

ENGR1110: Introduction to Industrial & Systems Engineering



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Lecture 6: Work Design, 2/19/02

Purpose of Work Measurement/Design

- To improve efficiency
 - work output / human effort
- This in turn improves productivity = output/input
- This in turn increases the profitability of an organization

Uses of Work Measurement/Design

- Determining equipment requirements
- Determining labor requirements
- Determining training methods
- Designing schedule procedures
- Designing Incentive systems
- Gauging work performance
- Estimating Costs

Recording and Analysis Tools

- Used to record the *present* manufacturing or service method
- Operations Process Charts
- Flow Process Charts
- Flow Diagrams
- Left-Hand-Right-Hand Charts
- Multiple Activity Charts

Operations Process Charts

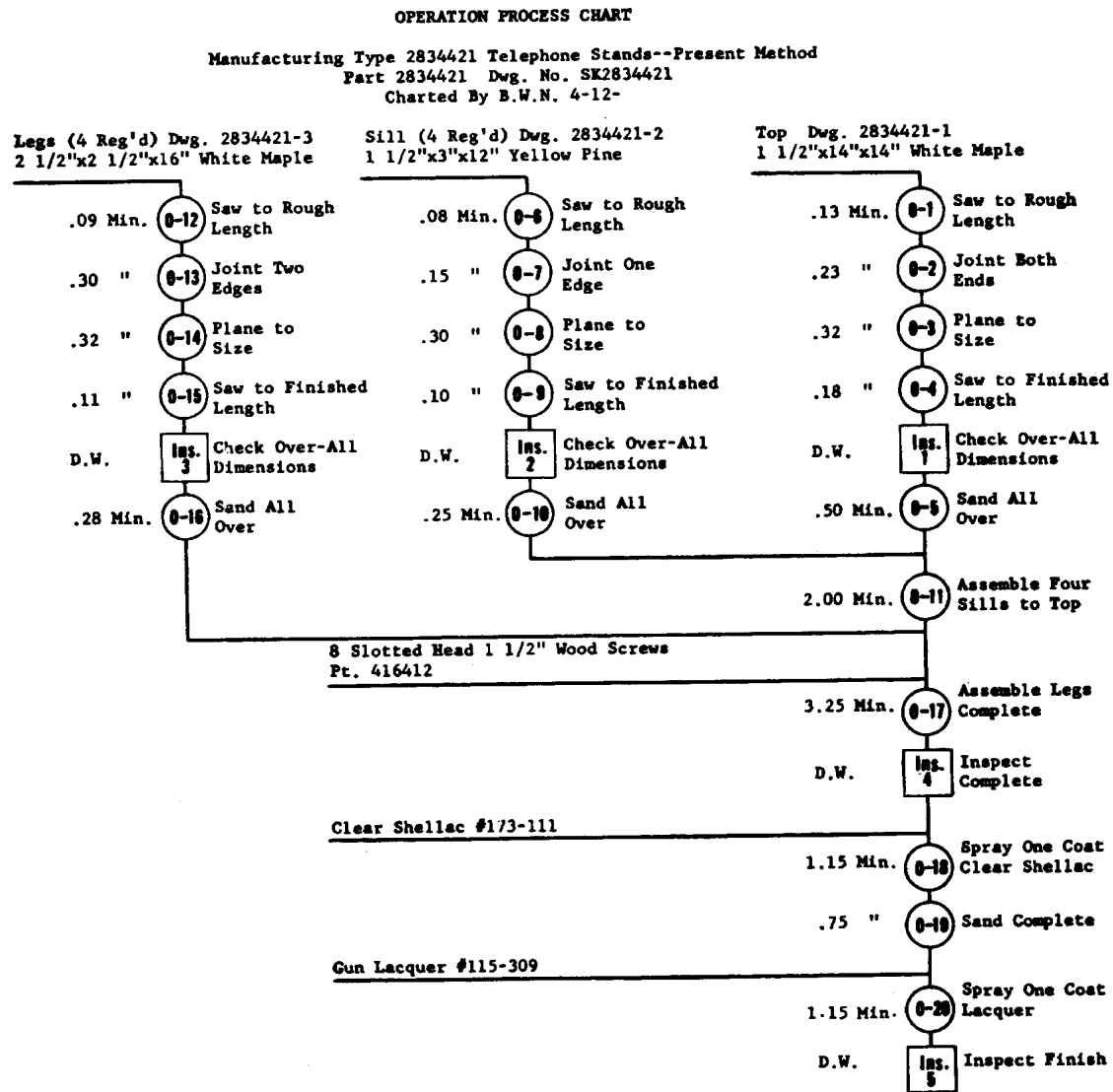
- Provides a chronological sequence of all activities and materials involved in the manufacture of a product or sub-assembly
- Depicts entrance and exit of all components and sub-assemblies of products
- Provides information on the number of employees and time required for inspections

Operations Process Chart



FIGURE 2-7

Operation process chart illustrating manufacture of telephone stands.



SUMMARY:

Event	Number	Time
Operations	20	17.58 minutes
Inspections	5	Day work

Flow Process Charts

- More detailed than the operations chart
- Used for closer observation of smaller components or assemblies
- Shows all moves (distances) and storage delays (times) for product/service movement

Flow Process Chart Symbols

FIGURE 2-8

The ASME standard set of process chart symbols.


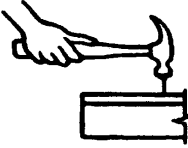


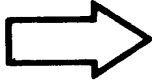




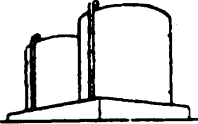
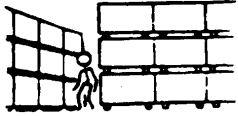
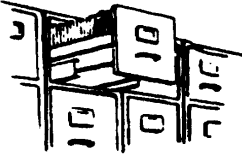



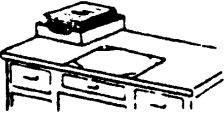




<p>OPERATION</p>  <p>A large circle indicates an operation, such as →</p>	 <p>Drive nail</p>	 <p>Mix</p>	 <p>Drill hole</p>
<p>TRANSPORTATION</p>  <p>An arrow indicates a transportation, such as →</p>	 <p>Move material by truck</p>	 <p>Move material by conveyor</p>	 <p>Move material by carrying (messenger)</p>
<p>STORAGE</p>  <p>A triangle indicates a storage, such as →</p>	 <p>Raw material in bulk storage</p>	 <p>Finished stock stacked on pallets</p>	 <p>Protective filing of documents</p>
<p>DELAY</p>  <p>A large capital D indicates a delay, such as →</p>	 <p>Wait for elevator</p>	 <p>Material in truck or on floor at bench waiting to be processed</p>	 <p>Papers waiting to be filed</p>
<p>INSPECTION</p>  <p>A square indicates an inspection, such as →</p>	 <p>Examine material for quality or quantity</p>	 <p>Read steam gauge on boiler</p>	 <p>Examine printed form for information</p>

FIGURE 2-11

Flow process chart (worker) for field inspection of LUX.

Flow Process Chart

Location: Dorben Co.		Summary			
Activity: Field Inspection of LUX		Event	Present	Proposed	Savings
Date: 4-17-97		Operation	7		
Operator: T.Smith	Analyst: R. Ruhf	Transport	6		
<i>Circle appropriate Method and Type:</i> Method: <u>(Present)</u> Proposed Type: <u>(Worker)</u> Material Machine		Delay	2		
		Inspection	6		
		Storage	0		
		Time (min)	32.60		
Remarks:		Distance (ft)	375		
		Cost			

Event Description	Symbol	Time (In Minutes)	Distance (In Feet)	Method Recommendation
Leave vehicle, walk to front door, ring bell.	○ → D □ ▽	1.00	75	Call home in advance to reduce waiting delays.
Wait, enter home.	○ → D □ ▽			
Walk to field reservoir.	○ → D □ ▽	.25	25	
Disconnect field reservoir from unit.	○ → D □ ▽	.35		
Inspect for dents, cracks in shroud, cracked glass or missing hardware.	○ → D □ ▽	1.25		This can be done while walking back to vehicle.
Clean unit with approved cleaner and disinfectant.	○ → D □ ▽	2.25		This can be done more effectively at vehicle.
Return to vehicle with empty tank.	○ → D □ ▽	1.00	75	
Unlock vehicle, place empty tank in fixture and connect hardware.	○ → D □ ▽	1.75		
Open valve; begin fill.	○ → D □ ▽	.25		
Wait for tank to fill.	○ → D □ ▽	12.00		Clean unit while being filled.
Check humidifier for proper function.	○ → D □ ▽	.5		Eliminate. No need to do this twice.
Check pressure (indicator).	○ → D □ ▽	.2		
Check reservoir contents (indicator).	○ → D □ ▽	.2		
Return to patient with filled tank.	○ → D □ ▽	1.10	100	
Hook up filled tank.	○ → D □ ▽	1.00		
Check humidifier for proper function.	○ → D □ ▽	.75		
Wait for patient to remove nasal cannula or face mask.	○ → D □ ▽	2.00		
Install new nasal cannula or face mask.	○ → D □ ▽	2.50		
Check flows with patient.	○ → D □ ▽	2.25		
Affix a dated, initialed inspection sticker.	○ → D □ ▽	1.00		Perform this while unit being filled.
Return to vehicle.	○ → D □ ▽	1.00	100	

Flow
Process
Chart →

Flow Diagrams

- A pictorial representation of plant/office layout
- Shows location of activities listed in the flow process chart
- Can help identify backtracking and possible traffic congestion areas

Flow Diagrams

Before: →
 $P = 500/\text{shift}$

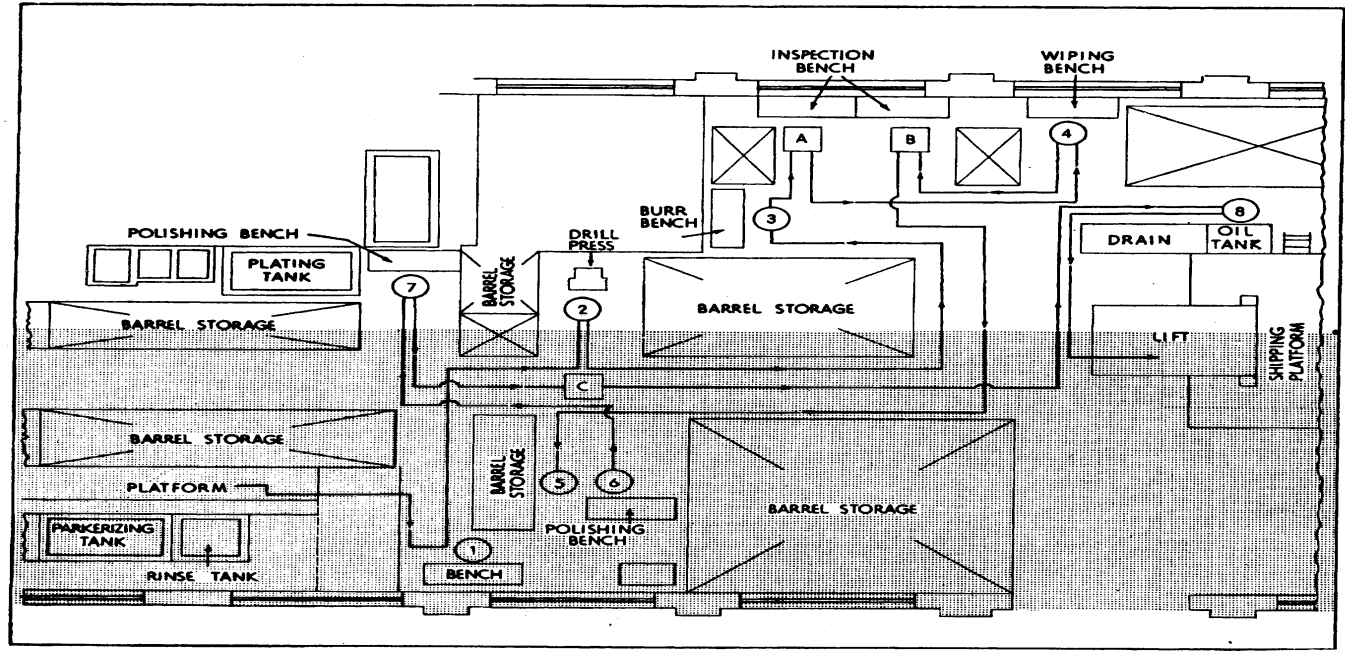
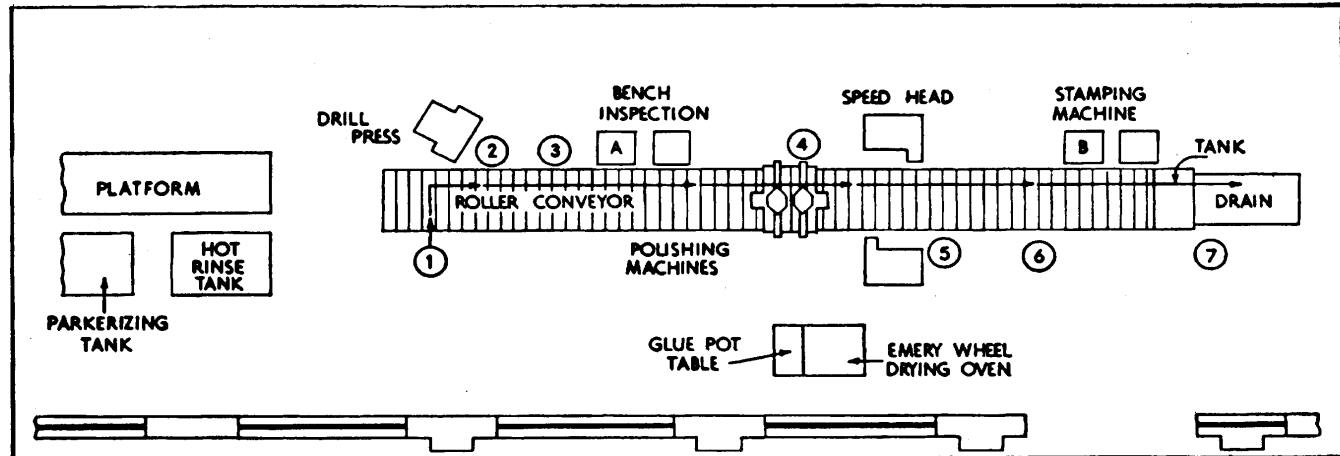


FIGURE 2-13

Flow diagram of the revised layout of a group of operations on the Garand rifle.

After: →
 $P = 3,600/\text{shift}$



Left-Hand-Right-Hand Charts

- Also known as a two-hand process chart
- More detailed than flow process chart
- Shows all movements and delays made by the left and right hands during the activities that make up an operation
- Used to evaluate one person at a specific station
- Used to identify effective and ineffective therbligs

Left-Hand Right-Hand Charts →

Effective Therbligs – Motions that directly advance the progress of work

Ineffective Therbligs – Motions that do not directly advance the progress of work

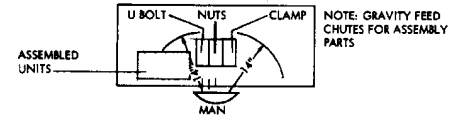
FIGURE 4-17

Two-hand process chart for assembly of cable clamps

Two-Hand Process Chart

Operation: Assemble Cable Clamps		Part: SK-112	Summary		Left Hand	Right Hand
Operator Name and No.: J.B. #1157			Effective Time:	2.9	12.2	
Analyst: G. Thuering		Date: 6-11-98	Ineffective Time:	11.4	2.1	
Method (circle choice): <u>Present</u> Proposed			Cycle Time =	14.30 sec.		

Sketch:



Left Hand Description	Sym- bol	Time	Time	Sym- bol	Right Hand Description
Get U-Bolt (10")	RE G	1.00	1.00	RE G	Get Cable Clamp (10")
Place U-Bolt (10")	M P RL	1.20	1.20	M P RL	Place Cable Clamp (10")
Hold U-Bolt	H	11.00	1.00	RE G	Get First Nut (9")
			1.20	M P	Place First Nut (9")
			3.40	U RL	Run Down First Nut
			1.00	RE G	Get Second Nut (9")
			1.20	M P	Place Second Nut (9")
			3.40	U RL	Run Down Second Nut
Dispose of Assembly	M RL	1.10	0.90	UD	Wait

Multiple Activity Charts

- Also known as Gang Process Charts
- Used when several workers operate a single machine or render a single service
- Used when a single worker is operating several machines
- Used to show the exact relationship between idle and operating times of both workers and machines

Multiple Activity Chart for Emergency Tracheotomy

	Nurse	First Doctor	Orderly	Second Doctor	Nurse Supervisor	Scrub Nurse
0	Detects Problem					
1	Alerts Doctor					
2						
3	Gets Cart	Makes Diagnosis				
4						
5	Notifies Nurse Sup	Assists Patient To Breath				
6						
7	Notifies Sec. Doc				Opens OR Calls Scrub Nurse	
8	Notifies Orderly			Makes sure Instruments Available		
9	Moves Patient to OR	Moves to OR	Moves Patient to OR			
10						Moves to OR & Sets up Equip.

Principles of Motion Economy

Concepts used to design efficient work methods

- **Elimination**- all possible steps, job irregularities, muscular force, fixed postures, idle time, danger
- **Combination**- replace short motions & sudden changes in direction with long continuous motions; Combine tools & controls
- **Rearrangement**-Distribute work evenly between hands; Use simultaneous & symmetrical patterns.
- **Simplification**- Use simplest combinations of motions; Reduce eye travel and number of fixations; Adapt handles, levers, pedals, buttons to users

Objective of Work Measurement

Determine time (Normal Time) it should take an average, trained person to perform a task over an 8-hour day at a normal pace (Normal Pace).

Actual Time - observed time required

Rating -relative score of performance

Allowances - time added to normal for personal needs, unavoidable delays, & fatigue (% of Normal Time)

Work Measurement Equations

Normal Time = Actual Time \times (Rating/100)

$$\mathbf{NT} = 35 \times (115/100) = 40.25$$

Standard Time - the time required for an average, fully qualified, trained operator, working at a normal pace and exerting average effort to perform the operation

Standard Time = NT \times (1 + Allowance)

$$\mathbf{ST} = 40.25 \times (1 + 0.12) = 45.08$$

Methods of Work Measurement

Direct Time Study

Time Study standard data

Predetermined time systems

Predetermined time systems standard data

Work Sampling

Time Study Equipment

Minimum Equipment:

Stopwatch.

Time study board.

Time study forms.

Calculator.

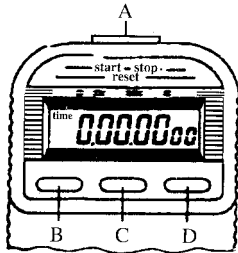
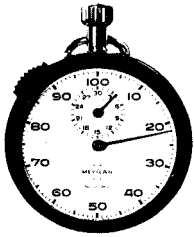
Writing instruments.

Additional Equipment:

Data Loggers

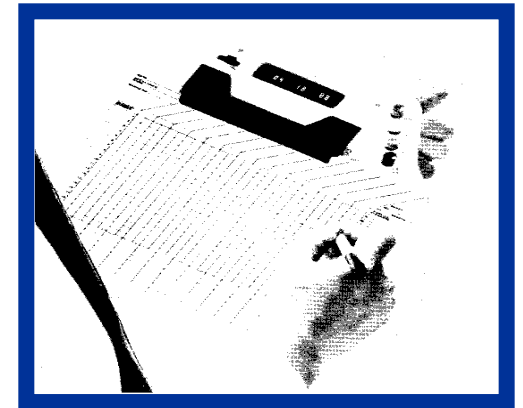
Video Tape

Time Study Equipment



- **Stopwatches**

Study Boards -



- **Data Loggers**

Time Study Form

•W = Watch Time.

•OT = Observed Time.

•R = Ratings.

•NT = Normal Time.

•ST = Standard Time

Time Study Observation Form

Study No.: 2-85 Date: 3-1 Page 1 of 1
 Operation: DIE CASTING Operator: B. JONES Observer: AF

Element No. and Description	1 REMOVE PART FROM DIE, LUBRICATE DIE, INSPECT				2 PLACE PART IN FIXTURE, TRIM ASIDE PART															
	Note	Cycle	R	W	OT	NT	R	W	OT	NT	R	W	OT	NT	R	W	OT	NT		
		1	90	90	30	270	90	113	23	207										
		2	100	40	27	270	100	61	21	210										
		3	90	92	31	279	90	25	23	207										
		4	85	50	35	298	100	70	20	200										
		5	100	98	28	280	100	38	20	200										
		6	110	43	25	275	110	61	18	188										
		7	90	92	31	279	90	46	24	216										
		8	100	44	28	280	85	68	24	204										
		9	90	500	32	288	90	23	23	207										
		10	110	49	26	286	105	68	19	200										
		11																		
		12																		
		13																		
		14																		
		15																		
		16																		
		17																		
		18																		

Summary									
Total OT	2.93	2.15							
Rating	-	-							
Total NT	2.805	2.049							
No. Observations	10	10							
Average NT	.281	.205							
% Allowance	17	17							
Elemental Std. Time	.329	.205							
No. Occurrences	1	1							
Standard Time	.329	.205							
Total Standard Time (sum standard time for all elements):									.569

Foreign Elements				Time Check			Allowance Summary	
Sym	W1	W2	OT	Description	Finishing Time	3:48.00	Personal Needs	5
A					Starting Time	3:42.00	Basic Fatigue	4
B					Elapsed Time	6.00	Variable Fatigue	8
C					TEBS	.66	Special	-
D					TEAF	.32	Total Allowance %	17
E					Total Check Time	.92	Remarks:	
F					Effective Time	5.08		
G					Ineffective Time	0		
Rating Check					Total Recorded Time	6.00		
Synthetic Time					% Unaccounted Time	0		
Observed Time					Recording Error %	0		