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AVNG SYSTEM OBJECTIVES AND CONCEPT

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ABSTRACT

Any verification measurement performed on potentially classified nuclear material must satisfy two constraints. First and foremost, no classified information can be released to the monitoring party. At the same time, the monitoring party must gain sufficient confidence from the measurement to believe that the material being measured is consistent with the host's declarations concerning that material. The attribute measurement technique addresses both concerns by measuring several attributes of the nuclear material and displaying unclassified results through green (indicating that the material **does** possess the specified attribute) and red (indicating that the material **does not** possess the specified attribute) lights. The AVNG that we describe is an attribute measurement system built by RFNC–VNIIEF in Sarov, Russia. The AVNG measures the three attributes of "plutonium presence," "plutonium mass >2 kg," and "plutonium isotopic ratio (^{240}Pu to ^{239}Pu) <0.1" and was demonstrated in Sarov for a joint US/Russian audience in June 2009. In this presentation, we will outline the goals and objectives of the AVNG measurement system. These goals are driven by the two, sometimes conflicting, requirements mentioned above. We will describe the conceptual design of the AVNG and show how this conceptual design grew out of these goals and objectives.

BACKGROUND

In 1996 The United States of America, the Russian Federation and IAEA proposed the Trilateral Initiative, which was intended to address technical, legal and financial issues of IAEA inspections of weapon plutonium, released from defense programs in the two states. A joint working group was created, the task of which was to carry out investigations, tripartite consultations and prepare annual reports to the ministers and the general director. A number of meetings took place at the ministerial and director general's level, where the fulfilled work results were considered and guidelines for future activity under the Trilateral Initiative were developed.

ATTRIBUTES AND INFORMATION BARRIERS

One of the activity directions under the Trilateral Initiative was the development of hardware/methodical provisions for the task of plutonium attribute verification. The term "attribute" in this context refers to one of the agreed parameters used to characterize mass or composition of a fissile material in the situation when the actual mass and/or isotopic composition cannot be specified because of the requirements of the material-related information protection. The joint working group of technical experts developed and preliminarily agreed to general technical requirements (GTR) and functional specifications (FS) for plutonium attribute verification systems with information barriers (IBs). [1] This paper is part of a special session at the 2010 INMM meeting noting the completion of the Russian attribute measurement system known as the AVNG. [2]

Such a measurement system should allow a number of plutonium attributes to be verified without disclosing classified information. The Trilateral Initiative stipulated verification of the following three attributes: plutonium presence, plutonium quality (weapons/non-weapons grade) and plutonium threshold mass exceeding an agreed threshold. After a comprehensive analysis, a high-resolution gamma spectrometer and a neutron multiplicity counter were determined to be the most acceptable basic hardware elements for the attribute measurement system.

CONCEPTUAL DESIGN

The most general view of an attribute measurement system with IB is shown in the conceptual diagram presented in Fig. 1. The data barrier assures that only unclassified information can be sent to the operator's panel; to be displayed in YES/NO form. Those components in this drawing that may contain some classified information (detector systems and threshold comparison units) are constrained within the limits of the information barrier (these components are indicated in red). The control panel, power supply, and the indication panel to display verification results, which are accessible to the operator, are outside of the information barrier. An implementation of this concept is the measurement system termed the "attribute verification system with information barriers for plutonium with classified characteristics, built on the neutron multiplicity counting and high-resolution gamma-spectrometry" or AVNG. [3]

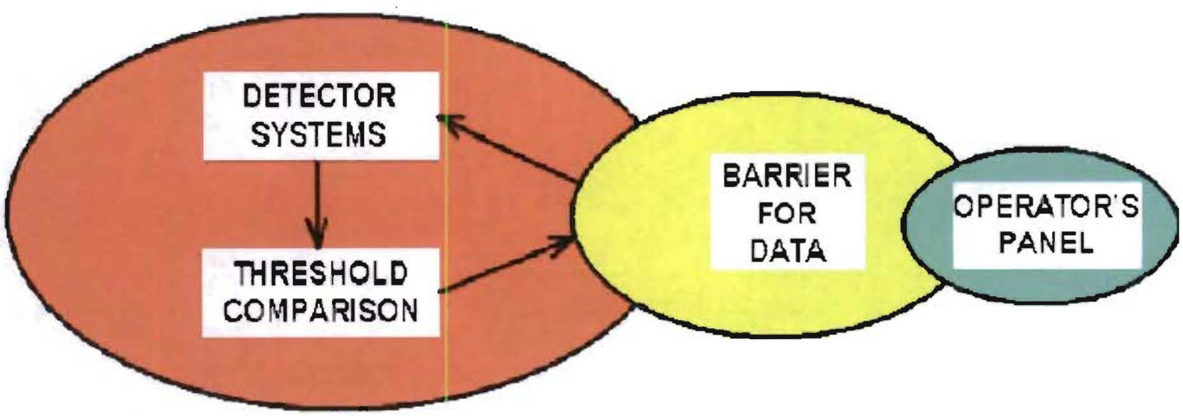

Fig. 1. Conceptual design of AVNG system.

According to the technical requirements AVNG System should:

1) perform measurements and indicate results for the measured parameters as compared with the specified threshold values in YES/NO form,
2) assure protection for any classified information of the controlled material.

The AVNG System measures the following attributes of plutonium inside of an AT-400R container:

1) plutonium presence in the container (detected by the presence of characteristic lines in the

gamma radiation spectrum),

2) plutonium quality (weapons/non-weapons grade) (detected by the radiation intensity ratio of isotopes $^{240}Pu/^{239}Pu$ in a narrow energy range near 640 keV), and
3) confirmation of plutonium mass in the container greater than an agreed threshold value (based on neutron multiplicity counting and isotopic ratio information obtained in test 2)

To provide increased inspector confidence that the attribute measurement system is functioning correctly, the AVNG incorporates two operating modes –"classified" and "unclassified." The classified mode is the regular operating mode for the system. The purpose of the classified mode is to control the amount of information displayed concerning plutonium whose characteristics should not be disclosed. In this mode the AVNG operates with all IB features activated; the measurement results are indicated on the display panel only as red or green indicators. The unclassified operating mode of the system is used to check the correctness of the system's operation. To facilitate these checks, a set of reference materials of plutonium of diverse mass and composition is used. In unclassified mode, in addition to the indicator lamp panel, an external display and printer connecting to the system's computer is provided that allows the display of complete measurement information. The system is not allowed to arbitrarily switch into unclassified mode. Automatic switching into unclassified mode is possible only when a modified AT-400R container is installed in the measurement compartment of the neutron detector. This modification is immediately visible and cannot be imitated by normal wear and tear of the container. Figure 2 presents the appearance of the modified container.

Fig. 2. Modified AT-400R container design highlighting changes to indicate unclassified contents.

DETAILED DESIGN

The hardware and software for the AVNG is an integrated system that includes:

1) a subsystem for automated control of AVNG operation,
2) a subsystem for measurement data acquisition, processing and analysis,
3) a subsystem for data presentation, and
4) a subsystem for power supply.

The automated AVNG control subsystem provides control of AVNG operation and control of its safety systems (presence sensors, sensors of container presence and type, fire sensors, etc.). The measurement data acquisition, processing and analysis subsystem includes the hardware and software components of the neutron and gamma measuring subsystems as well as a threshold comparison algorithm. The data presentation subsystem displays agreed-upon information about the controlled plutonium item without disclosing classified data. The information is displayed as red/green indicators on the operator's panel and, if a modified AT-400R container is present, on the detailed display monitor. The power supply subsystem provides the measurement system with uninterrupted power and regulates the turnoff of the system (in either emergency or scheduled shutdowns), to ensure the deletion of any potentially classified measurement information.

The AVNG includes the following basic elements: gamma-radiation detector based on a high-purity germanium detector, high-efficiency neutron detector based on ^{3}He counters in polyethylene moderator, an instrument rack with a set of measurement and control equipment (analyzers of gamma and neutron measurement systems, measurement and control computers, controllers for security systems, and power supplies), a control/indicator panel, and cable communications.

The AVNG design does not include any nonvolatile memory for measurement and analytic information storage. To prevent possible information "leakage" in abnormal situations (normal power-off, activation of access control devices, emergency shutdown in any mode, fire, etc.), the AVNG design includes a procedure for forced memory cleaning at the end of each of the operating modes and if any unexpected event occurs. In compliance with the general technical requirements, the system software (including the operating system) was developed so as to allow for exhaustive testing by certification authorities. [4]

Structural and functional flowcharts of the AVNG system are shown in Figs. 3 and 4 below. The system components responsible for the data acquisition, analysis and management, are standard commercially available devices.

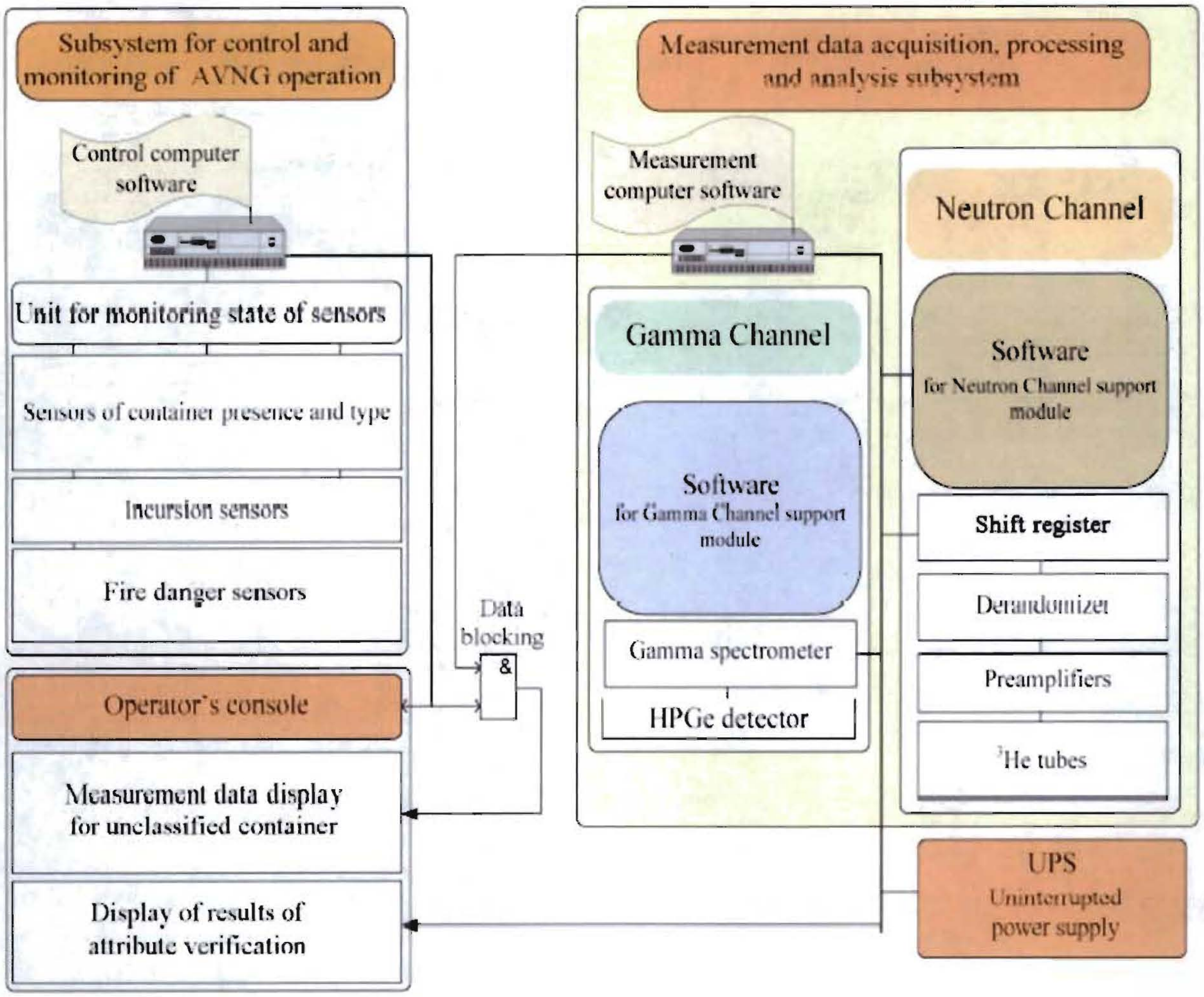

Fig. 3. Structural flowchart of AVNG system functions.

All the system elements are located in a shielded enclosure. The exceptions are the operator's panel, which is mounted outside of the enclosure, and the display monitor, which is outside the enclosure during unclassified operation. Signals from the operator's panel to the system and *vice versa* are transmitted through the IB using hardware and software data barriers to prevent transmission of classified information transmission to the display.

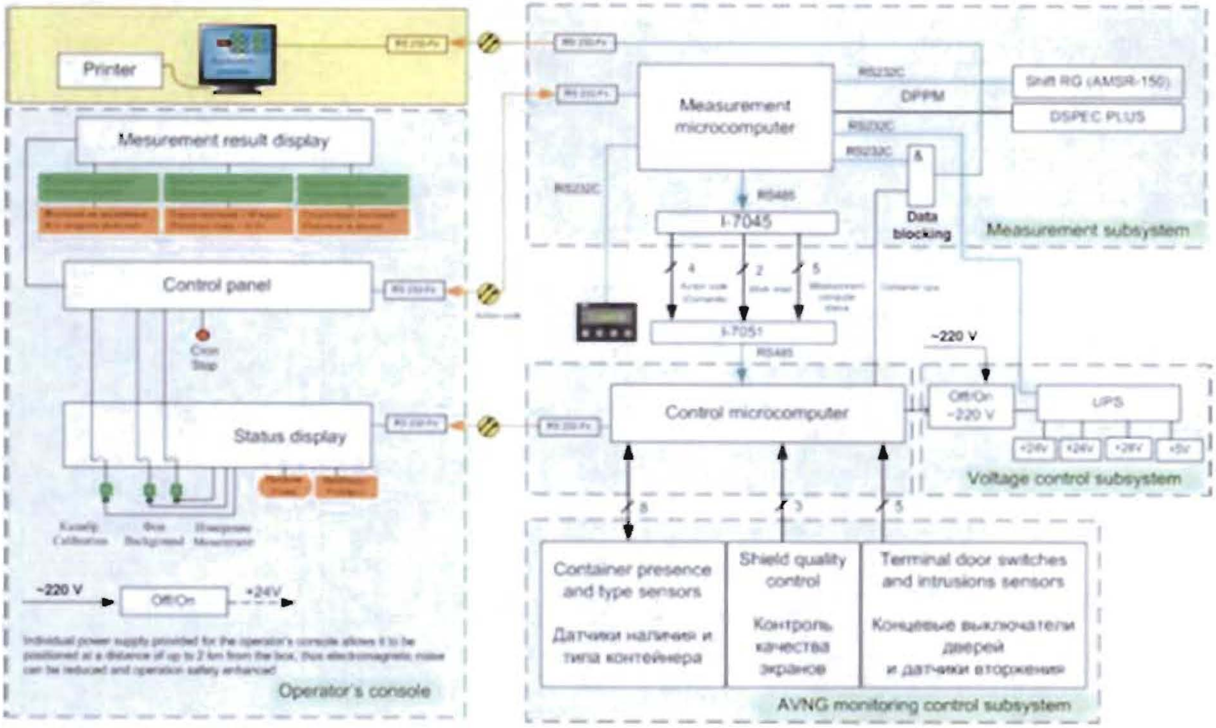

Fig. 4. Functional flowchart of AVNG system.

AVNG CONSTRUCTION, TESTING AND DEMONSTRATION

Upon receipt of all the necessary permissions, the task order for "The development, testing, certification and demonstration of the plutonium attribute verification system" was signed on November 30, 2001 in Vienna. This contract was modified and extended in the intervening years. In particular, one of the most complicated tasks – fabrication of a set of state reference materials (SRM) for plutonium mass and composition – was designated as a separate task order to be accomplished in parallel with AVNG construction.

After fabrication and certification, the SRM were placed in modified AT-400R containers illustrated in Fig. 2. The SRM set was fabricated in the form of plutonium dioxide on the base of mixtures of plutonium from two reactor types, BN and VVER, of different mass and isotopic composition. The SRMs were placed into containers of AT-400R type, modified to comply with the AVNG concept. [5]

The construction of the AVNG is discussed in the following paper in this session. [6] After laboratory testing of the AVNG, [7] its operation was demonstrated with the use of the mentioned SRM set during visit of a US delegation to Sarov in June 2009. [8]

ACKNOWLEDGEMENT

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