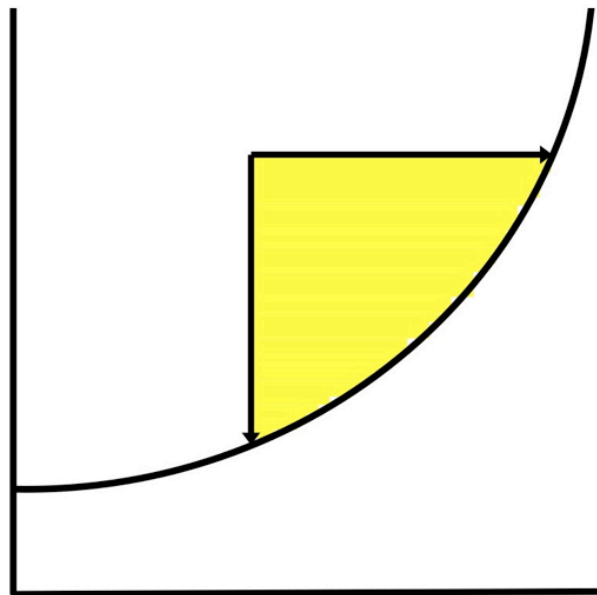# Using Safety Time as an Alternative to Safety Stock

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An Inventory Curve Management Guide

Organizations frequently utilize **safety stock** as a key component in their inventory planning. Safety stock is used as a buffer to protect from variation in demand. There are a number of approaches used to determine safety stock levels, but in many organizations, safety stock can be "hit and miss." As a result, inappropriate, incorrect or inconsistent use of safety stock can drive up inventory investment, reduce turnover and in some cases, negatively impact service.

This paper will look at the use of **safety time** and explore how it might be used **under certain conditions** as an **alternative to safety stock** with the end result of still maintaining a safety buffer while reducing inventory investment and increasing turnover.

This document will cover:
- Real world inventory analysis based on the use of ABC codes and related inventory performance reporting[*]
- How classic inventory theory may explain the observed results
- AND propose an approach to use **Safety Time** under certain conditions to reduce inventory investment and improve inventory turnover while still maintaining a safety buffer.

Results of Real World Inventory Analysis

One of the things that I observe when looking at inventory across multiple organizations is that A items typically cause service issues and C items typically cause inventory turnover issues.   A typical inventory snapshot by ABC Code is shown below.

Inventory Snapshot by ABC Code

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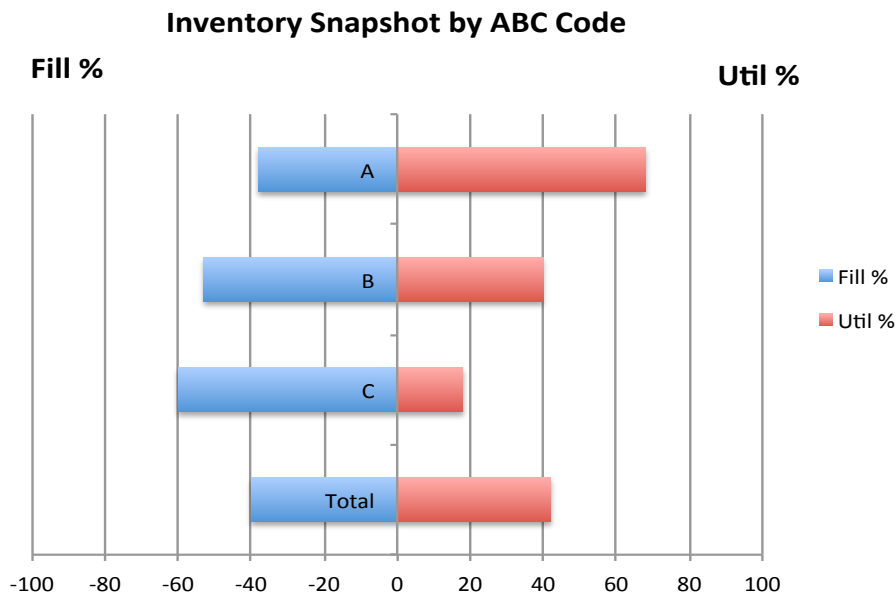
[*] For more on ABC Reporting and Analysis, see the document, **The Inventory Curve Guide to ABC Codes.**

The snapshot shows a reasonable Fill % (left side of graph), recognizing that it is only evaluating the next month's worth of demand. The inventory Utilization % (right side of graph) shows a reasonably high rate for the A items, with diminishing rates for B's and C's. This is indicative of low turnover rates for B's and C's. [†]

Is this a hard and fast rule? I don't know for sure, but I have rarely seen instances where this relationship has not held.

Put another way, A items typically have better-than-average turnover rates but more frequent out of stocks, and C items generally have high fill rates but much lower turnover. The logical conclusion is that increasing the inventory level of A's can lead to higher service levels with only a slight decrease in A turnover, and by decreasing the inventory of C's, it is possible to achieve a significant reduction in inventory investment, thus improving turnover while still maintaining high fill rates. The net effect is an overall improvement in service levels and a reduction in inventory investment leading to higher turnover.

ABC Analysis

Many times when I do reporting and analysis of inventory by ABC code, I find that the turnover (ITO) is much lower than would be expected based on an organization's stated strategy.

For example, an organization has a strategy and programs in place to drive replenishment as follows:
- A items – replenish weekly
- B items – replenish monthly
- C items – replenish quarterly

Apply the following formulas:
- Average inventory (simple form), is one-half of the replenishment quantity
- Inventory turnover = 360 (or 365 days) ÷ average inventory in days

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[†] For more information on Inventory Snapshots see
http://www.inventorycurve.com/Inventory_Snapshots.html

The performance of the various ABC segments using this weekly, monthly, quarterly replenishment strategy would then be expected to be:

	Replenishment Plan	Average Inventory	Turnover
A items	Weekly	3.5 days	103
B items	Monthly	14 days	26
C items	Quarterly	45 days	8

TABLE 1

Yet, when reporting is done on the actual inventory, the days on hand exceed the planned inventory for each ABC segment.

	Avg Inventory Plan	**Days on hand Actual**	**% Days On-hand over Plan**
A items	3.5 days	12.1	255.9
B items	14 days	33.7	140.7
C items	45 days	63.0	40.0

TABLE 2

One possible reason for the discrepancy between the plan and actual days on hand might be safety stock.

We will explore the possible impact by stepping back and looking at classical inventory theory using the sawtooth diagram.

The relationship between Days-On-Hand (DOH) and Inventory Turnover (ITO)

In many cases, it is valuable to be able to toggle back and forth between inventory as measured in Days On Hand (DOH) and Inventory Turnover (ITO). For ease of mental calculation, I use 360 days for a year. The relationship between DSO and ITO is then:
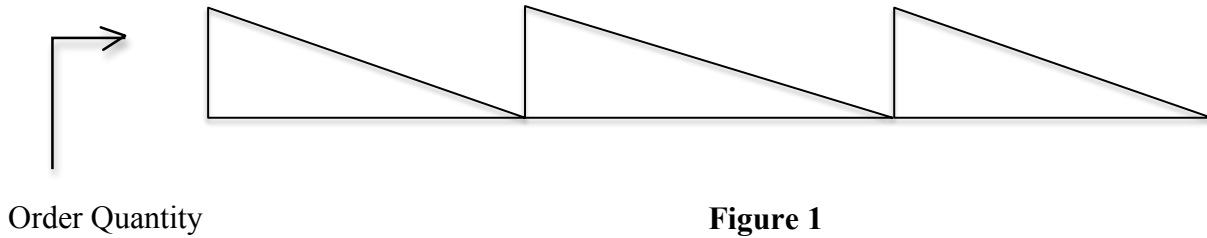
$$360/DOH = ITO$$

If DOH = 90, then ITO = 4
If DOH = 60, then ITO = 6
If DOH = 30, then ITO = 12

4

Looking at Inventory With Sawtooth Diagrams

A basic inventory concept is the sawtooth diagram as shown below.

Order Quantity   **Figure 1**

The sawtooth diagram represents inventory behavior **at the item level**. It shows multiple order receipts with material coming into inventory followed by the consumption of that material over time until it gets, ostensibly, to zero. In a perfect world, a new receipt will come in just as the inventory reaches zero. In reality, we know that this may not happen as often as we would like; but for this discussion, I ask that you accept this basic approach. One of the goals of just-in-time (JIT) programs is to achieve this type of timing.

> *Note: I recognize that 1) demand is not always linear and 2) the unanticipated demand can consume inventory before the replenishment order is received resulting in stockouts.*

From this simple model of inventory performance at the item level, we can observe what I consider to be one of the most important inventory formulas: **AVERAGE INVENTORY.**

By adding a line for the average inventory level to the sawtooth diagram, we can visualize its position on the graph.

Average
Inventory

Figure 2

Order Quantity
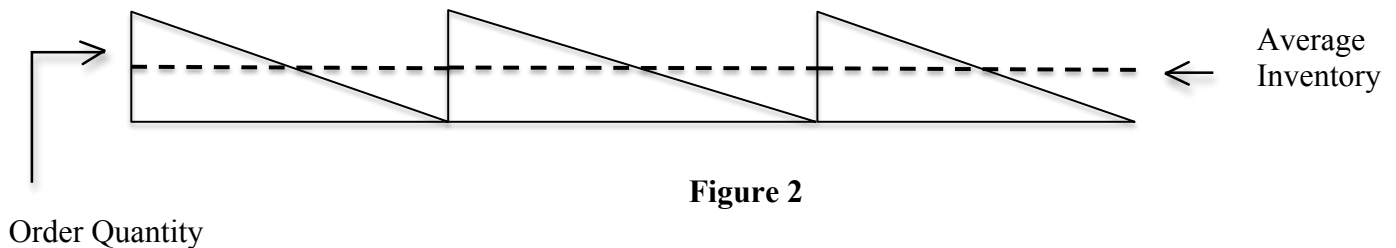
As you can see, regardless of the consumption rate, the average inventory is half the receipt quantity. Even if the consumption rate is not linear, the fact is that a given amount of inventory will be consumed over a period of time and the average will be half the order quantity. This is the simple model and the simple definition of average inventory is one-half of the order quantity, which is easy to estimate and calculate.

Adding safety stock increases complexity. Safety stock adds a buffer to the inventory to account for variations in the demand rate. The sawtooth diagram with safety stock looks like this.
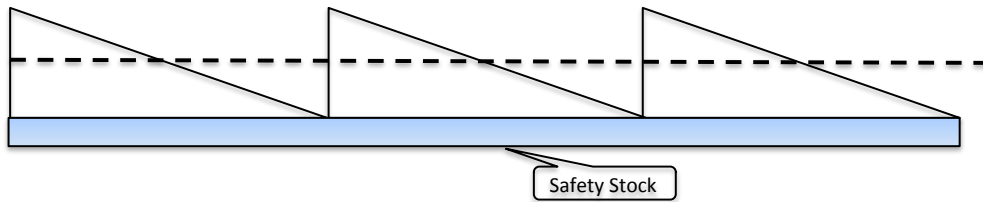
Figure 3

When safety stock is added, **the formula for average inventory changes** to one-half the lot size (order quantity) plus the safety stock. [‡]

Table 1A modifies Table 1 to show the impact on inventory turnover of adding in safety stock, for example, by 5 days across the board.

	Replenishment Plan	Average Inventory including 5 days Safety Stock	Turnover
A items	Weekly	8.5 days	42
B items	Monthly	19 days	19
C items	Quarterly	50 days	7

Table 1A

Comparing the conceptual turnover rate from Table 1 with the turnover rate in Table 1A, you can see that:
- A item turnover declined by 61 turns from 103 to 42
- B item turnover declined by 7 days from 26 to 19
- C item turnover declined by 1 day from 8 to 7

This is simply a result of increasing safety stock across the board by 5 days for each item.

Realistically, this would not happen with a well-defined safety stock strategy, but it has been known to happen.

Looking at Actual Data

The following table reflects data for the Raw Material inventory for an actual manufacturing operation. The real, quantitative data (item counts, inventory values and

[‡] APICS Dictionary, Eleventh Edition, 2005

usage) have been adjusted for reflect confidentiality. In this organization, the replenishment quantities were planned as follows:

- A items – weekly with an average inventory of 3.5 days
- B items – bi-weekly with an average of 7 days
- C items – monthly with an average of 15 days

The other values in the table are actuals and proportional to the actual data.

Many organizations do not routinely split out safety stock value in reports; however, with today's data warehouses and reporting software, this is something organizations should be able to do.

Inventory Report for Raw Materials

ABC code	Item Count	Avg Usage Value / day	% Usage Value / Spend	Tot Inv Value w/ Safety Stock	Days in Inven-tory	Safety Stock Days	Days in Inv less Safety Stock Days	ITO with Safety stock (turns)	ITO less Safety Stock (turns)
A	1,119	8,013	9.8%	67,462	8.4	6.1	2.3	43.4	158.7
B	3,947	10,846	13.2%	208,517	19.2	5.5	13.7	19.0	26.6
C	27,462	63,183	77.0%	1,352,734	21.4	6.9	14.5	17.0	25.2
Other	1,142	62	.1%	14,399	231.2		231.2	1.6	1.6
Total	**33,670**	**82,104**	**100%**	**1,643,112**	**20.0**	**6.6**	**13.4**	**18.2**	**27.2**

Table 3

Looking at Table 3, the first observation is that the organization is achieving a turnover rate of 18.2 even with the safety stock. Not bad, but if safety stock was totally eliminated (probably not a good idea), the turnover could be increased by 49% to 27.2 turns. The days in inventory less safety stock category has values reasonably close to average inventory (1/2 the planned replenishment quantity) for A's and C's, but higher for B's.

As an aside, a strange situation is visible with the split between A, B and C categories. Typically, organizations will assign ABC classification based on the % of annual usage/spend value. A common scheme is A's – 80%, B's – 15% and C's – 5%. However, in this situation, the percent splits seem to be reversed. The item counts are typical for a "normal" ABC split and the days in inventory less safety stock approximates the planned replenishment guidelines, but the usage values are off. This suggests the organization has not updated and recalculated its ABC codes for some time or used some other methodology for assigning ABC codes.

A items have 2.3 days in cycle inventory and 6.1 days of safety inventory. Is that amount of safety stock needed? For B and C items, the safety stock days represent 29 and 32% of the total inventory days, respectively. Could those amounts be judiciously reduced without compromising availability?

Reflect back to the sawtooth diagram with safety stock, Figure 3. Given that the B and C items are being replenished on a bi-weekly or a monthly basis, does it make sense to carry safety stock **early** in the replenishment cycle when the demand likely will be satisfied by the cycle inventory? The risk of stockouts is low until late in the replenishment cycle, so what if there was a way to carry safety stock only late in the cycle? In fact, there is. It is **safety time**.

Safety Time

From a conceptual perspective, safety stock is used to provide a buffer for variation in demand. **Safety time** is used to provide a buffer for variation in delivery and lead time; but it can also be used to drive short-term buffer capability late in the replenishment cycle. The effect of using safety time is to bring in inventory prior to the time that it is actually needed. This is different from increasing lead time.

In an ERP system, the system will generate a signal to replenish an item when the actual or projected inventory level for an item drops below a threshold level based on the planning parameters established for the item. The threshold is typically called the order point. The timing of the action message is offset by the lead time. (Keep in mind that the full lead time includes not only the delivery time quoted by the supplier, but transit time and internal times for both reviewing and placing the order and for processing the order upon receipt.)

In practice, different systems have diverse capabilities for dealing with lead times. On the low end, they may have only a single lead time factor. Others are more complex with actual fields for internal order review and processing, supplier lead time, transit time (these give an order due date) plus internal receiving, inspection and stocking times to arrive at the total lead time to be used (see figure 4).
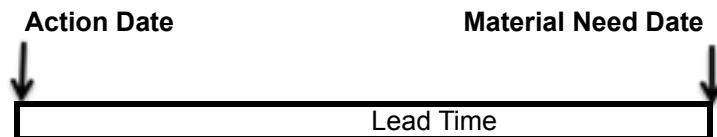
Action Date   **Material Need Date**

Lead Time

Figure 4

Simply increasing the lead time to account for a safety time component sends an action message to place the replenishment order earlier and lengthens the lead time. It does not change the need/due date and as a result, does not provide a safety buffer late in the replenishment cycle by bring product in before it is needed (see figure 5).

Action Date

Material Need Date

Safety Time incorporated with lead time

Figure 5

With systems that allow for safety time, the safety time is additive to the lead time and pushes the required delivery earlier and, as a result, also pushes out the planned order (action) date (see figure 6.)

Action Date   **Delivery Date**   **Material Need Date**

Lead Time	Safety Time

Figure 6

When **safety time** is used, a **new, expanded formula** for average inventory **comes into play.**

When safety time is used, the average inventory is one-half the replenishment quantity PLUS the remaining existing inventory on-hand when the replenishment quantity is received. Conceivably, this provides the safety quantity to buffer stockouts close to the end of the replenishment cycle, and likely results in carrying much lower safety inventory than continuously carrying safety stock for the item throughout the complete replenishment cycle (see figure 7).
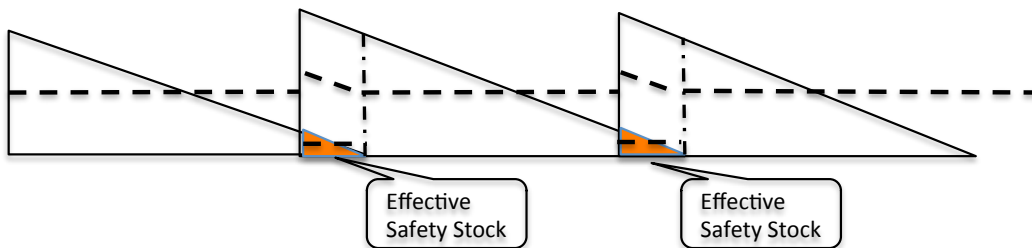
Effective Safety Stock

Effective Safety Stock

Figure 7

The impact of using Safety Time for B and C items based on the Raw Material Report as shown in Table 3

Table 3 is now updated as Table 3A to reflect the use of Safety time of 3 days for B and C items. No change is made for A items. For B items, the safety stock of 5.5 days is eliminated (remember, it is additive for the full cycle inventory) and replaced by bringing in the next replenishment order 3 days early. For C items, the 6.9 days of safety stock is eliminated and the replenishment order is brought in 3 days early.

Inventory Report for Raw Materials

ABC code	Item Count	Avg Usage Value / day	% Usage Value / Spend	Tot Inv Value w Safety Stock	Days in Inven-tory	Safety Stock (A's) or Time for B and C's	Days in Inv less Safety Stock/ Time Days	ITO with Safety stock / time (turns)	ITO improve-ment over Table (turns)
A	1,119	8,013	9.8%	67,462	8.4	6.1	2.3	43.5	0
B	3,947	10,846	13.2%	181,128	16.7	3 days	13.7	21.9	2.9
C	27,462	63,183	77.0%	1,105,703	17.5	3 days	14.5	20.9	3.9
Other	1,142	62		14,399	231.2		231.2	1.6	
Total	**33,670**	**82,104**	**100%**	**1,368,692**	**16.7**	**3.3**	**13.4**	**21.9**	**3.7**

Table 3A

Replacing the safety stock on B and C items with 3 days of safety time (bringing in the replenishment order 3 days early) results in the following inventory performance improvements:
*   Total inventory value is reduced by 274,420 (16.7%)
*   Total Days in Inventory is reduced by 3.3 days (16.7%)
*   Safety Stock Value is reduced by 270,943 (50.2%)
*   Total ITO is increased by 3.7 turns (20.3%)

It is important to recognize an unknown in this example. Nowhere have we seen a description of the plan or mechanics used to drive the safety stock for any of the A, B or C items. At this point, we do not know what logic was used to drive the safety stocks to 6.1, 5.5 and 6.9 days respectively. This lack of understanding and visibility is common in many systems. What we looked at here was the resulting days in inventory using some unknown methodology and tested it against a different approach using safety time.

Evaluating the Logic at the Item Level

Once again, the definitions of average inventory with safety stock and average inventory with safety time are as follows:

*   **Average inventory with Safety Stock:** One-half order quantity **plus** safety stock

- **Average inventory with Safety Time:** One-half order quantity **plus** on-hand inventory remaining when the replenishment order is received early.

Assuming the order quantities are the same, order quantity is not a factor and the comparison is between safety stock quantity and the remaining on-hand inventory when the replenishment order is received.

If the remaining on-hand inventory (when the replenishment quantity is received) equals the safety stock, then either method provides the same result from an average inventory and turnover perspective. For example, if the safety stock is 5 days of demand and the remaining on-hand inventory is equivalent to 5 days of demand, then either method will provide the same average inventory.

If the remaining on-hand inventory (when the replenishment quantity is received) is greater than the safety stock, then using safety stock is a better approach. For example, the replenishment order is brought in 7 days early resulting in an average remaining quantity of 7 days of demand. The safety stock of 5 days of demand would have a better turnover.

However, if the remaining quantity on-hand inventory (when the replenishment quantity is received, say 3 days early) is less than the safety stock, then this would be a clear improvement in average inventory and turnover compared to carrying 5 days of safety stock.

At the individual item level, this may seem like a fairly modest improvement, but since B and C items normally make up a large proportion of the items in inventory (93% of the items shown in Table 3), in aggregate, the impact can be significant.

The trade-off between safety stock and safety days can be computed as:

break-even safety days = safety stock / average daily demand rate.

While not recommended, it is possible to use both safety stock and safety time at the same time for a given item. In that case:

Average inventory = one-half order quantity **plus** safety stock **plus** on-hand remaining inventory when the replenishment order is received.

CONCLUSION

One way to improve inventory performance and turnover is to substitute the use of safety time for safety stock on slower-moving B and C items. This has the effect of reducing the safety buffer investment by avoiding safety stock early in the replenishment cycle when the risk of stockouts is low, yet provides a level of safety coverage late in the replenishment cycle when stockouts are most likely to occur.

About the author
"Looking at inventory performance improvement through a different lens."

David Armstrong is a consultant, writer and commentator on inventory, supply chain and operations. He has over 40 years experience with end-to-end supply chains and related functional areas in consumer products and high-tech manufacturing, wholesale/distribution and retail in both operations and systems. Continuous improvement and lean approaches are fundamental in his work.

He has been published in the Harvard Business Review and Handling and Shipping Magazine and taught at The University of Colorado – Denver and Front Range Community College.

The flow of inventory and related information through the supply change is a primary interest and David has developed new concepts and novel ideas related to better understanding the characteristics of inventory and improving its performance in organizations. In doing so, he asks, "what is the data telling us" and balances theory with data. He is tenacious, pragmatic, is more concerned with satisficing than optimizing and spans boundaries in his thinking between systems, operations, physics and cognitive disciplines.

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