# Risk Management of Materials Supply

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## Abstract

The article is devoted to risk management in the business process of materials supply for industrial enterprises.

The goals of the business process are considered, and the risks of the failure to achieve goals are identified. Probabilities and influence of negative events are estimated. The risk treatment is considered on critical risks, including forming of insurance supplies of materials. The calculations of insurance supplies of materials, taking into account risks, are conducted on the basis of statistical information.

> *One of the tasks of effective control of inventories—to "satisfy or exceed expectations of buyers in regard to the presence of commodities."*
>
> *... on the other hand, it is needed to remember—"effective control of inventories allows organizations to create such supplies of every commodity, which maximize a net income."*
>
> John Shraybfeder, president of Effective Inventory Management, Inc.

In the unbroken chain of business process, the purpose of which is a sale of commodities to clients, the process of supplying with materials plays an important role[1].

Therefore, as one of the strategic goals of a company, there must be a trouble-free supply of materials of the required quality on condition of rational cost of supplies.

Continuity guarantees the presence of the commodities in storage; quality of materials provides quality of products and acceptable losses from defective goods; the rational cost of supplies prevents "freezing" of company finances.

Thus, the purposes of supply of materials can be formulated as follows:

- providing of terms of deliveries;
- providing of the required quality of materials;
- providing of rational volume of delivery.

The factors influencing achievement of the purposes listed above can be the following:

- stability of material properties;
- discipline of shipping of materials to a supplier;
- implementation of terms of materials delivery to a transport company;
- observance of norms at unloading and warehousing of materials;
- observance of norms at preparation of materials for production;
- quality of planning of orders in a company;
- stability of producing goods.

Risk management from the moment of determination of the strategic goals of the company supposes step-by-step fulfillment of actions that are based on simple (it is possible to say everyday) logic—to identify risks, to estimate importance, to develop the sufficient measures of mitigating risks, to realize measures and to take risks under control.

Such logic is traced to all of the known regulating documents in the area of risk management [2-5].

This process is reasonable to risk management of business process of materials supply. After forming of strategic goals, it is necessary to expose risks.

The risks of the failure to achieve the goals mentioned above are the following:

- insufficient quality of materials from instability of production by supplier;
- incomplete deliveries of materials through the fault of the supplier and stealing at transporting;
- delays of shipping a supplier;
- delays at transporting;
- delays at unloading and warehousing through the fault of personnel and because of disrepair of equipment;
- delay at preparation of materials through the fault of personnel and because of disrepair of equipment;
- increase of amount and volume of orders as compared to planned;
- unevenness of production because of repairs and planning of loading equipment.

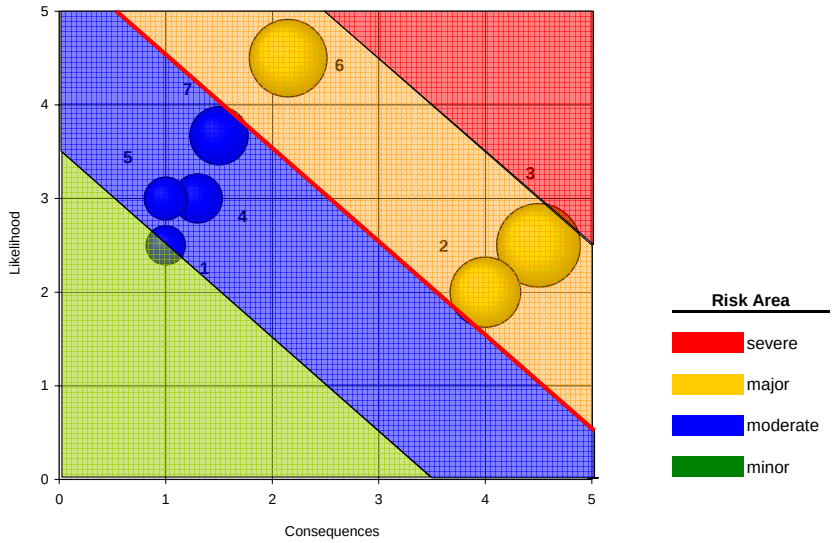
Estimation of risks, inherent in the business process, is conducted on the basis of expert and statistical information (Table 1).

**TABLE 1**
**Estimation of Inherent Risks**

| № | Risk Name | Probability % | Influence (Delay of Production Output), Day | Weighted Estimation, Day | Rank of Risk |
|---|---|---|---|---|---|
| 1 | Insufficient quality and incomplete deliveries of materials through fault of supplier | 20 | 0,05 | 0,01 | 6 |
| 2 | Delays of shipping | 10 | 1 | 0,1 | 3 |
| 3 | Delays of transporting | 20 | 1,5 | 0,3 | 1 |
| 4 | Delays at unloading and warehousing | 30 | 0,08 | 0,024 | 5 |
| 5 | Delay at preparation of materials | 30 | 0,03 | 0,009 | 7 |
| 6 | Increase of amount and volume of orders | 80 | 0,26 | 0,208 | 2 |
| 7 | Unevenness of production | 50 | 0,15 | 0,075 | 4 |

At setting of risk appetite at the level of six numbers, that corresponds to 0,15 days of delay of supplying with materials or dead time of equipment. Three risks are estimated as high level risks, requiring action by the company management.

**Figure 1**
**The Map of Inherent Risks**




Some parts of risks, because they are external (supplier, carrier company, client), can not be removed in principle.

Internal risks are personnel (worker, repair, administrative), equipment and organization of the business process, which can be managed in a greater degree. A limit on efficiency of risk treatment, mainly, is financial. But it does not eliminate the residual risks of anthropogenic character.

Risk treatment includes the following.

*Insufficient quality of materials and incomplete deliveries:*

- choice of reliable supplier, diversification of suppliers;
- creation of insurance inventory of materials.

*Slower delivery of materials:*

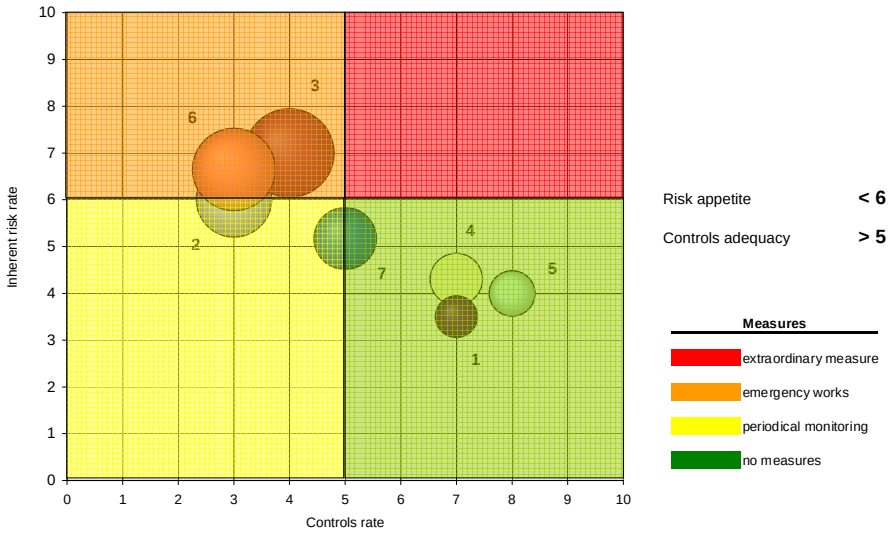
- choice of reliable supplier, diversification of suppliers;
- choice of reliable carrier companies, diversification of carrier companies;
- selection of skilled personnel, motivation;
- prophylactic and current repair of equipment;
- creation of insurance inventory of materials.

*Ineffective planning of orders and unevenness of production:*

- optimization of purchase parties of materials;
- observance of regulation of products planning;
- work with a client for planning of orders;
- prophylactic and current repair of equipment;
- creation of insurance inventory of materials.

In Figure 2, the risk map is produced without taking into account the creation of insurance inventory of materials. This measure will be used for ineffectiveness of the realized measures of mitigation of risks.

**Figure 2**
**The Map of Risks**
**(Without the Insurance Inventory)**




As follows from Figure 2, realized measures are not enough to reduce risks to the acceptable level.

By the high level measure, which can compensate risks, creation of insurance inventory of materials can be examined. The only limit on efficiency of this measure is financial.

Traditionally, inventory of materials is settled 50 percent from the level of current inventory (here we are not stipulating probability of coverage of deficit of materials). Taking into account instability of market relations supplier-producer and producer-client, it is expedient to ground an insurance inventory for any large company, taking into account its concrete features.

For pipe factories, the insurance supply of material in a general case can be expected on the following formula:

$$\grave{O}insur(day) = \Delta\grave{O}deliv(day) + \Delta\grave{O}transp(day) + \Delta\grave{O}unload(day) + \Delta\grave{O}prepar(day)$$
$$+ (\Delta Qdeliv + \Delta Qplan + \Delta Qprod) / R^{aver}use(ton/day);$$

where:

ΔT = positive deviation from the mean values of duration of subprocesses of materials delivery;

ΔQ = a shortage of material through fault of supplier, because of receipt of new orders and unevenness of production;

$R^{aver}use(ton/day)$ = the average daily use of material during a month.

It is suggested to consider as estimations of insurance inventory:

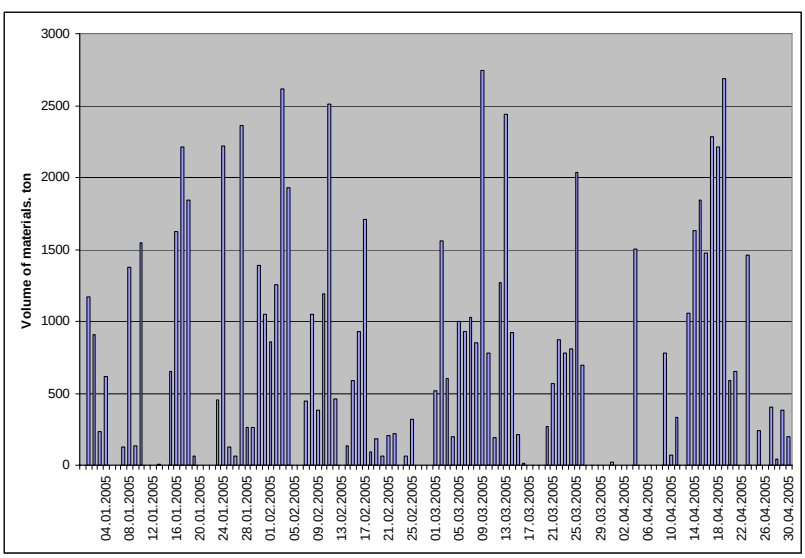
1. Sum of maximal deviations of delay in material delivery and dead time of equipment. In this case the guarantee estimation of volume of insurance inventory with a zero risk is obtained. It makes 2,8 days (Table 1).

2. Traditional (good practice) estimation—50 percent from a current supply—0,7 days.

3. Estimation, from simulation on the basis of distribution function of constituents of insurance inventory.

The actual arguments of deliveries considerably differ from planned (Figure 3), because of the influence of risk factors (Table 1).

**Figure 3**
**Statistics of Materials Supplying for Four Months**



The simulation of the probability distribution of time of delay of materials supply and dead time of equipment will take advantage of the next statistical information.

**TABLE 2**
**Data of Insurance Inventory Given for a Simulation**

| № | Risks | Interval of Deviations, Day | | Parameters of Deviations Distribution | |
|---|---|---|---|---|---|
| | | Minimum | Maximum | Mean Deviations, Day | Probability of Deviations |
| 1 | Insufficient quality and incomplete deliveries of materials | -0,1 | 0,24 | 0,05 | 20% |
| 2 | Delays of shipping | -0,5 | 0,44 | 1 | 10% |
| 3 | Delays of transporting | -0,5 | 0,8 | 1,5 | 20% |
| 4 | Delays at unloading and warehousing | -0,08 | 0,12 | 0,08 | 30% |
| 5 | Delays at preparation of materials | -0,08 | 0,07 | 0,03 | 30% |
| 6 | Increase of amount and volumes of orders | -0,15 | 0,88 | 0,26 | 70% |
| 7 | Unevenness of production | 0 | 0,23 | 0,15 | 50% |

Probability distributions of risks are approximated by gamma density. Distributions are shown in Figures 4 and 5 as examples for some risks.

**Figure 4**
**The Distribution of Dead Time of Equipment for Risk № 1**
**(Insufficient Quality and Incomplete Deliveries of Materials)**

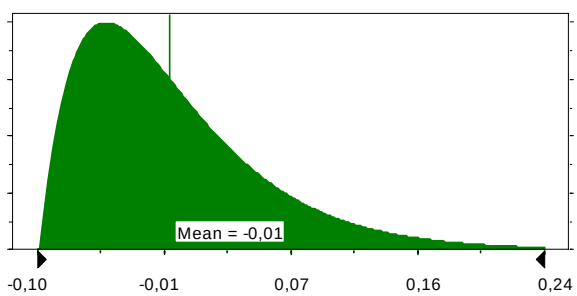
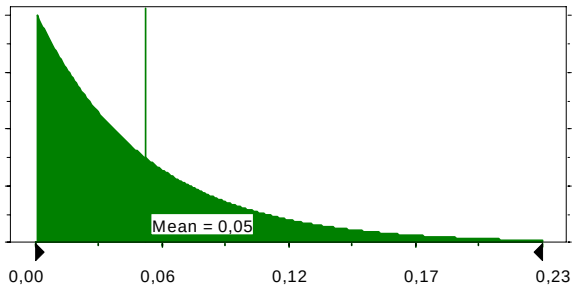
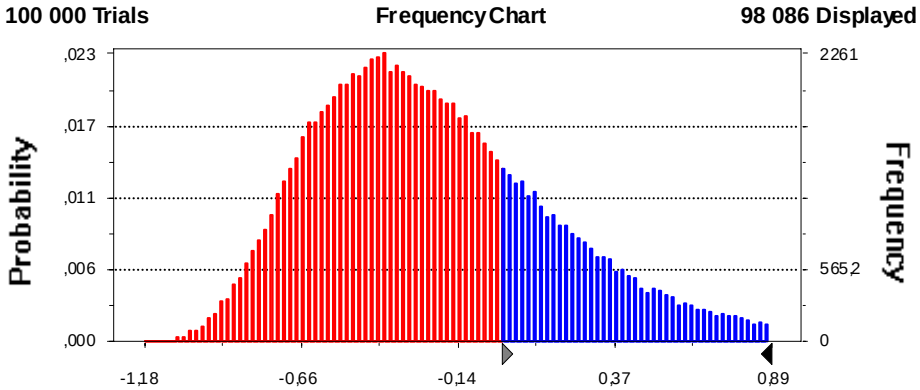


**Figure 5**
**The Distribution of Dead Time of Equipment for Risk № 7**
**(Unevenness of Production)**




As a result of simulation, the bell-shaped distribution of delay of supplying with materials and dead time of equipment is achieved (Figure 6).

**Figure 6**
**The Distribution of Delay of Supplying With Materials and Outage of Equipment**




Parameters of distribution are presented in Figure 6:

- interval of duration of delays and outage, day — 0-2,8
- probability of delays and outage, % — 27
- expectation value of delays and outage, day — 0,26
- confidence interval of duration of delays and outage (probability 0,99), day — 0-0,9

As follows from Figure 6, the rational volume of insurance inventory of materials, from the results of the simulation, makes 0,9 day.

Thus, it is possible to compare the variants of estimations of insurance inventory.

**TABLE 3**
**Estimations of Volume of Insurance Inventory**

| Estimation of Insurance Inventory | Guarantee Estimation | Good Practice | Simulation |
|---|---|---|---|
| Volume of insurance inventory, day | 2,8 | 0,7 | 0,9 |
| Coverage of risk an insurance inventory, % | 100 | 85 | 99 |
| Residual risk (probability), % | 0 | 15 | 1 |
| Interval of delays and outage, day | 0 | 0,7-2,8 | 0,9-2,8 |
| Expectation value of delays and outage, day | 0 | 0,8 | 0,9 |

Conclusions from the resulting research with regards to the volumes of insurance inventory of materials are the following:

1. The guarantee estimation sets the volumes of inventory considerably too high, because it does not take into account distribution of probabilities of duration of delays of supplying with materials and outage of equipment.

2. Good practice gives an average industry estimation, and it is oriented on the stable terms of supplying with materials and long-term relations within the framework of the planned economy. Such estimation, probably, is a low bound for the modern market conditions of production.

3. Simulation for the concrete company in modern terms of production, related to mobility and changeability of external and internal factors, gives a more grounded estimation of volumes of insurance inventory. This estimation lies in an interval, limited from above by guarantee and from below by good practice estimations.

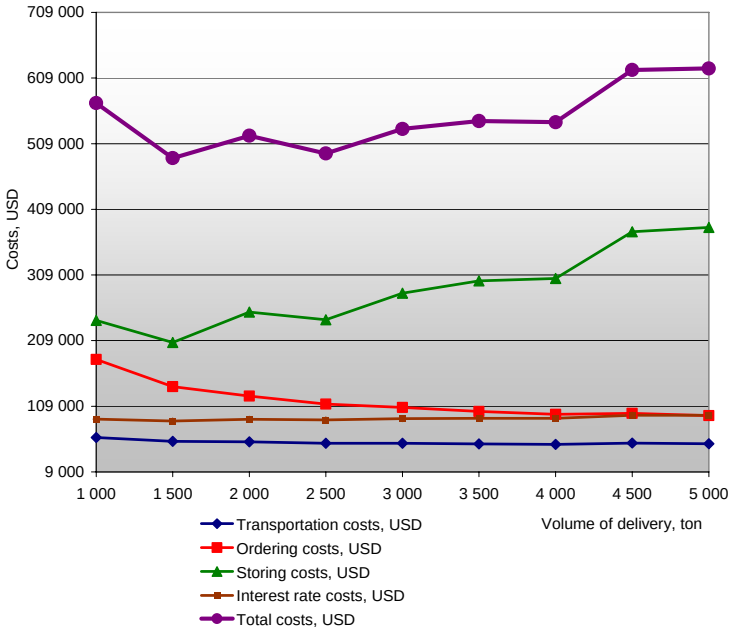
If a company assumes the delay of supplying with materials, i.e., sets some level of risk appetite for supplying with materials, the volume of insurance inventory does not change in this case, but frequency of its filling in goes down.

For example, if a risk appetite is equal to 0,15 days, probability of delay of delivery in an interval 0,15-2,7 days will go down to 20 percent, and frequency of replenishment will be reduced in 1,3 time.

The use of the process of forming and replenishment of insurance inventory allows more grounds to solve the problem of estimation of actual parameters of supplying with materials, namely the problem of the choice of rational volumes and periodicity of delivery.

Total costs of supplying with raw materials are shown in Figure 7, including ordering, transportation, storing and interest rate costs.

**Figure 7**
**Estimation of Rational Parameters of Materials Supplying**

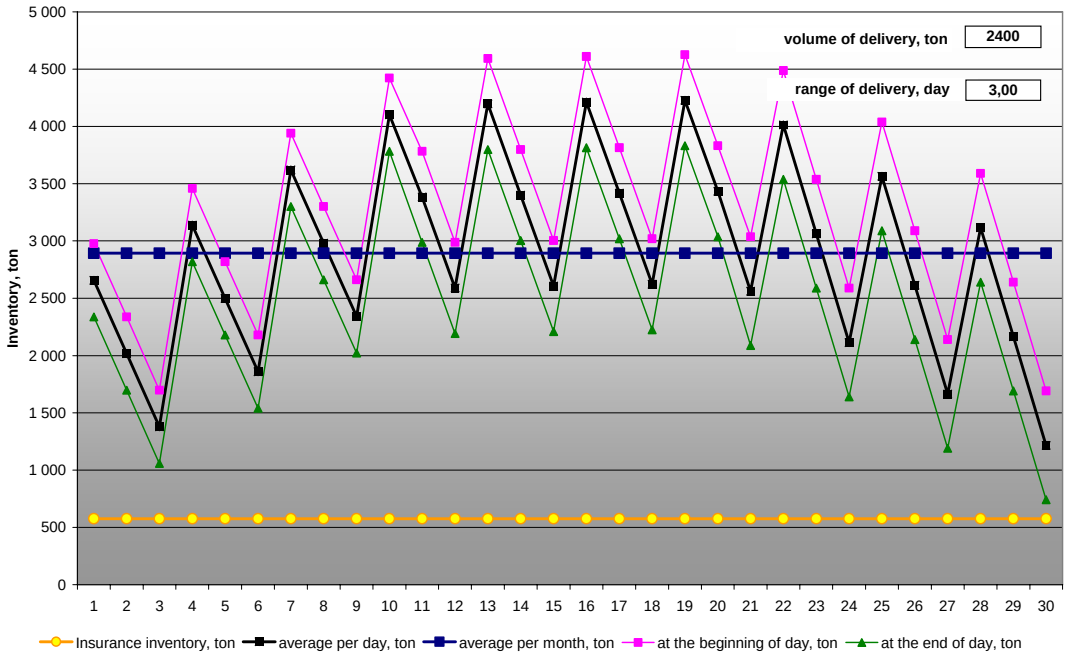



As follows from the figure resulted higher, the volume of delivery makes 2,000-2,500 tons. This volume is optimal since total costs of supplying is minimal.

Periodicity of three days corresponds to this volume. The insurance inventory of materials makes 580 tons; that corresponds to 0,9 days that are appraised at the simulation of duration of supplying with material (Figure 3).

The change of inventory during a month is shown in Figure 8.

**Figure 8**
**Change of Inventory During a Month**

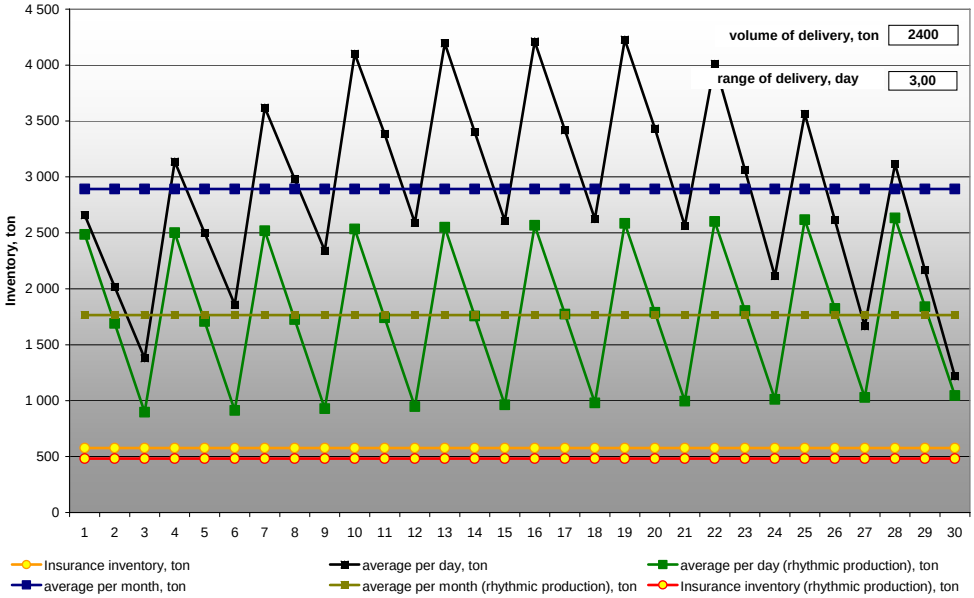



At the calculation of volumes of inventory, a risk factor №7 was taken into account—it is an unevenness of production—with the following parameters:

- 1 10-day period—27 percent;
- 2 10-day period—33 percent;
- 3 10-day period—40 percent.

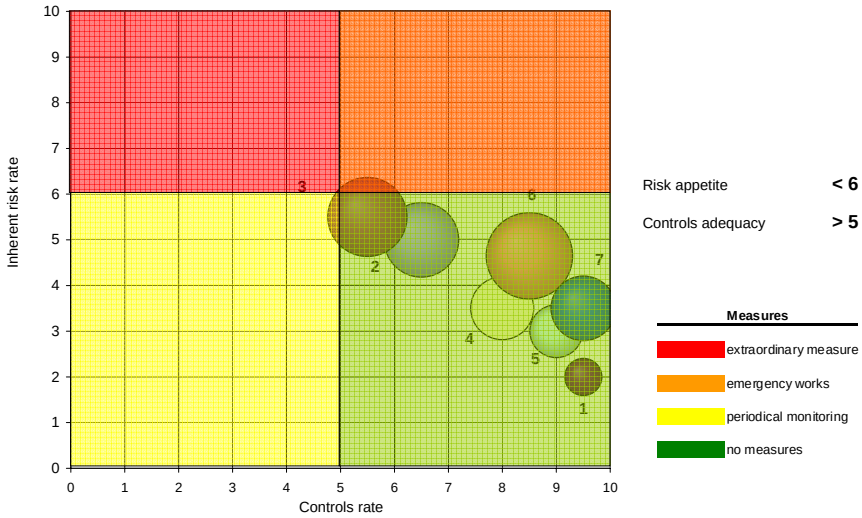
If a production was a balanced load, the volume of insurance inventory would make 480 ton, or 0,75 days (Figure 9). This is a difference of 100 ton, or 0,15 days, and there is a contribution of unevenness of production to the volume of insurance inventory, appraised at ranging of risks (Table 1).

**Figure 9**
**Change of Inventory During a Month at a Rhythmic and Unrhythmic Production**




Thus, realization of effective measures of mitigation of risks, such as forming and maintenance of insurance inventory, allows the reduction of the risks of business process of supplying with materials to the acceptable level, shown in Figure 10.

**Figure 10**
**The Map of Risks**
**Taking into Account an Insurance Inventory**



As an additional measure of the response on risks, it is necessary to consider the variants of new suppliers of materials and carrier companies that would execute the requirements of contracts more neatly.

The presented methodology of risk management of business process of supplying with materials in general is universal and can be applied for risk management of other business processes in the chain of development, production and sale of commodities to clients.

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