Calculating Item Minimum and Maximum Inventory Levels

The basic questions of inventory management are when to buy and how much. Item minimums (MINs) are the primary tool to signaling when to purchase an item and maximums (MAXs) determine suggested purchase quantities. Lacking some more specific methods, many times managers just set them at simply one month and two months of average sales respectively, using them as just reference information. Or, at the other end of the spectrum there are plenty of books on setting inventory management parameters containing numerous formulae with plenty of math and statistics behind them. Some computerized calculations are so complex that managers are hard pressed to explain where their computer came up with them. But in the end, setting MIN and MAX levels is as much subjective judgment that’s based in experience and knowledge of real world factors as it is on statistics.

The questions of when and how much are driven by the objective of maximizing revenue through the number of units sold and yet keep the investment minimal. There is no perfect answer or approach to achieve that objective. No matter how sophisticated the calculation, most of the values assigned the variables rely on estimates and “guesstimates”, in attempts to predict the future. But while eliminating guessing is a noble statistical crusade, it can go to extremes with diminishing returns. Though the old one month-two month solution may be too little, high end sophistication may be too much, especially for smaller companies whose managers wear many hats and can’t afford to spend all day neck deep in statistics.

There is a healthy compromise. While there are numerous variables in the more complex approaches, there are just four basic elements that are common to all of them. Understanding these elements and a little simple arithmetic, combined with the judgment of an individual who works with the items on a daily basis, will many times produce as good or better results as the highly complex approaches, especially in smaller operations.

The four core elements of any method for determining MIN/MAX levels are:

* Demand (the units of the individual item sold over a given amount of time)
* Lead Time (the number of days to expect before receiving the item purchased)
* Safety Stock (the amount of stock judged to be worth keeping in case the receiving is late or demand high)
* Turns (the goal for the ratio of sales to investment)

Demand and lead time are measurements of past performance. How many were sold and how long did it take to get them. But they may be influenced by knowledge of the future. Is there an up or down trend in demand or an impending event that will influence it? Is there a reason to believe that past lead times will not be accurate? So both figures, though based on real data from the past, may need consideration for the future.

Safety stock and turns are far more subjective. Safety stock is insurance on the accuracy of the wager that projections of demand and lead time will be accurate. If they were perfectly accurate then no safety stock would be required. If not and there is no safety stock then there is a “stock out” and sales might be lost. But if safety stock is overly cautious, so that it is never depleted, then the surplus must be regarded as money invested with no return.

The ideal item is one with almost no lead time. Items with short, reliable lead times typically justify less safety stock. Evaluating items with regard to their needs for safety stock is greatly influenced by their sales volume, frequency and profitability. A very popular item with a long lead time would warrant a large safety stock. Determining which items deserve more or less safety stock is aided by ABC (also known as Pareto or 80/20) item analysis.

Turns are the number of times an inventory investment is sold during the year. If you invest $5000 in inventory and sell $30,000 (at cost) during the year then your investment has “turned” six times. Turns are the baseline performance measure of inventory management. Higher turns (less inventory investment and carrying costs) means a better return. But shoot for turns that are too high and the cost of operations (more frequently placing and receiving POs) and risk of “stock out” lost sales (more frequent buying means thinner margins for error) become excessive. Like safety stock, setting goals for turns seeks to balance costs and risks.

Turns goals are frequently constrained by factors beyond those related to the individual item. If an item is one of many purchased from one vendor and that vendor requires a high minimum order, a turns goal for that item may not be achievable. A starting point for the turns goal for an item is to take the total sales of items purchased from that vendor in a year divided by the minimum requirement for a purchase from that vendor. If $10,000 (cost) of that vendor’s items are sold in a year and the vendor requires a minimum purchase of $2,000, then turns goals of more than 5 will be difficult for items in that vendor’s line.

Using just two of the four elements a simple MIN can be calculated:

* 480 units of item A were sold last year, or an average of 40 units per month of demand.
* It takes an average of one half month lead time from the time a PO is placed for the item until it is received.
* If these figures perfectly reflect the future then when the item hit a level of 20 units in inventory, a PO should be placed so that at the moment the inventory level hit 0 the new stock would arrive.
* 20 would be the perfect MIN inventory level.

But if the shipment were late in arriving or demand higher than average then those twenty would be gone before new stock arrived. The item would be out of stock. There would be continued demand but no inventory to meet it. Some sales might be delayed (backordered) but some might be lost because buyers went elsewhere. In this case safety stock might need to be added to the MIN to protect against this.

Determining safety stock depends on factors like:

* The lead time is either very short, minimizing the potential length of a stock out condition, or very long, increasing the time of stock outs.
* The lead time is highly unpredictable or a pending event like a strike may distort it.
* The demand is highly unpredictable or uneven over a given period.
* The item is crucial to your market and the risk of losing customers during a stock out period high, or the item is not one the customers typically need in short order and a backorder is acceptable.
* The item is one of a number of items purchased from a vendor whose minimum order requirements exceed the ability to consider this item’s minimum to be the sole factor in triggering a purchase.

If the lead time is just a couple of days and the item is not a crucial to customers then no safety stock may be warranted. But if the item is one that customers require on short order, the market for the item is growing, a large order is required by the vendor, and/or the lead time is more than a couple of months, then a significant safety stock would probably be advisable.

Safety stock is typically expressed as demand per time, as in “two months demand”, or 80 in the example above, making the total MIN 100. This means if the lead time is accurate and demand remains at the average rate then there would still be 80 units in inventory when the new order arrived. If the lead time and demand were always perfectly accurate then none of those 80 would ever be sold. They would be a permanent inventory investment and the cost of carrying the inventory would eventually exceed their potential profit if they ever were finally sold. Too little or too much safety stock is potentially very costly.

There are plenty of theories on the level of safety stock. None of them work perfectly so the most important thing is to monitor and adjust. One rule of thumb is to start at 50% of the lead time demand. In the example above that would set the safety stock at 10. If an item hits zero before an order arrives, consider increasing the safety stock. If, over a number of receipts, the item level never goes below the safety stock level then consider decreasing it.

The MAXimum is the quantity, also expressed as demand per time, of the item that is “ordered up to.” So MAX might be set at 4 months demand, for example, meaning 160 units. When the inventory level reached the MIN a PO would be placed for the difference between the available inventory (in this case equal to the MIN) and the MAX. In the initial example, when the inventory reached 20 a PO for 140 (MAX minus available inventory) would be ordered. If the inventory level had sunk to 0 before a PO was placed (lead time or demand inaccurate or just late ordering), then 160 would be ordered. If the lead time was accurate and the PO placed for 140 at the MIN then the highest stock level would be 140 on the day of receiving, because the stock available at the time the order was placed would have been sold. But if the PO wasn’t placed until stock was completely out then the highest stock level would be 160 and sales may have been lost during the lead time.

The average between the lowest and highest point an item’s inventory level reaches would be considered the average inventory investment in the calculation of inventory turns. (This is a simple average. Depending on the sampling scope an item’s average will vary. If 100 units of an item are held all year and all 100 sold on the last day of the year, while its high and low avaerage for the year would be 50 its truer average inventory would be closer to 100.) With no safety stock, and perfect lead time and demand, the item would have an average inventory of 70 ((0 + 140)/2). Since 480 of the item are sold annually the turns would be calculated as nearly 7 (480/70). But if the half lead time of safety stock suggested above is included in the MIN (20 + 10) then the highest stock level would be 150 (140 + 10) and the average would be 80 (10 at its lowest and 150 at its highest) making the turns just 6. Obviously safety stock has a significant impact on turns. The greater investment performance desired (i.e., more turns) the greater the risk. Lower risk, less return on investment (low turns.)

The formula for MIN then is simply Lead time (L) + Safety Stock (S), with each variable expressed as units of demand as a factor of time.

***MIN = L + S***

The formula for MAX is a little more complex. It begins with the desired turns (T) being equal to the annual demand (D) divided by the average inventory (MAX - L + S)/2. Solving for MAX, T = D/((MAX - L + S)/2) becomes

***MAX = (2D/T) + L - S***

So in the example where annual demand is 480, turns desired is 6, lead time demand is 20 and safety stock demand is 10, then the MAX is 170 ((960/6) + 20 - 10.) The easiest way to begin to see the impact of the variables on stock performance is with a spreadsheet. In the spreadsheet below the annual demand is assumed to be 480 and the lead time is one half month. It quickly becomes apparent that the greater the safety stock the fewer turns possible. With two months safety stock, unless the safety stock is depleted due to late receiving or higher demand, 6 turns or more are impossible because the average inventory would have to be 80 (480/6) but that’s the lowest the inventory would ever be. The MAX would calculate as just 100 so when the MIN of 100 was reached the “order up to” MAX of 100 would not recommend any purchase quantity. It would only recommend a purchase of 1 when the stock level of 99 was reached. Obviously the MAX must be greater than the MIN to trigger any purchase at all unless the order is placed after the item has gone below the MIN.

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| SAFETY STOCK MONTHS | SAFETY STOCK DEMAND | TURNS TARGET | MIN | MAX |
| 0 | 0 | **6** | 20 | 180 |
| 0.25 | 10 | **2** | 30 | 490 |
| 0.25 | 10 | **6** | 30 | 170 |
| 0.5 | 20 | **3** | 40 | 320 |
| 0.5 | 20 | **4** | 40 | 240 |
| 0.5 | 20 | **6** | 40 | 160 |
| 1 | 40 | **4** | 60 | 220 |
| 2 | 80 | **2** | 100 | 420 |
| 3 | 120 | **1** | 140 | 860 |

While maximizing the turns while also minimizing lost sales at the individual item level may be the most obvious goal of MIN/MAX management, factors unrelated to the item may play a big role as well. If, for example, a vendor requires a minimum purchase that is larger than a single item would justify, your turns goals may be driven by that. If total sales at cost of a vendor’s products are $30,000 and the minimum purchase required is $10,000 then turns of more than 6 times for that vendor’s items as a whole would be impossible even if there was no lead time or safety stock since the average inventory would be $5,000. Warehouse space or cash management may be other factors.

With variables being so dependent on forecasting the future (demand and lead time) or so subjective (best level of safety stock and desired turns) it’s easy to see why MINs and MAXs will need adjustment over time. And external factors may affect them further. Reviewing actual performance (actual turns and stock outs) is the best cure for the uncertainty of MIN and MAX settings.