INFO PAPER

MATERIAL FORECAST WITH SAP - VV

HOW TO OPTIMIZE FORECAST PARAMETERS AND USE THE VV MRP TYPE TO ITS FULEST EXTENT

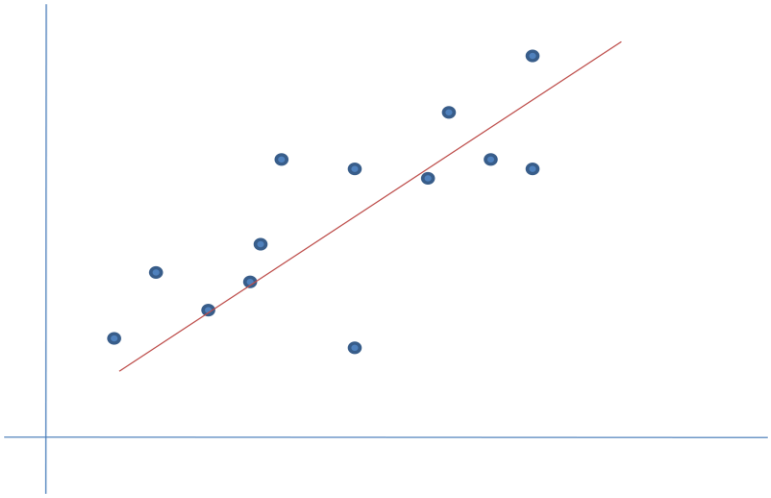
OCTOBER 1ST, 2009

MATERIAL FORECAST WITH VV

OPTIMIZING FORECASTING PARAMETERS

MRP type VV allows for consumption driven MRP in SAP. The VV type uses historical consumption to calculate future forecasted requirements. This type of forecasting is called the 'material forecast' in SAP (as opposed to the 'external forecast' used in SAP's S&OP).

The **forecast** is carried out on a periodic basis and consists of the **following procedure**: after the MRP controller has determined feasibility on a given material for VV planning and set all the required data in the material master record the system then initializes the forecast using a number of initialization periods. It then looks at past consumption values and smoothing factors to see whether there is a model that can be determined or if the past consumption values do not show any regularity.



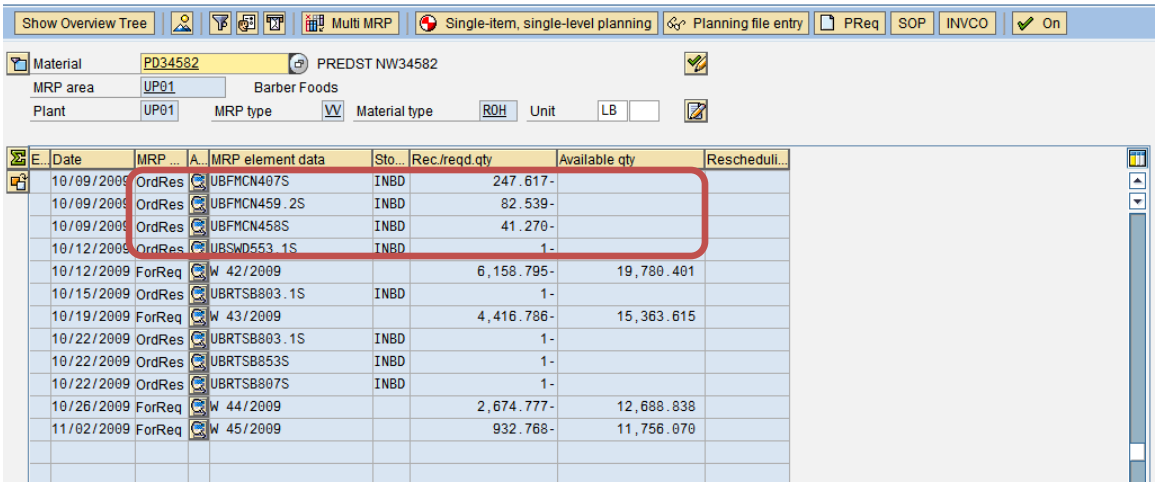
Consumption values that represent a trend model (up) after being initialized and smoothed

The forecast is then calculated and periodic forecast requirements are paced in the materials stock/requirements list. The MRP run will then determine net requirements and cover any shortages with order proposals.

E...	Date	MRP ...	A...	MRP element data	Rec./reqd.qty	Available qty
	11/09/2009	PurRqs		0001071482/00010	40,000	43,384.710
	11/09/2009	ForReq		W 46/2009	33,988.696-	9,396.014
	11/16/2009	PurRqs		0001001546/00010	40,000	49,396.014
	11/16/2009	ForReq		W 47/2009	34,133.242-	15,262.772
	11/23/2009	PurRqs		0001013714/00010	40,000	55,262.772
	11/23/2009	ForReq		W 48/2009	34,277.788-	20,984.984
	11/30/2009	PurRqs		0001008323/00010	40,000	60,984.984
	11/30/2009	ForReq		W 49/2009	34,422.334-	26,562.650
	12/07/2009	PurRqs		0001071483/00010	40,000	66,562.650
	12/07/2009	ForReq		W 50/2009	34,566.880-	31,995.770
	12/14/2009	PurRqs		0001001548/00010	40,000	71,995.770
	12/14/2009	ForReq		W 51/2009	34,711.426-	37,284.344
	12/21/2009	ForReq		W 52/2009	34,855.972-	2,428.372
	12/28/2009	PurRqs		0001071484/00010	40,000	42,428.372
	12/28/2009	ForReq		W 53/2009	35,000.518-	7,427.854
	01/04/2010	PurRqs		0000995380/00010	40,000	47,427.854
	01/04/2010	ForReq		W 01/2010	35,145.064-	12,282.790

Netted forecast requirements with their respective order proposals to cover future shortages

When using MRP type VV the material in question is controlled by SAP's consumption based planning. This means that deterministic demand – from a customer order or a forecast – is not considered in the systems net requirements calculation. This can be seen in the stock/requirements list where any dependent demand does NOT reduce the available quantity.



E...	Date	MRP ...	A...	MRP element data	Sto...	Rec./reqd.qty	Available qty	Rescheduli...
	10/09/2009	OrdRes		UBFMCN407S	INBD	247.617-		
	10/09/2009	OrdRes		UBFMCN459.2S	INBD	82.539-		
	10/09/2009	OrdRes		UBFMCN458S	INBD	41.270-		
	10/12/2009	OrdRes		UBSWD553.1S	INBD	1-		
	10/12/2009	ForReq		W 42/2009		6,158.795-	19,780.401	
	10/15/2009	OrdRes		UBRTSB803.1S	INBD	1-		
	10/19/2009	ForReq		W 43/2009		4,416.786-	15,363.615	
	10/22/2009	OrdRes		UBRTSB803.1S	INBD	1-		
	10/22/2009	OrdRes		UBRTSB853S	INBD	1-		
	10/22/2009	OrdRes		UBRTSB807S	INBD	1-		
	10/26/2009	ForReq		W 44/2009		2,674.777-	12,688.838	
	11/02/2009	ForReq		W 45/2009		932.768-	11,756.070	

Any dependent demand – like order reservations through the BOM – do NOT reduce the available quantity for the determination of net requirements and therefore do NOT trigger the creation of order proposals

Order proposals are only generated for forecasted requirements. Hence a consumption driven material like the VV is 'cut-off' from deterministic planning and therefore not susceptible to demand variation or incorrect forecasts.

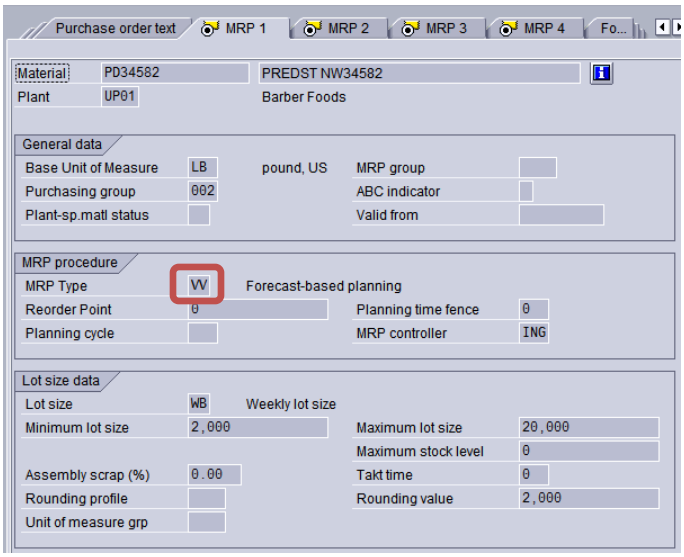
VV panning is used primarily for materials which are:

- Showing a consumption pattern that is regular over a period of time
- Fairly low in value
- Require a long replenishment lead time (when a reorder procedure would require too high of a reorder level or a deterministic procedure would require too much safety stock)

Therefore, these planning procedures are used for planning both B- and C-parts and operating supplies. The type of order proposal which is automatically generated during materials planning depends on the procurement type of the material. For materials that are produced internally, a planned order is always created. For materials procured externally, the MRP controller has the choice between creating a planned order or a purchase requisition. If he decides to create a planned order, he must then convert it into a purchase requisition and make it available for the purchasing department.

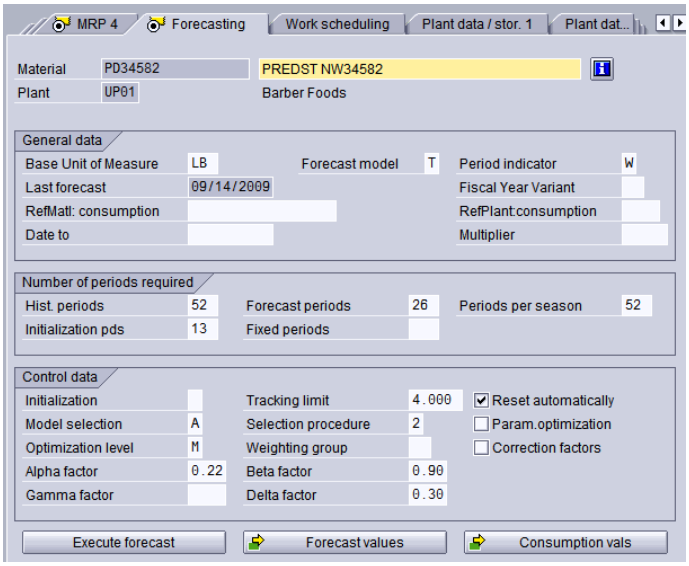
SAP's material forecast is used to anticipate future demand independent of deterministic demand. Using information about past behavior ne assumes that the forecasted requirements will allow to maintain an economical inventory level for the future (not to much and not to little) for materials with long replenishment lead times and fairly regular consumption.

To set up an item (finished, good or raw material) for material forecasting the items material master record needs to be set up – particularly the MRP and forecasting screens. When setting the MRP type VV in the master record's MRP1 screen, a decision has been made to control the items planning by consumption driven methods.



MRP1 tab in the material master record with MRP type 'VV'

Now that the material is driven by forecast driven planning we have to maintain initial settings so that the system is able to carry out a forecast. Those items are maintained in the forecast screen.

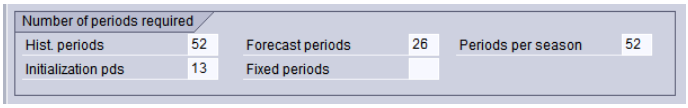


Forecasting tab with forecast settings

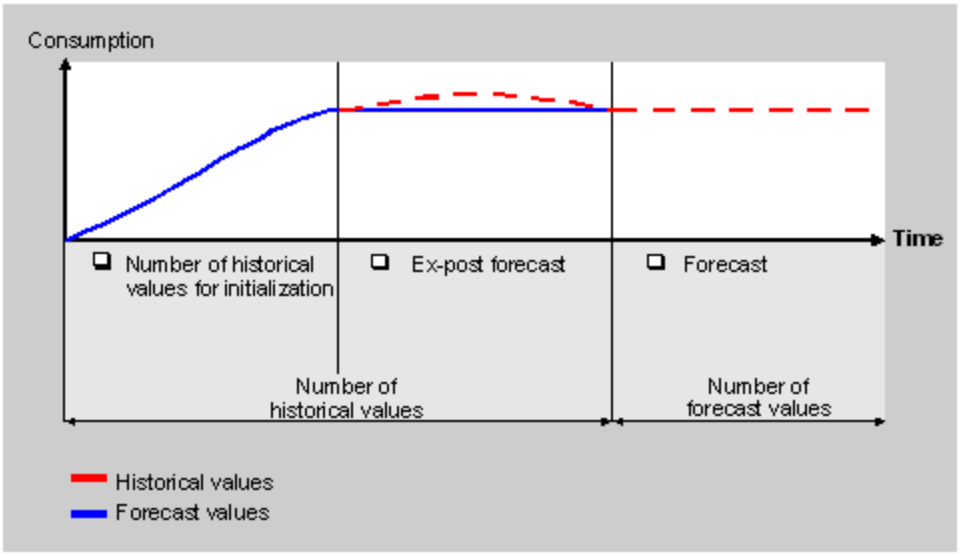
In the **general data** section of the forecasting data one can see the date for the last forecast and maintain information about using a phase-out material to collect historical consumption. In the field

Forecast Model you can either determine that the system selects a model during initialization by way of smoothing historical values and performing some tests – or – set the model manually and therefore tell the system based on your own researching of past consumption values. The period indicator fixes the period buckets in which the system collects past consumption figures and calculates the forecast requirements.

> *Set the period indicator right the first time – because otherwise, in case of a change later, you loose your past consumption values and you will have to maintain those manually.*



Looking at the tab **Numbers of Periods required** we can set the number of historical periods which the system uses for its calculations. When initialization takes place (either when forecasting for the first time or when the current model loses its validity) the system uses the number of periods in Initialization pds for initialization. If in the field Hist. periods there are more periods than in Initialization pds than an ex-post forecast is carried out using these excess values.



Ex-post forecast using excess historical values not used by initialization

The field Forecast Periods determines the number of periods for which forecast requirements are being calculated. In the field Fixed periods one can 'freeze' a number of periods so that its forecast values are no longer changed or re-calculated. Periods per season requires the number of periods for one season So if a product has a summer and a winter season the appropriate setting would be 6.

Fields in the tab Control data are better explained in the context of model selection, initialization and running the forecast.

There are three distinct procedures when planning a VV driven material:

1. First time planning and forecasting

2. Planning and forecasting after a model is invalidated

3. Regular planning and forecasting on a periodic roll-over basis

In the case of first time planning and forecasting the system needs to determine a model, which can be selected manually by an analyst or determined automatically by the system carrying out some tests. Then initialization follows with a possible ex-post forecast to eventually run some parameter optimization and calculation of forecasted requirements

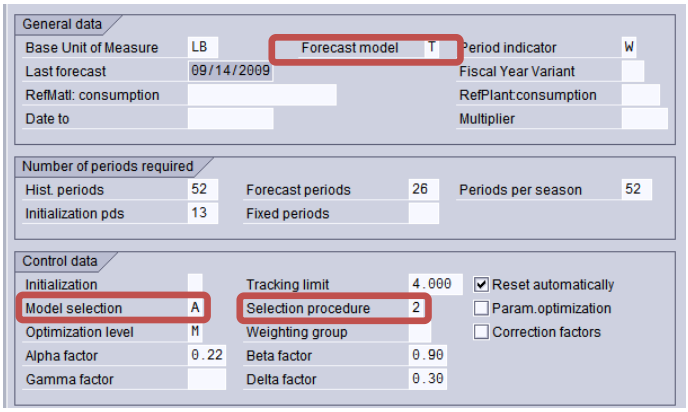
In the case of planning and forecasting after model invalidation the system first determines that the model is invalid (by use of tracking signal and comparison to the tracking limit), then performs tests and selects a new model and re-initializes (both of these things may be done automatically by the system, or manually set by a Controller). Parameter optimization and forecast calculation are then executed every following period.

During regular, periodic planning and forecasting, the system can be set that, besides calculating forecast values, it can perform parameter optimization and run thrug various test to confirm the validity of the model. It does so by performing a comparison between the tracking limit (set in the forecasting tab in the MMR) and a tracking signal (= forecast error / MAD). In the case where the model is invalidated an exception message is issued (visible either in MP33 Reprocess or in the forecast values screen)

After every forecast run – whether run individually or as a total – a results verification and evaluation of the forecast can be performed.

MODEL SELECTION

A model selection takes place either when a material is new and is to be forecasted for the first time or after an existing model is invalidated.



There is the option to select a model manually – to force a model by evaluating the past consumption. You set the field Forecast Model to the model you choose (anything but 'J').

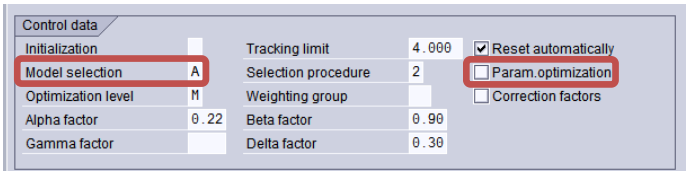
There is also the option to have the system set the model automatically based on some tests and smoothing it performs. Set the Forecast Model to 'J'. When having the system perform the model selection automatically you will also have to decide and set the Model Selection Procedure. During **MSP '1'** the system carries out statistical tests and checks whether a trend or a seasonal requirements pattern applies. In the trend test, the system subjects the historical values to a regression analysis and checks to see whether there is a significant trend pattern. In the seasonal test, the system clears the historical values of any possible trends and carries out an autocorrelation test. During **MSP '2'** the system calculates the models to be tested using various combinations for alpha, beta and gamma. The smoothing factors are also varied between 0.2 to 0.8 in intervals of 0.2. The model which is then chosen is the model which displays the lowest mean absolute deviation (MAD). Procedure 2 is more precise than procedure 1 but takes considerably longer.

A third option is automatic model selection with additional system check . Set the Forecast Model to 'J' and pick a Model Selection (T trend examination, S for seasonal fluctuation or A to check for both).

CARRYING OUT MODEL INITIALIZATION

In model initialization the system calculates either the basic value for a constant model, the trend value for a trend model or seasonal indices for seasonal models. Initialization is only carried out during the first forecast for any given model – either in case of a new material or after an existing model is invalidated.

Model initialization can be carried out automatically by the system – if Param. Optiization is checked - or manually. You set your choice in the field Initialization.

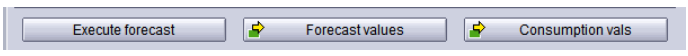


There must be a minimum number of historical values depending on the model, so that the system can initialize. For the constant model 1 past consumption period is needed; for trend we require 3 and for seasonal models 3 are required plus a season (which is defined by the number of historical values for one season. A seasonal trend model needs 3 plus 1 season, the 2nd order exp. Smoothing needs 3 and moving average and weighted moving average each need 1.

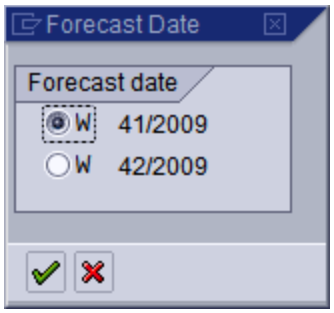
> *The system calculates the basic value on the basis of an average value, and the trend using the results of the regression analysis. The seasonal indices result from the quotient of the actual past value and the basic value which has been adjusted for the trend value.*

RUNNING THE FORECAST

The forecast can be run as a total run using MP38, individually for any given material with MP30 or out of the MMR's forecast screen using the following buttons.

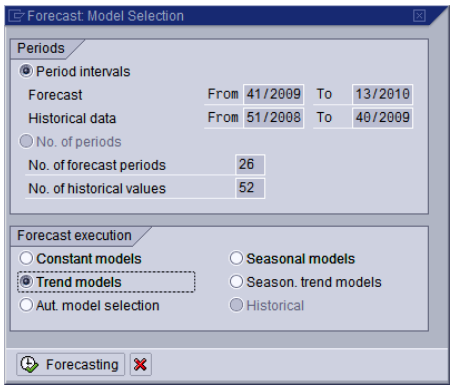


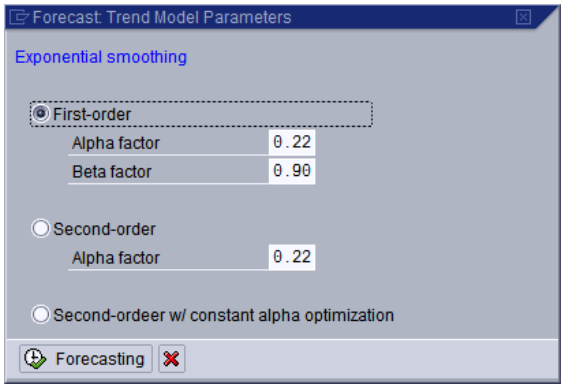
Buttons for executing forecast, examining the forecast result and evaluating past consumption values in the material master record.



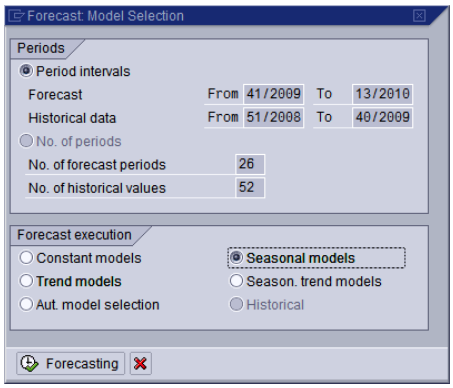
Choose is the current week or next week for a run to calculate forecast values

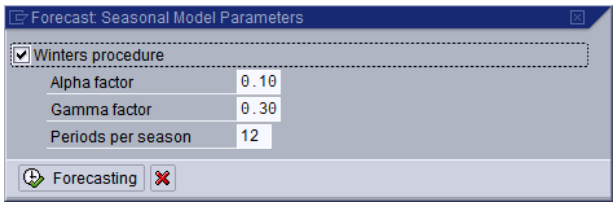
Even though we chose to have the system calculate a forecast mdel automatically a screen is popping up where another choice may be made



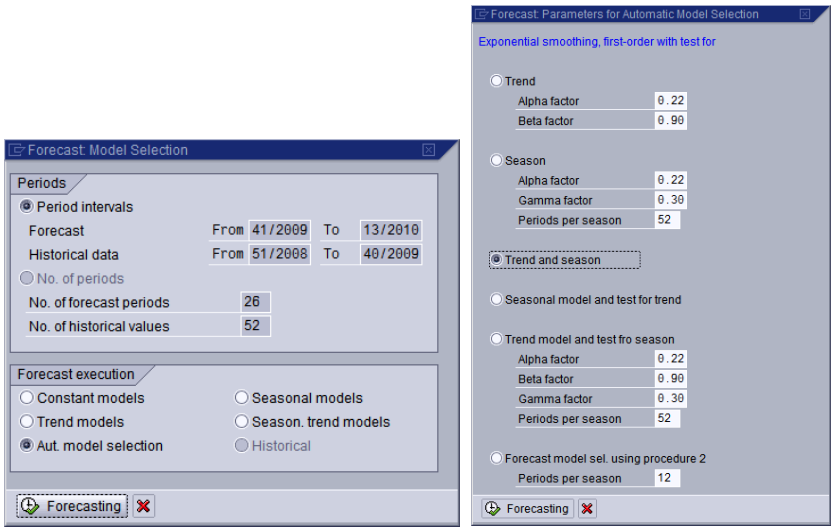


In case of a trend model chosen for the selection of a forecast model the system offers to change the smoothing factors alpha (to smooth basic value) and beta (to smooth the trend value





In case of a seasonal model being chosen, the system also offers the gamma factor (to smooth seasonal indeces) for changing



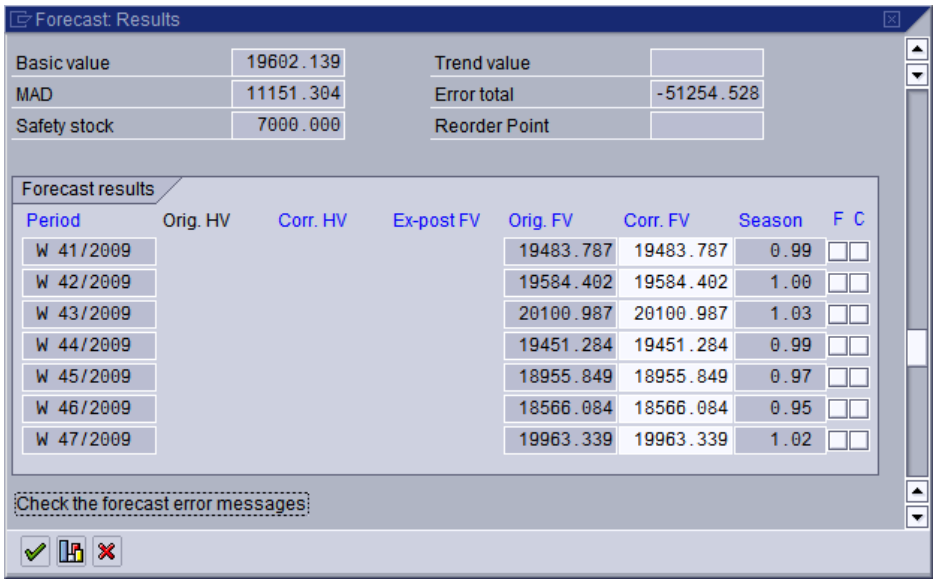
And it case we stay with the automatic model selection, the system offers to perform various tests

Now the forecast module performs all necessary calculations to arrive at forecasting values according to a selected model.

FORECAST EVALUATION AND REPROCESSING

The following screen shows the result f the forecast calculations A basic value was calculated which means that a constant model was selected.

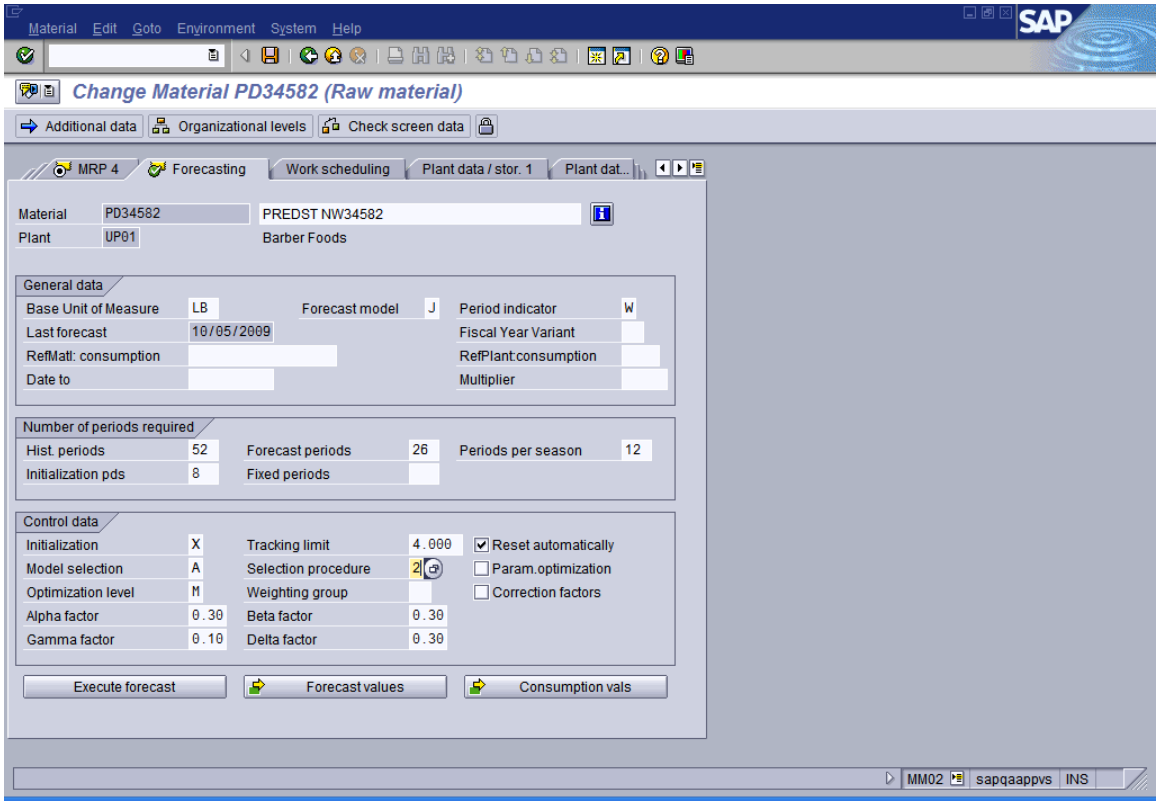
However if one divides the error total by the MAD (to calculate the tracking signal) the result exceeds the tracking limit set in the forecasting tab. Therefore the model failed and the item is awaiting further optimization. What's happening is that the system determines the model; then calculates the tracking signal and compares it to the tracking limit.

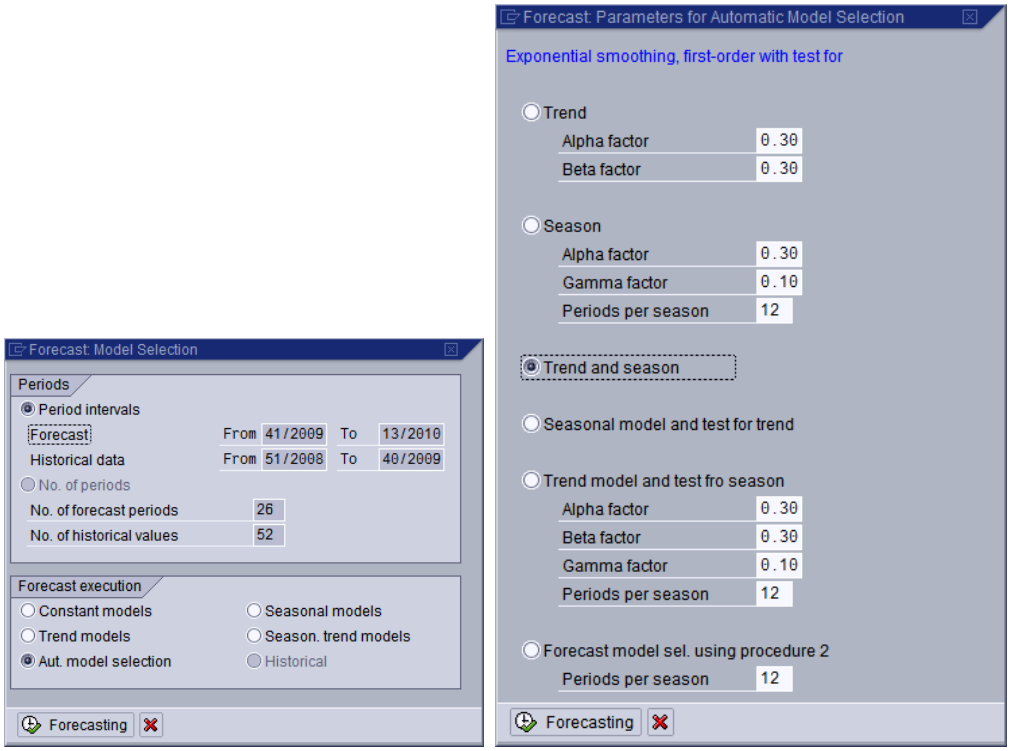


In our case the tracking limit was higher than 4.000 and therefore the Model was not selected (Model Selection stays blank) and the initialization was left at 'X' meaning that we can still perform

forecast calculations with different parameters until we arrive at a model that has a tracking signal which is lower than the tracing limit.

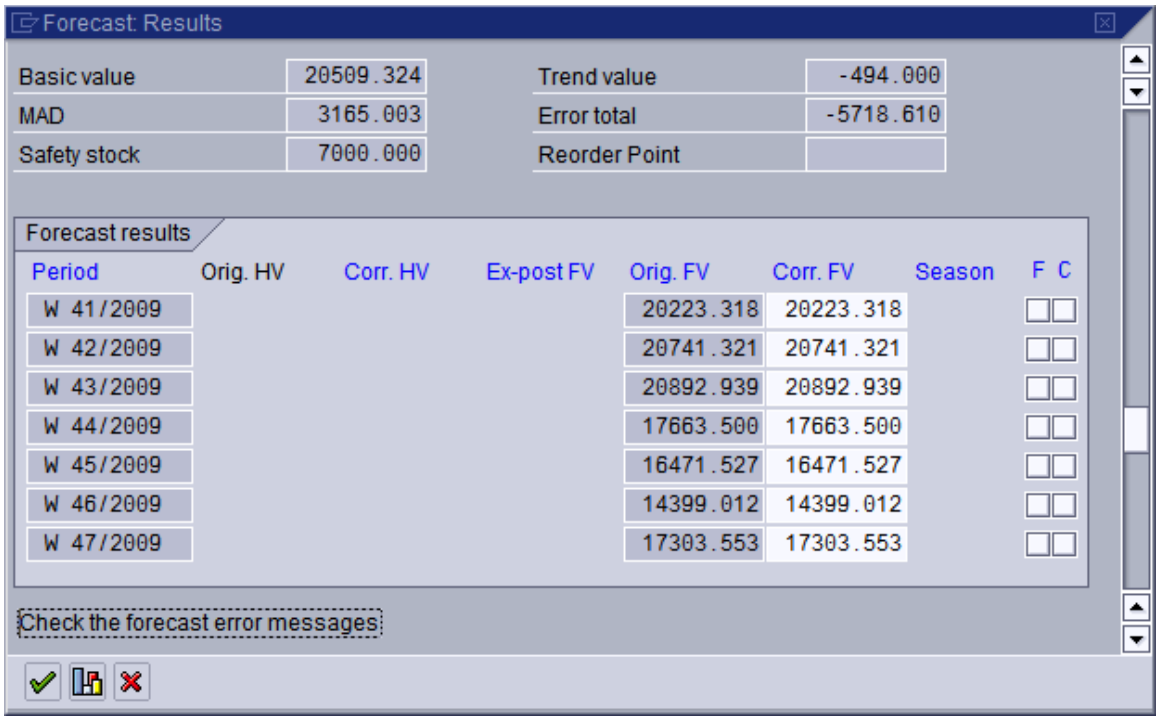
Next we will perform another forecast with Automatic model selection 'J' initialization 'X', model selection 'A' and selection procedure '2'



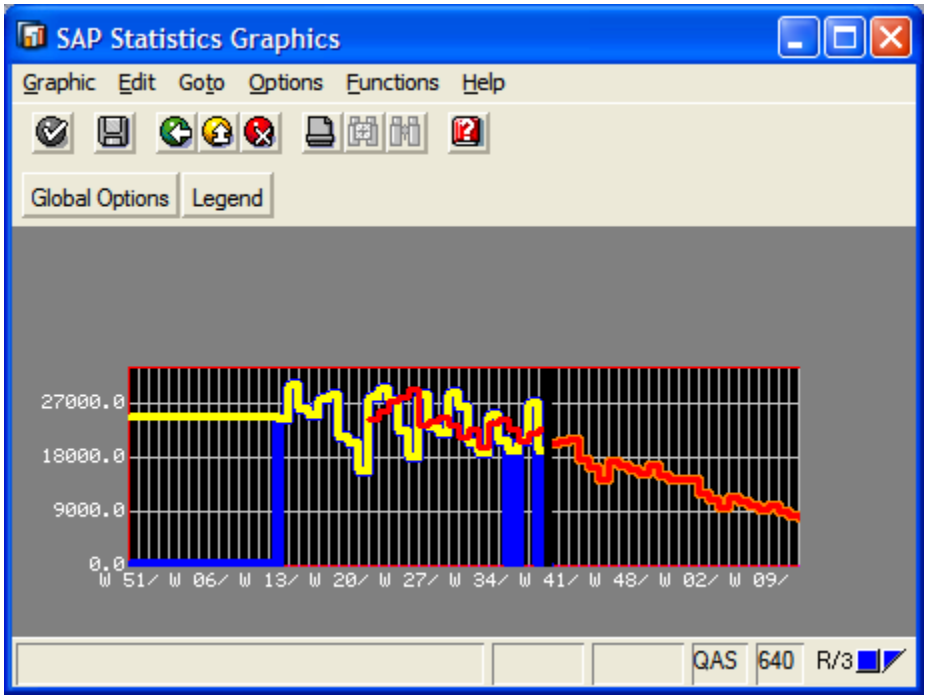


Automatic model selection with test for trend and season

The result is a model selection (we're not sure yet which) with a tracking signal lower than the tracking limit.

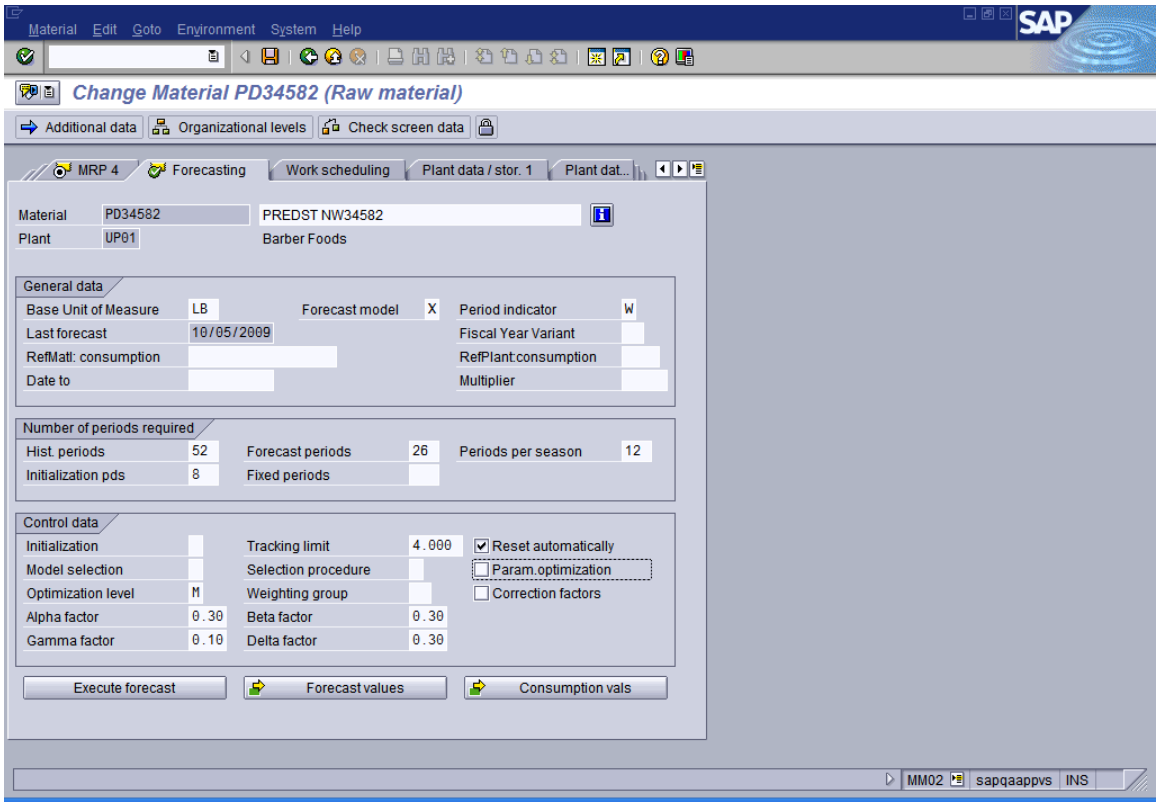


5718 / 3165 is lower than 4.000

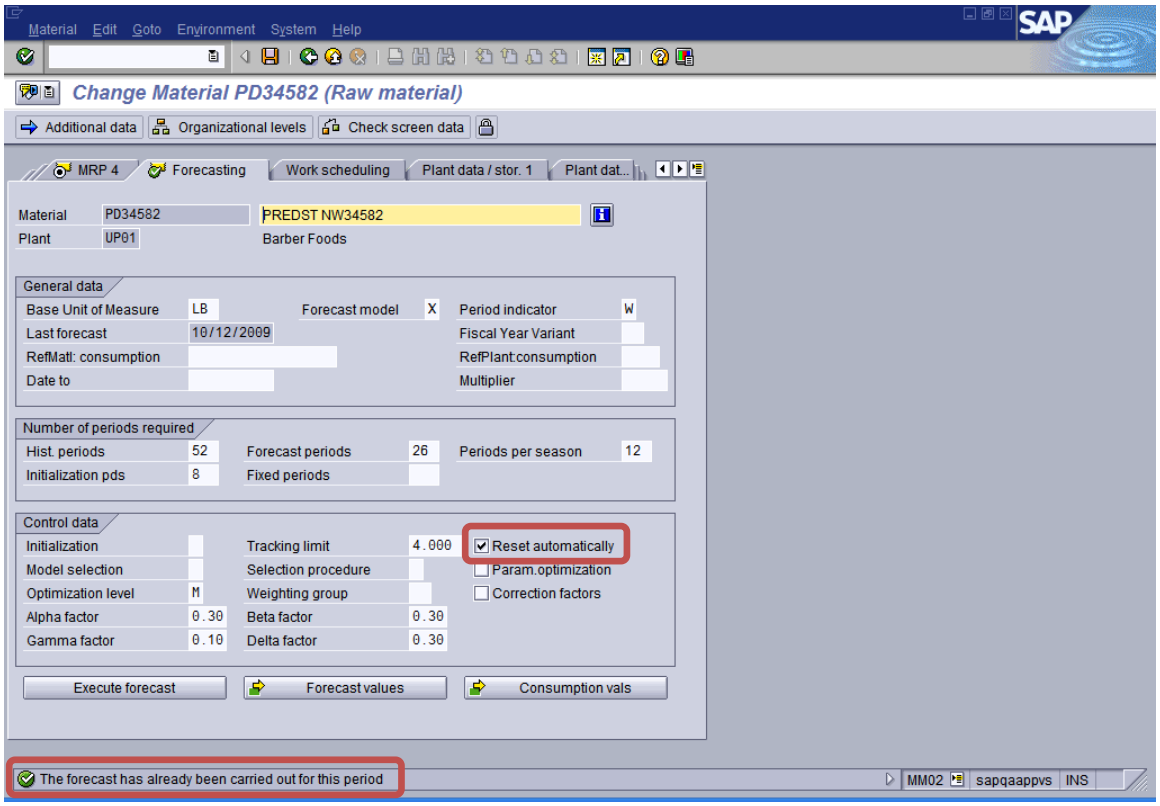


Graphical representation of past consumption (yellow), ex-post forecast (red in past) and forecast (red in future) with corrected historical values (blue)

In the forecast tab we can now see that the model selected (X for trend/seasonal) - because the tracking signal was below the tracking limit. Initialization and selection procedure were reset and set to blank

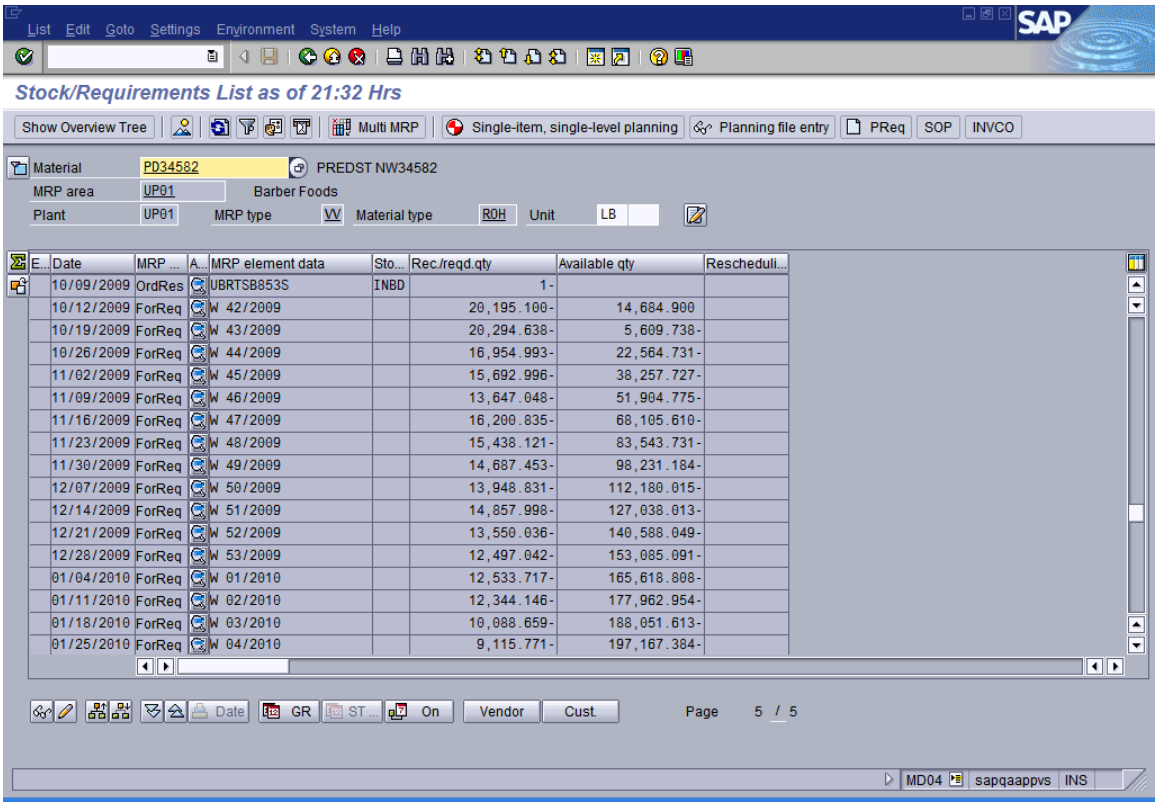


Now the forecast model is valid and the next time you attempt to run the forecast the system comes up the appropriate message:



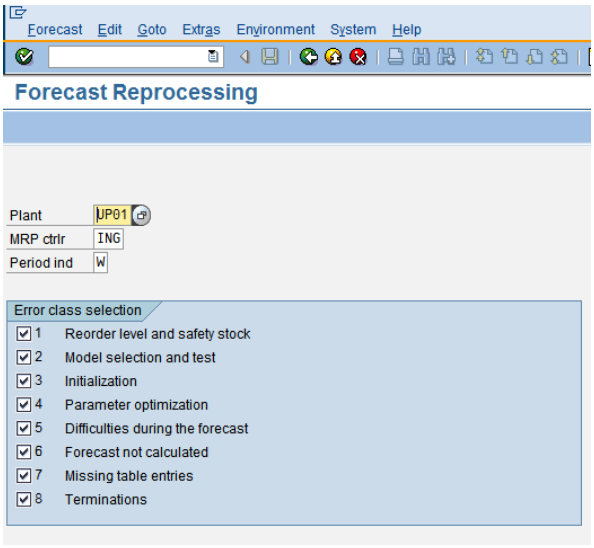
Only after a future forecast calculation results in a tracking signal higher than the tracking limit will the system replace the Forecast model 'X' with blank and reset the Initialization 'X' and selection procedure This is due to the setting **Reset Automatically**.

Now we can see all forecasted requirements in the stock / requirements list and the next MRP run will generate the appropriate order proposals.



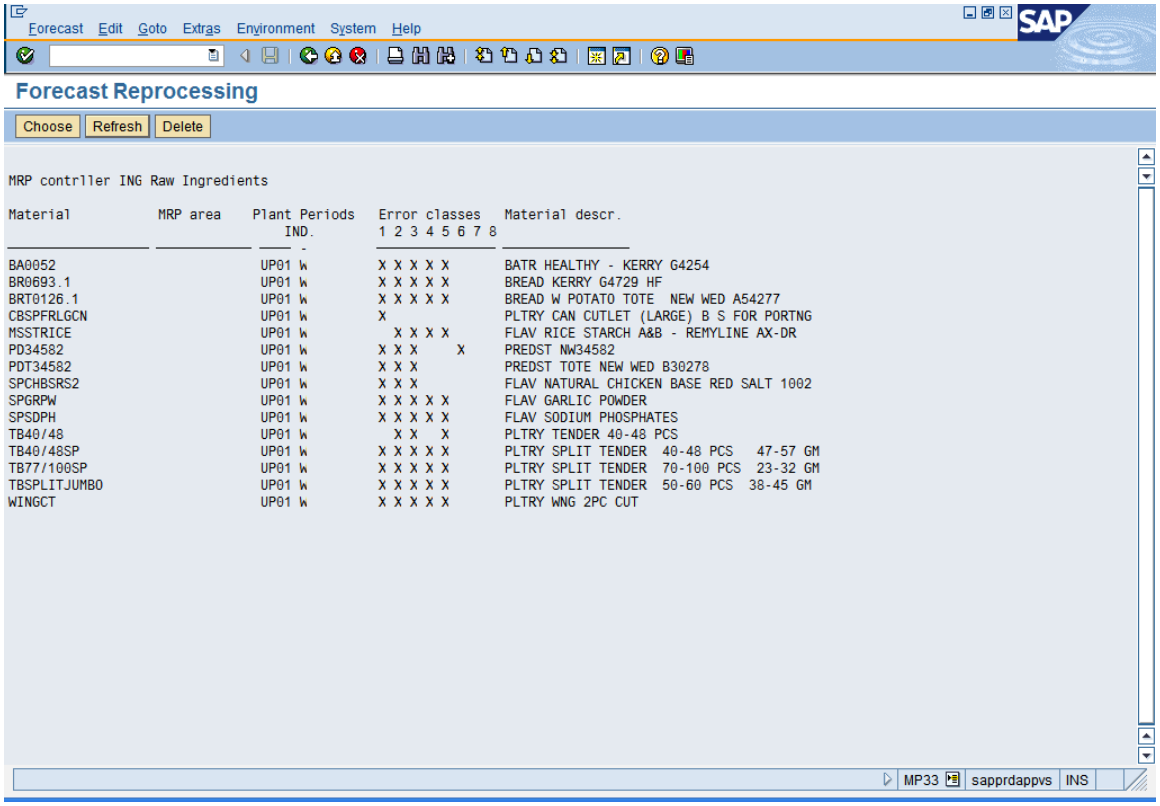
Stock requirements list with forecasted requirements before MRP netting

> *When running total forecasting (periodic run of the forecast for al materials), it is advisable to check the forecast result and to possibly rerun aterials with exceptional messages This can be done with transaction* ***MP33***

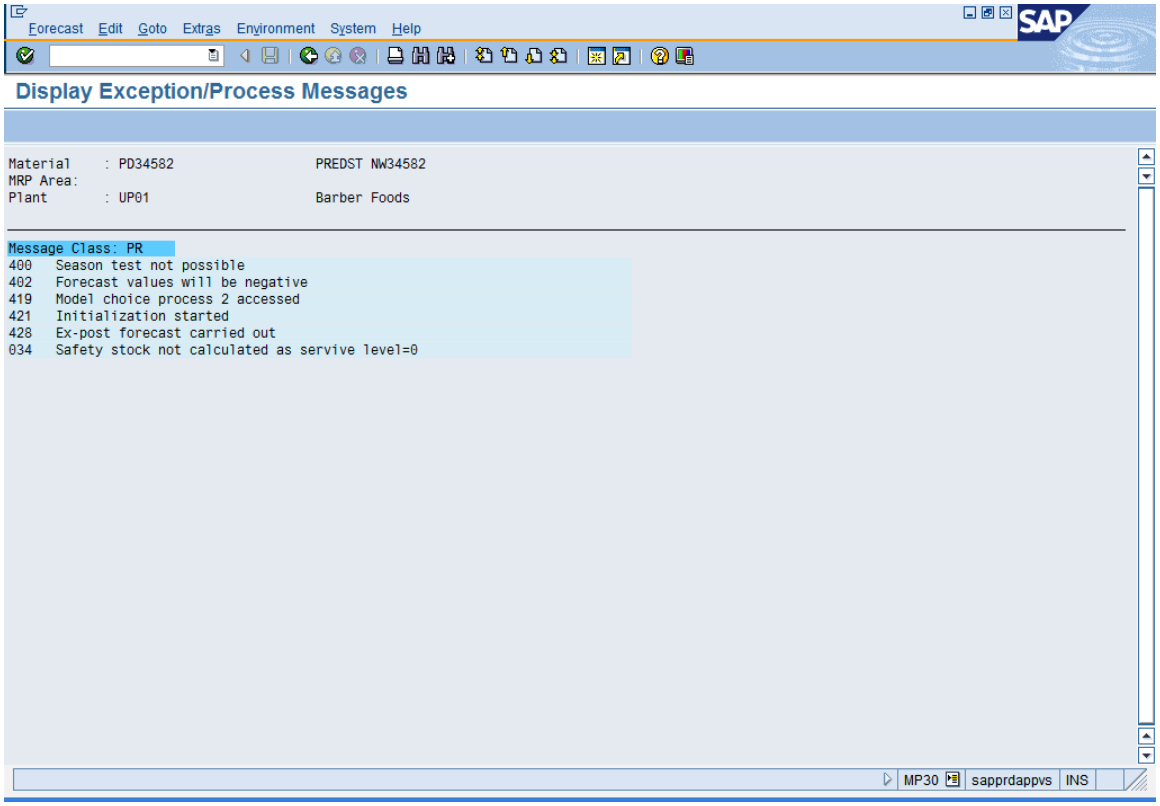


Transaction MP33 – Forecast Reprocessing

We want to look at al materials with exceptional messages in all message groups:



Overview to al materials needing reprocessing



Analyzing exceptional messages for a given materials

PARAMETER OPTIMIZATION

If you set parameter optimization, the system will overwrite the originally set smoothing factors with those which have been newly calculated by the optimization process.

The following factors are used by the system, depending on the model, for exponential smoothing. Thus, for example, only the alpha and the delta factors are required for the constant model whereas all of the smoothing factors are required for the seasonal trend model.

Alpha factor

The system uses the alpha factor for smoothing the basic value. If you do not specify an alpha factor, the system will automatically use the alpha factor 0.2.

Beta factor

The system uses the beta factor for smoothing the trend value. If you do not specify a beta factor, the system will autimatically use the beta factor 0.1.

Gamma factor

The system uses the gamma factor for smoothing the seasonal index. If you do not specify a gamma factor, the system will automatically use the gamma factor 0.3.

Delta factor

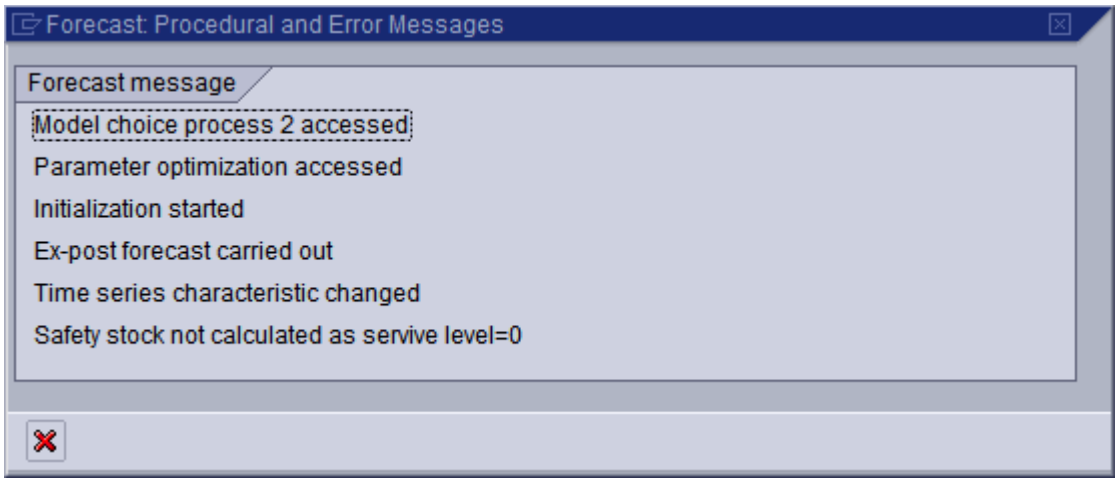
The system uses the delta factor for smoothing the mean absolute deviation and the error total. If you do not specify a delta factor, the system will automatically use the delta factor 0.3.

EVALUATING FORECAST ACCURACY

The system provides some means of monitoring the accuracy of the forecast by means of exception messages (not to confuse with the exception monitor MD07 but rather MP33) and tracking signal and tracking imit.

EXCEPTION MESSAGES

Exception messages provide information about what the system did during the forecast calculation.



Exception messages may be accessed through MP33 or individually for every material from te forecast tab when looking at the forecast result.

TRACKING SIGNAL

A good indication of whether a selected model still has validity is the tracking signal's value. The tracking signal is calculated by dividing the total error by the MAD. The total error is the sum of all absolute deviations of the forecast value from the actual value and the MAD represents a median deviation of the forecast values from the actual values using exponential smoothing.

The ex-post forecast is an excellent basis for the calculation of these deviations.

Therefore the bigger the total error, the bigger is the resulting tracking signal which means that there are big deviations (spikes) in the consumption pattern. Those spikes invalidate the model if they exceed a certain limit That limit can be set in the forecasting tab – the tracking limit (4.000 as a recommendation)

After every forecast the system compares tracking signal with tracking limit and either confirms the model (in setting the indicator in the field 'Model Selection' and resetting Initialization) or it does not confirm the model and allows for a rerun and renewed model initialization until a valid model is found.

Following the formulas to calculate mode validity

ERROR TOTAL

$$(12) \qquad ET = \sum_{t-1}^{n} \left[V(t) - P(t) \right]$$

MEAN ABSOLUTE DEVIATION FOR INITIALIZATION

$$(13) \qquad MAD = \frac{1}{n} \sum_{t-1}^{n} \left| P(t) - V(t) \right|$$

$$n = \text{Number of periods for initialization}$$

MEAN ABSOLUTE DEVIATION FOR THE EX-POST FORECAST

$$(14) \qquad MAD(t) = (1 - \delta) * MAD(t-1) + \delta * \left| V(t) - P(t) \right|$$

TRACKING SIGNAL

$$(15) \qquad TS = \left| \frac{ET}{MAD} \right|$$

THEIL COEFFICIENT FOR THE EX-POST FORECAST

$$(16) \qquad U = \sqrt{\frac{\sum_{t=1}^{T} \left(P(t) - V(t)\right)^2}{\sum_{t=1}^{T} \left(V(t) - V(t-1)\right)^2}}$$

After a model change or a forecast model initialization, the error total is automatically reset to zero and the MAD to its initial value.