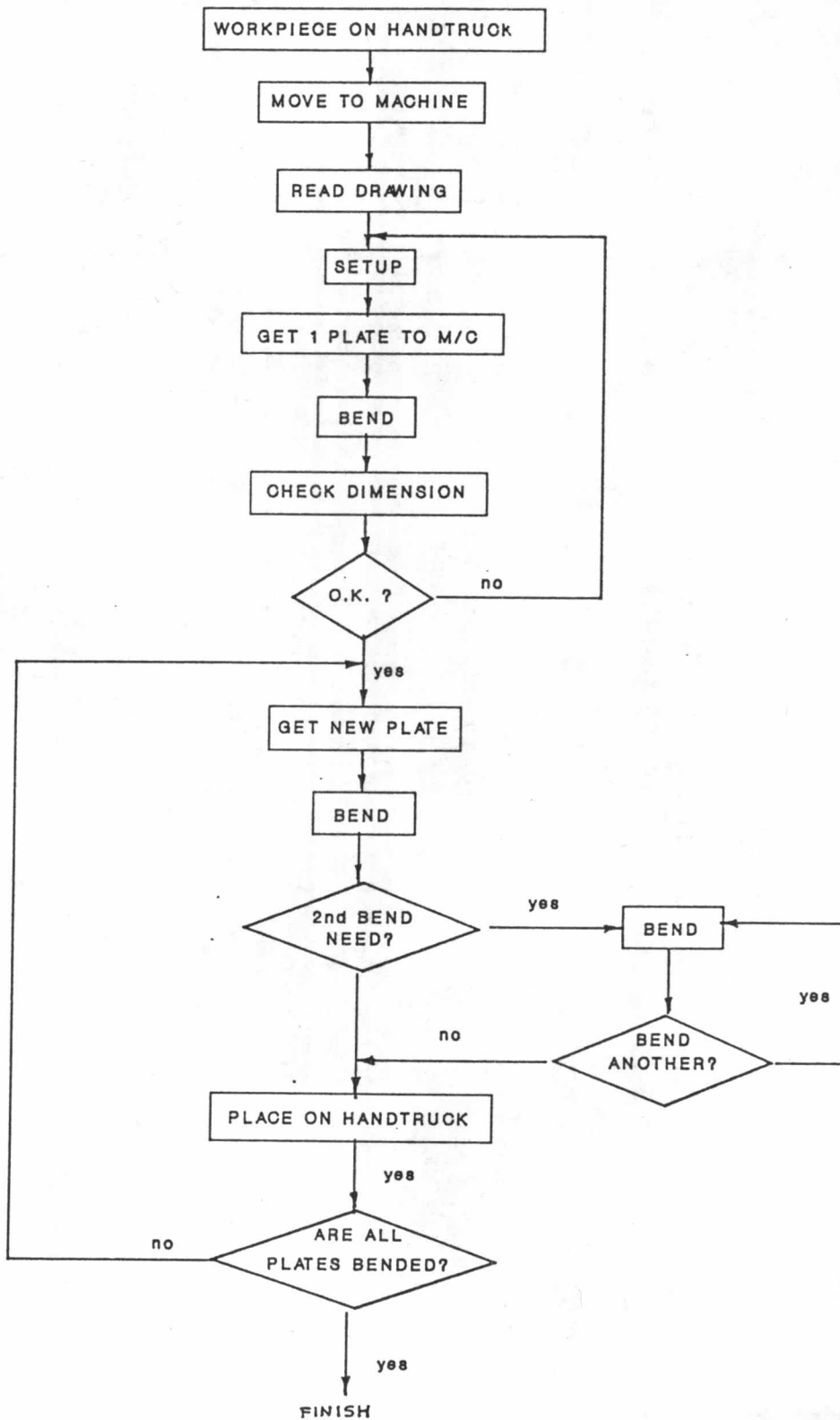


Figure 3.6. Standard bending procedure.

# Flow Process Chart

Type : ~~Man~~ / Material  
 Method : Present / ~~Proposed~~  
 Job : production of sheet metal

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No.	Description	○ → □ ▢ ▽	Dist. (m)	Remarks
1	Raw plate on racks			
2	Lift by fork truck			
3	Transport to table		5.0	Average distances are measured from one to another work center.
4	Place on table			
5	Wait for setup activities			
6	Load 1 plate by manual to m/c			
7	Shear raw plate to size			
8	Move plate to table			
9	Wait until the final plate is produced and finished from setup			
10	Load 1 plate to m/c			
11	Shear on 1st side			
12	Wait until the final plate is produced and finished from setup			
13	Move the plate to front of m/c		2.0	
14	Load 1 plate to m/c			
15	Shear on 2nd side			
16	Stack the plate on hand truck			
17	Wait until the final plate is produced			
18	Transport to punch press m/c		3.6	
19	Wait for setup activity			
20	Load 1 plate to m/c			
21	Punch			
22	Place on hand truck			
23	Wait until the final plate is produced (Workpieces normally require two or more steps for punching operation)			
24	Transport plate to notching m/c		12.2	
25	Wait for setup activity			
26	Load 1 plate to m/c			
27	Notch			
28	Place on hand truck			
29	Wait until the final plate is produced			
30	Transport plate to press brake m/c		18.0	
31	Wait for setup activity			
32	Load 1 plate to m/c			
33	Bend			
34	Place on hand truck or pallet			
35	Wait until the final plate is bended (Workpieces normally require two to five steps for bending operation)			
36	Transport to paint spray		5.0	Some workpieces need welding or rolling before spraying.
			45.8	

Figure 3.7. Flow process chart of the production of sheet-metal.

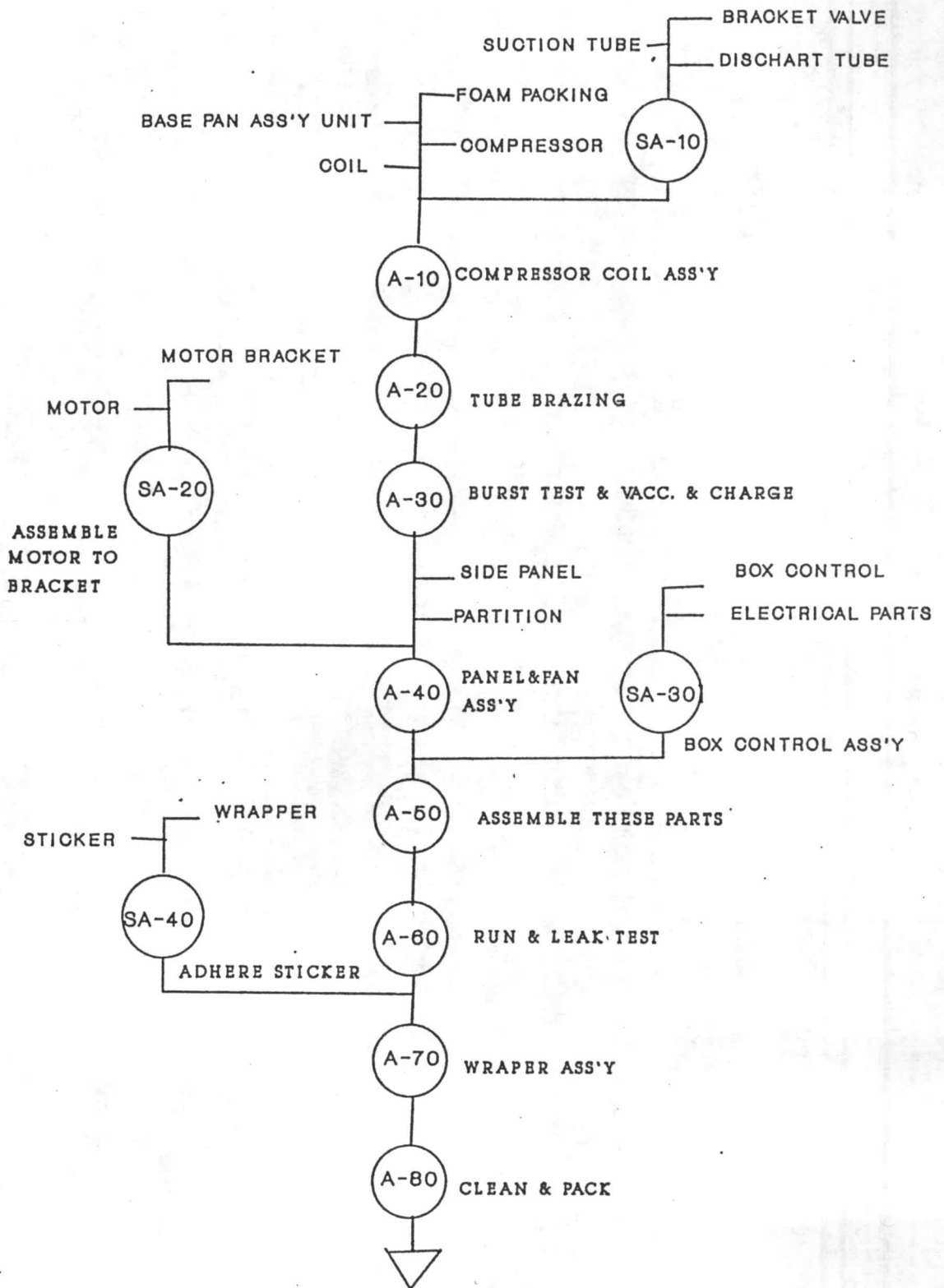


Figure 3.8. Example of operation process chart.

unit) consist of an evaporator coil and evaporator fan.

c) *Chilled water system*, the system uses water passed through a condenser unit so as to reduce the water temperature to 42-50 degrees farenheight. The chilled water is then passed through a fan coil unit to reduce the room temperature.

In the studied plant, product classifications are based upon marketing requirements. The types of products are given in Table 3.1.

Table 3.1. Product classification.

No	Type	Capacity (ton)
1.	Non duct split-indoor	up to 1.5
2.	Non duct split-outdoor	up to 1.5
3.	Duct small split-indoor	1.5 to 5.0
4.	Non duct small split-indoor	1.5 to 5.0
5.	Non duct small split-outdoor	1.5 to 5.0
6.	Duct large split-indoor	over 5.0
7.	Duct large split-outdoor	over 5.0
8.	Duct large package unit	over 5.0
9.	Reciprocating chillers	
10.	Air handling unit	
11.	Air terminal	
12.	Applied others	

### Machines

Sixteen machines are used in the fabrication section. These

Table 3.2. Machines and their utilities.

Machine No.	Type	Use for	Workpieces arriving from	Remarks
S-1,S-2	Shearing machine	S-1 use for large plate and S-2 for medium and small.	Racks.	3048 mm. blade length.
B-1,B-2, B-3, RG-50 (or B-4)	Press brake machine	Bending operation	Shearing or notching or punch press machines.	3660 mm. blade length for B-1 and B-2. 2000 mm. length for B-3 and RG-50.
N-1,N-2	Notching machine	Notching operation	Shearing or punch press machines.	
P-1  P-2,P-3, P-5,P-6, P-7	Nipping machine  Punch press machine	Punching large holes operation.  Punching operation.	Punch press machine.  Shearing or notching machines.	The hole's dia. or length must not over 80.0 mm.
AMADA (or P-9)	Punch press machine	Punching large workpieces which have many holes.	Shearing machine.	This machine is CNC turret punch press

consist of three NC press brake machines, one CNC turret punch press, and twelve manual machines. The NC and CNC machines are used for workpieces which have complex shapes to allow a reduction of overall machine setup time. Several details for typical types of machines are given in Table 3.2.

#### Material handling equipment

Flexible-path material handling equipments including counterbalanced fork trucks, four-wheeled hand trucks, and pallet hand trucks are used in the fabrication section. The fork truck is used both for storage and for speedy heavy load transportation from one to another workplaces. The manual hand trucks ( Figure 3.9 ) are used for carrying materials along machines throughout the shop.

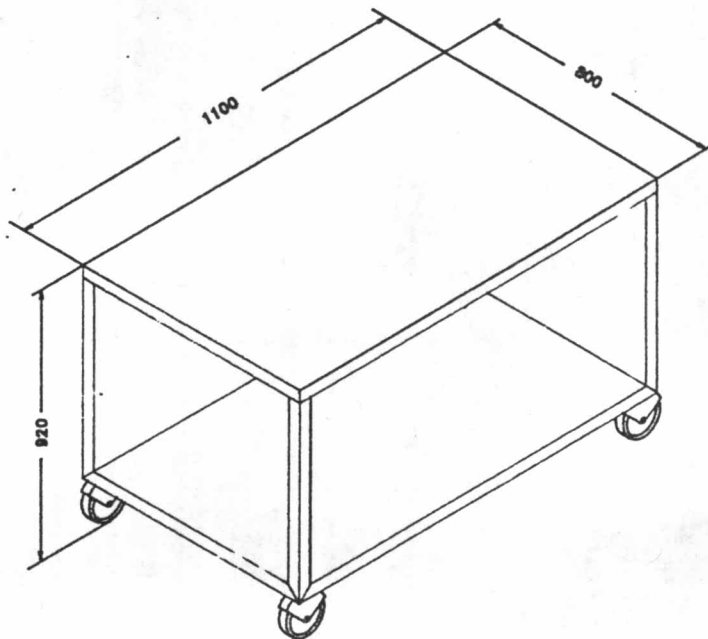


Figure 3.9. The manual four-wheeled hand truck.

S1 and S2 = Shearing M/C

N1 and N2 = Notching M/C

P-2, P-3, P-5, P-6, P-7, and P-8 = Manual Punch Press M/C

PEGA 357 = CNC Turret Punch Press M/C

B1, B2 and B4 = Manual Press Brake M/C

RG 50 = NC Press Brake M/C

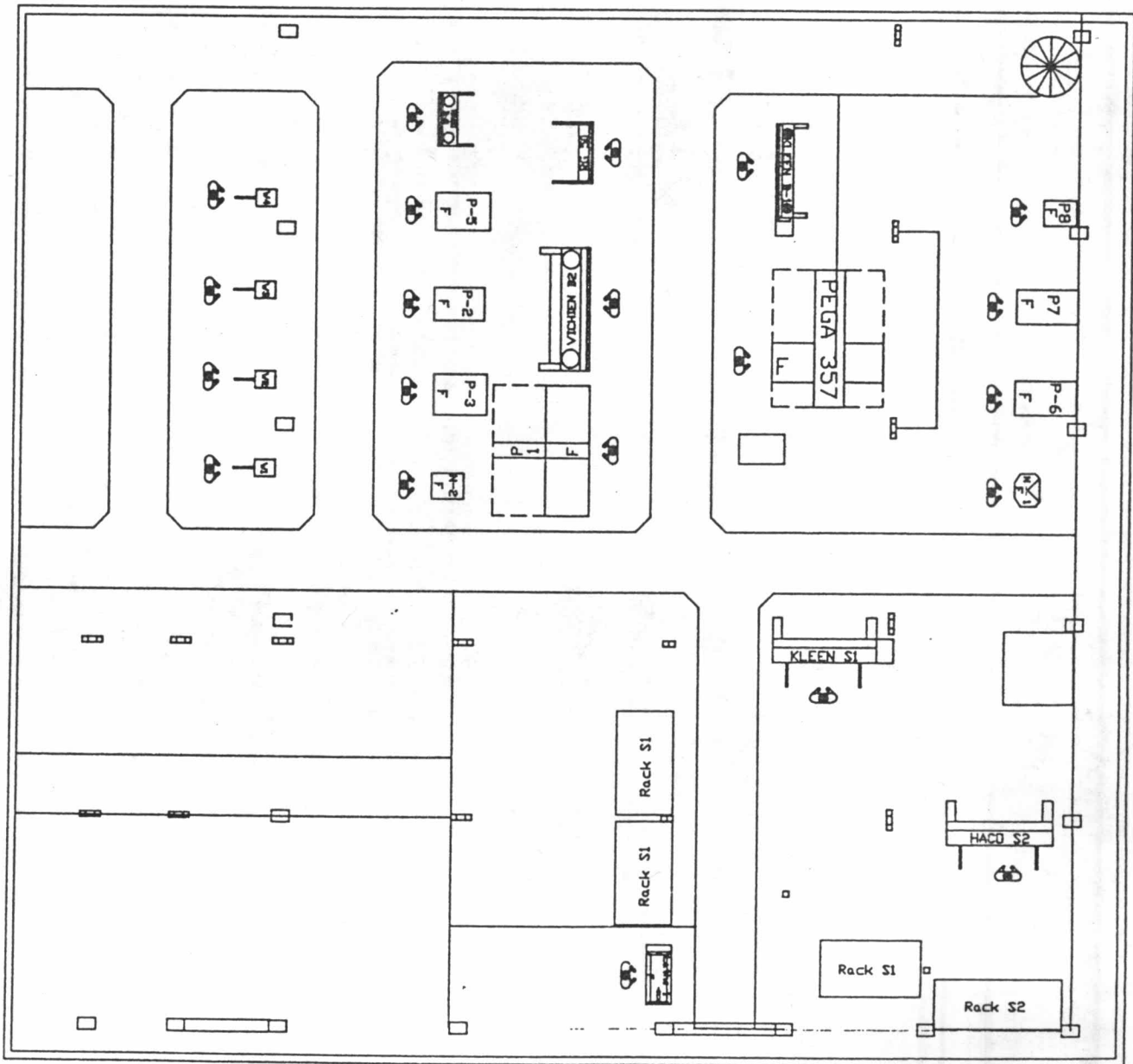


Figure 3.10. Present layout of fabrication section.

### Workplace layout

Fabrication sections of the studied plant are laidout by process as shown by Figure 3.10. The process layout has advantages such as : high utilization of equipment; work can be transferred to other similar machines whenever the machine breakdowns; and increased flexibility to accomodate changes in sequences; volume, or manufacturing times. Due to the random work flow, this creates disadvantages such as: more handling of materials; large volumes of work-in-process; and more complicated system of production control when compared to a product layout.

### Parts list

Large numbers of both make and buy components are required in an air-condition unit assembly. Examples of purchased parts are motors, compressors, fan blades, plastic components, screws, etc. Many sheet-metal components are made in the fabrication production section. However, some are made by sub-contractors. All components are collected in part lists and one example of part lists is given in Table 3.3.

The fabrication section produces a wide variety of different sheet-metal components. The shapes, sizes, and number of components per air-conditioner unit varies by product type and model.

An example of sheet-metal components of small split-type units is shown in Table 3.4.



Table 3.3. An example of part list.

No	Part Name	Commodity Code	Part No.	Qty Used
1	Motor 1/8 hp	B	38RT11828	1
2	Fan Blade	B	38RT11829	1
3	Sticker, Suction	B	51MSA550127	1
4	Sticker, Liquid	B	51MSA550128	1
5	Tag	B	99CT501172	1
6	Screw, Stainless Truss 5x16	Y	AL45JA217	4
7	Screw, Philip 8x3/8	Y	AL46AB165	4
8	Tape, Insulation	B	CGTIS	0.128real
9	Certificate, Unit Quality	B	CUQ	1
10	Washer, Flat	B	FWCM10	3
11	Strap, Nylon	B	GSN127	0.04 real
12	Clip Strap, Nylon	B	GSN127C	2
13	Tape Packing 2 inch.	B	GTP76	0.04 real
14	Nut, Hex 5/16	B	NCM516	4
15	Tape, Tranfer	B	PE0118	0.03 real
16	Tape, Tranfer	B	PE011825	0.03 real
17	Silver Rod 5X	B	SMRS25	1
18	Screw, Stainless Philip	Y	SSP4X10	10
19	Pan Base	A	51MSA520304	1
20	Channel Hat	A	51MSA520305	2
21	Angle Support	A	51MSA400100	1
22	Angle Support	A	51MSA400101	1
23	Orific	B	51MSA510207	1
24	Wrapper	B	51LCA550464	1
25	Partition	A	51MSA520301	1
26	Mounting Motor	A	51MSA520306	1
27	Condenser Coil	B	51MSA450600	1
28	Tube, Discharge	A	51MSA550602	1
29	Terminal Cover	B	51MSA550114	1
30	Plastic Bag 1230x720	B	51MSA520318	1
31	Sticker	B	51MSA400104	1
32	Insulation front	B	51MSA520313	1
33	Insulation Panel	B	51MSA520314	1
34	Insulation Partiton	B	51MSA520315	1
35	Sticker, Wiring Diagram	B	51MSA570800	1
36	Sticker, Insulation	B	51MSA400106	1
37	Sticker, Strip	B	51MSA520316	1
38	Sticker	B	51MSA520317	1
39	Insulation Manual	B	51MSA400103	1
40	Sticker, Warranty	B	51MSA400108	1
41	Rubber, Upper	B	51MSA560704	4
42	Rubber, Lower	B	51MSA560705	4
43	Spring	B	51MSA560706	1
44	Sticker	B	51MSA560603	1

No	Part Name	Commodity Code	Part No.	Qty Used
45	Panel Rear	B	51MSA520300	1
46	Support Valve	A	51LCA400102	1
47	Bolt 5/16x2.3/8	B	51MSA550340	3
48	Base Comp	A	51MSA520303	1
49	Carton	B	51MSA520310	1
50	Foam Packing	B	51MSA520311	2
51	Foam Packing	B	51MSA520312	1
52	Assy, Wiring Component	P	51MSA420304	1
53	Assy, Liquid Tube	P	51MSA450601	1
54	Assy, Suction Tube	P	51MSA450602	1
55	Panel RH	A	51MSA520322	1
56	PE. Tape 10x1500x3 mm.	B	51MSA400114	2
57	PE. Tape 0.3x1500x3 mm.	B	51MSA400115	0.25
58	Compressor, Assy	B	51MSA450603	1
59	PE. Foam 10x170x10 mm.	B	51MSA400114	1
60	Paper Support	B	51MSA520320	1
61	Sticker, Terminal	B	51MSA400118	1

Table 3.4. Example of Sheet-metal part list.

No	Part Name	Plate Type	Thick (mm)	W * L (mm)	Model			Qty
					018	036	060	
1.	Corner Post	HD	1.2	504.0* 48.0	x			2
2.	Corner Post	HD	1.2	707.2* 48.0		x	x	2
3.	Fan Motor Leg	HD	1.0	280.0* 80.8	x			3
4.	Fan Motor Leg	HD	1.0	478.0* 80.8		x	x	3
5.	Angle	HD	1.0	50.8* 42.1	x		x	1
6.	Cover Control	HD	1.0	315.4*142.7	x		x	1
7.	Motor Mounting	HD	1.0	495.1* 38.1	x	x	x	1
8.	Bracket Support	HD	1.6	78.0* 57.2	x		x	1
9.	Partition	HD	1.0	624.5*406.4	x			1
10.	Partition	HD	1.0	636.0*609.6		x	x	1
11.	Control Box	HD	1.0	360.7*360.7	x		x	1
12.	Control Box	HD	1.0	441.0*358.0		x		1
13.	Bracket Valve	EG	1.6	106.0* 52.5	x	x	x	1
14.	Support Coil	HD	1.0	70.0* 28.4		x		1
15.	Cover Box	HD	1.0	343.0*201.0		x		1

### Operation sequences

Because of the different component designs and random process routings, part production requires different lengths of operation sequence, resources and process times to manufacture the different types of components. However, most of components must pass through shearing (or cut to size), punching and bending operations.

As shown in Table 3.5, the components (of some models of fan-coil units) require different lengths of operation sequence, although

some components may have identical sequences with different resource requirements. The alternated process sequences with percentages are shown in Table 3.6.

Table 3.5. Operations sequences of sheet-metal components of fan coil unit for model 42 CA.

Part Name	Operation				
	Shear	Notch	Punch	Nip	Bend
Baffle Coil	x	x	x		x
Base Pan Ass'y	x	x	x		x
Coil Support	x		x		x
Condensate Tray	x	x	x		x
Cover Coil	x	x	x		x
Cover Coil Ass'y (a)	x	x	x		x
Cover Coil Ass'y (b)	x		x		
Fan Deck Ass'y	x	x	x	x	x
Fan Housing Ass'y	x	x	x		x
Inlet Ring	x		x		x
Motor Bracket	x	x	x		x

Table 3.6. Percentages of alternate process sequences.

Process sequence	Percent	Remarks
S N P B	47.37	S = Shear
S P B	32.46	N = Notch
S P	5.26	P = Punch
S B	3.51	Np = Nip
S N B	2.63	B = Bend
S P Np B	2.63	
S N P Np B	1.75	
S	1.75	
S N Np B	0.88	
S N P Np	0.88	
S N P	0.88	
	100.00	