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DAMAGE TO POWER VALVES AND THEIR INPUT CONTROL

П.Я. Павлишин. **Пошкодження енергетичної арматури і її вхідний контроль.** Енергетична арматура займає ключове місце в питаннях надійності енергообладнання АЕС. Арматура встановлена на трубопроводах, що пов'язують практично все основне і допоміжне обладнання електростанції, крім цього, арматура широко поширена на електростанціях. Аналіз ситуації показує, що передумови виходу з ладу арматури можна розділити на чотири групи Представлена таблиця основних несправностей та пошкоджень арматури за результатами аналізу даних ремонтних цехів АЕС. Показано, що основні проблеми арматури зав'язані на два фактори: старіння і знос арматури, тобто проблеми її експлуатації і помилки конструкції і виготовлення, що представляють вже заводські причини. Вхідний контроль арматури на АЕС носить в основному документальний характер, тобто виконується перевірка комплектності документації та деталировки обладнання. Також проводять огляд устаткування на предмет видимих пошкоджень. Ремонтні і монтажні організації також не проводять спеціальних тестів для арматури, спираючись на довіру до заводу-виробника. Пропонується реалізувати на електростанціях методику вибіркового вхідного контролю арматури. Пропонований вид вхідного контролю пов'язує практично всі основні параметри арматури – її умовний діаметр, тиск на вході при гарантованому закриття арматури, допустимий пропуск середовища і номінальний крутний момент. Результати експериментальних досліджень, проведені на реальній арматурі, показали ефективність такого методу контролю, який дозволяє не тільки встановити рівень пропуску арматури, а й визначити необхідне зусилля закриття арматури електроприводом. Крім цього, такий метод контролю дозволяє виявити непрацездатну арматуру, чого не можна зробити візуальним контролем. Такий контроль дозволить виявляти не тільки помилки конструкції, але і розбіжність витратних характеристик однотипної арматури і пропуск арматури при її регламентному закритття.
Ключові слова: енергетична арматура, несправність арматури, вхідний контроль, експериментальне дослідження

P. Pavlyshyn. **Damage to power valves and their input control.** Energy valves occupy a key place in the reliability of NPP power equipment. The valves are installed on the pipelines connecting practically all main and auxiliary equipment of the power plant, besides, the valves are widely spread in power plants. The analysis of the situation shows that the prerequisites for the failure of the valves can be divided into four groups. The table of the main faults and damages of valves according to the results of analysis of data of NPP repair shops is presented. It is shown that the main problems of the valve are tied to two factors: aging and wear of the valve, i.e. problems of its operation and errors in design and manufacture, which are already factory reasons. Input control of valves at NPPs is mainly of documentary nature, i.e. check of completeness of documentation and equipment details. The equipment is also inspected for visible damage. Repair and installation companies also do not carry out special tests for the valves, relying on the confidence in the manufacturer. It is proposed to implement at power plants a method of selective input control of the valve. The proposed type of inlet inspection connects almost all basic parameters of the valve - its nominal diameter, inlet pressure at the guaranteed closure of the valve, the permissible medium flow and the nominal torque. The results of experimental studies carried out on real valves have shown the effectiveness of such a method of control, which allows not only to establish the level of passage of the valve, but also to determine the required force of valve closure by electric actuator. In addition, this method of control allows you to identify inoperable valve, which can not be done visual control. Such control will allow to detect not only design errors, but also the divergence of flow characteristics of the same type of valve and valve passage at its regular closing.
Keywords: power valve, valve failure, input control, experimental investigation

Introduction. Reliability of operation of power valves largely determines the reliability of the main equipment of NPP. Timely detection of damage to the valves will help to avoid unscheduled stops and accidents of the plant heating equipment. And vice versa, failure of the responsible valve can lead to serious events. One can recall the failure of the pulse valve of the pressure compensator at Trimile Island NPP, which ended with the first serious accident at the world's nuclear power plants [1]. A similar failure of the CPU was noted at the RAPP, but was detected and eliminated in time.

Thus, the energy valves occupy the key place in questions of reliability of power equipment of NPP. The valves are installed on the pipelines connecting practically all main and auxiliary equipment of the power plant and there are known cases, besides, the valves are widely spread at the power plants, so the 1000 MW block contains more than 9 thousand items of different energy valves. It should also be noted that damage to valves within the NPP unit leads to serious economic costs. For this, it is necessary to have a sufficiently large staff of repair personnel and special equipment for repairing valves [2].

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Aim of the article. To identify the weakest points of the valves, to determine if they can be identified at the entrance control. It is also important to compare the pass criteria for two different types of fittings.

Analysis of the problem and its actuality. The analysis of the situation shows that the prerequisites for valve failure can be divided into four groups:

1. Factory-specific damage, which occurs when the output control of a fitting in the factory is poor.
2. Damage caused during transportation or factory damage that was not detected during the NPP input inspection.
3. Damages arising directly during operation (vibration and erosion-corrosion damage).
4. Damage caused by poor quality repairs to the fitting and its components.

Below is presented the Table 1 of the main faults and damages of the valves according to the results of analysis of data of NPP repair shops.

Table 1

Distribution of fitting faults by type and cause of damage (in quantity)

Armature type / Reasons for damage	Built-in control valve	Gate valve	Gate valve	Gate valve shut-off	Valve safety	Valve solenoid	Water level indicator	Total
Without reading	58	30	40	8	32	9	36	212
Electrical effects	14	–	13	2	1	2	–	32
Ageing	100	21	154	103	55	15	43	497
Contamination	21	–	6	9	5	2	4	47
Wear	150	13	91	194	143	42	4	637
Material inconsistency	16	1	11	–	4	–	1	33
The control, the influence of the equipment	12	1	24	5	5	3	2	52
Feed effect	3	–	–	2	1	1	2	9
Beneficiary impact	–	–	1	–	–	–	–	1
Corrosion	1	–	2	1	2	–	1	7
Maintenance	2	1	3	2	2	–	–	10
Manufacturing errors	36	–	19	12	14	17	6	106
Design errors	18	1	5	1	3	16	–	44
Total	433	68	369	339	207	107	104	1687

As can be seen, the main problems of the valve are tied to 2 factors: aging and wear of the valve, i.e. problems with its operation and errors in design and manufacture, which are already factory reasons. The sample analysis shows that only 12.5 % of the original valve worked without indications, i.e. no failures. The main failure rate is for shut-off and control valves (over 80 %). Table 2 shows which parts of the fitting are most exposed to damage [3].

Table 2

Distribution of faults to the intended use and to the component parts of the fitting (%)

Fault Distribution		Lock,	Regulating	Protective	Safety
		0.62	0.24	0.11	0.03
Flange couplings, gland joints, separating part guides	0.29	0.18	0.07	0.03	0.01
Removable parts	0.58	0.36	0.14	0.06	0.02
Drivers	0.08	0.049	0.019	0.009	0.002
Electrical part	0.05	0.031	0.012	0.006	0.001

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Damage is caused by aggressive influences of vibration, erosion and corrosion. This indirectly reflects both the purpose of the fitting and its place of installation. It can also be seen from Table 1 that about 20 % of the damage is the result of a factory defect.

Recommendations. At present, the input control of the valves at nuclear power plants is mainly of documentary nature. Thus, when the valves are received from the plant, the completeness of documentation and detailing of equipment is checked. In some cases, the equipment is inspected for visible damage: slits, corrosion, etc. As a rule, repair and installation companies also perform no special tests for the fitting and install it based on the confidence in the manufacturer. Below are the main goals and tasks of input control at NPP [4].

Input control (IC) of products is carried out for the purpose:

– to prevent launching into production of products that do not meet the established requirements;

– protection of economic interests of NPP.

The main tasks of the input control are:

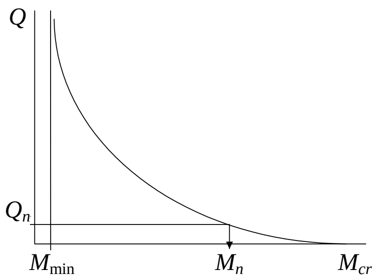
– carrying out of the entrance control at the stage of the receipt of products to the warehouses UPTK in the scope of technical inspection (VK-1);

– entrance control at the stage of receipt of products from UPTK warehouses in the volume of technical inspection (VK-2);

– all products arriving at NPPs are subject to entrance control. The applied volumes and methods of control depend on the purpose of products.

Special types of metal control at the request of curators VK conducts metal control department.

As it is possible to see, these recommendations do not allow to reveal factory errors of design and manufacturing, in the best case it is possible to define only discrepancy of metal of a product to the declared.



Dependence of the valve throughput on the degree of twisting: Q_n – nominal valve throughput according to its passport data; M_n – nominal torque ensuring the valve throughput; M_{cr} – critical torque leading to failure of the valve stem; M_{min} – torque at the beginning of valve closure

Taking into account the above mentioned it seems expedient to implement at power plants the method of selective input control of valves immediately before their installation on pipelines or at the input control at nuclear power plants. The proposed type of inlet inspection connects practically all the main parameters of the valve – its nominal diameter, pressure at the inlet at the guaranteed closure of the valve, permissible medium flow and nominal torque. Typical dependence of the passage of the valve e. g. on the value of torque on the rod at a constant pressure at the inlet is shown in Figure. The dependence is shown taking into account the studies [5] and looks close to the parabola.

Experimental studies carried out on a real valve [5] have shown that this method of control not only allows you to determine the level of passage of the valve, but also to determine the necessary degree of its closure by torque, for example, on the installed actuator. In addition, this method of control makes it possible to detect inoperable valves, which cannot be done by visual inspection [5].

Such a check-up will not only detect design errors, but also discrepancies between the flow characteristics of a valve of the same type and the valve's flow rate during routine closing.

Conclusions

1. The analysis of damage to energy valves has shown that the main causes are wear and tear, aging, and design and manufacturing errors.

2. It is proposed to expand the input control of energy valves, experimental study of the characteristics of the valve passage on a special stand.

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