MODERNIZATION OF THE UKRAINIAN NPP INSTRUMENTATION AND CONTROL SYSTEMS

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Abstract

Modernization of many instrumentation and control systems for all type of reactors is under way now in Ukraine. Main principles of modernization, standards that are used for modernization are described in the report.

1. BACKGROUND

Ukrainian nuclear power plants (N PP's) have now 14 operating units; new Zaporozhe NPP unit 6 started in the end of 1995. Chernobyl NPP unit 1 was decommissioned after 19 years of operation in 1996. The dominating type of reactors in Ukraine is WWER–1000 (2 reactors of unit I and 2 South Ukraine NPP type V-302 and 9 reactors - type V-320). The share of NPPs electricity production in Ukraine is increasing every year and now nearly accounts for 40 %.

All one type WWER and RBMK units in USSR, including instrumentation and control systems (I&C), was created by similar design; these units originally had only little differences each other. The designs were ended 15–20 years ago and corresponded to the existed level of USSR non-military technique of that time. Many of these design deficiencies became clear after installation and starting of operation of every type first units.

Some modernization was fulfilled immediately after first units starting (for example, improving of unified hardware complex UKTS by diagnostic elements installation). Elaboration of perspective I&C design for WWER-1000 units was realized in 1987-1991 with spread using of microprocessors. Many technical decisions in this design had satisfied the modern requirements. But the USSR collapse stopped this process. Now modernization of similar Ukrainian and Russian NPP is being independently implemented by each country.

The main present reasons of I&C modernization may be divided on two groups. The first of them is connected with the morale obsolesce, the changes of the computer techniques. non-complete compliance of operating systems with modern safety requirements. This group of reasons includes:

- non-satisfactory diagnostics of hardware and software;
- discrepancy to seismic requirements;
- low fire resistance;
- absence of system for information personnel support; absence of high (general plant) level co-operated with unit level .

We can add to this group of reasons that I&C of unit isn't a whole system, it's only the set of the subsystems which have:

- different element bases;
- different technical realization for decision of same tasks;
- different structures;
- difficulties with interface between heterogeneous components.

I&C is very bulky one (for example, there are near 700 cabinets only of unified hardware complex UKTS in WWER-1000), that have resulted in large staff labor expenses.

Modernization of I&C can result to safety improvement. Approximately one third of Ukrainian NPP safety violations took place consequently of I&C failures.

Second group of reasons of modernization connected with physical obsolesce. Lifetime of many instruments is now over or close to the end (8-10 years). But our investigation shows that the level of operating reliability of the instruments (sensors, meters, computers, actuators, recorders, etc.) didn't decrease during time. Moreover after long (1-2 years) infant mortality time curve of failure intensity have reducing character for the many types of instruments [1, 2].

Big problem is absence of spare parts. Many manufacturers stopped to produce spare parts and now are producing new type of I&C equipment or equipment for other aims. Collapse of USSR destroyed economical connection between Ukraine and Russia which was main manufacturer of I&C equipment.

2. TRENDS OF THE I&C MODERNIZATION

Technical policy of Ukrainian NPP I&C modernization is connected with general changes in Ukrainian economy and marketing. In past there are common technical decisions for all NPP with same type of reactors in USSR including Ukraine. These decisions were proposed by General Designer (Atomenergoproect, etc.).

Now every NPP in Ukraine has possibility to lead own technical politic, to replace any type of equipment and to choose any manufacturer in Ukraine, Russia or another countries. There are different tendencies of I&C modernization in Ukraine now.

First one is based on the using of new Ukrainian national equipment. The main designers and manufacturers of NPP I&C in Ukraine are Khartron and Shevchenko plant in Kharkov. In past these companies have produced cosmic and rocket control systems.

There are next advantages of this modernization trend:

- all hardware and software will be produced in Ukraine that lead to technical independence in future NPP operation from another countries;
- it is a decision of conversion problem for these companies previously producing military techniques;
- Khartron and Shevchenko plant has big experience in elaboration of computer systems and have modern manufactory equipment.
- Khartron propose whole system which have to decide all control tasks for main and additional technological systems of WWER-1000 units and high (general NPP) level.

The deficiencies of the first tendency consist of as follow:

- Khartron hadn't any experience in designing and producing of NPP I&C (Shevchenko plant had experience in creation of turbine control systems);
- The process of new apparatus creation would be very hard and long one;

Second tendency is using equipment which is produced by foreign companies (USA, Germany, Russia, France, Czech Republic). This way has such advantages as:

- The most of this companies - Westinghouse (USA), Siemens (Germany), Skoda (Czech Rep.), SNIP (Russia) have big experience in elaboration, producing and installation of different types of NPP I&C;

- A part of similar equipment is under successful operation in NPPs in other countries (for example, Westinghouse Distributed Process Family - WDPF-II); therefore these companies are at a high level of NPP confidence.

There are next deficiencies of second way:

- Different companies propose different hardware and software; Ukrainian units with similar technological equipment will use different I&C; this difference will cause to complicate of maintenance;

- Necessity of spare parts supplying produced by foreign countries.

The both trends deficiencies force to combine them via a creation of joint ventures . For example, Westron is joint company created by Westinghouse (USA) and Khartron (Ukraine) for producing unit information computer systems, safety parameters display systems, etc. based in WDPF-II. Other example is ABB-Monolit. This joint venture was created ABB (USA) and Monolit - Shevchenco plant (Ukraine) for producing NPP diagnostic and monitoring equipment, feedwater control system, *etc.*

The problem of I&C modernization is of a special importance for two new NPP units: Rovno-4 and Khmelnitsky-2. For these units completion and upgrading Ukraine begins to receive a support from European Commission (EC). Ukrainian Government Committee Goskomatom, EDF and Ukrainian. Russian and European companies developed "Program of modernization Ukrainian WWER-1000 (V-320) NPPs" that includes many actions for I&C modernization. All actions were divided into the groups as follows:

- improvement of safety;
- rise of equipment operation availability;
- improving of operation organization.

Modernization of these units will follow by second tendency with the use of European companies' equipment.

3. LIST OF MODERNIZATION

The list of main modernization projects for operating units is shown on Table 1. Mostly the project are implemented in WWER-1000. Common peculiarity of new systems is a wide utilization of state of the art computer techniques:

- presence of high performance workstations;
- presence of local computer networks and unit buses;
- using of optical fibre for local computer nets;
- CRT displays with high resolution;
- high level of diagnostic;
- *possibility of control by display keys;*
- possibility to replace malfunctioning elements without the shutdown of the system;
- opening to connect additional instruments and to implement step by step.

TABLE 1. MAIN UKRAINIAN PROJECTS ON I&C MODERNIZATION

System	Manufacturer name	Manufacturer country	NPP, Unit	Present state
Type of reactor	**VVER**	**- 1000**		
Steptype electromagnetic drive	Skoda-YaM	Czech Republic	Y-1	Installed in 1996
Group and Individual Control System	Skoda-Control	Czech Republic	Y-1	Installed in 1996
Unit Computer Information System	Westron	Ukraine-USA	Y-1	Pilot system installed (1-st phase) in 1996 Installation-1998
Reactor Protec-tion System and Neutron Flux Mo-nitoring System	Siemens	Germany	R-4	Type testing of hardware and software has finished. Design is preparing
Steam Generator and Feedwater Control system	WESE, Traktebel, Westron, LvivOrgres	Belgium Belgium Ukraine Ukraine	Y-1	Design is preparing Installation-1998
Safety Parameters Display System	Westron	Ukraine-USA	Z-1	
Automatic Power Regulator, Power Limited Regulator	Khartron	Ukraine	Z-3	Pilot system installed in 1996
Automatic Turbine Control System	Shevchenko Plant	Ukraine	Y-1 Z-1	Installed in 1996 Installation 1997
Safety Engineering System Train N3	Radium, Parus, Khartron	Ukraine	Z-1	Installation 1998
Type of reactor	**VVER**	**- 440**		
Unit Information Computer system	SYSECA	France	R-1, R-2	Design is preparing
In-Core Reactor Monitoring System	SNIIP	Russia	R-2	
Type of reactor	**RBMK**	**-1000**		
Safety Parameters Display System	Westing-house NIKIET Westron	USA Pussia Ukraine-USA	Ch-3	Design is preparing

R- Rivne NPP , **Z**- Zaporizhya NPP ,
Y- South-Ukraine NPP, **Ch**- Chornobyl NPP

I&C consists of programme-technical complexes, that are built similar from different functions. I&C as rule has distributed hierarchical structure.

Safety Parameters Display System (SPDS) is a new type of system for Ukrainian NPPs. Implementation of SPDS is supposed to all Ukrainian units in future; the first such system will be used in Chernobyl RBMK-1000 unit by design which is similar for Russian RBMK-1000 units. This project is supported by US Department of Energy.

It is necessary to note, that the part of apparatus (sensors, actuators, cables, control room equipment, etc.) are saved in modernization process and new foreign technique (Siemens, Westinghouse, Skoda, etc.) have to have interface with old equipment. The description of several systems are published in "Proceedings of the International Topical Meeting on WWER Instrumentation and Control" [3–6].

One of the most sufficient limitation in modernization process connected with short time of reactor shutdowns (for example, for on-load refueling) when there are possibility to fulfill demounting, mounting and another works.

One of the way for this problem decision is creation of pilot systems which are operating jointly with regular systems.

For example, reconstruction process of unit computer information system (South-Ukraine NPP, unit 1) is being split into 2 phases. Phase I consist of installing Westinghouse WDPF equipment (primarily WEStations) that will monitor plant functions in parallel with the existing CM-2M unit information system "ComplexUran-2" (Fig. 1.). During Phase I all input/output devices will be provided through a custom CM-2M computer interface with the exception of analogue inputs required for the turbine generator monitoring system which will be accessible via Distributed Processing Unit (DPU) installed in Phase I . Phase I configuration includes seven WEStations, two DPU and two CM-2M computer complexes.

Phase 2 consist of installing the remainder of the Westinghouse WDPF equipment (primarily DPUs) replacing the CM-2M computer and all of the CM-2M input/output devices.

During Phase 2 the CM-2M computer complex and all of the existing CM-2M input/output equipment (information complex M-60) will be replaced with Westinghouse WDPF equipment (primarily Redundant DPUs). The Phase 2 configuration includes additional WEStations, additional redundant DPUs and Computer time Clock Unit. The CM-2M computer complexes will be reconfigured to provide information from the In-core Monitoring System and Turbine Control System. Data links from these systems were previously connected to the CM-2M Computer Complexes.

4. STANDARDS AND RULES FOR I&C MODERNIZATION

High level document in Ukraine is Law of Ukraine "On Nuclear Energy Utilization and Radiation Safety" (1995). This Law is a fundamental one in the nuclear legislation in Ukraine. It established the priority of human safety and environmental safety, governs the activities associated with the use of nuclear installation. According to Articles 8: "...Observation of the regulation, codes and standards of nuclear and radiation safety is mandatory when exercising any activity in the sphere of utilization of nuclear energy". Next level of documents is divided on 4 groups:

1) USSR NPP Safety Guides and Rules;
2) Ukrainian NPP Safety. Guides and Rules;
3) USSR State Standards (GOST), what is related to NPP I&C;
4) Ukrainian State Standards what is related to NPP.

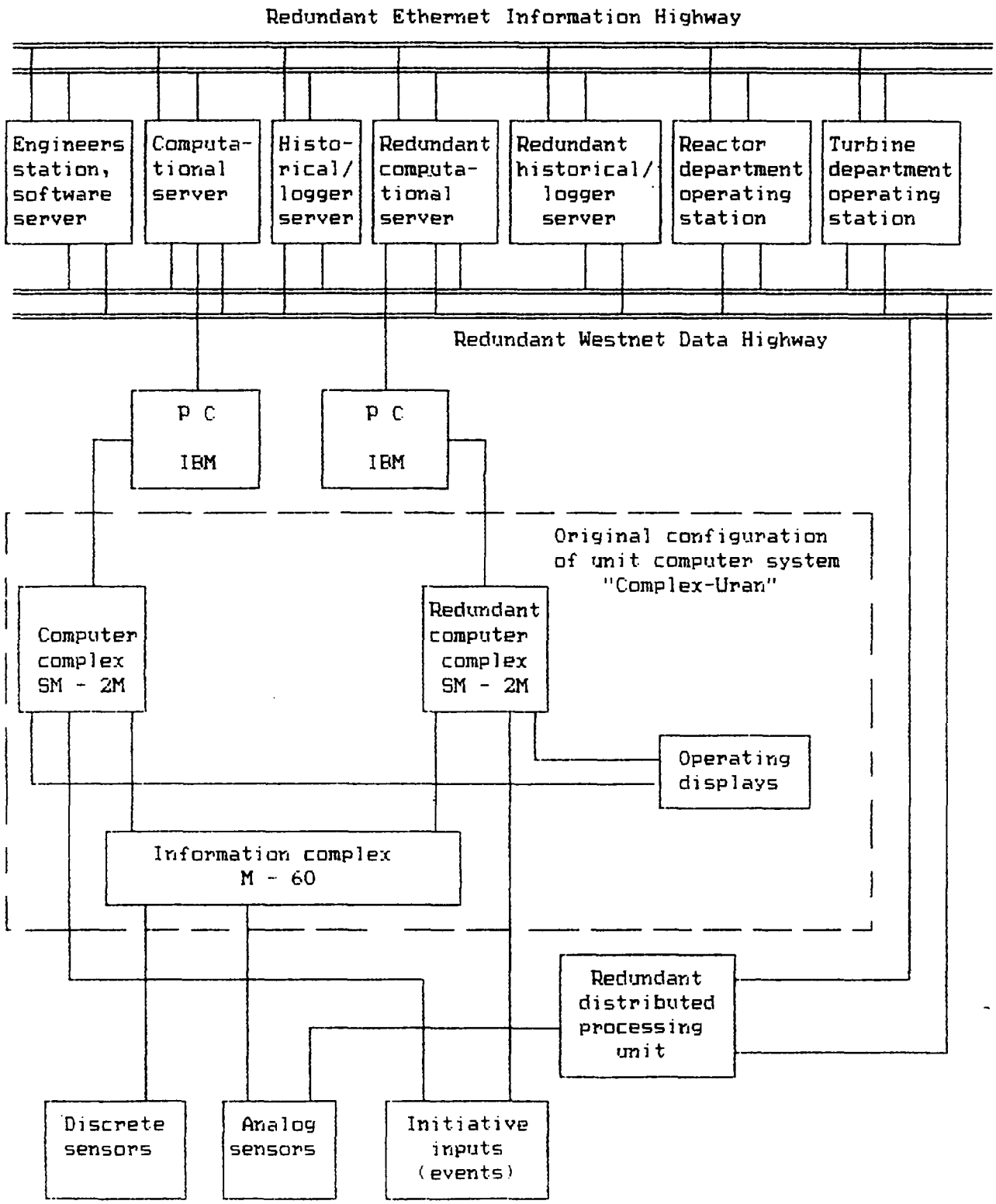

Fig. 1. Modernization of yuzhnoukrainsk unit computer system (phase 1).

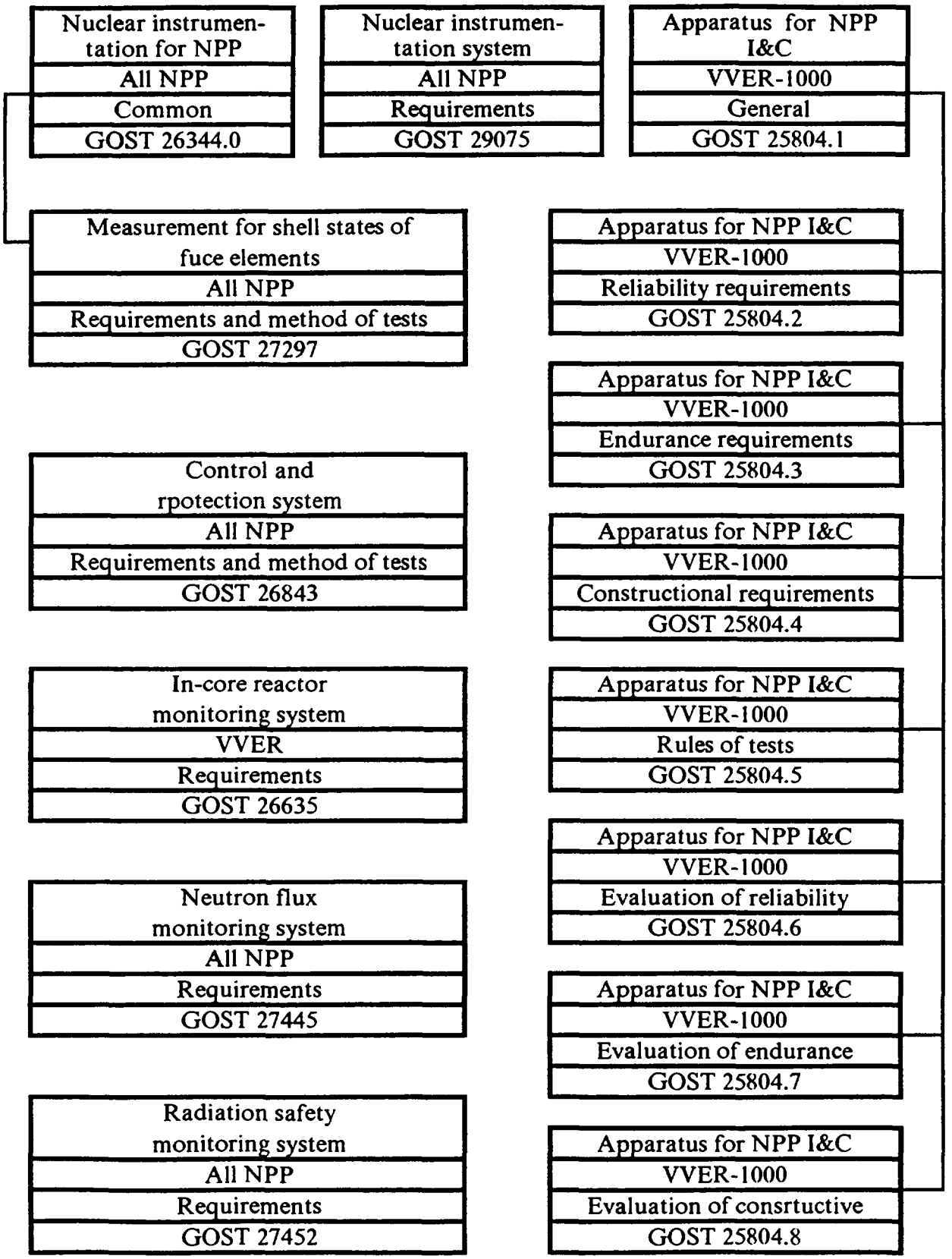

Fig. 2. Some of the USSR standards relevant to I&C modernization.

1) Ukrainian Nuclear Regulatory Administration (NRA) had confirmed list of USSR Safety Guides and Rules in force as to different NPP equipment included I&C. It was decision NRA N I of 4.01.92. This list include 79 documents. Its items I and 2 in this list are the most important documents for nuclear safety - OPB-88 [I] and PBYa RU AS-89 [2]. Main idea of this decision was the conservation in Ukraine of NPP safety documents in force in USSR.

2) Ukrainian NRA only begins to create own system of guides and rules. There is only one documents devoted to I&C (problem of I&C life extension) [9]. Creation of standards with safety requirements to I&C and their components is fulfilling now.

3) Related to NPP I&C USSR Standards can divided in subgroups in such order: a) USSR common technical standards related to I&C (for example about reliability, metrology, etc.);

   a) USSR standards what are acted to different NPP equipment, including I&C; c) USSR standards what are acted to I&C in different branches of industry, including NPP;
   b) USSR standards directly applied to NPP I&C.

The scheme of this subgroup is shown on Fig. 2. Each box in this picture consist of 4 parts as follows:

- name of systems what are considered in the standard;
- type of NPP;
- subject of standardisation (requirements or methods, etc.);
- number of standard.

Right branch in Fig. 2 corresponds to standards series connected with WWER-1000 I&C (except reactor control and protection system - SUZ described in the other standards). This branch was created in 1980-1983 and contains different detailed requirements to reliability, to resistance and strength to environment factors, to apparatus construction, the rules of test and acceptance, the methods of checking of compliance with the requirements. The requirements of these standards are very rigorous and exceed those in other USSR and international standards. Standard 2907591 in the middle of this picture is one of the modern USSR standards which is widely spread now in Ukraine (also in Russia too). It should be noted that there are a lot of contradictions between different standards of this subgroup.

4) Ukrainian State Standards were elaborated now only as common technical standards (similar to subgroup 3a).

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