Abstract: In the paper is presented the factors that influence the reliability of the valves to can determine the ways of increasing it based on the causes of defects and their evaluation. After many researches was finding that by following in operation the behavior of more than 20 valves from each family, the component element that influences the reliability of the serial system, of the valve, is the stem gasket, and the result of the researches are connected around the fluid leakages from the gland gasket.

Key-words:- reliability, valves, gasket, compaction phenomenon, sealing ring.

1. Introduction
In general, the valves have numerous properties, but only some of them can determine, at one moment, the quality, and they are called quality features. In the specialty standards, in the valves, manufacturers norms and tender books are established the technical conditions for the essential quality features of the valves. In order to estimate the quality of a product, it is necessary to verify if these technical conditions are fulfilled. The quality features have appeared as a consequence of the beneficiaries, demand in appraising the quality of the products, of the environment in which they correspond to their purpose. Depending on them, the following important quality features can be differentiated: the reliability and the maintainability.

The reliability \( R(t) \) represents the probability that a product operates without defects within the \((0, t)\) interval, under determined conditions. [1], [2].

2. Valves’ reliability
In order to determine the ways of increasing the valves’ reliability it is necessary to be known the factors that influence the reliability, to be analyzed the causes of the defects and to be evaluated the reliability from the quantitative point of view.

For the valves, the time elapsed in hours from the date of the putting into operation until the appearance of the successive defects as well as the number of close-open maneuvers have been chosen as reliability criteria.

From the point of view of the stages in which there are evaluated the principles of the indicators that characterize the valves, reliability, we distinguish [1]:

• \textit{Previsional reliability} (preliminary or designed) represents the reliability of a product determined on the basis of the considerations regarding the operation requirements by analogy with other similar products or through calculations adequate for this field.

• \textit{Experimental reliability} represents the reliability of a product determines don the basis of the experiments in labs, on testing and verification benches, by creating the requirements conditions similar with the ones from operation.
Operational reliability (effective at the beneficiary) represents the reliability of a product determined on the basis of the results regarding the behavior in operation on a certain period of time, of a determined number of elements with identical features. Nominal reliability represents the reliability of a product written in the specification or the delivery Passport to the beneficiary. Estimated reliability represents the reliability of a product punctually determined or for a given interval of tests, on the basis of the results appeared from lab testing or from operation.

2.1. Operational reliability

The valves are the products formed of many components. In the reliability language they are called systems. For the calculation, for the determination of the reliability of a system, respectively, it is necessary to know the reliability of every component. The component elements of a system can directly or indirectly influence its good operation. If at a system the components are connected between them so that they do not operate, if one of the components, no matter which one, is defected, it is considered that this system is a serial system. A serial system is graphically represented as follows:

Fig.1. Serial system

The reliability of the system is given by the relation:

\[ R(t) = R_1(t) \cdot R_2(t) \cdot R_3(t) \cdot \ldots \cdot R_n(t) \]  \( (1) \)

where \( R_{1\ldots n}(t) \) represents the reliability of the elements 1,2,3, \ldots, n at time t.

Because the reliability of an element is maximum 1, it results that the reliability of the system is smaller than the reliability of the element from the system with the most reduced reliability.

For the valves it was chosen [4] as reliability criteria time in hours, elapsed, from their putting into operation up to the appearance of the first defect. The statistical model used in this study to determine the reliability indicators is the Weibull repartition.

The values of the reliability indicators are determined by the processing of the experimental data, obtained by the tracking of a number of 20 valves for every family. The remarks on the valves are made using the censored plan of tests to which there are made the remarks after the appearance of a number of defects initially established, meaning 4 consecutive defects for each valve. The families followed in this study are as follows:

- wedge gate valve with non-rising stem, PN 4bar pressure;
- wedge gate valve with non-rising stem, PN 10bar.

In order to determine the reliability of the 2 families of valves, it was followed the behavior manner on operation of a number of 20 valves from the date of the putting into operation until the appearance date of the 4th consecutive defect (censored plan of tests).

The elements that got defected during the operation process, as it results from study [4], were:

- the gland gasket;
- the sealing rings from the seats from the body and from the gate.

Next it was calculated the reliability for the component elements that got defected, being determined the reliability of the 2 valves with the help of formula (1).

For the two elements, with the help of the Allan-Plait diagram, there were determined the Weibull distribution law parameters \((\beta, \eta)\).

\[ R(t) = \exp \left[ - \left( \frac{t}{\eta} \right)^\beta \right] \]  \( (2) \)

3. The wedge gate valves, with non-rising stem, PN 4 and Pn10 reliability values

The results obtained for the two above-mentioned valves are presented in the following tables and formulas:

- the reliability function \( R_{21s}(t) \), for the stem gasket at the gate valve, PN4
where \( \beta=4; \eta=9.700 \) hours
-the reliability function \( R_{1,1}(t) \), for the stem gasket at the gate valve, PN10

\[
R_{1,1}(t) = \exp\left[-\left(\frac{t}{9.700}\right)^4\right]
\] (3)

where \( \beta=4; \eta=9.700 \) hours

- the reliability function \( R_{2,1}(t) \), for

\[
R_{2,1}(t) = \exp\left[-\left(\frac{t}{7.800}\right)^3\right]
\] (4)

where \( \beta=3; \eta=7.800 \) hours

Table 1

<table>
<thead>
<tr>
<th>( t )</th>
<th>2000</th>
<th>4000</th>
<th>6000</th>
<th>8000</th>
<th>10000</th>
<th>12000</th>
<th>14000</th>
<th>16000</th>
<th>18000</th>
</tr>
</thead>
<tbody>
<tr>
<td>( R_{1,1}(t) )</td>
<td>1.000</td>
<td>0.970</td>
<td>0.862</td>
<td>0.628</td>
<td>0.323</td>
<td>0.096</td>
<td>0.015</td>
<td>0.000</td>
<td>0.000</td>
</tr>
<tr>
<td>( R_{2,1}(t) )</td>
<td>0.990</td>
<td>0.877</td>
<td>0.632</td>
<td>0.341</td>
<td>0.121</td>
<td>0.026</td>
<td>0.003</td>
<td>0.000</td>
<td>0.000</td>
</tr>
</tbody>
</table>

-the reliability function \( R_{2,1}(t) \), for the sealing rings from the seats from the body and from the gate, at the gate valve, PN4

\[
R_{1,2}(t) = \exp\left[-\left(\frac{t}{45.000}\right)^5\right]
\] (5)

where \( \beta=5; \eta=45.000 \) hours

- the reliability function \( R_{2,2}(t) \), for the sealing rings from the seats from the body and from the gate, at the gate valve, PN10

\[
R_{2,2}(t) = \exp\left[-\left(\frac{t}{37.000}\right)^4\right]
\] (6)

Table 2

<table>
<thead>
<tr>
<th>( t )</th>
<th>8000</th>
<th>16000</th>
<th>24000</th>
<th>32000</th>
<th>40000</th>
<th>48000</th>
<th>56000</th>
<th>64000</th>
<th>72000</th>
</tr>
</thead>
<tbody>
<tr>
<td>( R_{1,2}(t) )</td>
<td>1.000</td>
<td>1.000</td>
<td>0.961</td>
<td>0.823</td>
<td>0.574</td>
<td>0.251</td>
<td>0.050</td>
<td>0.003</td>
<td>0.000</td>
</tr>
<tr>
<td>( R_{2,2}(t) )</td>
<td>1.000</td>
<td>0.961</td>
<td>0.840</td>
<td>0.571</td>
<td>0.255</td>
<td>0.059</td>
<td>0.005</td>
<td>0.000</td>
<td>0.000</td>
</tr>
</tbody>
</table>

The reliability of the two valves is determined with formula (1), indicated for the calculation of the reliability of a serial system, meaning:

\[
R_e(t) = R_{1,1}(t) \times R_{1,2}(t)
\] (7)

For the gate valve PN4

\[
R_e(t) = R_{2,1}(t) \times R_{2,2}(t)
\] (8)

For the gate valve PN10

The reliability of each valve, as a system, can be determined by means of the
Allant Plait diagram, using the same steps as in the case of determining the reliability of the system’s components, but the results are very close to those obtained with the formulas (7) and (8).

4. Conclusions
The operational reliability (effective at the beneficiary) was determined by following in operation the behavior of 20 valves from each family, adopting the censored plan of tests.

The component element that influences the reliability of the serial system, of the valve, is the stem gasket. The reliability of the stem gasket and at the gate valve PN4 and PN10 is smaller that the reliability of the sealing rings from the seat and from the gate. The valve reliability is conditioned in great measure by the element with the lower reliability – in this case the gland gasket reliability.

In order to increase the valves reliability, the stem gasket reliability must be increased.

It was found that the fluid leakages from the gland gasket are caused by the compaction phenomenon in the contact area with the stem because of the repeated maneuvers and because the stem is not perfectly centered. This compaction causes the decrease of the contact pressure between the gasket and the stem, permitting the passing of the working pressure towards the exterior. If because of the maintenance personnel negligence the gland is not enough tightened or it is not changed, it leads to the appearance of the stem erosion phenomenon in the contact area with the gasket.

It can be solved as follows: the change of the gaskets material, the introduction of a lubricant (the use of the double sealing boxes), the change of the stem’s material.

References: