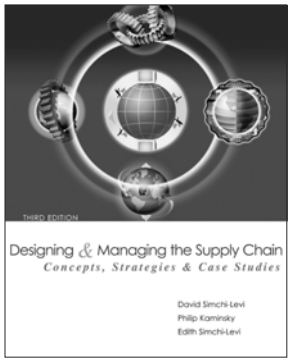


Chapter 4

Supply Contracts

4.1 Introduction

- Significant level of outsourcing
- Many leading brand OEMs outsource complete manufacturing and design of their products
- More outsourcing has meant
  - Search for lower cost manufacturers
  - Development of design and manufacturing expertise by suppliers
- Procurement function in OEMs becomes very important
- OEMs have to get into contracts with suppliers
  - For both strategic and non-strategic components

4.2 Strategic Components

Supply Contract can include the following:

- Pricing and volume discounts.
- Minimum and maximum purchase quantities.
- Delivery lead times.
- Product or material quality.
- Product return policies.

2-Stage Sequential Supply Chain

- A buyer and a supplier.
- Buyer's activities:
  - generating a forecast
  - determining how many units to order from the supplier
  - placing an order to the supplier so as to optimize his own profit
  - Purchase based on forecast of customer demand
- Supplier's activities:
  - reacting to the order placed by the buyer.
  - Make-To-Order (MTO) policy

Swimsuit Example

- 2 Stages:
  - a retailer who faces customer demand
  - a manufacturer who produces and sells swimsuits to the retailer.
- Retailer Information:
  - Summer season sale price of a swimsuit is $125 per unit.
  - Wholesale price paid by retailer to manufacturer is $80 per unit.
  - Salvage value after the summer season is $20 per unit
- Manufacturer information:
  - Fixed production cost is $100,000
  - Variable production cost is $35 per unit

What Is the Optimal Order Quantity?

- Retailer marginal profit is the same as the marginal profit of the manufacturer, $45.
- Retailer's marginal profit for selling a unit during the season, $45, is smaller than the marginal loss, $60, associated with each unit sold at the end of the season to discount stores.
- Optimal order quantity depends on marginal profit and marginal loss but not on the fixed cost.
- Retailer optimal policy is to order 12,000 units for an average profit of $470,700.
- If the retailer places this order, the manufacturer's profit is 12,000(80 - 35) - 100,000 = $440,000

Sequential Supply Chain

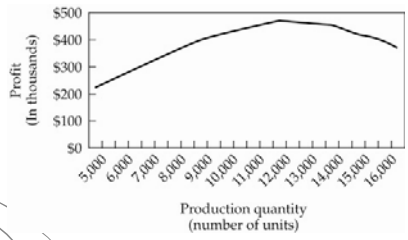


FIGURE 4-1: **Optimized safety stock**

Risk Sharing

- In the sequential supply chain:
  - Buyer assumes all of the risk of having more inventory than sales
  - Buyer limits his order quantity because of the huge financial risk.
  - Supplier takes no risk.
  - Supplier would like the buyer to order as much as possible
  - **Since the buyer limits his order quantity, there is a significant increase in the likelihood of out of stock.**
- If the supplier shares some of the risk with the buyer
  - it may be profitable for buyer to order more
  - reducing out of stock probability
  - increasing profit for both the supplier and the buyer.
- Supply contracts enable this risk sharing

Buy-Back Contract

- Seller agrees to buy back unsold goods from the buyer for some agreed-upon price.
- Buyer has incentive to order more
- Supplier's risk clearly increases.
- Increase in buyer's order quantity
  - Decreases the likelihood of out of stock
  - Compensates the supplier for the higher risk

Buy-Back Contract Swimsuit Example

- Assume the manufacturer offers to buy unsold swimsuits from the retailer for $55.
- Retailer has an incentive to increase its order quantity to 14,000 units, for a profit of $513,800, while the manufacturer's average profit increases to $471,900.
- Total average profit for the two parties
  = $985,700 (= $513,800 + $471,900)
- Compare to sequential supply chain when total profit = $910,700 (= $470,700 + $440,000)

Buy-Back Contract Swimsuit Example

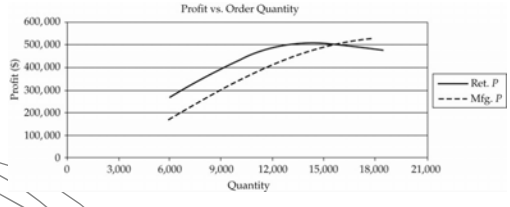


FIGURE 4-2: **Buy-back contract**

Revenue Sharing Contract

- Buyer shares some of its revenue with the supplier
  - in return for a discount on the wholesale price.
- Buyer transfers a portion of the revenue from each unit sold back to the supplier

Revenue Sharing Contract Swimsuit Example

- Manufacturer agrees to decrease the wholesale price from $80 to $60
- In return, the retailer provides 15 percent of the product revenue to the manufacturer.
- Retailer has an incentive to increase his order quantity to 14,000 for a profit of $504,325
- This order increase leads to increased manufacturer's profit of $481,375
- Supply chain total profit
  = $985,700 (= $504,325+$481,375).

Revenue Sharing Contract Swimsuit Example

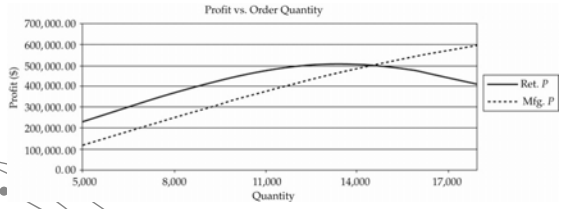


FIGURE 4-3: **Revenue-sharing contract**

Other Types of Contracts

- **Quantity-Flexibility Contracts**
  - Supplier provides full refund for returned (unsold) items
  - As long as the number of returns is no larger than a certain quantity.
- **Sales Rebate Contracts**
  - Provides a direct incentive to the retailer to increase sales by means of a rebate paid by the supplier for any item sold above a certain quantity.

Global Optimization Strategy

- What is the best strategy for the entire supply chain?
- Treat both supplier and retailer as one entity
- Transfer of money between the parties is ignored

Global Optimization Swimsuit Example

- Relevant data
  - Selling price, $125
  - Salvage value, $20
  - Variable production costs, $35
  - Fixed production cost.
- Supply chain marginal profit, 90 = 125 - 35
- Supply chain marginal loss, 15 = 35 – 20
- Supply chain will produce more than average demand.
- Optimal production quantity = 16,000 units
- Expected supply chain profit = $1,014,500.

Global Optimization Swimsuit Example

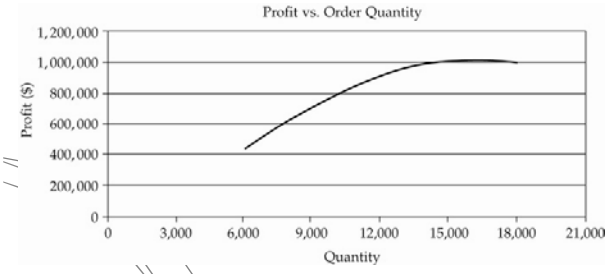


FIGURE 4-4: Profit using global optimization strategy

Global Optimization and Supply Contracts

- Unbiased decision maker unrealistic
  - Requires the firm to surrender decision-making power to an unbiased decision maker
- Carefully designed supply contracts can achieve as much as global optimization
- Global optimization does not provide a mechanism to allocate supply chain profit between the partners.
  - Supply contracts allocate this profit among supply chain members.
- Effective supply contracts allocate profit to each partner in a way that no partner can improve his profit by deciding to deviate from the optimal set of decisions.

Implementation Drawbacks of Supply Contracts

- **Buy-back contracts**
  - Require suppliers to have an effective reverse logistics system and may increase logistics costs.
  - Retailers have an incentive to push the products not under the buy back contract.
    - Retailer's risk is much higher for the products not under the buy back contract.
- **Revenue sharing contracts**
  - Require suppliers to monitor the buyer's revenue and thus increases administrative cost.
  - Buyers have an incentive to push competing products with higher profit margins.
    - Similar products from competing suppliers with whom the buyer has no revenue sharing agreement.

4.3 Contracts for Make-to-Stock/Make-to-Order Supply Chains

- Previous contracts examples were with Make-to-Order supply chains
- What happens when the supplier has a Make-to-Stock situation?

Supply Chain for Fashion Products Ski-Jackets

Manufacturer produces ski-jackets prior to receiving distributor orders

- Season starts in September and ends by December.
- Production starts 12 months before the selling season
- Distributor places orders with the manufacturer six months later.
- At that time, production is complete; distributor receives firms orders from retailers.
- The distributor sales ski-jackets to retailers for $125 per unit.
- The distributor pays the manufacturer $80 per unit.
- For the manufacturer, we have the following information:
  - Fixed production cost = $100,000.
  - The variable production cost per unit = $55
  - Salvage value for any ski-jacket not purchased by the distributors= $20.

Profit and Loss

- For the manufacturer
  - Marginal profit = $25
  - Marginal loss = $60.
  - Since marginal loss is greater than marginal profit, the distributor should produce less than average demand, i.e., less than 13, 000 units.
- How much should the manufacturer produce?
  - Manufacturer optimal policy = 12,000 units
  - Average profit = $160,400.
  - Distributor average profit = $510,300.
- Manufacturer assumes all the risk limiting its production quantity
- Distributor takes no risk

Make-to-Stock Ski Jackets

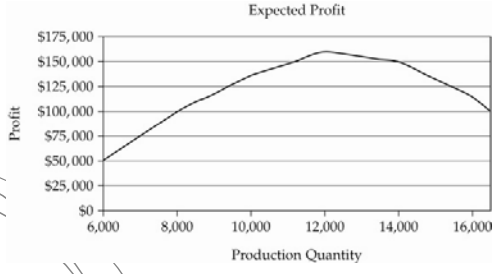


FIGURE 4-5: **Manufacturer's expected profit**

Pay-Back Contract

- Buyer agrees to pay some agreed-upon price for any unit produced by the manufacturer but not purchased.
- Manufacturer incentive to produce more units
- Buyer's risk clearly increases.
- Increase in production quantities has to compensate the distributor for the increase in risk.

Pay-Back Contract
Ski Jacket Example

- Assume the distributor offers to pay $18 for each unit produced by the manufacturer but not purchased.
- Manufacturer marginal loss = 55-20-18=$17
- Manufacturer marginal profit = $25.
- Manufacturer has an incentive to produce more than average demand.
- Manufacturer increases production quantity to 14,000 units
- Manufacturer profit = $180,280
- Distributor profit increases to $525,420.
  - Total profit = $705,400
- Compare to total profit in sequential supply chain = $670,000 (= $160,400 + $510,300)

Pay-Back Contract
Ski Jacket Example

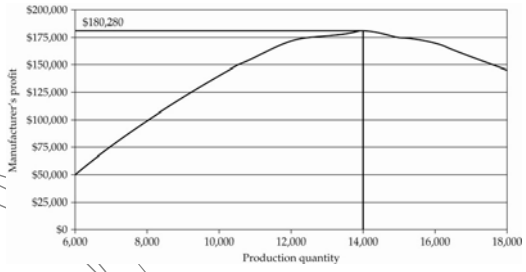


FIGURE 4-6: **Manufacturer's average profit (pay-back contract)**

Pay-Back Contract
Ski Jacket Example (cont)

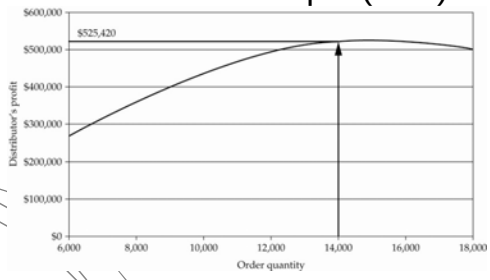


FIGURE 4-7: **Distributor's average profit (pay-back contract)**

Cost-Sharing Contract

- Buyer shares some of the production cost with the manufacturer, in return for a discount on the wholesale price.
- Reduces effective production cost for the manufacturer
  - Incentive to produce more units

Cost-Sharing Contract
Ski-Jacket Example

- Manufacturer agrees to decrease the wholesale price from $80 to $62
- In return, distributor pays 33% of the manufacturer production cost
- Manufacturer increases production quantity to 14,000
- Manufacturer profit = $182,380
- Distributor profit = $523,320
- The supply chain total profit = $705,700
  Same as the profit under pay-back contracts

Cost-Sharing Contract Ski-Jacket Example

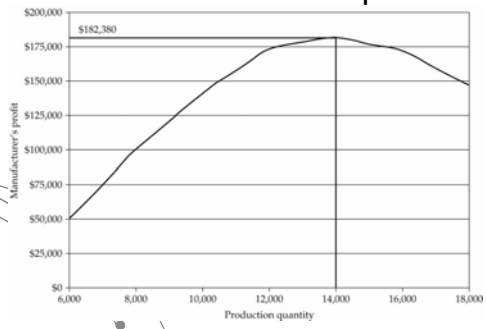


FIGURE 4-8: **Manufacturer's average profit (cost-sharing contract)**

Cost-Sharing Contract Ski-Jacket Example (cont)

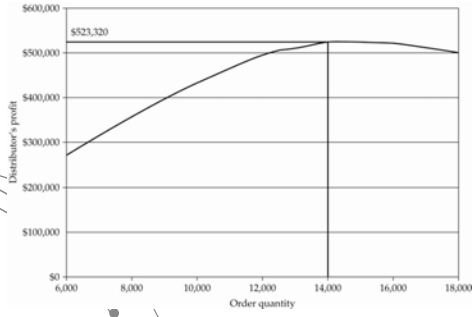


FIGURE 4-9: **Distributor's average profit (cost-sharing contract)**

Implementation Issues

- Cost-sharing contract requires manufacturer to share production cost information with distributor
- Agreement between the two parties:
  - Distributor purchases one or more components that the manufacturer needs.
  - Components remain on the distributor books but are shipped to the manufacturer facility for the production of the finished good.

Global Optimization

- Relevant data:
  - Selling price, $125
  - Salvage value, $20
  - Variable production costs, $55
  - Fixed production cost.
- Cost that the distributor pays the manufacturer is meaningless
- Supply chain marginal profit, 70 = 125 – 55
- Supply chain marginal loss, 35 = 55 – 20
  - Supply chain will produce more than average demand.
- Optimal production quantity = 14,000 units
- Expected supply chain profit = $705,700

Same profit as under pay-back and cost sharing contracts

Global Optimization

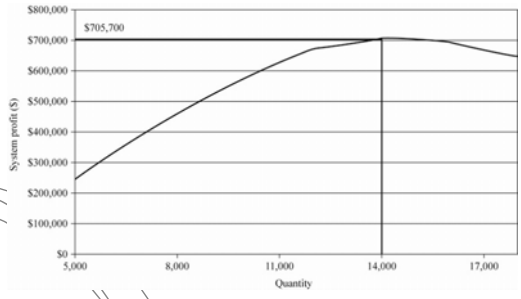


FIGURE 4-10: **Global optimization**

4.4 Contracts with Asymmetric Information

- Implicit assumption so far: Buyer and supplier share the same forecast
- Inflated forecasts from buyers a reality
- How to design contracts such that the information shared is credible?

Two Possible Contracts

- Capacity Reservation Contract
  - Buyer pays to reserve a certain level of capacity at the supplier
  - A menu of prices for different capacity reservations provided by supplier
  - Buyer signals true forecast by reserving a specific capacity level
- Advance Purchase Contract
  - Supplier charges special price before building capacity
  - When demand is realized, price charged is different
  - Buyer's commitment to paying the special price reveals the buyer's true forecast

4-37

4.5 Contracts for Non-Strategic Components

- Variety of suppliers
- Market conditions dictate price
- Buyers need to be able to choose suppliers and change them as needed
- Long-term contracts have been the tradition
- Recent trend towards more flexible contracts
  - Offers buyers option of buying later at a different price than current
  - Offers effective hedging strategies against shortages

4-38

Long-Term Contracts

- Also called *forward or fixed commitment contracts*
- Contracts specify a fixed amount of supply to be delivered at some point in the future
- Supplier and buyer agree on both price and quantity
- Buyer bears no financial risk
- Buyer takes huge inventory risks due to:
  - uncertainty in demand
  - inability to adjust order quantities.

4-39

Flexible or Option Contracts

- Buyer pre-pays a relatively small fraction of the product price up-front
- Supplier commits to reserve capacity up to a certain level.
- Initial payment is the *reservation price* or *premium*.
- If buyer does not *exercise* option, the initial payment is lost.
- Buyer can purchase any amount of supply up to the option level by:
  - paying an additional price (*execution price* or *exercise price)*
  - agreed to at the time the contract is signed
  - Total price (reservation plus execution price) typically higher than the unit price in a long-term contract.

4-40

Flexible or Option Contracts

- Provide buyer with flexibility to adjust order quantities depending on realized demand
- Reduces buyer's inventory risks.
- Shifts risks from buyer to supplier
  - Supplier is now exposed to customer demand uncertainty.
- Flexibility contracts
  - Related strategy to share risks between suppliers and buyers
  - A fixed amount of supply is determined when the contract is signed
  - Amount to be delivered (and paid for) can differ by no more than a given percentage determined upon signing the contract.

4-41

Spot Purchase

- Buyers look for additional supply in the open market.
- May use independent e-markets or private e-markets to select suppliers.
- Focus:
  - Using the marketplace to find new suppliers
  - Forcing competition to reduce product price.

4-42

Portfolio Contracts

- Portfolio approach to supply contracts
- Buyer signs multiple contracts at the same time
  - optimize expected profit
  - reduce risk.
- Contracts
  - differ in price and level of flexibility
  - hedge against inventory, shortage and spot price risk.
  - Meaningful for commodity products
    - a large pool of suppliers
    - each with a different type of contract.

4-43

Appropriate Mix of Contracts

- How much to commit to a long-term contract?
  - **Base commitment** level.
- How much capacity to buy from companies selling option contracts?
  - **Option** level.
- How much supply should be left uncommitted?
  - Additional supplies in spot market if demand is high
- Hewlett-Packard's (HP) strategy for electricity or memory products
  - About 50% procurement cost invested in long-term contracts
  - 35% in option contracts
  - Remaining is invested in the spot market.

4-44

Risk Trade-Off in Portfolio Contracts

- If demand is much higher than anticipated
  - Base commitment level + option level < Demand,
  - Firm must use spot market for additional supply.
  - Typically the worst time to buy in the spot market
    - Prices are high due to shortages.
- Buyer can select a trade-off level between price risk, shortage risk, and inventory risk by carefully selecting the level of long-term commitment and the option level.
  - For the same option level, the higher the initial contract commitment, the smaller the price risk but the higher the inventory risk taken by the buyer.
  - The smaller the level of the base commitment, the higher the price and shortage risks due to the likelihood of using the spot market.
  - For the same level of base commitment, the higher the option level, the higher the risk assumed by the supplier since the buyer may exercise only a small fraction of the option level.

4-45

Risk Trade-Off in Portfolio Contracts

		Base commitment level: Low	Base commitment level: High
Option level	High	Inventory risk (supplier)	N/A*
	Low	Price and shortage risks (buyer)	Inventory risk (buyer)

*For a given situation, either the option level or the base commitment level may be high, but not both.

4-46

CASE: H. C. Starck, Inc.

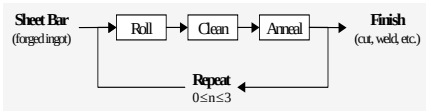
- Background and context
- Why are lead times long?
- How might they be reduced?
- What are the costs? benefits?

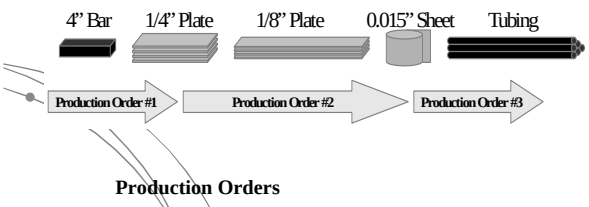
4-47

Metallurgical Products

- Make-to-order job shop operation
- 600 sku's made from 4" sheet bar (4 alloys)
- Goal to reduce 7-week customer lead times
- Expediting is ad hoc scheduling rule
- Six months of inventory
- Manufacturing cycle time is 2 – 3 weeks
- Limited data

4-48





Production Orders

Why Is Customer Lead Time 7 Weeks?

- From sales order to process order takes 2 weeks
- Typical order requires multiple process orders, each 2 – 3 weeks
- Expediting as scheduling rule
- Self fulfilling prophecy?

What Are Benefits from Reducing Lead Time?

- New accounts and new business
- Protect current business from switching to substitutes or Chinese competitor
- Possibly less inventory
- Better planning and better customer service
- Savings captured by customers?

How Might Starck Reduce Customer Lead Times?

- Hold intermediate inventory
  - How would this help?
  - How much? Where?
- Eliminate paper-work delays
- Reduce cycle time for each process order
  - How? What cost?

Two-Product Optimal Cycle Time

$$Cost(T) = \frac{K_B + K_F}{T} + T\left(\frac{h_B D_B}{2} + \frac{h_F D_F}{2}\right)$$

$$T^* = \sqrt{\frac{2(K_B + K_F)}{h_B D_B + h_F D_F}}$$

$$T^* = \sqrt{\frac{2(400+400)}{.06\times 100\times 526000 + .06\times 125\times 183000}} = 0.02 \text{ years}$$

Intermediate Inventory

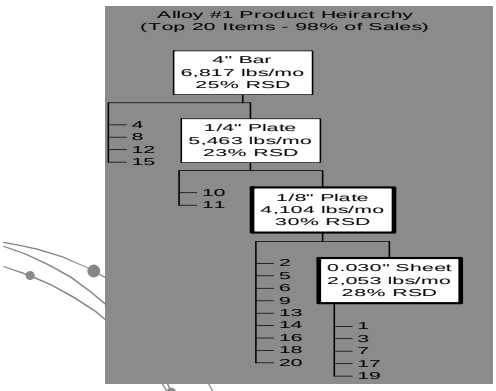
- Characterize demand by possible intermediate for each of two alloys
- Pick stocking points based on risk pooling benefits, lead time reduction, volume
- Determine inventory requirements based on inventory model, e. g. base stock

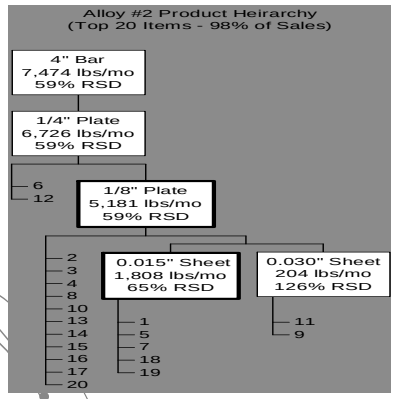
Popularity	Material	Gauge -	Description	1999 Invoiced Sales - Pounds per month									Total	Cum%
				Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep		
1	1011	0.002	Foil	618	1,079	1,215	1,188	1,020	290	1,590	849	1,017	8,866	22%
2	1004	0.015	Sheet	68	611	1,263	167	1,917	803	321	377	404	5,931	37%
3	1003	0.005	Sheet	263	576	584	812	617	969	572	359	909	5,661	50%
4	1029	0.500	Disk - 10" dia	275	0	353	0	581	0	530	414	1,017	3,170	58%
5	1009	0.030	Sheet	0	122	614	275	422	360	686	246	177	2,902	65%
6	1008	0.040	Sheet	321	101	191	486	8	98	263	176	660	2,334	71%
7	1002	0.010	Sheet	20	56	287	179	41	204	560	143	276	1,766	76%
8	1014	0.250	Plate	6	12	0	770	0	752	0	0	174	1,714	80%
9	1007	0.060	Plate	0	146	32	117	129	414	581	26	191	1,636	84%
10	1012	0.125	Plate	228	8	32	90	432	17	8	0	450	1,265	87%
11	1013	0.150	Plate	1,100	0	0	0	0	35	0	0	0	1,135	90%
12	1028	0.500	Ring - 10" OD x 8.5" ID	0	189	0	48	293	93	0	0	174	797	92%
13	1010	0.020	Sheet	0	54	102	183	45	54	126	92	119	775	94%
14	1017	0.750	Tube - 3/4"	0	0	0	8	12	568	0	0	12	590	95%
15	1015	0.375	Plate	0	0	0	0	0	0	375	0	0	375	96%
16	1018	0.015	Tube - 1.0" OD	8	0	0	0	0	230	0	41	0	279	97%
17	1001	0.005	Sheet - 1.0" x 23.75"	171	0	0	20	0	0	0	17	0	208	97%
18	1016	0.500	Tube - 0.50" OD	3	0	0	51	6	54	33	27	33	207	98%
19	1023	0.010	Sheet - 1.0" x 23.75"	0	99	14	18	0	0	0	0	0	131	98%
20	1027	0.015	Sputter Target - 2.0" x 5.0"	0	105	0	0	0	0	0	0	0	105	98%
Other	-	-	17 Other Items	217	36	57	86	101	40	52	43	35	666	100%
													40,513	

Alloy 1

Sales Rank	Material	Gauge -	Description	1999 Invoiced Sales - Pounds per Month									Total	Cum%
				Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep		
1	2040	0.015	Welded Tube .75" OD	298	936	2,989	1,366	2,468	980	657	528	1,392	11,623	27%
2	2031	0.020	Sheet Annealed	761	521	826	671	889	1,004	3,975	27	7	9,681	48%
3	2035	0.030	Sheet Annealed	1,638	116	1,138	634	524	579	1,672	703	517	7,920	65%
4	2041	0.020	Welded Tube .75" OD	0	50	316	3	379	0	2,856	0	0	3,604	74%
5	2043	0.015	Welded Tube 1.0" OD	0	0	480	444	0	77	118	343	0	1,462	77%
6	2027	0.060	Plate Annealed	0	0	277	323	60	0	504	12	205	1,382	80%
7	2050	0.015	Welded Tube 1" OD With Cap	0	0	0	1,003	0	0	176	0	0	1,179	83%
8	2029	0.045	Sheet Annealed	137	122	430	18	37	16	0	368	5	1,133	88%
9	2026	0.010	Sheet Annealed	0	0	435	0	251	412	0	0	0	1,098	88%
10	2051	0.022	Welded Tube 1.25" OD	0	0	0	1,014	0	0	0	0	0	1,014	91%
11	2025	0.002	Foil Annealed	551	0	0	0	0	0	0	0	0	551	92%
12	2034	0.125	Plate Annealed	0	35	78	63	34	0	0	208	0	418	93%
13	2045	0.030	Welded Tube 1.0" OD	0	0	370	0	0	1	0	0	41	412	94%
14	2044	0.020	Welded Tube 1.0" OD	0	0	0	32	241	109	4	0	0	388	95%
15	2047	0.030	Welded Tube 1.50" OD	0	255	100	0	0	0	0	0	0	355	96%
16	2039	0.020	Welded Tube .50" OD	0	0	181	142	0	0	0	0	0	323	96%
17	2052	0.035	Tube 1.25" OD	0	0	302	0	0	0	0	0	0	302	97%
18	2036	0.015	Sheet Annealed	108	0	13	56	0	27	0	0	1	205	98%
19	2046	0.015	Welded Tube 1.5" OD	0	0	0	40	0	0	133	0	0	173	98%
20	2012	0.045	4" Repair Disk	0	8	6	15	0	84	7	9	8	137	98%
Other	-	-	35 Other Items	77	115	66	67	113	133	44	29	112	753	100%
													42,709	

Alloy 2





Sales Rank	Material	Gauge -	Description	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total (Pounds)	Monthly Average	Standard Deviation	% RSD
From 0.030" Sheet																
11	2025	0.002	Foil Annealed	551	0	0	0	0	0	0	0	0	551	61	184	300%
9	2026	0.010	Sheet Annealed	0	0	435	0	251	412	0	0	0	1,098	122	190	156%
			Monthly Subtotal	551	0	435	0	251	412	0	0	0				
			90% Input required at yield	**612**	**0**	**484**	**0**	**279**	**458**	**0**	**0**	**0**	**1,833**	**204**	**256**	**126%**
From 0.015" Sheet																
1	2040	0.015	Welded Tube .75" OD	298	936	2,989	1,366	2,468	980	657	528	1,392	11,623	1291	900	70%
5	2043	0.015	Welded Tube 1" OD	0	0	480	444	0	77	118	343	0	1,462	162	202	125%
7	2050	0.015	Welded Tube 1" OD With Cap	0	0	0	1,003	0	0	176	0	0	1,179	131	332	254%
18	2036	0.015	Sheet Annealed	108	0	13	56	0	27	0	0	1	205	23	37	163%
19	2046	0.015	Welded Tube 1.5" OD	0	0	0	40	0	0	133	0	0	173	19	45	232%
			Monthly Subtotal	404	936	3,481	2,869	2,598	1,093	1,084	871	1,393				
			90% Input required at yield	**449**	**1,040**	**3,870**	**3,188**	**2,887**	**1,215**	**1,205**	**967**	**1,548**	16,269	**1,808**	**1175**	**65%**
From 0.125" Sheet																
			0.030" Sheet to Supply Above	612	0	484	0	279	458	0	0	0	1,833	204	256	126%
			0.015" Sheet to Supply Above	449	1,040	3,870	3,188	2,787	1,215	1,205	967	1,548	16,269	1808	1175	65%
2	2031	0.020	Sheet Annealed	761	521	826	671	889	1,004	3,975	27	7	9,681	965	1184	123%
4	2041	0.020	Welded Tube .75" OD	0	50	316	3	379	0	2,856	0	0	3,604	400	933	233%
14	2044	0.020	Welded Tube 1.0" OD	0	0	0	32	241	108	4	0	0	386	43	83	193%
16	2039	0.020	Welded Tube .50" OD	0	0	181	142	0	0	0	0	0	323	36	72	200%
10	2051	0.022	Welded Tube 1.25" OD	0	0	0	1,014	0	0	0	0	0	1,014	113	338	300%
3	2035	0.030	Sheet Annealed	1,638	116	1,138	634	524	579	1,672	703	517	7,920	836	533	64%
13	2045	0.030	Welded Tube 1.0" OD	0	0	370	0	0	1	0	0	41	412	46	122	268%
15	2047	0.030	WELDED TUBE 1.50" OD	0	255	100	0	0	0	0	0	0	355	39	87	221%
17	2052	0.035	Tube 1.25" OD	0	0	302	0	0	0	0	0	0	302	34	103	300%
8	2029	0.045	Sheet Annealed	137	122	430	18	37	16	0	368	5	1,133	126	163	130%
20	2012	0.045	4" Repair Disk	8	6	15	0	84	7	9	8	0	137	15	26	171%
			Monthly Subtotal	3,597	2,113	8,022	5,737	5,136	3,464	9,718	2,074	2,127				
			90% Input required at yield	**3,997**	**2,347**	**8,913**	**6,352**	**5,706**	**3,849**	**10,798**	**2,305**	**2,363**	**46,630**	**5,181**	**3053**	**59%**
From 0.250" Plate																
			0.125" Sheet to Supply Above	3,997	2,347	8,913	6,352	5,706	3,849	10,798	2,305	2,363	46,630	5181	3053	59%
6	2027	0.060	Plate Annealed	0	0	277	323	60	0	504	12	205	1,382	154	183	119%
12	2034	0.125	Plate Annealed	0	35	78	63	34	0	0	208	0	418	46	67	145%
			Monthly Subtotal	3,997	2,382	9,268	6,738	5,801	3,849	11,302	2,524	2,568				
			80% Input required at yield	**4,996**	**2,978**	**11,585**	**8,423**	**7,251**	**4,811**	**14,128**	**3,156**	**3,210**	**60,538**	**6,726**	**3990**	**59%**
From 4.0" Sheet Bar																
			0.250" Plate to Supply Above	4,996	2,978	11,585	8,423	7,251	4,811	14,128	3,156	3,210				
			90% Input Required at Yield	**5,551**	**3,309**	**12,872**	**9,359**	**8,057**	**5,346**	**15,698**	**3,506**	**3,567**	67,264	**7,474**	**4433**	**59%**

Alloy 1

Sales Rank	Material	Gauge -	Description	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total (Pounds)	Monthly Average	Standard Deviation	% RSD
From 0.030" Sheet																
11	2025	0.002	Foil Annealed	551	0	0	0	0	0	0	0	0	551	61	184	300%
9	2026	0.010	Sheet Annealed	0	0	435	0	251	412	0	0	0	1,098	122	190	156%
			Monthly Subtotal	551	0	435	0	251	412	0	0	0				
			90% Input required at yield	**612**	**0**	**484**	**0**	**279**	**458**	**0**	**0**	**0**	**1,833**	**204**	**256**	**126%**
From 0.015" Sheet																
1	2040	0.015	Welded Tube .75" OD	298	936	2,989	1,366	2,468	980	657	528	1,392	11,623	1291	900	70%
5	2043	0.015	Welded Tube 1" OD	0	0	480	444	0	77	118	343	0	1,462	162	202	125%
7	2050	0.015	Welded Tube 1" OD With Cap	0	0	0	1,003	0	0	176	0	0	1,179	131	332	254%
18	2036	0.015	Sheet Annealed	108	0	13	56	0	27	0	0	1	205	23	37	163%
19	2046	0.015	Welded Tube 1.5" OD	0	0	0	40	0	0	133	0	0	173	19	45	232%
			Monthly Subtotal	404	936	3,481	2,869	2,598	1,093	1,084	871	1,393				
			90% Input required at yield	**449**	**1,040**	**3,870**	**3,188**	**2,887**	**1,215**	**1,205**	**967**	**1,548**	16,269	**1,808**	**1175**	**65%**
From 0.125" Sheet																
			0.030" Sheet to Supply Above	612	0	484	0	279	458	0	0	0	1,833	204	256	126%
			0.015" Sheet to Supply Above	449	1,040	3,870	3,188	2,787	1,215	1,205	967	1,548	16,269	1808	1175	65%
2	2031	0.020	Sheet Annealed	761	521	826	671	889	1,004	3,975	27	7	9,681	965	1184	123%
4	2041	0.020	Welded Tube .75" OD	0	50	316	3	379	0	2,856	0	0	3,604	400	933	233%
14	2044	0.020	Welded Tube 1.0" OD	0	0	0	32	241	108	4	0	0	386	43	83	193%
16	2039	0.020	Welded Tube .50" OD	0	0	181	142	0	0	0	0	0	323	36	72	200%
10	2051	0.022	Welded Tube 1.25" OD	0	0	0	1,014	0	0	0	0	0	1,014	113	338	300%
3	2035	0.030	Sheet Annealed	1,638	116	1,138	634	524	579	1,672	703	517	7,920	836	533	64%
13	2045	0.030	Welded Tube 1.0" OD	0	0	370	0	0	1	0	0	41	412	46	122	268%
15	2047	0.030	WELDED TUBE 1.50" OD	0	255	100	0	0	0	0	0	0	355	39	87	221%
17	2052	0.035	Tube 1.25" OD	0	0	302	0	0	0	0	0	0	302	34	103	300%
8	2029	0.045	Sheet Annealed	137	122	430	18	37	16	0	368	5	1,133	126	163	130%
20	2012	0.045	4" Repair Disk	8	6	15	0	84	7	9	8	0	137	15	26	171%
			Monthly Subtotal	3,597	2,113	8,022	5,737	5,136	3,464	9,718	2,074	2,127				
			90% Input required at yield	**3,997**	**2,347**	**8,913**	**6,352**	**5,706**	**3,849**	**10,798**	**2,305**	**2,363**	**46,630**	**5,181**	**3053**	**59%**
From 0.250" Plate																
			0.125" Sheet to Supply Above	3,997	2,347	8,913	6,352	5,706	3,849	10,798	2,305	2,363	46,630	5181	3053	59%
6	2027	0.060	Plate Annealed	0	0	277	323	60	0	504	12	205	1,382	154	183	119%
12	2034	0.125	Plate Annealed	0	35	78	63	34	0	0	208	0	418	46	67	145%
			Monthly Subtotal	3,997	2,382	9,268	6,738	5,801	3,849	11,302	2,524	2,568				
			80% Input required at yield	**4,996**	**2,978**	**11,585**	**8,423**	**7,251**	**4,811**	**14,128**	**3,156**	**3,210**	**60,538**	**6,726**	**3990**	**59%**
From 4.0" Sheet Bar																
			0.250" Plate to Supply Above	4,996	2,978	11,585	8,423	7,251	4,811	14,128	3,156	3,210				
			90% Input Required at Yield	**5,551**	**3,309**	**12,872**	**9,359**	**8,057**	**5,346**	**15,698**	**3,506**	**3,567**	67,264	**7,474**	**4433**	**59%**

Alloy 2

Material	Monthly Demand	Monthly Sigma	Period (Weeks)	Average (Pipeline)	Period Sigma	Service Level	Reliability Factor	Buffer	Safety	Total
Alloy #1										
0.125" Plate	**4,104**	**1,213**	**1**	947	583	**95%**	**90%**	958	191	**2,100**
0.030" Sheet	**2,053**	**569**	**1**	474	273	**95%**	**90%**	450	92	**1,020**
Alloy #2										
0.125" Plate	**5,181**	**3,053**	**1**	1,196	1,467	**95%**	**90%**	2,412	361	**3,970**
0.015" Sheet	**1,808**	**1,175**	**1**	417	564	**95%**	**90%**	928	135	**1,480**

Estimated Inventory Requirements

Case Summary

- Demonstrate applicability of risk pooling and postponement, EOQ modeling, and inventory sizing to improve customer service in make-to-order job shop setting
- Demonstrates value from getting and looking at data