IBM

Application Program

H20-0471-1

System/360 Inventory Control

Application Description

The IBM inventory control application consists of a group of integrated programs and techniques designed for the selection and implementation of order point inventory control where it applies in manufacturing organizations.

The programs provide for (1) classification of inventory items for determining the type of control, (2) calculation of economic order quantities on the basis of usage information or future requirements, (3) computation of safety stock and order point, (4) projection of demand on the basis of historical data and (5) basic programs for transaction processing and report preparation.

This manual includes a general description of these programs, the machine configuration, general systems charts, sample reports, and a discussion of inventory control concepts applicable to the use of the programs.

Second Edition

This edition is a major revision of, and obsoletes, H20-0471-0.

Significant changes or additions to the specifications contained in this publication will be reported in subsequent revisions or Technical Newsletters.

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CONTENTS

The IBM inventory control programs have been developed to assist manufacturing companies in the installation of an effective order point inventory control system.

For planning purposes, programs are provided to assist management in their judgments regarding the type of control to be exercised for the inventory items. In addition, other programs will calculate economic order quantity, order point, and safety stock for inventory items on the basis of usage data and the type of control that is selected.

The projection phase consists of a group of programs that analyze historic demand data and generate the information necessary to project future requirements. These programs also provide for keeping the information current so each projection or forecast can reflect the latest information.

The execution phase relates to processing the day-to-day transactions that must be recorded in the inventory file. Several programs are provided for updating the inventory file and for preparing reports. The package also contains suggested techniques, subroutines and the documentation to enable each user to develop a more comprehensive system for this phase of inventory control.

All programs in the package are designed in such a way that each user can easily modify them to meet the specific requirements of his installation.

As an additional aid to the user, a summary chart appears after the discussion of each phase of the program application.

PURPOSE AND OBJECTIVES

The principal objective of these programs is to provide an approach that will enable System/360 users to implement an order point inventory control application with relative ease.

Many manufacturers are not taking advantage of data processing techniques as applied to inventory control because implementation costs appear to be excessive, or because the overall design aspect seems to be too difficult. The programs should remove these obstacles for many companies, thus permitting them to obtain the benefits of more efficient inventory control.

The benefits that can be gained by using the techniques provided represent many dollars of saving for a typical manufacturer. Inventory is a substantial investment, and a reduction in this area without a decrease in service is one of the most important benefits to be gained. The determination of economic order quantities consistent with usage and costs, plus the establishment of order points and safety stock consistent with the level of service required, are factors which make these savings possible. Usually, making these determinations is not economically feasible with a manual system. However, the determinations are ideally suited for a computer.

The large number of inventory items and the transactions that affect these items make it difficult to manually keep up-to-date status information necessary for the execution of management's inventory policy. The expense of record maintenance and transaction recording is another area of potential saving for the user.

In addition, many of the routine decisions are made by the system, thus permitting a more thorough examination of items that require attention. Exception conditions are highlighted for judgments outside the system.

The inventory control application consists of programs, subroutines, and supporting documentation to assist each user in developing his inventory control system.

These programs are divided into three phases:

Planning
- Inventory Analysis
- Order Point
- Order Quantity

Projection
- Edit
- Model Select
- Initial Update
- Update and Project

Execution
- Transaction Processing
- Status Reporting

Figure 1 illustrates the general relationship of the three phases and the specific programs. Within the planning phase, inventory analysis provides information to be used by the order point and order quantity programs. The latter two programs update the item master file. Normally, the user will take advantage of the analysis for implementation aspect of these two programs. Basically, this enables the user to analyze the possible effects of changing order points and order quantities before implementing the changes.

The projection programs edit and analyze historic sales or usage data to determine whether patterns exist and to compute the initial parameters to be stored on the item master file. The initial update program uses the output of the other programs and places the information in the item master file.

The update and project program keeps the item parameters current and projects future usage on the basis of the parameters. This program uses the most recent period's demand, supplied by the execution phase.

The execution phase keeps the files up to date. It processes the day-to-day transactions and provides status reports and exception highlighting.

Each program is discussed in more detail on the following pages.

While the programs will have widespread use in relation to many inventory categories, their primary function is for control of finished goods and service parts inventories. As such, they conform to the general concepts contained in the IBM manual The Production and Information Control System (E20-0280) in relation to forecasting end items. Particular attention should be devoted to the description of the time series planning subsystem in that manual for those items which have wide variations in usage from time period to time period. This usually occurs for items where the demand is dependent upon orders issued for higher-level assemblies and items that have exception demand.

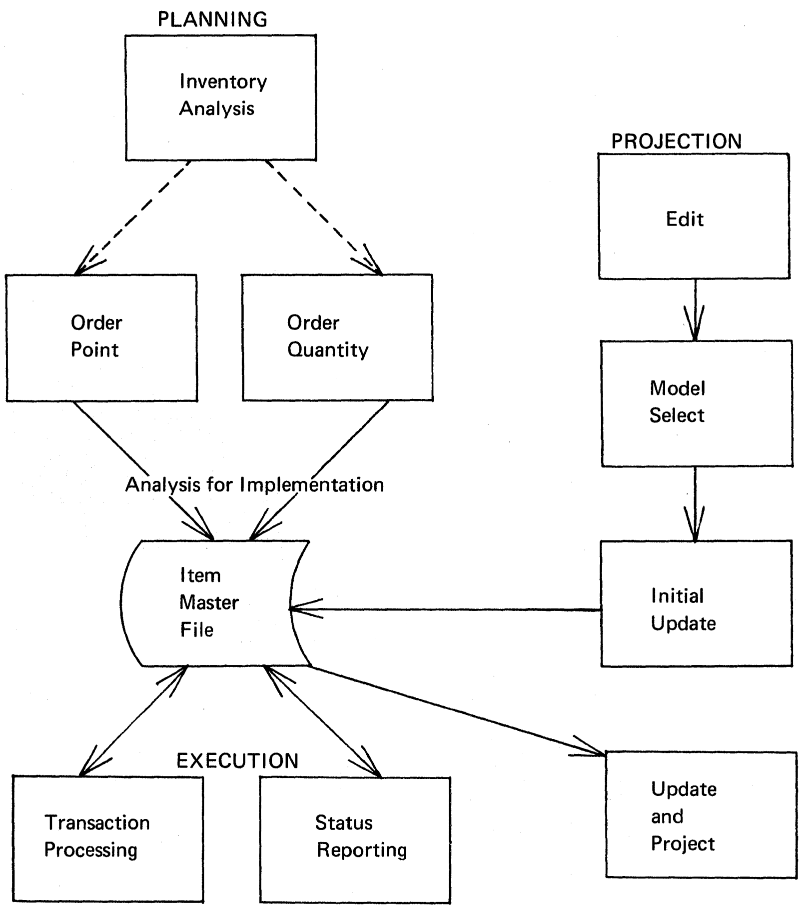


Figure 1. General relationship of programs

INVENTORY ANALYSIS

Inventory analysis should be the first step toward implementation of an inventory control system. It helps to answer the following questions: "What do we control?" and "How do we control it?"

General experience has shown that a company should not use the same type of control for low-cost stock items that is used for high-value items. If it does, perhaps too much is being spent for the control of the low-cost items relative to what might be spent for a slightly higher inventory of these items. Or, perhaps too much time is spent controlling these items, thus neglecting the higher-valued items that should receive more attention. In either event, an analysis of the inventory items should point out areas of potential saving and increased efficiency.

The analysis helps to separate the inventory into segments or groups to which various levels of control can be applied. These groupings are generally based on a measure of dollar value and annual usage. The investment in inventory that an item represents is determined by the cost of producing the item and the annual quantity produced or used. If these factors are extended for each item in an inventory, the items can be ranked in sequence by annual usage evaluation. A typical breakdown of inventory would show that a high percentage dollar value of annual usage is concentrated in relatively few items, while at the other end, a high percentage of items account for a very small amount of annual usage evaluation.

For example, if three classes were used, a breakdown of inventory might show:

Class	Annual Usage Evaluation	Percentage of Items
A	80%	20%
B	15%	30%
C	5%	50%

This value analysis is sometimes called ABC analysis. The number of classes into which an inventory is divided depends upon the characteristics of the specific inventory and the use or requirement for having a specific number of classifications. For example, these classes can be used to prepare codes for each item master record for use by the order quantity and order point programs. The inventory analysis program can place codes on the item master file on the basis of value classification cards or item code cards.

The value analysis helps to segment the inventory so that a company can concentrate on the items for which it has the largest investment. The analysis should also influence the selection of the method by which order quantities and order points are established. Some items may be ordered on the basis of exact requirements, while the order quantity of other items may be calculated on the basis of estimated usage. In many cases, safety stock and order point may be calculated using statistical techniques that provide a specified level of service: (See the order point section for additional information on level of service.) At other times the choice may be to calculate safety stock by multiplying average demand by a specific amount of time or by a percentage of lead time. The choice of these and other options regarding inventory policy can be made more effectively after this analysis.

As an example of the types of judgments that can be made to reduce costs, assume the following with regard to an inventory. There are 2000 items whose annual usage valuation (usage x unit cost) is equal to $3,000,000. Each item is ordered three times a year with an order quantity of four months' usage, resulting in 6000 orders per year. Assuming constant usage, the average value of the cycle stock is 1/2 order quantity value ($500,000). Safety stock is set at two months' supply or 1/6 of the yearly usage (1/6 x $3,000,000 = $500,000). The average inventory level is equal to cycle stock plus safety stock ($500,000 + $500,000 = $1,000,000. This information is summarized in the upper part of Figure 2.

An analysis of these items indicated that the breakdown corresponded to the percentages cited earlier. The ordering policy is changed in the lower part of Figure 2 so that the A items are ordered eight times a year, the B items three times a year, and the C items only once a year. Note that the number of orders is identical to the previous example, yet the cycle stock is reduced from $500,000 to $300,000. If the safety stock is not changed, the average inventory level is reduced to $800,000 ($500,000 + $300,000 = $800,000). Further discussion of this example takes place under order point and order policy.

Class	No. of Items	Usage Valuation	Orders Per Yr.	Total Orders	Order Quantity Valuation	Cycle Stock Valuation
All	2,000	$3,000,000	3	6,000	$1,000,000	$500,000

Safety stock = 2 month supply = 1/6 year = 1/6 (3,000,000) = 500,000

Total Average Inventory = Cycle Stock + Safety Stock
= $500,000 + $500,000
= $1,000,000

Class	No. of Items	Usage Valuation	Orders Per Yr.	Total Orders	Order Quantity Valuation	Cycle Stock Valuation
A	400	2,400,000	8	3,200	300,000	150,000
B	600	450,000	3	1,800	150,000	75,000
C	1,000	150,000	1	1,000	150,000	75,000
	2,000	$3,000,000		6,000	$ 600,000	$300,000

Total Average Inventory = Cycle Stock + Safety Stock
= $300,000 + $500,000
= $800,000

Figure 2. ABC analysis and order policy

The inventory analysis program contains the logic to retrieve inventory records from the item master file or to accept optional item records containing the necessary information to extend annual usage by unit cost and, where appropriate, unit price (see Figure 4).

An output record is prepared that contains the results of these calculations. The output records are sorted and listed in descending sequence by annual usage value.

An example of an inventory analysis is illustrated in Figure 3. All items were not included on the example so that just the indicative profile for the complete inventory could be shown. The horizontal lines were included to indicate the ABC classifications.

INVENTORY ANALYSIS							
Item Number	Item Count	Cumulative % Items	Annual Units	Unit Cost	Annual $ Usage	Cumulative $ Usage	Cumulative % $ Usage
T 7061	1	.0	51,553	3.077	158,629	158,629	.5
S 6832	13	.1	243,224	.317	77,102	1,652,395	5.0
S 7036	93	.8	4,250	7.369	31,318	5,254,583	15.9
G 9282	308	2.8	23,908	.640	15,301	9,914,307	30.0
G 9034	352	4.9	244,690	.045	11,011	13,252,124	40.1
G 9109	879	8.0	56,304	.115	6,475	18,209,277	55.1
S 5251	1099	10.0	3,756	1.234	4,635	21,414,903	64.8
M 7868	1352	12.3	21,683	.205	4,445	21,844,523	66.1
S 5843	1539	14.0	23,796	.181	4,307	23,662,146	71.6
S 6121	2198	20.0	7,239	.490	3,547	26,438,152	80.0
N 3501	2615	23.8	9,967	.209	2,083	27,495,678	83.1
M 2643	2747	25.0	1,138	1.720	1,957	27,793,107	84.1
S 7822	3296	30.0	3,509	.450	1,579	29,015,872	87.8
K 2174	3747	34.1	1,042	1.256	1,309	29,742,921	90.0
S 5904	5494	50.0	1,305	.800	1,044	31,395,306	95.0
S 6219	6593	60.0	1,904	.282	537	31,891,021	96.5
G 4713	7692	70.0	2,439	.123	300	32.353,688	97.9
N 9773	9098	82.8	3,750	.048	180	32,783,308	99.2
T 6613	9241	84.1	198	.505	100	32,915,499	99.6
T 6562	10900	99.2	210	.143	30	33,034,471	99.9
M 3742	10988	100.0	0	.073	0	33,047,690	100.0

Figure 3. Inventory analysis

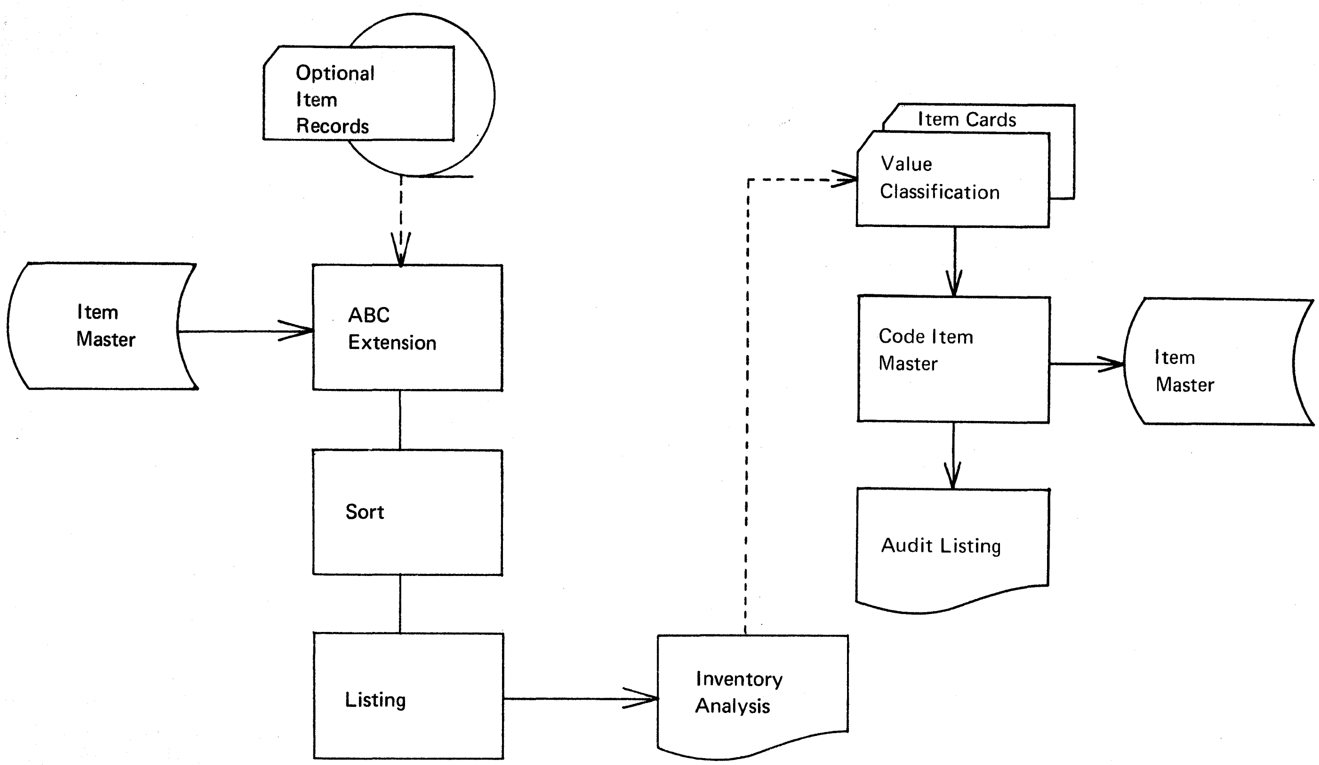


Figure 4. General system chart – inventory analysis

INVENTORY ANALYSIS SUMMARY CHART			
Input	Routines	Item Master File	Output
Parameter card Optional item records Value classification cards Item cards	Inventory analysis Code item master	Item number Number of periods of demand Demand quantity for number of periods Unit cost Unit price	Inventory analysis Audit listing of item master codes

ORDER POINT

Some of the most significant decisions to be made regarding inventory control are concerned with order point and order quantity. They address themselves to the two fundamental questions of inventory control: (1) when to order, and (2) how much to order. These decisions affect the amount of investment for inventory, the level of customer service, and the efficiency of plant operation. Obviously, each company should strive to use the most effective techniques for implementing its ordering policy.

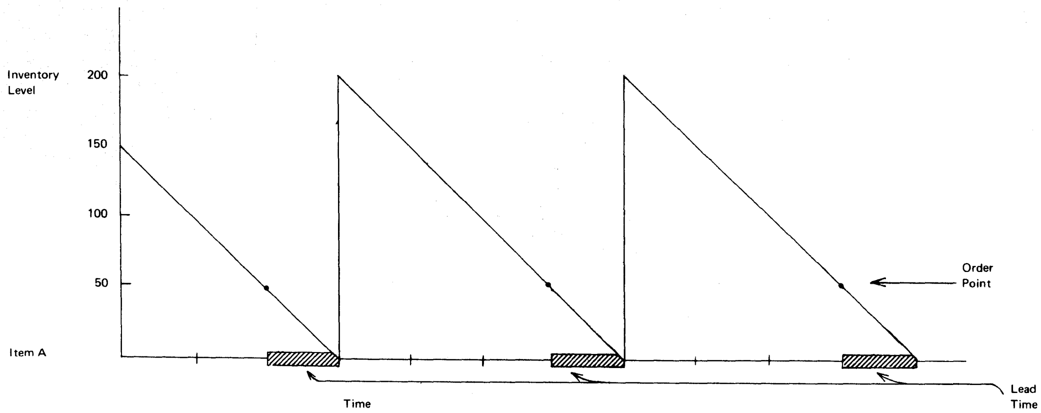
Several methods for the calculation of order point and order quantity are provided in the inventory control program so that each user can select the techniques that are best suited for his operation. This section of the manual discusses order point; the following section is devoted to order quantity.

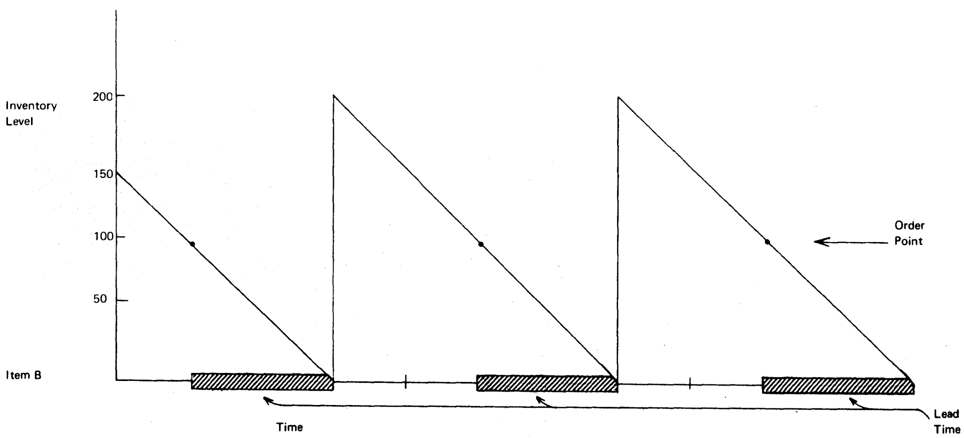
Basically, order point is a quantity which, when compared to available stock (on hand + on order), indicates whether a replenishment order should be issued. When the stock is reduced to this point and the order is issued, enough items should remain to take care of the demand until the quantity from the new order is available. Under ideal circumstances, it would be desirable to run out of an item just as the new order is received.

To set the order point, several factors must be known. Two principal factors are lead time and usage. Lead time is defined as the elapsed time between the issue of an order (purchase or production) and the receipt of the item in the stockroom. Usage is defined as the number of units of an inventory item consumed during a length of time. Usually, some averaging technique is applied so that actual usage is converted to average usage or average demand, which is expressed as a quantity per time period (the calculation technique is discussed in the projection section of this manual).

Order point = Lead time x Average demand

Figure 5 illustrates the relationship of order point, lead time, and average demand. For these examples, the time unit for lead time and average demand is the same. The average demand for items A and B is 50 units; however, the lead time for A is 1 while the lead time for B is 2. Note that the order point is 50 for item A and 100 for item B; this is equal to expected demand for their respective lead times. The order quantity is assumed to be the same for both items.





Item Number	Average Demand	Lead Time	Order Point	Order Quantity
A	50	1	50	200
B	50	2	100	200

Figure 5. Order point based on lead time and average demand

Another factor that can be used in the calculation of order point is review time. Review means comparing an item's order point with the available stock for that item. This is done to determine whether order action is necessary. If the review is done on a periodic basis, or if orders are issued only at specific intervals, there is an additional amount of time between the time an item reaches the order point and the time an order is issued. If the review time is significant, it should be considered in the calculation. Provision has been made for including review time in the program.

Order point = (Lead time + Review time) x Average demand

This may be clarified by an example of what happens if review time is not considered. Assume that an item is being reviewed weekly. If lead time is two weeks, and usage per week is 50, order point is 100 without the addition of review time. Suppose that available stock is 101 at the time of a particular review; since this is above order point, no order is placed. During the following week, the normal usage of 50 reduces the available stock to 51. An order is now placed, but since lead time is two weeks, the item will be out of stock during the second week. The avoidance of such stockouts would require that review time be added to lead time, making order point 150 in the case cited.

Direct access storage devices make it economical to review the available stock at the time of each transaction; this is often referred to as continuous review. If continuous review is used, and order action is initiated without excessive delay, the review time can be set to zero, thereby enabling a reduction of inventory. For the item discussed above, the 50 additional items probably would not be required.

SAFETY STOCK

Up to now, in the discussion of order point, safety stock has not been mentioned. Order point was calculated using lead time, review time, and average demand.

Safety stock is the quantity of an item that is maintained as a hedge or protection against stockout resulting from above average or unexpected demand during the lead time. Since order point is based on average demand, it is raised to allow for the time when the average is less than the actual usage during lead time. This creates a buffer of inventory called safety stock. Adding safety stock has the effect of increasing the average inventory, with an associated increase in maintenance cost. The additional inventory may be considered a good investment, up to some reasonable point, because stockouts may cause production delays or lost sales.

To better understand how safety stock might work, look at the same item twice, first without safety stock (Figure 6), then with it (Figure 7). In both cases lead time is 1. Note that with no safety stock, when actual usage is equal to average demand, the inventory is reduced to zero just as the new shipment comes in. Similarly, with safety stock, the level at which safety stock would be issued is reached when the shipment comes in.

If actual usage exceeded average demand, there would be a stockout in the first case; however, in the second case, safety stock would be used to fill orders.

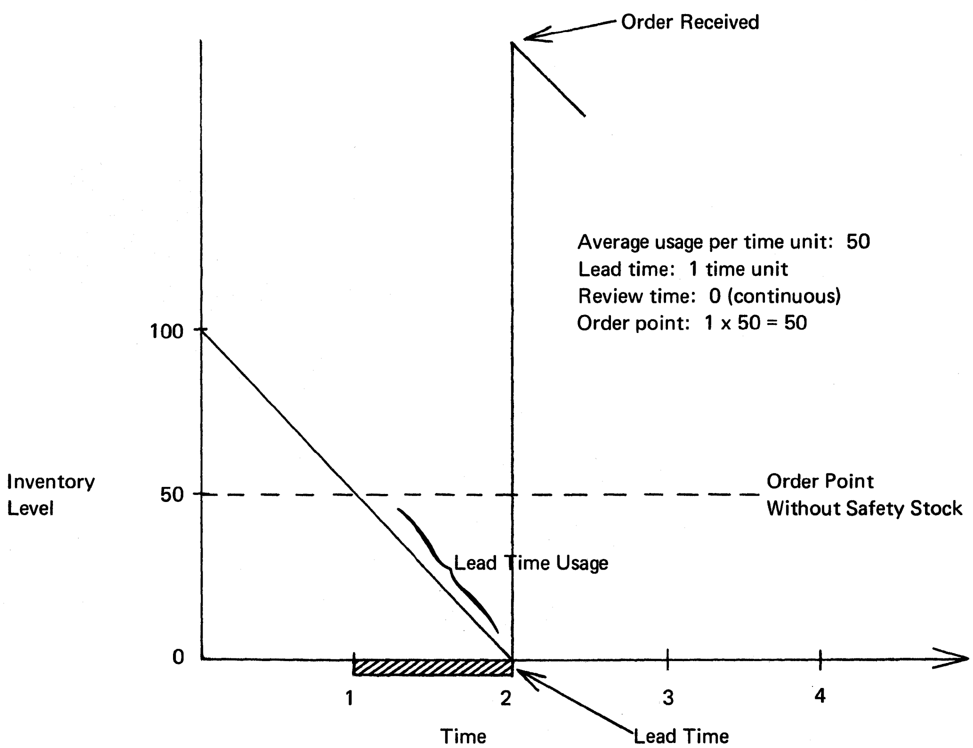


Figure 6. Inventory behavior without safety stock

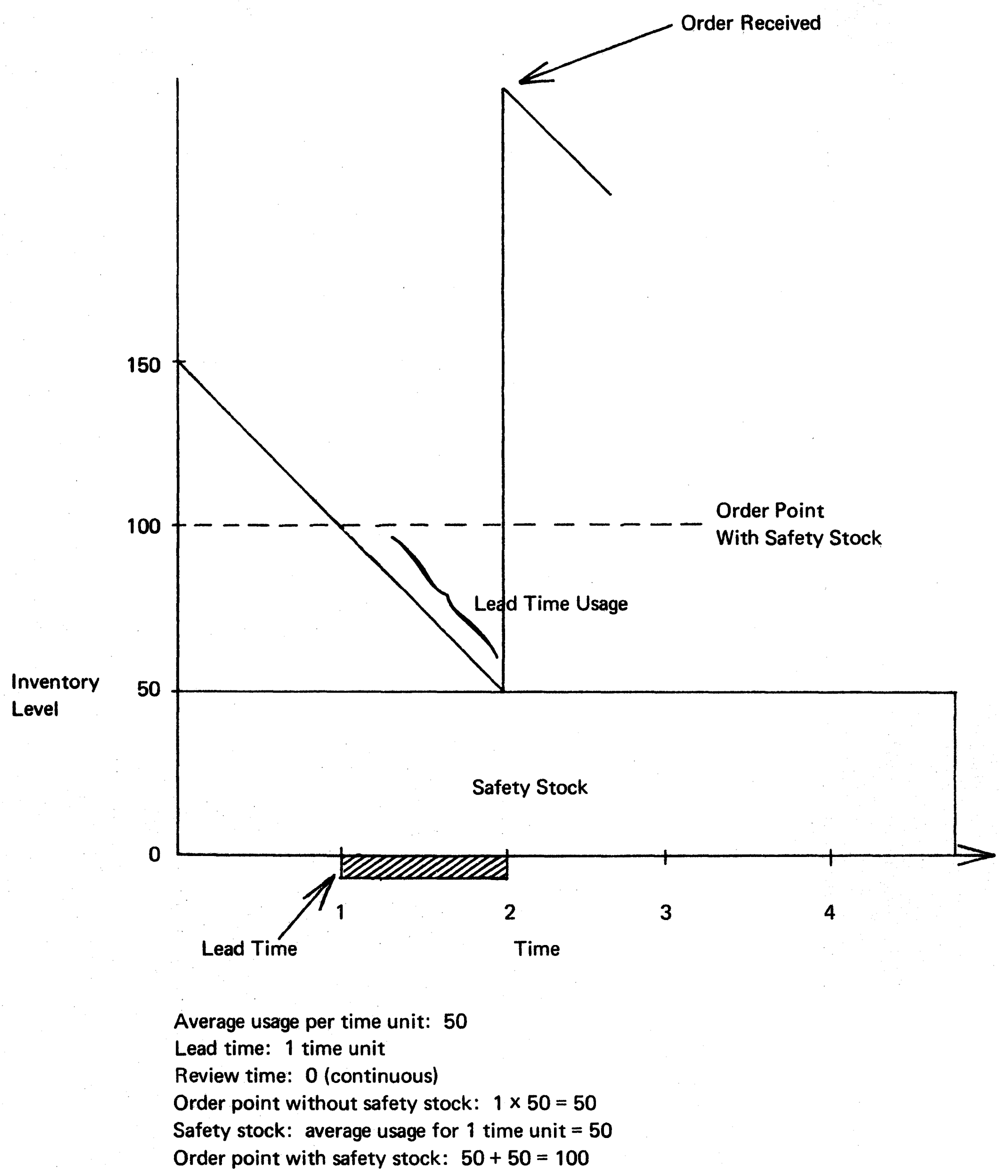


Figure 7. Inventory behavior with safety stock

Safety stock can be calculated in several ways. These vary from simply specifying an amount of time to be multiplied by demand (for example, one month's supply) to statistical methods using mean absolute deviation (MAD) and safety factors. These methods are discussed below.

The order point formula, expanded to include safety stock, is as follows:

Order point = (Lead time + Review time) x Average demand + Safety stock

The inventory control package supplies several options for calculating safety stock:

1. A fixed quantity which the user assigns

2. An amount of time which will be multiplied by the average demand per unit of time. (Note: In the ABC analysis, the safety stock equaled two months' supply; therefore, the safety stock equaled 1/6 of $3,000,000 or $500,000.)

3. A percentage of average demand expected during the lead time

4. A percentage of the order cycles for which the user does not want to have stockouts occur (order service)

5. The unit service desired

Methods 4 and 5 use techniques that take advantage of statistical concepts that permit the user to base safety stock upon a measure of projection (or forecast) error.

The measure of error used is mean absolute deviation. Deviation is simply the difference between each period's actual demand and the average. Absolute indicates that all deviations are considered positive. Mean is another term for average of the absolute deviations. For example, if the average demand were 100, and the actual demands were 110, 90, 112, 88, MAD would be 11 [(10+10+12+12)/4].

MAD can be used to determine how accurately the average demand has projected usage. This can be expressed in percentages based upon a normal distribution curve, which is illustrated in Figure 8. The relationship between MAD and normal statistical standard deviation may be expressed as follows: Standard deviation = 1.25 x MAD. A table of safety factors can be constructed based upon this relationship (see Figure 9). This provides an estimate of how well the average demand will project future usage. If, for example, the average demand of an item is 100, and the MAD is 10, the following probabilities exist:

Usage in next period not greater than	Probability (expressed as a percentage)
100	50 (average demand)
110	78.8 (average demand + 1 MAD)
120	94.5 (average demand + 2 MAD)
130	99.2 (average demand + 3 MAD)

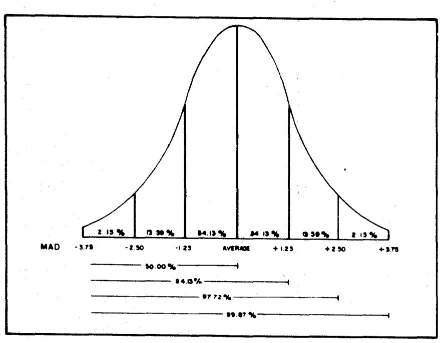


Figure 8. Area relationships under the normal curve - mean absolute deviation (MAD)

Safety Factor	% of Order Cycles with No Stockout
0.00	50.00
1.00	78.81
1.25	84.13
1.60	90.00
2.00	94.52
2.50	97.72
3.00	99.18
3.75	99.87

Figure 9. Safety factors for service levels using MAD (service based on frequency of stockout)

MAD can be used to calculate safety stock. It is usually multiplied by a safety factor which is related to the percentages stated above. For items where the MAD is small, safety stock will be small, and where the MAD is large, safety stock will be large. Assume two items (A + B) have an average demand of 100 units; however, the MAD for item A is 10, and the MAD for item B is 30. If the safety factor is 2.50, item A will have a safety stock of 25 units (2.50 x 10), while item B will have a safety stock of 75 units (2.50 x 30).

Up to this point, it was assumed that the lead time for an item and the length of time for average demand and MAD were the same. Normally, lead time is not the same as the projection interval (time period for average demand), and MAD must be adjusted to reflect the difference. This is done by a mathematical formula which is part of the package. From now on it is assumed that MAD has been adjusted to conform to lead time.

Using this quantity (MAD or MAD multiplied by a factor) for safety stock, we can be reasonably sure that no stockout will occur during the replenishment lead time for a specific percentage of the orders. Figure 9 illustrates several safety factors and the corresponding percentage of order cycles with no stockout.

If the user's input to the program indicates that a safety factor of 2.50 should be multiplied by MAD to determine safety stock, he can expect that about 98% (97.72) of the replenishment orders for that item will arrive before a stockout. This percentage is referred to as service level, which in this case is based upon the frequency of stockouts.

This level of service is an estimate of how frequently stockouts will occur, and not an estimate of the quantity or size of unfilled orders. The expected frequency of stockout is related to the frequency of replenishment orders. That is, if 100 orders were placed for a particular item, it is probable that 98 of them would be received without a stockout occurring. If this item were ordered once a year, stockouts would occur in only two years out of 100. If the item were ordered weekly, a stockout would occur about once a year.

Service levels are usually set for each inventory item on the basis of the number of stockouts that can be tolerated when this measure of service is used. If, for example, service were specified as "one stockout per year", an item that was reordered ten times per year would have a service percentage of 9/10 or 90%; while an item that was reordered five times per year would have a service percentage of 4/5 or 80%, meaning that a stockout would be tolerated during one of the five reorder cycles. The service percentage is then used with the table in

Figure 9. A service percentage of 90, for example, would require 1.6 MAD's as safety stock.

With this measure of service it is possible to:

1. Establish the service level policy in terms of the number of stockouts per year that can be tolerated

2. Divide the order quantity into annual usage to determine the number of reorder cycles

3. Calculate the percentage of reorder cycles that should <u>not</u> have stockouts and use this percentage to determine the proper safety factor.

When using this measure of service, the program accepts the service level stated as a percentage or as the number of stockouts per year. If number of stockouts is used, the percentage is automatically calculated on the basis of information stored on the item master record.

Another measure of service can be used which allows the user to satisfy a specified percentage of unit demand. This measure of service addresses itself to filling a given percentage of demand from the shelf. For example if we received orders totaling 100 pieces, and we could supply 99, then our unit service would be 99%. This is accomplished by considering the relationship between order quantity and projection error when determining the safety factor to be used for safety stock. Each item will have its own safety factor.

The program determines the appropriate value (safety factor) using the table in Figure 10 and the following formula:

$$\text{Service function} = \frac{\text{Order quantity}}{\text{MAD for lead time}} \times (1 - \text{desired service level per.})$$

Service function is an intermediate value which, when compared to the table in Figure 10, indicates the safety factor to be used.

Safety Factor	Service Function
0.0	.4998
0.2	.4062
0.4	.3252
0.6	.2561
0.8	.1985
1.0	.1510
1.2	.1131
1.4	.0829
1.6	.0600
1.8	.0425
2.0	.0294
2.2	.0199
2.4	.0134
2.6	.0088
2.8	.0056
3.0	.0035
3.2	.0023
3.4	.0015
3.6	.0009
3.8	.0005
4.0	.0004

Figure 10. Service function for the normal distribution of forecast errors

The order quantity and MAD interact to affect the percentage of demand filled routinely. If order quantity is large in relation to the error, the order quantity alone provides protection for some time after goods are received. This is illustrated in Figure 11, where item A has a larger order quantity in terms of time supply than does item B. Taking this into account will yield a lower safety factor for item A than for item B, while satisfying the same percentage of demand for both items.

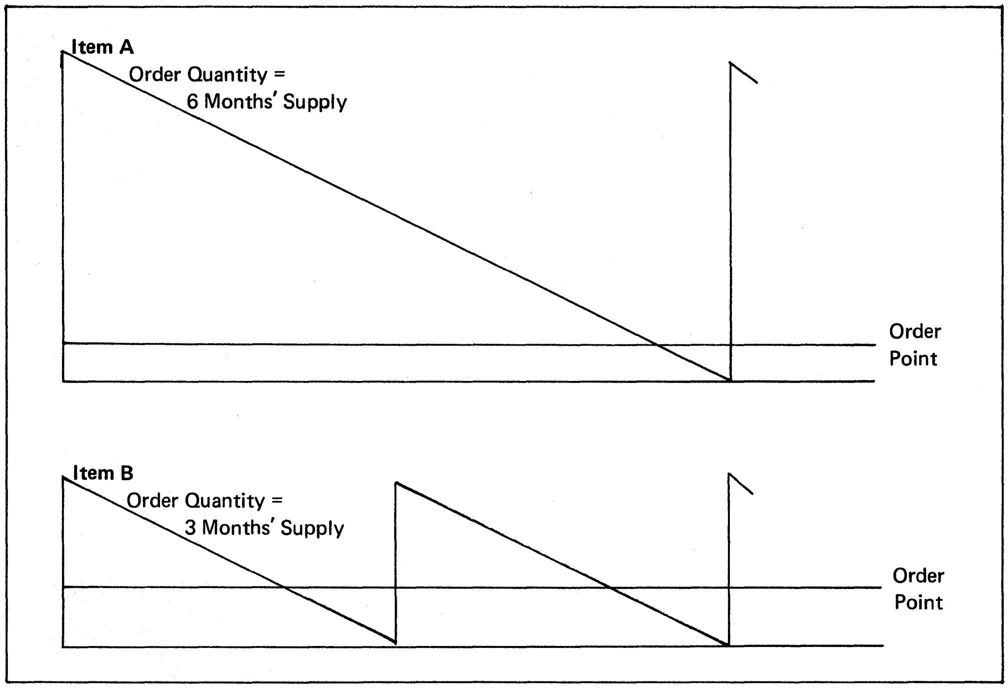


Figure 11. Exposure to stockout of items with different order quantities

Examples:

Item A

Order Quantity: 600 (annual usage is 1200, so this represents a six-month supply)

MAD of projection error during lead time: 75

Desired service: 95%

Service function: $\frac{600}{75}(1-.95) = .4$

From Figure 10, safety factor for service function of .4 = .2

Item B

Order quantity: 300 (annual usage is 1,200, so this represents a three-month supply)

MAD of projection error during lead time: 75

Desired service: 95%

Service function: $\frac{300}{75}(1-.95) = .2$

From Figure 10, safety factor for service function of .2 = .8

Note that the safety factor for this measure of unit service is lower than when based on frequency of stockout (order service). In aiming to satisfy a given percentage of demand, emphasis is not placed on determining how frequently a stockout will occur, or on how large any particular stockout will be. What is being specified is that over a length of time some desired percentage of demand will be filled from goods on the shelf.

OTHER FEATURES

The order point program can also furnish an index value useful for estimating when an item should reach order point. The program subtracts the order point quantity from the available quantity. If the difference is minus or zero, the item has reached the order point, and the index is set to zero. If the difference is plus, it is divided by average demand to provide an estimate of how many time periods of supply exist over the order point. This routine is especially applicable to fixed review periods normally encountered in warehouse replenishment. It could also be used to determine what to order for a family of items. That is, for groups of items, it may be more economical to order several items within the group at one time. This may be caused by vendor restrictions or because of setup in the plant. There may be a high cost associated with setup of a particular machine that can be utilized for other items in the family by making slight modifications.

In this way, the large setup cost can be distributed to many parts rather than to one or two. The user can process these items separately to obtain a report to aid in formulating ordering judgments. For example, assume there are 30 items in a particular family, and four of these have reached order point. If this number of orders is not economical, additional items can be selected using the index value. Items that have a value between 0.1 and 0.9 should reach order point during the next time interval, while those with values between 1.0 and 1.9 have an additional time period of supply. This progresses to the maximum value of 9.9.

The order point report is illustrated at the end of this section. It lists each item number and description, with codes for model type (M), order point calculation (O), and value classification (V). In addition, the safety factor, lead time, average demand, safety stock, order point, MAD, on hand, available stock, and index value are included.

The analysis for implementation feature of this module permits the user to analyze what might happen when different safety stock formulas or level of service values are used. This is accomplished by contrasting certain aspects of the existing technique to the aspects of the proposed technique.

If a user is currently calculating safety stock on the basis of two months' supply, and he would like to use one of the statistical methods, it would be advantageous to know the value of the safety stock for both methods. The program calculates the new safety stock and multiplies it and the old safety stock by unit cost. Separate totals are accumulated to determine the total value of each. Figure 12 illustrates this technique. The example uses the 400 items (high annual usage value) from the inventory analysis. This report compares the safety stock value for "two-month supply" to "98% unit service" technique. In this example, the safety stock is reduced from $400,500 to $52,900.

This feature can also be used to provide alternate plans and values so that management can select the plan to implement. If a user would like to implement safety stock on the basis of level of service, a logical question would be, "How much will this cost?" The answer can be provided by processing the order point items (or a selected sample) several times.

Each time, a different percentage of service is used. The value of the safety stock is accumulated and recorded for the different percentages, which can be contrasted to the present values. When the program is used in this way, the file is not changed.

SUMMARY

When a replenishment order is issued, uncertainty always exists about usage during the interval before receipt. Order point is set to allow for this uncertainty. If order point is based on average demand alone, stockouts can be anticipated during about half the replenishment cycles. To get better service requires raising order point by adding safety stock. Safety stock can be a specified quantity, a specified amount of time to be multiplied by average demand, or a percentage factor that is applied to lead time and multiplied by average demand. In addition, statistical concepts make it possible to find a safety factor which will yield a specified level of service. Two measures of service have been presented:

1. Frequency of stockout, without regard to size or number of unfilled orders (order service). The safety factor is taken directly from the normal curve table using service percentage or a calculated service percentage of reorder cycles in which no stockout is desired.

2. Size of stockout, without regard to frequency (unit service). This measure of service aims at filling a given percentage of demand from the shelf. The relationship between order quantity and projection error is considered in setting the safety factor.

The program requires the user to identify the items that are classified as order point items, as well as the method to be used for safety stock calculation. This may be accomplished by placing codes on the item master record, parameter cards, or specific input cards for an item.

The user must furnish the factors (that is, level of service, safety stock time, percentage of lead time, review time, and lead time) that are used in the program. MAD and average demand are calculated in the projection phase and are stored on the item master record.

The order point program is normally run at the end of each time period for which average usage is calculated. The usual inputs are parameter card, item master record, and base indices for seasonal items (if not stored on the item master). Item cards are used for processing only certain items or for overriding information on the item master file (see Figure 13).

ORDER POINT REPORT — I C MANUFACTURING COMPANY — XX/XX/XX PAGE XXX

ITEM NUMBER	DESCRIPTION	CODES N-O-V	SFTY FACT	LEAD TIME	AVERAGE DEMAND	SAFETY STOCK	ORDER POINT	MAD	ON HAND	AVAIL STOCK	INDEX VAL
E-1856279	PUMP FILTER UNIT	H E A	98	3	407.0	164	1,385	82.2	1,832	1,832	1.1

ORDER POINT ANALYSIS — I C MANUFACTURING COMPANY — XX/XX/XX

NUMBER OF ITEMS		400
NUMBER OF VARIANCE CHECKS		383
NUMBER OF ORDER CARDS		
NUMBER OF ITEMS ZERO ON HAND		9
EVALUATION ORDER QUANTITY	$	801,344
EVALUATION SAFETY STOCK OLD	$	400,500
EVALUATION SAFETY STOCK NEW	$	52,900
EVALUATION ON HAND	$	803,962

Figure 12. Order point reports

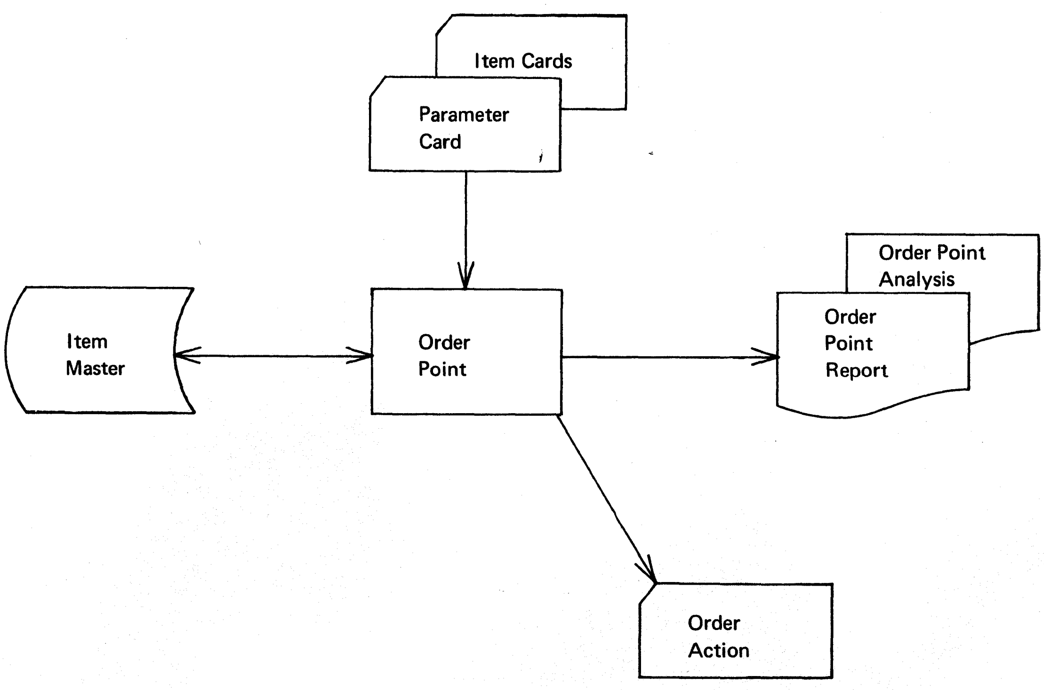


Figure 13. General system chart – order point

ORDER POINT SUMMARY CHART			
Input	Routines	Item Master File	Output
Parameter card Item cards The input cards contain such information as override data (for example, level of service, safety stock), option codes, etc.	Usage through lead time Safety stock Order point	Item number Item description Order policy code Order point calculation code Order point recommendation data code Safety stock Order point Model type First average Second average Average demand Trend Base Indices Mean absolute deviation Safety factor Lead time On-hand quantity On-order quantity	Updated item master Order point report Order point analysis Order action cards

An output report is prepared which indicates the results of these calculations. Codes are printed to highlight various conditions. A variance code indicates that the new order point has increased or decreased by a specified percentage. If the new order point is raised above available stock, order action is indicated by punching a card, which can be used for reentry into the system when the order is placed.

The item master file is updated by this program to reflect the new order points, which become the basis for order action in subsequent programs (execution phase).

ORDER QUANTITY

Determining how many of an item to order is one of the most significant aspects of inventory control management. The quantities in which items are manufactured or purchased have a direct relationship to the average level of inventory.

The formula for determining average inventory level where usage is relatively constant is:

$$\text{Average inventory} = \frac{\text{Order quantity}}{2} + \text{Safety stock}$$

Judgments regarding the size of the order quantity influence the number of dollars required for this investment. A company can realize substantial savings if significant reductions can be made to the inventory level. These reductions must not disrupt the operation of the plant nor should they be offset by a corresponding increase in other costs.

Figure 14 illustrates the relationship between inventory level and order quantity. The average inventory level for the item shown can be reduced from 600 units to 300 units by decreasing the order quantity from 900 units to 300 units. The item would have to be ordered more often, thus increasing the number of orders that must be processed and the number of times a production item must be set up in the shop.

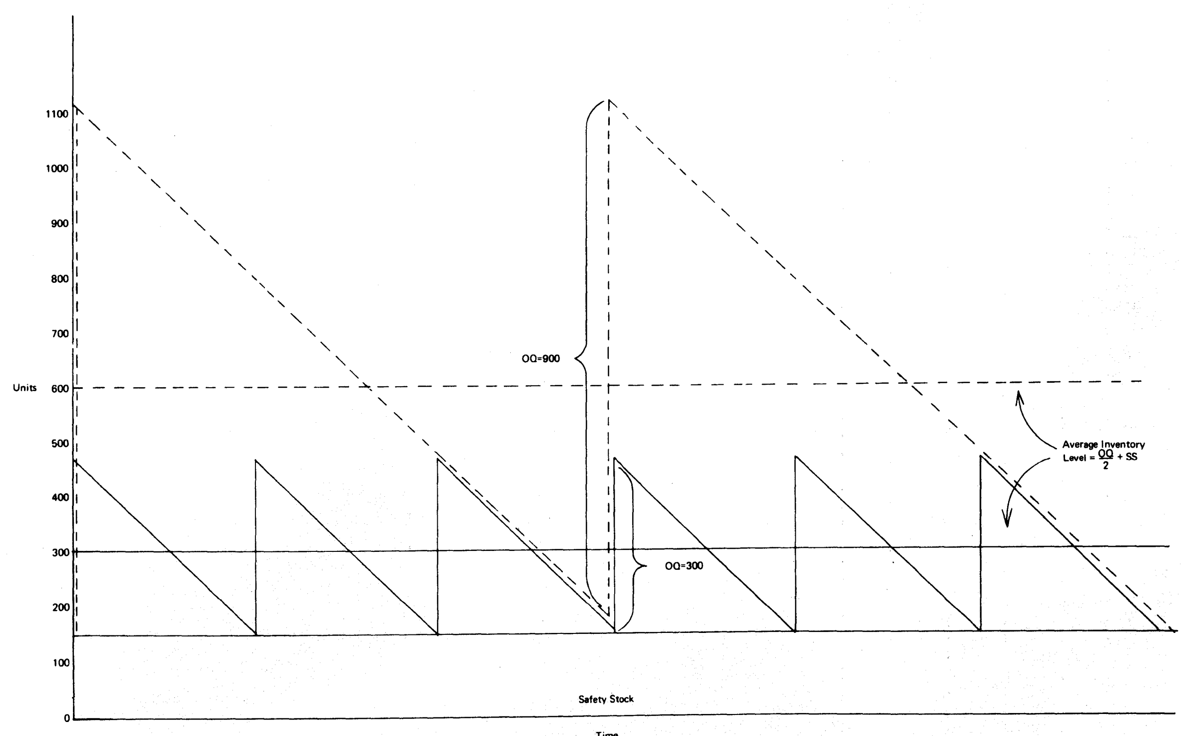


Figure 14. Order quantity and inventory level

STANDARD EOQ

The costs that go up as the lot size is decreased are those associated with the replenishment order. These include setup cost, order or paperwork cost, and some portion of the cost of expediting, scheduling, dispatching, etc. The costs that go down when the lot size is decreased are those associated with the higher level of inventory. These are usually described as inventory carrying costs and include the value of money tied up, storage cost, obsolescence, taxes, etc.

There should be an economic balance between the costs that increase and those that decrease as the order quantity varies. This determination is the principal task of economic order quantity calculations.

The standard economic order quantity (EOQ) formula can be used to balance these costs and calculate an order quantity for each item. Figure 15 illustrates graphically the concept of economic order quantity. The point at which the sum of the two lower curves reaches a minimum is the most economic order quantity. Normally, the total cost curve is flat in the area of the minimum. This fact allows some flexibility in rounding of order quantities to more convenient numbers.

The standard EOQ formula used by the program is:

$$Q + \sqrt{\frac{2AS}{I}}$$

Where:

Q = Order quantity or lot size

A = Cost of setup and order writing in dollars

S = Annual usage

I = Cost of holding one unit in stock one year
(unit cost x carrying rate)

Use of the formula implies certain assumptions:

1. The most significant costs in the purchasing decision are acquisition costs and maintenance costs.

2. The cost of an order is constant regardless of the number of orders.

3. The per unit cost of carrying an additional unit in inventory is constant regardless of the number of units in inventory.

4. The whole order quantity arrives at one time (no partial shipments).

5. Demand is known and constant.

6. The incremental cost of an additional unit in a single purchase is constant - that is, there is no automatic program handling of quantity discounts.

7. The purchasing decisions made for one item have no effect on the purchasing decisions for other items.

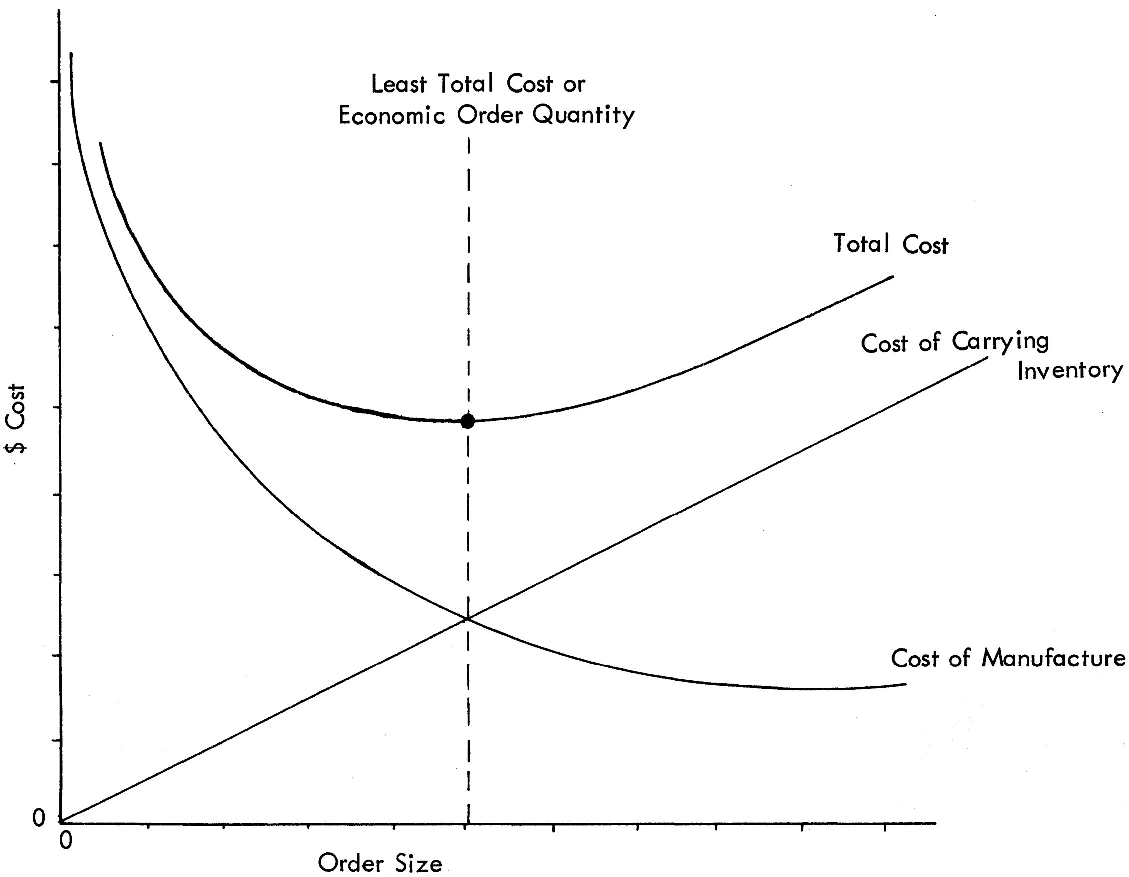


Figure 15. Economic order quantity

The calculation is relatively easy and the results can be obtained quickly. The factors used in the formula may be more difficult to ascertain. However, these factors are real - that is, there is a cost of carrying inventory and a cost associated with processing an order and each user must determine these values. They should be as realistic as possible in order to derive the most economical order quantities.

In some cases there may be other conditions that influence the lot size. For example, the physical size of an item relative to storage space, or the amount of time required on a specific machine may restrict the number of items to be produced at one time. Storage and/or packing requirements or the material from which the item is produced may require the lot to be made in specific increments.

The program has provided for minimum, maximum, and multiple quantities for each item. On an optional basis, the order quantity is checked to ensure that it is within the range of minimum and maximum lot size and that it has been rounded to the nearest multiple.

TIME PERIODS OF SUPPLY

The program provides another method for calculating order quantity on the basis of average usage. This enables the user to specify an amount of time to be used for determining order quantity (for example, three months' supply). The user supplies the number of time periods to be used for one or more items by placing the category code* on the inventory record. The program uses this information and the latest average to calculate order quantity. The number of time periods can be different for each category code. Note that this type of ordering policy was used in the ABC analysis example.

The economics of this technique depend upon the user's judgment regarding the cost of the item, its related carrying expense, and the setup cost. Other methods of calculation based upon future requirements are discussed later.

If a manufacturing company has not used some cost balancing formula for determining order quantities, many benefits can be derived by using this program. These benefits will probably be realized over a period rather than as a result of one calculation. It is very unlikely that a company would change the order quantities from the present values must the newly computed values in a short period.

ANALYSIS FOR IMPLEMENTATION

Many questions must be resolved before implementing economic order quantity calculations: What is the value of the savings that can be attained? Where are we now, and how can we realize these savings? What will happen to the number of orders that have to be issued? Are there items or groups of items that will provide substantial savings? Can we analyze what might happen before changing the quantities? If so, what action can be taken to reduce or eliminate undesirable aspects (for example, excessive setup requirements for a particular group of machines)?

The order quantity program provides an analysis for implementation report to help answer these questions.

Basically, this report enables the user to experiment with the various aspects of economic order quantity calculations for all, or a selected portion, of the inventory file. The program provides for contrasting the present order quantities with the newly calculated order quantities. For example, assume a user has performed an ABC analysis of the inventory and has divided it into several groups. Codes have been placed on the inventory records to identify the group to which each item belongs. The user would like to analyze the high-value items represented by a particular code.

He would like to know the difference in inventory level for these items if the lot sizes were changed to the order quantities calculated by the EOQ formula. In addition, it would be desirable to highlight the items where the difference is significant. Using a parameter card, the program processes this request. It locates each inventory record and calculates the order quantity on the basis of the input parameters for cost of carrying inventory and order cost. The item information

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*See "Analysis for Inplementation"

required in the formula is stored on each inventory record. The dollar values of the old and the new inventory levels (as determined by the order quantity) are computed and printed for each item and summarized by order quantity category code, and in total, for the entire run. Each item is checked to determine whether the difference in inventory level is such that the item should be highlighted on the output report. The totals would be useful to evaluate the effect that the new order quantities would have on inventory value.

During the same computer run, it is possible to determine the number of orders and the total setup cost per year for each item and to accumulate these figures for both order quantities. This information is useful in determining the effect the order quantities have on setup and order or paperwork costs.

At another time, the user may wish to determine what might happen to the load at a specific work center. He may wish to stay within certain limits regarding a factor related to the number of orders, for example, setup hours.

This can be accomplished by identifying the items so that the system can locate the specific inventory records and calculate order quantity. In this case, the setup hours would be multiplied by the number of orders per year to ascertain the total setup hours for the old and the new order quantities. The results can be used to determine what, if any, changes should be made to the new order quantities in order to keep the setup hours within this limit. Such changes can easily be made by adjusting the parameter for cost of carrying inventory. The new quantities would be calculated and placed on the inventory record.

This kind of analysis is very useful before changing order quantities. The program provides for variations in processing inventory records and performing calculations. The program can process all items in the inventory file or a portion of the file. Two methods are provided for determining which items to process. A code in the item master record, or input with item identification, can be used to select the items to be calculated.

The program has provision for using different ordering costs and carrying rates during the same calculation. This is based upon an order quantity category code stored on the item record. For example, code 1 uses the first ordering cost and carrying rate, while code 2 uses the second, etc. In this way, the user can take advantage of using different rates and ordering costs for items without storing this data on the item master record. This also makes it very easy to change these factors for experimentation purposes or in the process of evolving to the desired value of these factors. The setup cost, unit cost, and usage information for each item are stored on the item master record.

The program calculates the number of orders per year and multiplies this by a factor (for example, setup hours). This is done for two order quantities (existing and new), and the totals are accumulated for all items.

The order quantity is multiplied by a factor (for example, unit cost) to contrast the present to the new order quantities relative to the value of the inventory level. For some items, it may be desirable to substitute run time per unit, or a storage or space factor, for unit cost. Exits are included so that each user can insert his unique calculations to develop the factors to be multiplied by order quantity and number of orders.

In addition to the above, the carrying cost implicit for the present order quantities is calculated and printed as an optional feature. This can be used to identify items the user should examine closely to ascertain why the present order quantity is out of balance with management's policy on the cost of carrying inventory.

The analysis for implementation feature can be used with other formulas that calculate order quantity on the basis of average demand. The interface is provided by exits to user-written routines, which, in turn, make the newly computed order quantity available to the analysis routines. For example, the user may wish to write a routine that uses a modified EOQ formula that considers orders where the entire quantity does not go into inventory immediately. In this case, the inventory does not increase by the full amount of the lot size at one time. It increases according to the production and usage rates of the item.

BALANCING TECHNIQUE

Up to this point, the calculation of order quantity has been based on an average of past usage. Other methods offer advantages when future requirements are known or when they can be estimated. These methods are preferable for items where usage is expected to vary from period to period, as in the case of seasonal items. The two methods to be discussed (balancing technique and unit cost technique) balance order cost against carrying cost for the specific requirements rather than for averages.

Each item record is examined to determine the requirements by time. These requirements may be a result of exploding the bill of material for higher-level assemblies or simply an indication that the item is trend, seasonal, or trend-seasonal, and the program should estimate the future requirements.

On the basis of the order cost and the cost of carrying inventory for time periods, judgments are made to determine how the future requirements should be grouped for orders. The program accumulates the cost of carrying inventory and checks this total against setup and order costs. The lot size is determined when the cost of carrying inventory becomes equal to or larger than the fixed order cost.

As an example, assume the requirements for time periods 1 to 5 are 50, 60, 70, 80, 70, respectively. The unit cost of the item is $10.00, the order cost is $60.00, and the carrying rate is 2% per time period.

The program calculates the cost of carrying inventory by multiplying the quantity by the unit cost, carrying rate, and the number of time periods the quantity would be carried. The accumulation of this cost is compared against $60.00 to determine the period for the next setup. The setup should be made in the period in which the carrying cost exceeds the fixed order cost. The summary of this calculation is listed below. It indicates that the order quantity should be 180 (50+60+70) and the next setup should be in the fourth period.

Per.	Qty	Qty x U.C. x C.R. x Time	Total
1	50	(no carrying cost)	0
2	60	60x10x.02x1=12.00	12.00
3	70	70x10x.02x2=28.00	40.00
4	80	80x10x.02x3=48.00	88.00
5	70		

The program then computes the next order quantity starting with the requirement in period 4.

UNIT COST TECHNIQUE

This technique can be described as a least unit cost approach in that it calculates the combined ordering cost and carrying cost per unit, and selects the order quantity that produces the lowest unit cost. The technique is used to determine how the requirements for the time periods are to be combined for orders.

The program calculates the unit cost for the first period's requirements as if they were to be produced separately. Next, the program calculates the unit cost for the item with the second requirement combined with the first. The unit costs are compared, and if the second is lower, the program calculates the unit cost of an order that includes the next requirement. This process is continued until the least unit cost is reached (the point where the next requirement causes the unit cost to increase).

The following example illustrates how the order quantity is selected. The requirements are 50, 60, 70, 80, and 70, respectively, for the first five periods. Assuming the order cost to be $60.00, the cost of the item to be $10.00, and the inventory carrying rate to be 2% per period, the calculation for the first requirement (50) is as follows:

$$\text{Unit cost} = \frac{\text{Order cost + Carrying cost}}{\text{Quantity}} = \frac{60.00}{50} = 1.20$$

When the second requirement (60) is combined with the first (50), for an order quantity of 110, the unit cost decreases.

$$\text{Unit cost} = \frac{\text{Order cost + Carrying cost}}{\text{Quantity}}$$

$$\text{Unit cost} = \frac{60.00+(1x60x10x.02)}{110} = .654$$

When this procedure is repeated for the third period's requirements (70) for an order quantity of 180 (50+60+70), the unit cost is .656.

$$\text{Unit cost} = \frac{\text{Order cost + Carrying cost}}{\text{Quantity}}$$

$$\text{Unit cost} = \frac{60.00+(1x60x10x.02)+(2x70x10x.02)}{180} = .555$$

When the next requirement (80) is considered, the unit cost rises. The recommended order quantity to be run in period 1 is 180.

$$\text{Unit cost} = \frac{\text{Order cost + carrying cost}}{\text{Quantity}}$$

$$\text{Unit cost} = \frac{60.00+(1x60x10x.02)+(2x70x10x.02)+(3x80x10x.02)}{260} = .569$$

Figure 16 contains a summary of these calculations.

Period	1	2	3	4	5
Requirements	50	60	70	80	70

Calculation No.	Order Qty.	Unit Cost	Future Requirements			
1	50	1.200	60	70	80	70
2	50+60	.654	0	70	80	70
3	50+60+70	.555	0	0	80	70
4	50+60+70+80	.569	0	0	0	70

Figure 16. Least unit cost order quantity

The next order quantity would be calculated starting with the fourth period (based on the assumption that 180 would be produced in the first period).

SUMMARY

The program has provision for calculating order quantities four ways:

1. Standard or classical EOQ formula

2. Time periods of supply

3. Balancing technique

4. Least unit cost

A user exit is included for other methods of calculation. Methods 1 and 2 above are based on an average of past usage, while methods 3 and 4 utilize future requirements. If specified, methods 3 and 4 can also be used for items classified as trend, seasonal, or trend-seasonal.

The category code enables the user to specify many combinations of order cost and carrying rate without placing this information on the item master file. The carrying rate field is used for periods of supply when this type of calculation is specified. The category code is advantageous for making changes to these values to gradually bring them in line with management's ordering policy.

The frequency of running the order quantity programs depends upon each user's requirements. Normally, the items considered as having a fixed order quantity would be processed once or twice a year. This is true if the order quantities reflect the policy of management. If the quantities are not considered economical, the program and its analysis for implementation feature can be used again and again over a period to help ensure an orderly transition to the desired quantities.

The analysis for implementation feature used with methods 1 and 2 above encourages the user to evaluate the changes before implementing them. The evaluation provides a logical plan for obtaining the economical benefits of order quantity calculations without disrupting the day-to-day operation of the plant.

The program can accommodate a variety of options regarding the items to be processed. The parameter card and item cards are used for this purpose (see Figure 18).

This above input information, in conjunction with the item master file, is used for order quantity calculation.

Output consists of the order quantity report and the analysis for implementation summary. The item master record can be updated on an optional basis.

Figure 17 illustrates order quantity report and analysis, which is used for the inventory items discussed in the inventory analysis section of this manual. This report summarizes the new order policy for three categories of inventory. In this example, the method of order quantity calculation is based on number of time periods.

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ITEM NUMBER	DESCRIPTION	ORD QTY	$ VALUE	ORDERS	AND COST	ON HAND	UNIT COST	USAGE/YEAR	CL	CD
A1976520	FILTER ASSEMBLY	600	4,110	8.0	416	1,125	6.850	4,800	A	A
	OLD -	1,500	10,275	3.2	166					

ORDER QUANTITY ANALYSIS I C MANUFACTURING COMPANY XX/XX/XX

CODE	ITEMS	NEW---ORD QTY VALUE	---OLD	NEW-NO ORDERS	-OLD	NEW---SETUP COST	---OLD	ON HAND-VALUE	-ON ORDER
A	400	300,413	801,344	3,200	1,200	76,292	28,901	799,104	210,250
B	600	150,412	150,611	1,800	1,800	35,400	35,600	153,095	37,908
C	1,000	150,975	50,045	1,000	3,000	17,010	51,483	54,800	11,408
	2,000	601,800	1,002,000	6,000	6,000	128,702	115,984	1,007,000	259,566

Figure 17. Order quantity reports

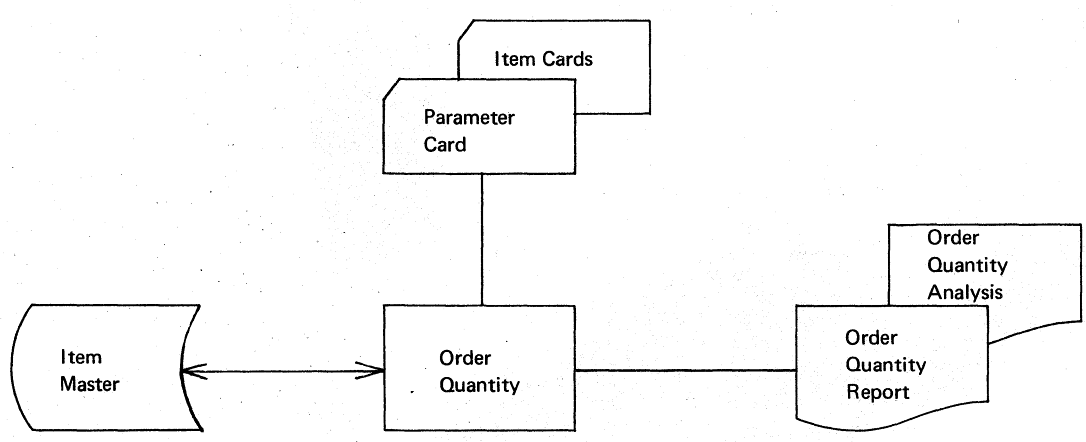

Figure 18. General system chart – order quantity

ORDER QUANTITY SUMMARY CHART			
Input	Routines	Item Master File	Output
Parameter cards	Standard EOQ	Item number	Updated item master
Item cards	Time periods of supply	Description	Order quantity report
The input cards contains such information as override data (for example, order cost, cost of carrying inventory), option codes, etc.	Analysis for implementation	Order quantity	Order quantity analysis
	Balancing technique	Setup cost	
	Least unit cost	Order quantity category code	
		Unit cost	
		Minimum	
		Maximum	
		Multiple	
		Gross requirements	
		Number of periods — Issues	
		Issues quantity	
		On-hand quantity	
		On-order quantity	

PROJECTION

A question often asked in a manufacturing organization is "How many of what items must we manufacture?" If too few of a given item are produced, orders may be lost. If too many are made, money may be wasted. The same is true if a desired item is not produced and vice versa. A manufacturing plan based on expected product demand must be established to resolve this question. In addition, a technique for estimating demand is essential for determining usage through lead time for order point items.

There are two basic methods of anticipating demand: prediction and projection. Prediction is an educated guess and involves no formalized use of numerical data. Projection, or forecasting, implies some manipulation of numerical data.

The role of projection is to analyze historical data about the demand process and project for a desired planning period (for example, lead time of an item, a season or a year).

Output of the projection programs can be combined with other information available to the planner such as economic trends, competition, market trends, etc., to yield a solid foundation for the plan.

While a computer projection by itself may not be completely sufficient for planning purposes, the man-machine cooperation achieved by such an approach takes advantage of the capabilities of both the planner and the computer.

The projection programs are designed to assist in the planning function. They also furnish the latest average and a measure (MAD) of how accurate the average is expected to be relative to estimating future demand, the latter being useful for safety stock and order point computations.

The projection programs use a technique known as exponential smoothing. Stated simply, smoothing is a technique comparable to finding an average of historical data and, as the data for each new period becomes available, developing a new average of the old and new data. The old average and the new period data are weighted in such a manner as to give relative importance to the old average, depending on the desires of the individual. The formal expression used is as follows: New average = Old average + α (New demand-Old average), where the alpha factor (α) is the weight assigned to the new data. The factor determines the relative weight to be given to old and new data.

The conventional moving average technique requires that several periods of the most recent data should always be maintained on the file. The smoothing approach requires only that the old average should be carried forward each period. The term exponential smoothing derives from the fact that the new piece of data, when averaged with the old average, has less effect on the overall calculation as time progresses. If the effect that a piece of data has on the new average over a period were plotted, it would follow an exponential curve. This effect is illustrated in Figure 19 for an alpha factor of .1. The latest demand makes up 10% of the new average. One period later, its contribution is reduced to 9%, two periods later to 8.1%, and so on, until 20 periods later, when the contribution of the data is about 1%.

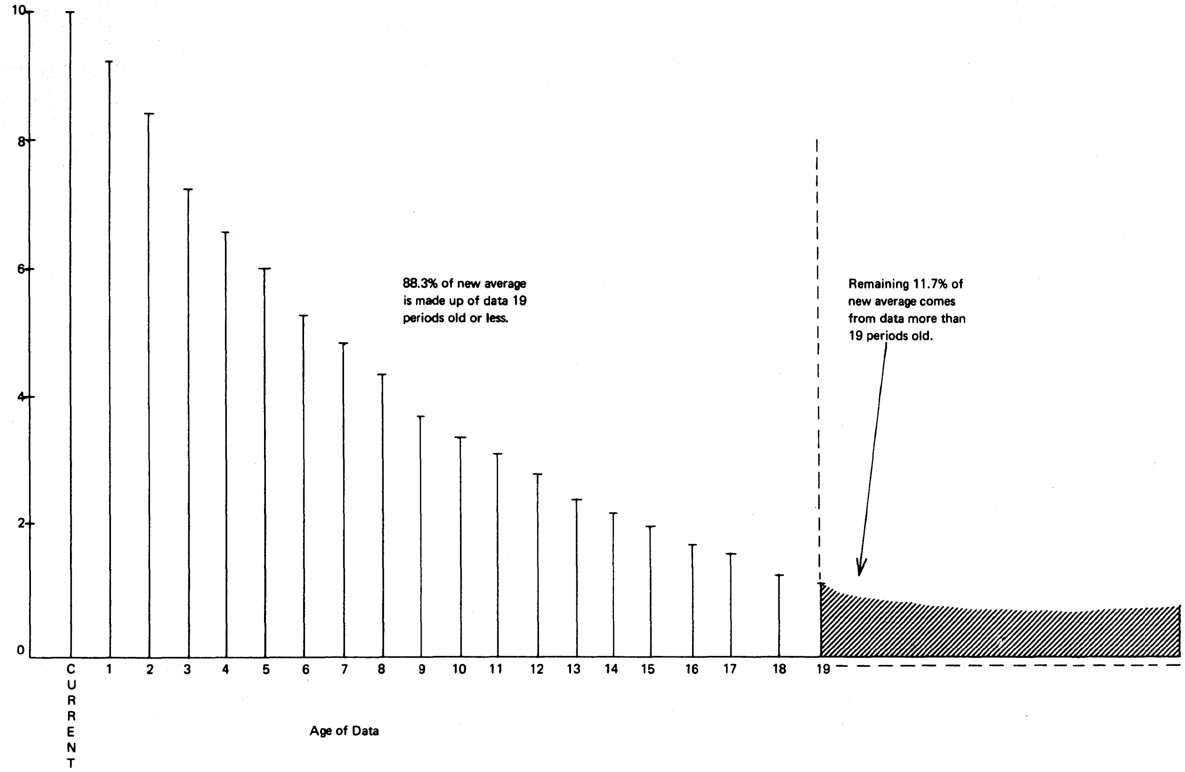

Figure 19. Weighting of data with smoothing constant = 0.1

The exponential smoothing technique, with variations, can be used to calculate the average(s) for several demand patterns. The projection programs provide for four demand patterns or models:

1. Horizontal (constant)

2. Trend

3. Seasonal

4. Trend-seasonal

These models are described below and are illustrated in Figure 20.

Horizontal Model. A representation of demand as centered around an average value, with variations which can be attributed only to random causes and which cannot be expected to occur in any consistent pattern. It is also called a constant or point model. The mathematical representation is a single number (first average) that may be determined by single exponential smoothing.

Trend Model. A representation of demand that consistently increases or decreases with the passage of time. It is also called a line, ramp, or slope model. The mathematical representation is two numbers (first average and second average), which are averages for different points in time so that the amount of change per time unit may be calculated and used to extend the line to the present or future. The projecting technique is double exponential smoothing, which is used to calculate and store the first and second averages of trend models.

Seasonal and Trend-Seasonal Models. A representation of demand that has high and low periods that recur as a function of time. These peaks or valleys should normally differ from the average by 30% to 50%. A further requirement is an identifiable reason for the swing, which leads to the conclusion that it is likely to recur; if not, there is no reason to select a model that will plan for the swing. The mathematical representation consists of the demand average(s) and base indices, which represent the average demand for the time intervals making up the cycle during previous years. Base indices are a series of factors used to adjust the demand for cyclic patterns; they are expressed as ratios of each time period's historic demand to the average demand for the item. The seasonal model may occur in conjunction with either a horizontal or trend model as illustrated in Figure 20.

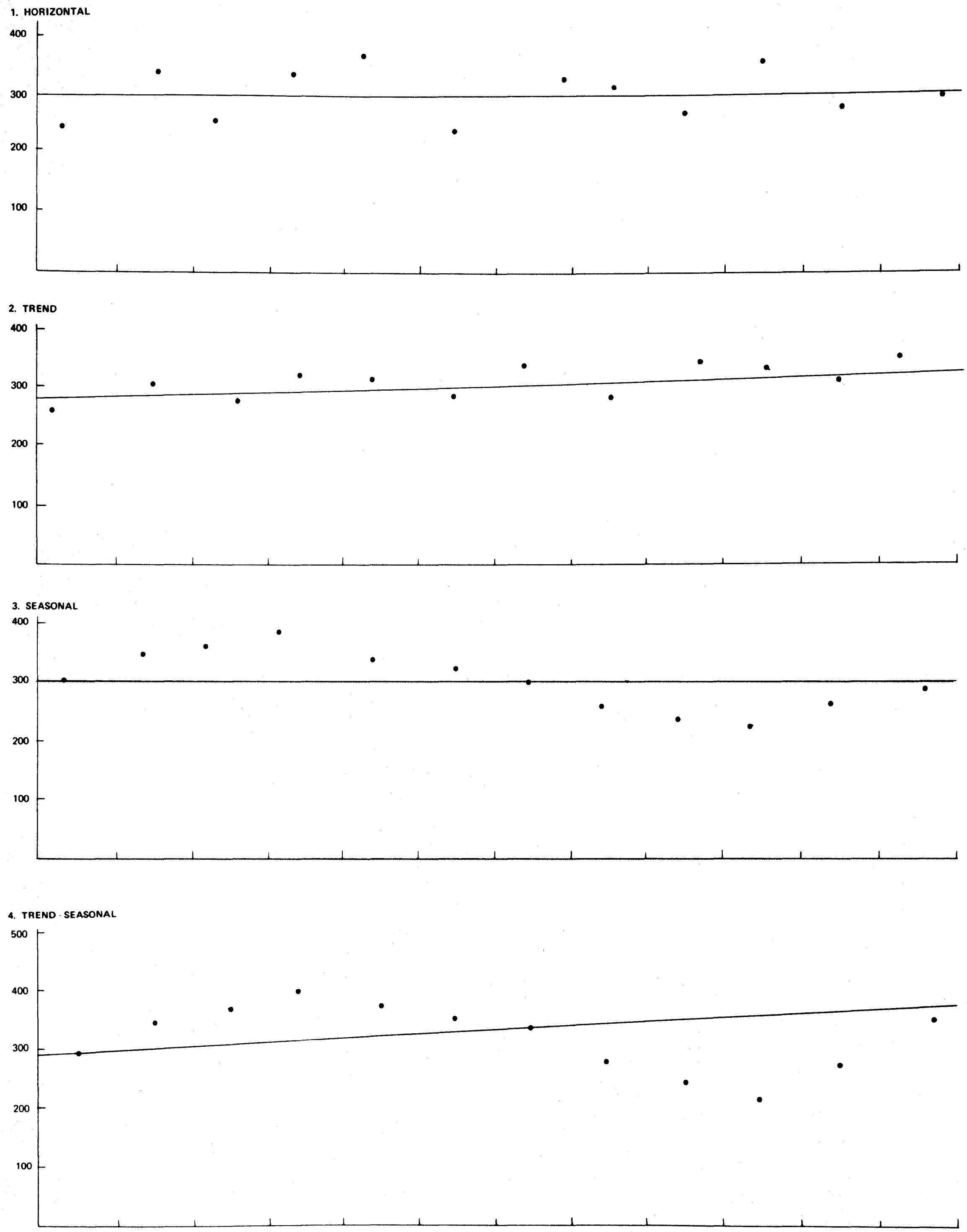

Figure 20. Four models for projection

Each model requires certain minimum information to be available. The fields are listed in Figure 21 with an indication as to which are required for each model. These values are initially computed by the model select program and stored on the item master record by the initial update program. They are kept up to date by the update and project program, which uses the latest demand, in conjunction with the existing values, to calculate the new values for these fields. The updated values can be used at any time to estimate future demand which reflects the latest information.

Fields	Horizontal	Trend	Seasonal	Trend-Seasonal
Model Type	H	T	S	Z
First Average	X	X	X	X
Second Average		X		X
Base Indices			X	X
Mean Absolute Deviation	X	X	X	X
Sum of the Deviations	X	X	X	X
Alpha	X	X	X	X

Figure 21. Data fields required by model

Two fields listed in Figure 21 will be briefly discussed before describing the programs. The mean absolute deviation (MAD) and the sum of the deviations are included for each model. They are computed by the update and project program and are used to determine the accuracy of the existing values (model type, first average, etc.) relative to the new demand that is made available each time period. Items can be highlighted for analysis outside the system when the new demand does not conform to existing patterns and values.

The mean absolute deviation is the average of the differences between expected demand and actual demand for each time period. The difference is always considered plus. The sum of the deviations is the algebraic sum of the differences.

The ratio of the numbers (sum of deviations ÷ MAD) is checked against an upper and a lower limit to determine whether the existing values are consistent with most recent demand(s). This ratio is usually referred to as the tracking signal, since it indicates how well the actual demand has been projected.

The projection programs can be divided into two broad categories: initialization and operational. The initialization programs are used to analyze historical demand data, select the model type, compute the initial values for data fields, and transfer this information to the item master record. The operational program keeps these values up to date and projects future demand on the basis of these values.

INITIALIZATION PROGRAMS

To select and implement the best projection plan, actual demand data has to be collected and analyzed. A set of initialization programs is provided to determine what patterns (if any) exist in past demand, and to compute the initial values that are stored on the item master record.

The programs can then be used as required to reinitialize an item to meet changing conditions. The initialization programs perform the following major functions:

1. Edit input to proper format

2. Select the projection model

3. Calculate initial values of factors used in single and double exponential smoothing

4. Calculate base indices for all seasonal items

The edit program is designed to convert the user's demand data file, which may be card, disk, or tape, to the format required for the model select program. The edit program performs the following functions:

1. Convert existing demand data to format required for model select program

2. Screen demand history for unusual variations

3. Combine up to 99 input demands to create a single output demand for a longer time interval

4. Calculate, if desired, annual dollar usage for each item and compare this with a user input for annual dollar usage

5. Print a listing by item of output data for visual examination by user

The model select program is designed to analyze past demand data for each item and determine which of four projection models (horizontal, trend, seasonal, or trend-seasonal) should be used for the best projection of future demand. The program then calculates and includes in the output the initializing values required for projecting with the model selected.

The model select program also performs the following functions:

1. Calculate the mean absolute deviation of the demand history

2. Calculate values for single or double smoothing of demand

3. Calculate base indices for seasonal items

4. Print output item detail

The initial update program uses the output of the model select program and moves the initial values to the item master record.

OPERATIONAL PROGRAM

The operational program, update and project, accepts the most recent demand and updates the item master record. The program also projects future demand on the basis of the information stored in the file.

The calculations for updating fields using the update and project program depend upon the type of model. Generally, the incoming demand is used to update the average(s), MAD, sum of the deviations, and base indices. For example, a horizontal item requires changes to the following fields: first average, MAD, and sum of the deviations. MAD and first average use the standard smoothing formula, while the sum of the deviations is an algebraic accumulation.

If the current demand were 330 and the first average were 300, the new first average would be 303 (alpha = .1).

New first average = Old first average + α (Demand - Old first average)
= 300 + .1 (330-300)
= 303

Using the same formula for MAD, the new value would be 21 if MAD were 20 before this period.

New MAD = Old MAD + α (Difference - Old MAD)
= 20 + .1(30-20)
= 21

The difference between demand and first average (330-300=30) is 30, which is exponentially smoothed with the existing value for the sum of the deviations.

The inventory record would be updated to reflect these changes. If the item were trend, seasonal or trend-seasonal, other fields would also be updated. Appendix 2 contains a summary of the calculations used in the projection programs.

The item information is ready for use in projection. The user can specify the number of time periods for which the projection is to be performed. In the case of a horizontal item the projection for the next time periods is the first average stored on the record.

For trend or seasonal items, the calculation is somewhat different. For trend items, the value of trend is computed for the time interval. This is added to each succeeding time period's projection. Therefore, the projection for the first time period is the average demand plus 1 multiplied by trend, while the projection for the second period is the average plus 2 multiplied by trend.

The average demand for the current time period is calculated on the basis of the first and second averages (Average demand = 2 x First average - Second average).

If the item were seasonal the average demand would be adjusted by the base indices that relate to the specific time periods into the future. The average is first adjusted for trend, if the item is coded as trend-seasonal.

Output from the update and project program consists of a projection report and updated item master records.

The update and project program also has the capability to calculate the new averages and project demand for all or specific items stored in the file. This can be done in various combinations on the basis of parameters made available to the program. For example, the user may wish to compute the new averages for all items, but project for only a portion of the file (for example, end items only).

At another time, the user may wish to project all end items (or perhaps only the high-value items as determined by a code in the master record) for one year. It may be desirable to do this independently of changing the averages, as the run is being made at other than the end of a time period.

These combinations are provided so that the user has a great deal of flexibility with regard to the capabilities of this program.

SUMMARY

The projection programs perform the necessary functions for estimating future demand (see Figure 23). These functions include (1) analysis of historical demand data to determine the pattern that best fits the item, (2) computation of the initial values based on the pattern selected for the item master record, (3) updating of these values on the basis of the most recent demand and (4) projection of future demand. The appendix contains the specific formulas used in this module.

The projection programs provide the information regarding demand that is used in the order point program. They have the flexibility of processing all records in the item master file, or a portion thereof, in addition to highlighting unusual conditions for examination outside the system.

The projection report is illustrated in Figure 22. For each item, the report lists the old and the new values for average demand, first average, second average, trend, MAD, and sum of the deviations. The values shown on the first line are the old values; those on the second line are the new values. The model type code, the alpha factor, and the current demand are also indicated. The projections for this trend item are extrapolated for twelve time periods in this example.

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ITEM NUMBER	DESCRIPTION	MODEL ALPHA	CURRENT DEMAND	AVERAGE DEMAND	FIRST AVERAGE	SECOND AVERAGE	TREND	MAD	SUM OF DEVIATIONS
A-1476843	ADAPTER UNIT	T	349	338.0	319.0	300.0	1.0	21.0	5.0
		.05		340.0	320.5	301.0	1.0	20.5	5.5

PROJECTION	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
12 PERIODS	341	342	343	344	345	346	347	348	349	350	351	352

Figure 22. Projection report

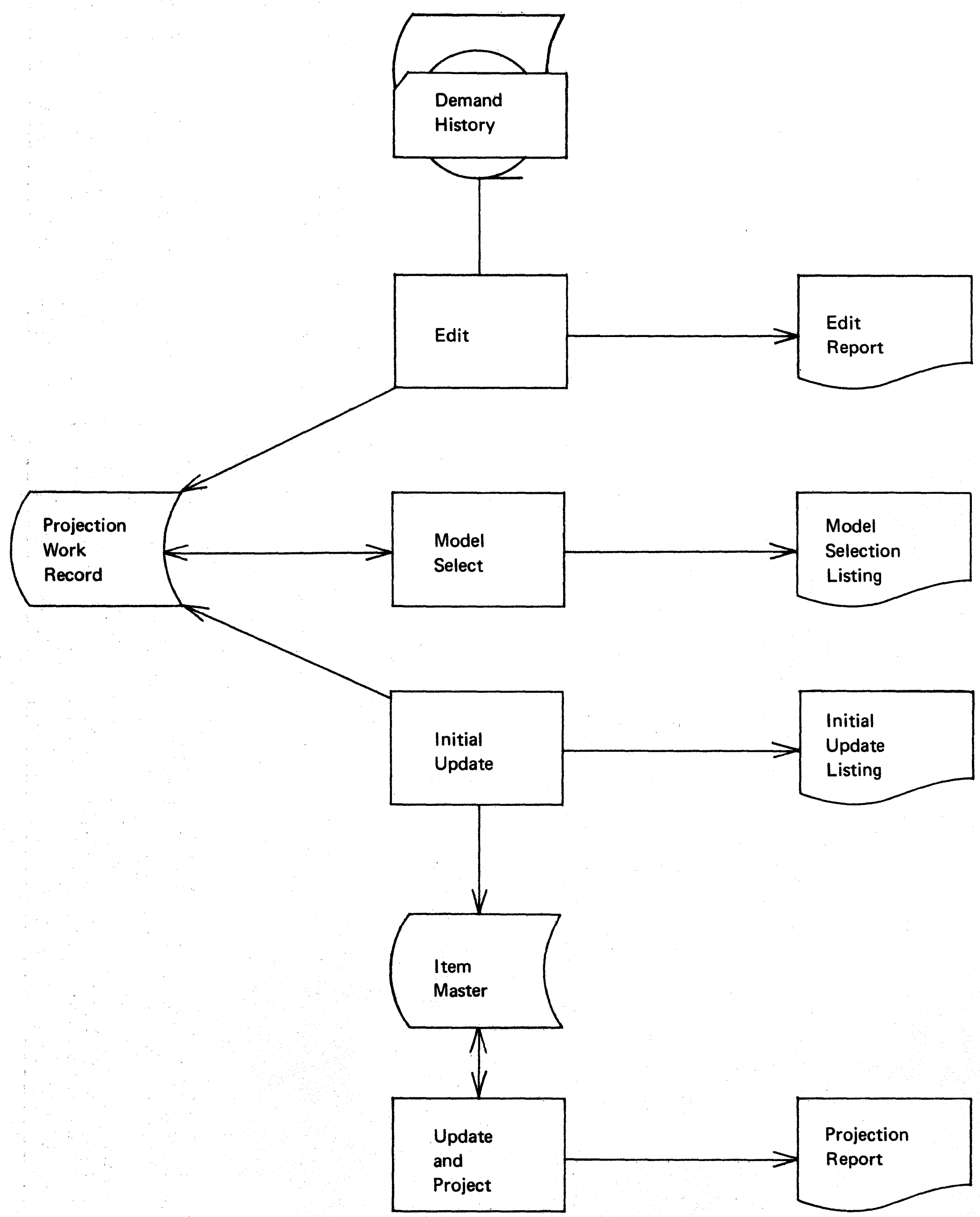

Figure 23. General system chart – projection

PROJECTION SUMMARY CHART			
Input	Routines	Item Master File	Output
Parameter cards Item records The input records contain information such as historic demand, current demand, options, etc.	Edit Model select Initial update Update and project	Item number Description Model type First average Second average Trend Average demand Mean absolute deviation Sum of deviations Base indices Current demand Alpha	Updated item master Edit report Model selection listing Initial update listing Projection report

EXECUTION

The third phase of inventory control relates to the processing of day-to-day transactions that must be recorded in keeping with management's policies regarding order point and order quantity. To accomplish this, the item master file must be updated to reflect inventory transactions. Receipts, issues, and adjustments, for example, must be recorded in the file to keep the on-hand inventory current, and balances must be checked to determine whether order action is necessary. In addition, when orders are issued, the transaction must also be recorded.

Reports must be prepared for many levels of management to assist them in their business judgments. A large variety of accounting reports are required for the day-to-day operation and for closing and year-end reporting. In many cases, special outputs and related inputs must be prepared for physical inventory reporting.

The execution phase of inventory control is provided to assist the user in the design of a system for keeping the item master up to date and for preparing reports. Two basic programs are included: transaction processing and status reporting.

The transaction processing program provides for updating fields in the item master record on the basis of input transactions, while the status reporting program uses the information stored on the item master record to produce a stock status report. Each program is discussed below.

The transaction processing program accepts punched card input that contains the item number, transaction code, and quantity. On the basis of this input, the program locates the specific item master record, determines the transaction type, updates the item master record, and prints a transaction listing.

Figure 24 illustrates the transactions and their effect on the item master record. Note that the transactions are identified with a code and the item master fields have symbolic labels. The remaining portion of the matrix indicates how the transaction quantity affects the fields on the item master record. Transactions that have an identical effect are grouped together. For example, the transaction for a work order and a work order adjustment-up (WO+WU) update the file in the same way and therefore are processed by the same portion of the program. Additional transaction codes can be added to each group, and changes to the identification codes can be made if the user desires. The technique is discussed in the section on program modification.

The transaction processing program punches an order action card if the available inventory is reduced below the order point. Additional tests (for example, minus available) can be made to determine whether the item should be highlighted for action outside the system.

The status reporting program prepares a stock status report on the basis of information stored in the item master file. It processes the entire file, or a portion thereof, on the basis of input specifications. The general logic includes sequentially locating each record, processing, editing, and printing the report. The format and contents of the stock status report may be modified if the user desires.

Transaction		Item Master Record				
		On Hand	On Order Purchasing	On Order Production	Allocated	Available
Typical Examples	Code	MOHTQ	MPUPQ	MPRPQ	MALQT	MAVAL
Work Order Work Order Adjustment — Up	WO WU			+		+
Cancel Work Order Work Order Adjustment — Down	CW WD			—		—
Purchase Order	PO		+			+
Receiving Report (vendor)	RR	+	—			
Receipt (production)	RC	+		—		
Cancel Purchase Order	CP		—			—
Requirement	RQ				+	—
Planned Disbursement	PD	—			—	
Inventory Adjustment — Up	IU	+				+
Inventory Adjustment — Down	ID	—				—
Miscellaneous Receipt	MR	+				+
Assembly Rework	AR			+	+	
Store Rework	SR	—		+		
Return to Stock	RT	+			+	
Cancel Requirement	CR				—	+

Figure 24. Representative inventory transactions and their affect on the item master record

PROGRAM MODIFICATION

The two execution programs are written in System/360 Report Program Generator Language and may be easily modified to expand their capabilities or used as a base to prepare additional programs.

Several aspects of the transaction processing program are discussed to illustrate the techniques for accomplishing changes.

Figure 25 illustrates the specification written to identify the transaction codes for Receiving Report and Receipt (codes RR and RC in Figure 24). In this example the codes are in card columns (positions) 1 and 2 of the transaction card, which has been named TRANSACT. The figure specifies that a resulting indicator of 4 is assigned to RR and a resulting indicator of 5 is assigned to RC. These indicators are used to determine the processing for each transaction.

					Record Identification Codes											
					1				2				3			
Filename	Sequence	Number (1-N)	Option (O)	Resulting Indicator	Position	Not (N)	C/Z/D	Character	Position	Not (N)	C/Z/D	Character	Position	Not (N)	C/Z/D	Character
7 8 9 10 11 12 13 14	15 16	17	18	19 20	21 22 23 24	25	26	27	28 29 30 31	32	33	34	35 36 37 38	39	40	41
TRANSACT				4	1			R	2			R				
				5	1			R	2			C				

Figure 25. Transaction identification – codes RR and RC

Figure 26 illustrates processing related to the above transactions and the matrix (Figure 24). The quantity received (QTY) is added to the inventory-on-hand total quantity (MOHTQ) and subtracted from on order - purchasing (MPUPQ) or production (MPRPQ). Note that the processing for indicator 4 is the same as the matrix specification for the RR code and the processing for indicator 5 performs the functions for the RC code.

These specifications as well as others that indicate content and format of reports are used by DOS/360 Report Program Generator to prepare programs.

The user can modify the record identification codes (see Figure 25) that specify the position(s) and the character(s) for each transaction. He can also increase the number of transactions for each group by adding other codes.

The processing for a particular group (resulting indicator) of transactions can be changed by modifying, deleting or adding instructions similar to those illustrated in Figure 26.

Indicators			Factor 1	Operation	Factor 2	Result Field	Field Length	Decimal Positions	Half Adjust (H)
	And	And							
Not 9 10 11	Not 12 13 14	Not 15 16 17	18 19 20 21 22 23 24 25 26 27	28 29 30 31 32	33 34 35 36 37 38 39 40 41 42	43 44 45 46 47 48	49 50 51	52	53
4			MOHTQ	ADD	QTY	MOHTQ	7	0	
4			MPUPQ	SUB	QTY	MPUPQ	7	0	
5			MOHTQ	ADD	QTY	MOHTQ	7	0	
5			MPRPQ	SUB	QTY	MPRPQ	7	0	

Figure 26. Transaction processing

The two execution programs include general functions that can be used as a basis for generating additional programs. These functions are (1) transaction input and identification, (2) retrieval of item master records, (3) calculation, (4) printed reports, and (5) optional card output.

Programs that require these general functions can be prepared by substituting different specifications for input, output, etc. For example, the user may wish to prepare a listing for the same items that appear on the stock status report. The output can be revised to the new requirements by changing the report specification before preparing the new program.

The documentation for the inventory control application will include examples and additional information regarding how the programs can be modified.

SUMMARY

The execution phase consists of two basic programs: transaction processing and status reporting. These programs are run as required to keep the item master file up to date and to prepare the stock status report (see Figure 27).

Input consists of transaction cards. Output consists of the transaction listing, stock status report, and order action cards. The programs may be easily modified to expand their capabilities or may be used as a base to prepare additional programs.

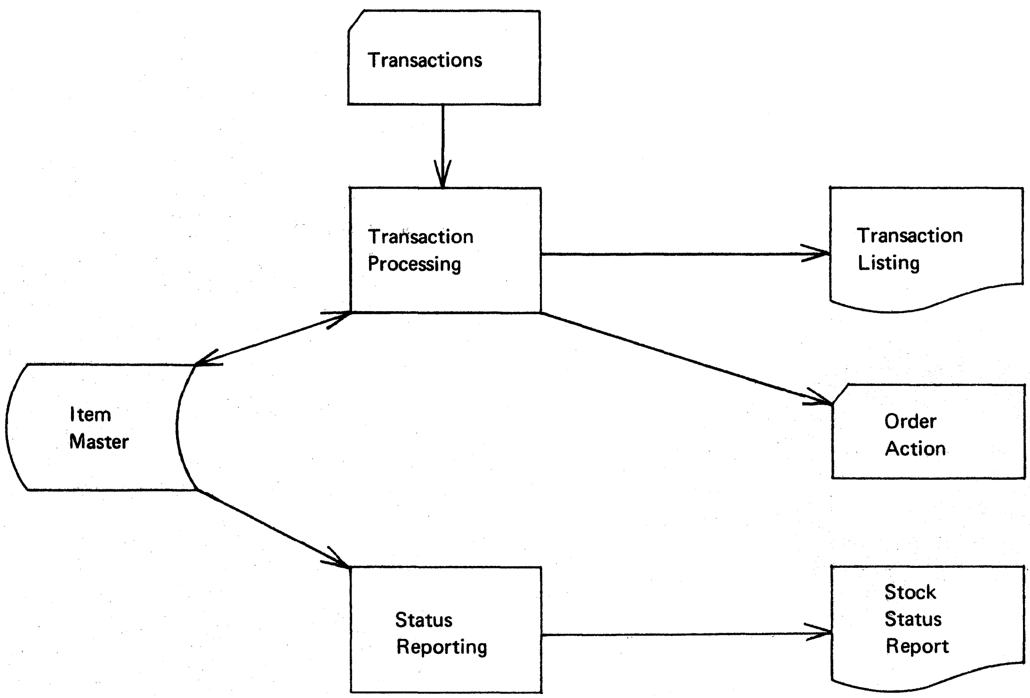

Figure 27. General systems chart – execution

EXECUTION SUMMARY CHART			
Input	Routines	Item Master File	Output
Transaction cards (for example, receipts, issues, adjustments, etc.)	Transaction processing Status reporting	Item number Item description Order code Inventory on hand On order — production On order — purchasing Allocated quantity Available stock Beginning inventory Receipts Issues Demand Transfers and adjustments	Transaction listing Stock status report Order action card

The inventory control programs, as discussed in this manual, utilize and update the information stored in the defined item master file.

Although this is the normal use of these programs, the programs are not limited to using this file. That is, the programs can interface with any file organized by the System/360 Bill of Material Processor (360A-ME-06X) or the IBM DOS/360 Indexed Sequential File Management System (360N-IO-457).

A company could use the programs and techniques for several files within the same installation. For example, a company with one or more branch warehouses and a central data processing system may wish to use the programs for processing inventory records of these warehouses. Any or all aspects of planning, projection and execution could be utilized with these files. Order point, safety stock, average demand, trend, etc., can be calculated for the items at each branch warehouse location. This information, in conjunction with the item master file, forms the basis for the user to develop a complete system for controlling item inventory for the plant and branch warehouses.

USER IMPLEMENTATION REQUIREMENTS

The user of the inventory control programs must have the data necessary to construct the item master file. The file can be organized using the IBM Bill of Material Processor Program or the IBM DOS/360 Indexed Sequential File Management System.

The specification of the fields to be included in this file is the responsibility of the user. Appendix 1 contains a list of the data requirements for each program.

The projection programs (edit and model select) and the planning programs (order quantity and order point) require historical usage data. The potential user should take steps to accumulate as much usage data as possible so that it is available when these programs are implemented.

If the potential user is not familiar with the techniques used for order quantity and order point computation and for exponential smoothing, he should review material that explains these concepts in more detail. The bibliography lists several references that are excellent for this purpose. The user should be prepared to make judgments regarding the cost of carrying inventory and order cost for order quantity calculations, the selection of an alpha factor(s) for projection, and the level of service desired for order point. This must be done in addition to having specific information for review time, lead time, item cost, etc.

Many reports have to be prepared to provide information for the day-to-day operation, for end-of-period accounting, etc. The identification and definition of these reports are the responsibility of each user as part of developing the total system. This includes the determination of what output is desired from the system, the frequency of these reports, what transactions are to be processed, and the related effect they have on the inventory record.

The IBM-provided programs and supporting documentation for the execution phase are designed to assist the user in the total implementation effort. In many cases, the programs to prepare the additional reports and process other transactions are similar to the overall logic of the execution programs. This should permit the user to use the same techniques for preparing the additional programs. Normally this would involve defining the input, output, and processing on specification sheets especially designed for this purpose.

The throughput speed of the programs for ths System/360 Inventory Control Application will vary considerably, primarily because of differences in machine configuration, method of file organization, program and input/output options that can be selected by an individual user, and variations in the input data (for example, demands per item) between users. For this reason specific timing estimates are not provided. In order to assist the user in preparing timing estimates, the primary factors that should be considered are discussed below.

The inventory control application includes initializing and operational programs. Inventory analysis, edit, model select, and initial update are designed to be used once to set up the system, then periodically (perhaps yearly) or as required to meet changing conditions. Order point and update and project are run on a regular basis (for example, every month or every two weeks). The frequency of using the order quantity program depends upon the user's requirements. Normally the items considered as having a fixed order quantity would be processed once or twice a year. This is true if the present order quantities are consistent with management's ordering policy. If the order quantities are not considered economical, this program with its analysis for implementation feature will be used from time to time until the order quantities agree with the policy. The two basic programs of execution (or modifications to these or the user's own programs) will be used in the day-to-day operation. The amount of use depends upon transaction volume and the number of reports the user prepares.

The inventory analysis program consists of several sections. The first section accepts usage information from the item master file or item cards and prepares a disk file work record. Timing for this section of the program can be based on the speed of the input unit and the time it takes to write the sequential output in the disk file.

The timing estimate for the second section can be based on the time it takes the IBM DOS/360 Disk Sort/Merge program to sort the work records that were created in the first section.

The third section reads the file of sorted work records and prints the ABC analysis report. The speed of the printer is the primary consideration for timing this section of the program.

The final phase of this program places codes on the item master file on the basis of value classification cards or item cards. The speed of the printer is the principal aspect for timing.

The order point program will normally be used to sequentially process all or a segment of the item master file. One line is printed for each item unless the analysis for implementation option is specified, in which case two lines are printed for each item. The major elements of timing to be considered are disk file access, read and write times, and the number of report lines printed for each item.

The order quantity program will be run periodically depending upon the requirements of each installation, and will probably be used in conjunction with the analysis for implementation feature (two printed lines for each item). The program processes the item master file sequentially or uses item cards for locating the records. As in the order point program, the principal factors to be considered when preparing timing estimates are disk file access, read and write times, and the number of lines printed for each item.

The edit program reads user input from cards, tape, or disk and creates the projection work records (sequential disk file) and a printed report. Timing, for the most part, depends on the number of input records and the number of lines printed for each item.

The model select program reads the disk file projection records created by the edit program, performs regression analysis, computes various initializing factors, and prints the output report. The processing time depends upon the number of time periods, the type of data (that is, trend, seasonal, etc.) and the options specified by the user.

The principal consideration for preparing a timing estimate is the time required for disk reading and writing, processing and printing the report. Because processing time depends upon many variable factors, and since this program is not used frequently, it may be preferable to disregard processing time and prepare the estimate using one-half the rated speed of the printer.

The initial update program reads the disk file projection record and moves the values to the item master record. Disk file access, read and write time, as well as printer speed, are the factors for estimating timing.

Timing estimates for the update and project program should consider disk file access, read and write times, as well as the amount of time it takes to print the projection report. The report may include several lines for each item if the projection of future demand is printed.

The transaction processing program reads input cards, updates the item master file, and prepares the transaction listing. The principal considerations for timing are disk access, read and write times.

The status reporting program reads the item master file sequentially and prepares the output report. The speed of the printer is the principal consideration for timing.

All input and output operations and associated error checking are performed using the standard IOCS support of the IBM DOS/360 Indexed Sequential File Management System or the IBM System/360 Bill of Material Processor.

The programs include the ability to count the number of records processed and to print certain control totals on reports. Exits are provided so that additional controls may be added by the user.

The user should prepare a backup copy of the item master file for reconstruction purposes. The frequency of preparing the backup copy of the file depends upon the requirements of each installation.

PROGRAMMING SYSTEMS

The inventory control programs are designed to operate under the IBM System/360 Disk Operating System. The planning and projection programs are written in System/360 Assembler Language, and the execution programs are written in System/360 Report Program Generator Language.

The minimum machine configuration required for use of the System/360 inventory control programs is as follows:

IBM System/360 Model 30 with:

2030 E	System/360 Central Processing Unit, 32K bytes
3237	Decimal Arithmetic Special Feature
1051 N1	Control Unit for Printer-Keyboard
1052	Printer-Keyboard (Model 8) with appropriate attachments
	System/360 Card Reader and Card Punch _or_ Card Read Punch capable of reading one file and punching a second file simultaneously.
	System 360 Printer with 120 print positions
2841	Storage Control (Model 1)
2311	Disk Storage Drives as required to contain Disk Operating System/360 and the user's data files.

APPENDIX 1: ITEM MASTER RECORD

The following table demonstrates the use of various item master record fields by the inventory control programs. Other fields which may be included in the item master record are discussed in the IBM manual The Production Information and Control System (E20-0280).

ITEM MASTER RECORD			Legend: x Required o Optional				
Label	**Name**	**Description**	**ABC**	**Order Point**	**Order Quantity**	**Projection**	**Execution**
TA$MFACA	FIRST ASSEMBLY COMPONENT ADDRESS		Fields and labels used by the IBM System/360 Bill of Material Processor (360A-ME-06X) — see Programmer's Manual (H20-0246).				
TA$MRCAC	RECORD COUNT — ASSEMBLY COMPONENT CHAIN						
TA$MFWUA	FIRST ASSEMBLY WHERE—USED ADDRESS						
TA$MRCWU	RECORD COUNT — ASSEMBLY WHERE—USED CHAIN						
TA$MLLC	LOW-LEVEL CODE						
TA$MNMRA	ADDRESSES OF NEXT MASTER RECORD IN CHAIN						
TA$MCPMR	COMPARE PORTION—NEXT MASTER RECORD						
TA$MRACN	RUN ACTIVITY CONTROL NUMBER						
TA$MOCAA	OVERFLOW CHAIN ADDRESS FOR ADDITIONS						
TA$MPN	Item number	The number that identifies the item.	x	x	x	x	x
MTYPN	Item type	Codes used to define an item, for example: 1. Assembly and subassembly 2. Fabricated parts 3. Raw material 4. Purchased part 5. Customer option	o	o	o	o	
MPDSC	Item description	The item name can range from a short noun abbreviation to a more descriptive wording.	o	o	o	o	o
MVACL	Inventory value classification	A code indicating the category of inventory for this item. Stratification of inventory is accomplished by correlating annual demand, investment. and net profit.	o	o	o	o	
MOPOC	Order code	Code to indicate the order policy to be be used for this item.	o	x	x	o	x
	A—Discrete quantity	The items covered by this code are ordered to meet requirements with minimum or no protective stock.					
	B—Order point/ order quantity	Ordering under this policy is of an order quantity (MOPOQ) ordered at some predetermined level of inventory (MOPOP).					
	C—Order point/ order-up-to level	When this code is assigned the order quantity is determined using the level quantity (MOPOQ).					
MOPOP	Order point	The quantity expected to be consumed during the replenishment lead time plus a reserve. It is average demand multiplied by lead time plus safety stock.		x			x
MOPOQ	Order quantity	Order quantity is the amount to be ordered when the order point is reached.		x	x		x

ITEM MASTER RECORD			Legend: x Required o Optional				
Label	Name	Description	ABC	Order Point	Order Quantity	Projection	Execution
		If item coded order-up-to level (C in MOPOC). this field has the level instead of order quantity.					
MOPSS	Safety stock	The amount of stock to protect against uncertainty in demand and in the length of the replenishment lead time.		x	o		
MOPMN	Minimum	User-specified minimum allowable order quantity.			o		
MOPMX	Maximum	User-specified maximum allowable order quantity.			o		
MOPMU	Multiple	The number to be used in rounding of order quantity (for example. even 100s or multiples of 10, etc.).			o		
MFCMT	Model type	Demand models may be classified into four types: constant. trend, seasonal, trend-seasonal.		x	o	x	
MFCFA	First average	Field used in 1st order smoothing and 2nd order smoothing to smooth the 1st average.		x	o	x	
MFCSA	Second average	Field used in 2nd order smoothing to smooth the 2nd average.		x	o	x	
MFCTN	Trend	The result of the trend calculations performed during the forecasting run.		o	o	o	
MFCAD	Average demand	The average demand as computed during each projection computation.		o		o	
MFCMD	Mean absolute deviation (MAD)	The average of the differences between actual demand and average demand for an average demand for an item, as determined each time average demand is calculated (e.g.. every 2 weeks). All differences are considered positive.		x		x	
MFCSD	Sum of deviations	Sum of deviations between actual demand and projected demand; used to determine the accuracy of the projection. The deviation is exponentially smoothed into the sum each period.				x	
MFCAL	Alpha	Smoothing constant. The weighting factor to be assigned to current data and past demand. The higher the factor the greater the weight given to recent demand.		x	o	x	
MTSSC	Tracking signal sequential count	A count of the number of times the tracking signal is tripped in sequence.				x	
MPJCD	Projection Code	Code to signal item is to be projected. Two classifications are utilized: (1) projected, (2) not projected.				o	

ITEM MASTER RECORD

Legend:
x Required
o Optional

Label	Name	Description	ABC	Order Point	Order Quantity	Projection	Execution
MFCFP	Number of periods	Number of periods to extend or to project.				o	
MFCBI	Base indices	A series of factors used to adjust the demand for cyclic patterns.		x	o	x	
MLTCD	Lead time code	Code to determine which lead time to use when computing order point.		o	o		
MLTPU	Lead time — purchasing	The time it takes to receive an order for a purchased item from a vendor; includes internal purchasing cycle and vendor lead time.		x	o		x
MLTPR	Lead time — production	The total time required to produce an order; includes setup, run, and queue/move time		x	o		x
MFCSP	Safety factor	A number used for computation of safety stock. If statistical methods are used, this factor is multiplied by MAD (adjusted for lead time) to determine safety stock. The safety factor may be time or a percentage of lead time which is used with average demand to calculate safety stock.	o	x			
MPUPD	Number periods demand	Periods of demand represented by MPUQD.	o		o	o	
MPUQD	Demand quantity	Total demand during past number of periods (MPUPD).	o		o	O	
MPUPI	Number periods issues	Periods of issues or disbursements represented by MPUQT.	o		o		
MPUQI	Issues quantity	Total disbursements during past number of periods.	o		o		
MPRGR	Gross requirements	Total requirements accumulated by time periods before consideration of available inventory.			o		
MPUPQ	Total purchase order quantity	Total quantity on order from purchase orders.		x	o		x

ITEM MASTER RECORD

Legend:
x Required
o Optional

Label	Name	Description	ABC	Order Point	Order Quantity	Projection	Execution
MPRPQ	Total on-order production quantity	Total quantity in production for this item.		x	o		x
MOQCC	Order quantity category code	Code used to determine order cost, carrying rate and formula for order quantity calculation.	o	o	x	o	
MOPCC	Order point calculation code	Code used to control the method used for computing the order point.	o	x			
MOPRD	Order point recommendation date code	A code that indicates the date on which an order recommendation was issued.		x			x
MUCSU	Setup cost	Cost of setting up a production run.			x		
MUCTL	Unit cost total	Item unit cost.	x	x	x		o
MUNPR	Unit price	Unit price of item.	o				
MCSBI	Beginning inventory	The amount in inventory at the beginning of the current time period.					x
MCSTA	Transfers and adjustments	Running sum of the transfers and adjustments made to the inventory of an item during the current time period.					x
MCSRE	Receipts	Running sum of the inventory receipts made during the current time period.					x
MCSIS	Issues	Running sum of the inventory disbursements made during the current time period.					x
MCSDE	Demand	Running sum of the actual demand for an item (whether satisfied or not) during the current time period.				o	
MOHTQ	On-hand total quantity	Total units on hand at all stock locations.		x	x		x
MALQT	Allocated quantity	A cumulative quantity of stock earmarked to cover requirements.		o	o		x
MAVAL	Available stock	Inventory quantity available for requirements. Available stock = on hand + on order - allocated.					o

APPENDIX 2: FORMULAS

Item Master Fields
- MFCFA = First Average
- MFCSA = Second Average
- MFCMD = MAD
- MFCSD = Sum of Deviation
- MCSDE = Current Demand
- MFCAD = Average Demand
- MFCTN = Trend
- MFCBI = Base Index
- MFCAL = Alpha Factor

Horizontal Updating

First Average

New MFCFA = Old MFCFA + MFCAL (MCSDE - Old MFCFA)

Average Demand

New MFCAD = New MFCFA

Trend Updating

First Average

New MFCFA = Old MFCFA + MFCAL (MCSDE - Old MFCFA)

Second Average

New MFCSA = Old MFCSA + MFCAL (New MFCFA - Old MFCSA)

Average Demand

New MFCAD = 2 x New MFCFA - New MFCSA

Trend

$$\text{New MFCTN} = \frac{(\text{New MFCFA} - \text{New MFCSA})}{\left(\frac{1-\text{MFCAL}}{\text{MFCAL}}\right)}$$

Seasonal Updating

First Average

New MFCFA = Old MFCFA + MFCAL (CDED - Old MFCFA)

where:

$$\text{Current Deseasonalized Demand or CDED} = \frac{\text{MCSDE}}{\text{MFCBI*}}$$

* Base index value for this time period

Base Index

New MFCBI = Old MFCBI + MFCAL (CBI - Old MFCBI)

where:

MCSDE

$$\text{Current Base Index or CBI} = \frac{\text{MCSDE}}{\text{Old MFCFA}}$$

Trend Seasonal Updating

First Average

New MFCFA = Old MFCFA + MFCAL (CDED - Old MFCFA)

where:

$$\text{CDED} = \frac{\text{MCSDE}}{\text{MFOBI}}$$

Second Average

New MFCSA = Old MFCSA + MFCAL (New MFCFA - Old MFCSA)

Average Demand

New MFCAD = 2 x New MFCFA - New MFCSA

Base Index

New MFCBI = Old MFCBI + MFCAL (CBI - Old MFCBI)

where:

$$\text{Current Base Index or CBI} = \frac{\text{MCSDE}}{\text{Old MFCFA}}$$

MAD and Sum of Deviations Updating

Mean Absolute Deviation

New MFCMD = Old MFCMD + MFCAL (CD - Old MFCMD)

where:

Current Deviation or CD = MCSDE - Old MFCAD

and

Old MFCAD = Old MFCFA (for horizontal)

Old MFCAD = 2 Old MFCFA - Old MFCSA (for trend)

Current Deviation is an absolute value

Sum of Deviations

New MFCSD = Old MFCSD + MFCAL (CD - Old MFCSD)

where:

Current deviation or CD = MCSDE - Old MFCAD

Tracking Signal

$$\text{TS} = \frac{\text{New MFCSD}}{\text{New MFCMD}}$$

MAD for lead time

MAD for lead time = MFCMD (Lead time x Conversion factor)β

where:

Conversion factor is constant supplied by user that provides relationship of lead time units to projection interval time unit

and

Beta (β) is value between .5 and 1.0 and denotes the relationship between MAD and time

Projecting Future Time Periods

Nonseasonal

1 = MFCAD + 1 MFCTN

2 = MFCAD + 2 MFCTN

.

.

.

n = MFCAD + n MFCTN

If horizontal, MFCTN = 0; MFCAD is projection for all periods

Seasonal

1 = (MFCAD + 1 MFCTN) x MFCBI for time period 1

2 = (MFCAD + 2 MFCTN) x MFCBI for time period 2

.

.

.

n = (MFCAD + n MFCTN) x MFCBI for time period n

If horizontal, MFCTN = 0

Adjustment for Change in Alpha (MFCAL)

Horizontal - No adjustment
Trend - Adjust MFCFA and MFCSA

First Average

$$\text{New MFCFA} = 2\ \text{Old MFCFA} - \text{Old MFCSA} - \frac{\text{1-New MFCAL}}{\text{New MFCAL}} \times \text{MFCTN}$$

Second Average

$$\text{New MFCSA} = 2\ \text{Old MFCFA} - \text{Old MFCSA} - 2\ \frac{\text{1-New MFCAL}}{\text{New MFCAL}} \times \text{MFCTN}$$

where:

$$\text{MFCTN} = \frac{\text{Old MFCAL}}{\text{1-Old MFCAL}} \times \text{MFCFA-MFCSA}$$

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