

Labor Planning for a Manufacturing Line

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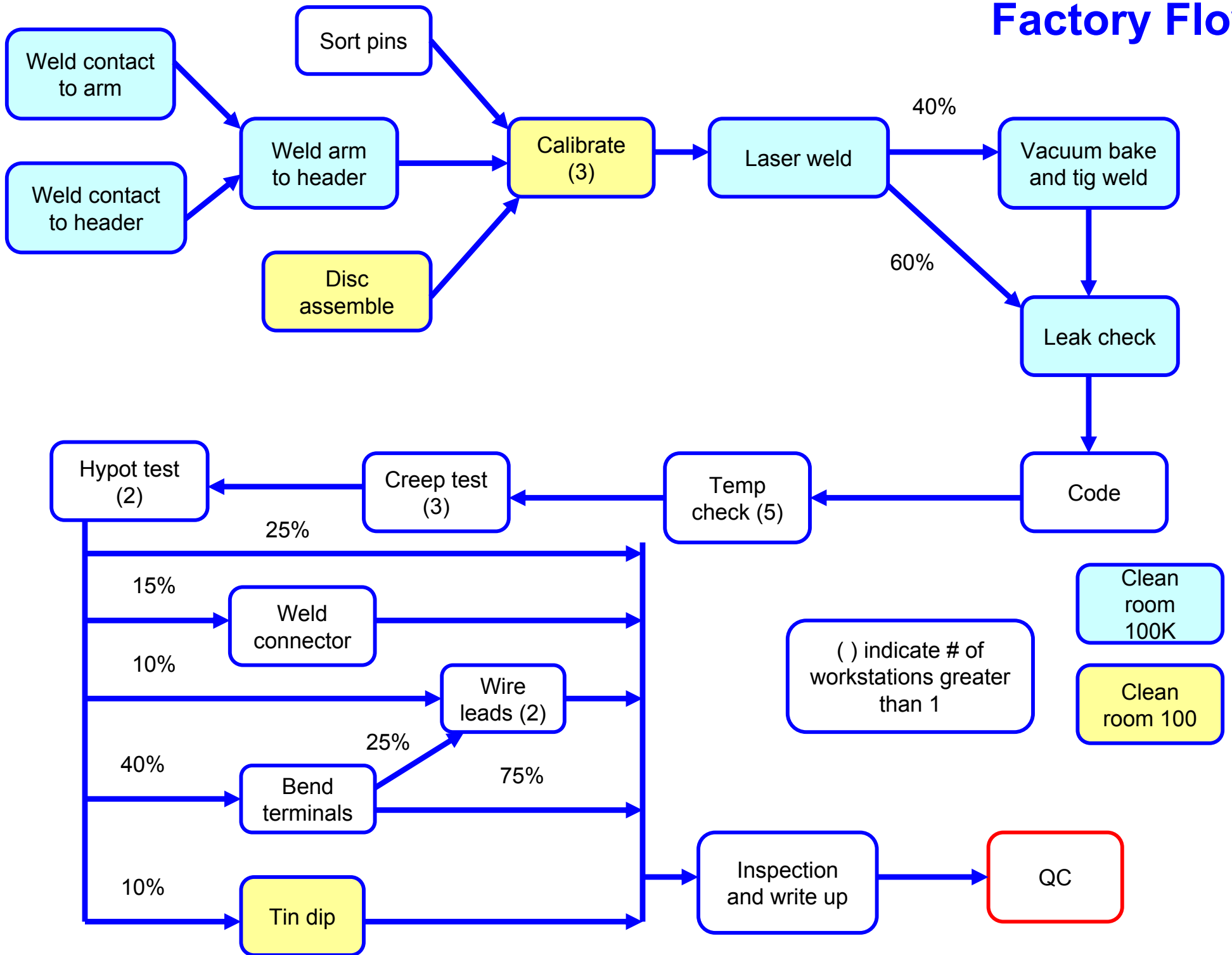
Agenda

- **Introduction**
- **Formulation of LP Model**
- **Use and Demonstration of LP Model**
- **LP Model Limitations**

TI Precision Thermostat Styles

(Images of six Klixon Precision Thermostats)

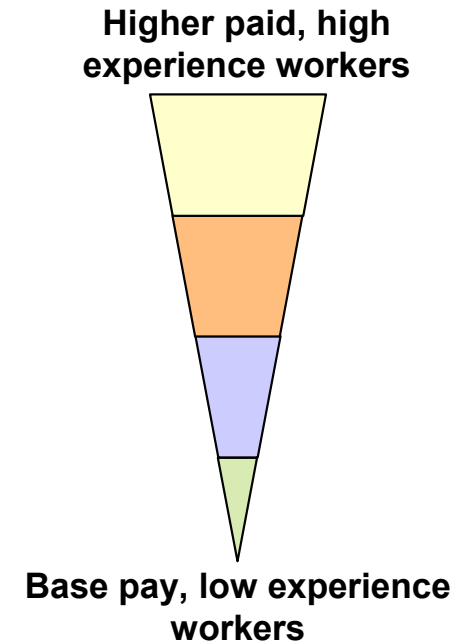
Factory Flow



Line History & Need For Model

Line History

- *Line in existence since 1960's*
- *Wide range of skill leads to complex staffing pay (pay code, shift differential, clean room pay)*
- *Some operators employed on line since 1960's!!
Consequently current work force is well cross trained but 'top heavy' and may not be ideal*



Current Need Model Addresses

- *Opportunities exist to manage and minimize labor cost on the production line given varying demand*

Description of the LP Model

Decision Variables

*Work Hours For Each
Pay Code and Operation*

of Shifts

	1st Shift				
Operation	1.1	2.1	3.1	4.1	5.1
Sort Pins	7.73	0.00	0.00	0.00	0.00
Weld contact to Header		8.00	0.00	0.00	0.00
Weld contact to Arm		8.00	0.00	0.00	0.00
Weld Arm to Header		8.00	0.00	0.00	0.00
Disc Assemble	5.37	0.00	0.00	0.00	0.00
Calibrate					24.00
Laser Weld			8.00	0.00	0.00
Vacuum bake/tig weld		8.00	0.00	0.00	0.00
Leak check		8.00	0.00	0.00	0.00
Code		16.00	0.00	0.00	0.00
Temp Test			40.00	0.00	0.00
Creep Test	21.46	0.00	0.00	0.00	0.00
Hypot Test	16.00	0.00	0.00	0.00	0.00
Bend Terminals	8.00	0.00	0.00	0.00	0.00
Weld Wire Leads		3.22	0.00	0.00	0.00
Tin Dip			6.44	0.00	0.00
Weld Connector		8.00	0.00	0.00	0.00
Inspection/ Writeup				0.00	54.39
	Shift 1	Shift 2	Shift 3		
	1	1	1		

Description of the LP Model

Constants/Inputs

- *Number of days per month*
- *Demand*
- *Fraction*
- *Current work force*
- *Number of work stations*
- *Max capacity per hour per operation*
- *Second and third shift fixed cost*

OPERATION	F(fraction)	A(#of stations)	Units/hr
Sort Pins	1	5	500
Weld contact to Header	1	1	180
Weld contact to Arm	1	1	180
Weld Arm to Header	1	1	180
Disc Assemble	1	1	720
Calibrate	1	3	120
Laser Weld	1	1	180
Vacuum bake/tig weld	0.4	1	60
Leak check	1	1	300
Code	1	2	120
Temp Test	1	5	60
Creep Test	1	3	180
Hypot Test	1	2	180
Bend Terminals	0.4	1	180
Weld Wire Leads	0.1	2	120
Tin Dip	0.1	1	60
Weld Connector	0.15	1	60
Inspection/ Writeup	1	5	60

Description of the LP Model

Constraints

- *Labor demand per day*
- *Machine capacity per shift*
- *Number of workers for each shift*
- *Work hours by each grade vs. the available number of work hours at each grade level*
- *Non-negativity constraints for decision variables*

Objective Function

To minimize the overall daily staffing cost of production. The cost is calculated by adding up the cost of labor on each operation per shift.

Our Integer Model Foray

- **Disadvantage of LP Model:**

Fractional work hours (not standard 8 hr employee shift)

- **Modification of LP Model to create an Integer Model:**

Number of workers added as decision variables and they were forced to be integers

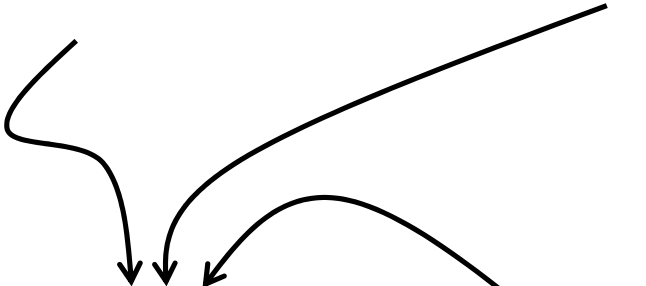
- **Disadvantage of the Integer Model:**

When demand increased (beyond 1-shift) model ran for too long without producing an optimal solution

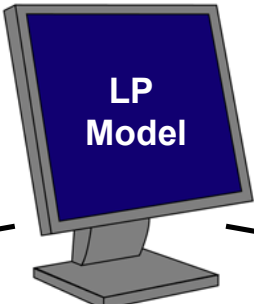
Supervisor Inputs

Monthly Demand

Current Workforce



of Work Days In Month



Model Outputs

- Paycode Specific Staffing Hours:*** by-shift hours/location required by each paycode
- Operation Specific Staffing Hours:*** by-shift total hours of each shift on each individual operation.
- Overall Paycode Staffing Hours:*** total staffing hours for each paycode
- Overall Shift Staffing Hours:*** total staffing hours on each shift used by management & facilities to gauge level of operation for each shift.
- Daily and Monthly Staffing Costs:*** lowest cost per day/month for staffing given current factory constraints.

Factory Manager Input/Output Interface

Entered Data		Inputs			
# Of Work Days In Month	22				
Monthly Demand	45000				
Existing Workforce					
	Paycode 1	Paycode 2	Paycode 3	Paycode 4	Paycode 5
Head Count	0	0	5	5	7

Decision Variables

Daily Paycode Specific Staffing Hours																
Operation	Avail Hours/Shift	1st Shift Staffing					2nd Shift Staffing					3rd Shift Staffing				
		Paycode 1	Paycode 2	Paycode 3	Paycode 4	Paycode 5	Paycode 1	Paycode 2	Paycode 3	Paycode 4	Paycode 5	Paycode 1	Paycode 2	Paycode 3	Paycode 4	Paycode 5
Sort Pins	40	4.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Weld contact to Header	8		0.00	0.00	0.00	8.00		0.41	0.00	0.00	2.95		0.00	0.00	0.00	0.00
Weld contact to Arm	8		8.00	0.00	0.00	0.00		3.36	0.00	0.00	0.00		0.00	0.00	0.00	0.00
Weld Arm to Header	8		0.00	0.00	0.00	8.00		3.36	0.00	0.00	0.00		0.00	0.00	0.00	0.00
Disc Assemble	8	2.84	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Calibrate	24					17.45					16.64					0.00
Laser Weld	7			0.00	4.05	2.95			2.50	1.86	0.00			0.00	0.00	0.00
Vacuum bake/tig weld	8		8.00	0.00	0.00	0.00		5.64	0.00	0.00	0.00		0.00	0.00	0.00	0.00
Leak check	8		6.82	0.00	0.00	0.00		0.00	0.00	0.00	0.00		0.00	0.00	0.00	0.00
Code	16		16.00	0.00	0.00	0.00		1.05	0.00	0.00	0.00		0.00	0.00	0.00	0.00
Temp Test	40			34.09	0.00	0.00				0.00	0.00			0.00	0.00	0.00
Creep Test	24	11.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Hypot Test	16	11.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Bend Terminals	8	4.55	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Weld Wire Leads	16		6.82	0.00	0.00	0.00		0.00	0.00	0.00	0.00		0.00	0.00	0.00	0.00
Tin Dip	8			3.41	0.00	0.00			0.00	0.00	0.00			0.00	0.00	0.00
Weld Connector	8		8.00	0.00	0.00	0.00		2.23	0.00	0.00	0.00		0.00	0.00	0.00	0.00
Inspection/ Writeup	40				34.09	0.00				0.00	0.00				0.00	0.00
Totals Per Day		34.20	53.64	37.50	38.14	36.41	0.00	16.05	2.50	1.86	19.59	0.00	0.00	0.00	0.00	0.00

Daily Operation Specific Staffing Hours				
Operation	Avail Hours/Shift	Shift 1	Shift 2	Shift 3
Sort Pins	40	4.09	0.00	0.00
Weld contact to Header	8	8.00	3.36	0.00
Weld contact to Arm	8	8.00	3.36	0.00
Weld Arm to Header	8	8.00	3.36	0.00
Disc Assemble	8	2.84	0.00	0.00
Calibrate	24	17.45	16.64	0.00
Laser Weld	7	7.00	4.36	0.00
Vacuum bake/tig weld	8	8.00	5.64	0.00
Leak check	8	6.82	0.00	0.00
Code	16	16.00	1.05	0.00
Temp Test	40	34.09	0.00	0.00
Creep Test	24	11.36	0.00	0.00
Hypot Test	16	11.36	0.00	0.00
Bend Terminals	8	4.55	0.00	0.00
Weld Wire Leads	16	6.82	0.00	0.00
Tin Dip	8	3.41	0.00	0.00
Weld Connector	8	8.00	2.23	0.00
Inspection/ Writeup	40	34.09	0.00	0.00

Outputs

Staffing Cost	
Daily	\$3,589
Monthly	\$78,968

Daily Shift Staffing Hours		
Shift 1	Shift 2	Shift 3
199.89	40.00	0.00

Daily Overall Paycode Staffing Hours				
Paycode 1	Paycode 2	Paycode 3	Paycode 4	Paycode 5
34.20	69.68	40.00	40.00	56.00



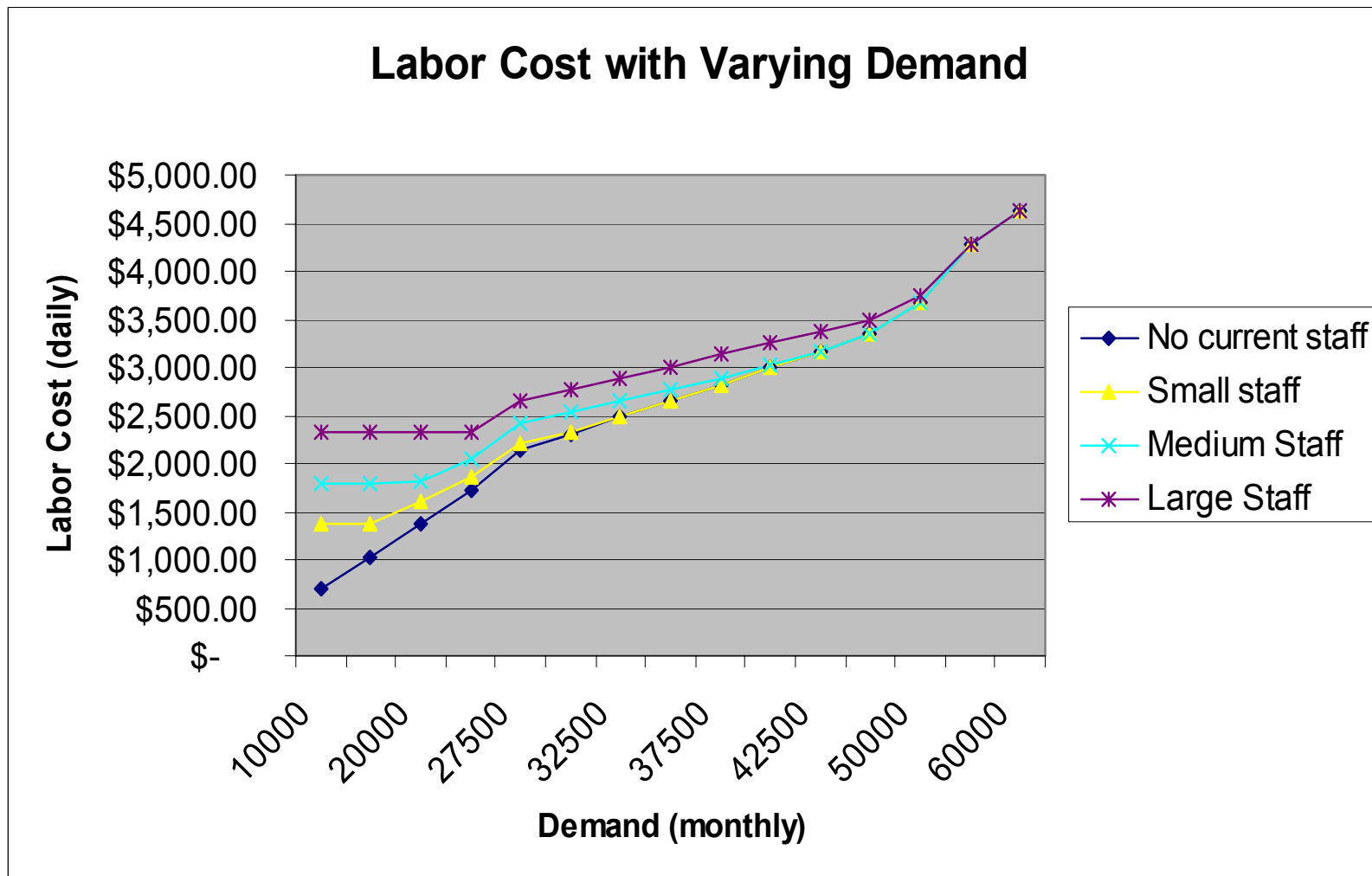
Denotes No Work Required Given Current Demand

Denotes Paycode Does Not Having Training To Complete Operation

Strategic Uses

Determining a “Target” Workforce

- *How many permanent staff in the face of varying demand*
- *Cost of holding too many workers vs. cost of hiring*



Strategic Uses

Understanding the Bottleneck

- *The machine that is most constrained causes more shifts*
- *New capital investment vs. working another shift*

Daily Operation Specific Staffing Hours				
Operation	Avail Hours/Shift	Shift 1	Shift 2	Shift 3
Sort Pins	40	5.45	0.00	0.00
Weld contact to Header	8	8.00	7.15	0.00
Weld contact to Arm	8	8.00	7.15	0.00
Weld Arm to Header	8	8.00	7.15	0.00
Disc Assemble	8	3.79	0.00	0.00
Calibrate	24	24.00	21.45	0.00
Laser Weld	7	7.00	7.00	1.15
Vacuum bake/tig weld	8	8.00	8.00	2.18
Leak check	8	8.00	1.09	0.00
Code	16	16.00	6.73	0.00
Temp Test	40	40.00	5.45	0.00
Creep Test	24	15.15	0.00	0.00
Hypot Test	16	15.15	0.00	0.00
Bend Terminals	8	6.06	0.00	0.00
Weld Wire Leads	16	9.09	0.00	0.00
Tin Dip	8	4.55	0.00	0.00
Weld Connector	8	8.00	5.64	0.00
Inspection/ Writeup	40	40.00	5.45	0.00

Model Limitations

- **Idealized plant view**
 - *No variation in machine rates*
 - *No defects*
 - *No machine downtime*
- **Idealized worker view**
 - No vacations, breaks, or sick time
 - Assumed all workers work at same rate
 - Forecasts hours not complete 8 hr shifts
- **Limited staff planning tool**
 - *Not a per-worker scheduling tool*
 - *Does not address soft-concerns*

Conclusions

- **Useful part of the “toolkit” for a manager**
- **Interpretation of the results is required**
- **LP models can get complex really fast**

Questions????