

# **Nuclear reactor instrumentation — Pressurized water reactor (PWR) of VVER design — Monitoring adequate cooling within the core during cold shutdown**

ICS 27.120.10

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## Summary of pages

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**Instrumentation des réacteurs nucléaires –  
Réacteurs à eau pressurisée (REP) de type VVER –  
Surveillance du refroidissement correct du cœur  
pendant les états d'arrêt**

**Nuclear reactor instrumentation –  
Pressurized water reactor (PWR) of VVER design –  
Monitoring adequate cooling within  
the core during shutdown**



Commission Electrotechnique Internationale  
International Electrotechnical Commission  
Международная Электротехническая Комиссия

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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**NUCLEAR REACTOR INSTRUMENTATION –  
PRESSURIZED WATER REACTOR (PWR) OF VVER DESIGN –  
MONITORING ADEQUATE COOLING WITHIN THE CORE  
DURING SHUTDOWN**

FOREWORD

- 1) The IEC (International Electrotechnical Commission) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of the IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, the IEC publishes International Standards. Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. The IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
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International Standard IEC 62118 has been prepared by subcommittee 45A: Reactor instrumentation, of IEC technical committee 45: Nuclear instrumentation.

The text of this standard is based on the following documents:

| FDIS          | Report on voting |
|---------------|------------------|
| 45A/400A/FDIS | 45A/403/RVD      |

Full information on the voting for the approval of this standard can be found in the report on voting indicated in the above table.

This publication should be read in conjunction with IEC 60911.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 3.

Annexes A and B are for information only.

The committee has decided that the contents of this publication will remain unchanged until 2006. At this date, the publication will be

- reconfirmed;
- withdrawn;
- replaced by a revised edition, or
- amended.

## INTRODUCTION

Adequate core cooling can be achieved only by providing sufficient coolant flow to the core to remove the heat. During normal power operations, core cooling is adequately controlled and monitored by reactor control and protection systems, and cooling is maintained by forced circulation with the pumps of the Reactor Coolant System (RCS). During hot or cold shutdown operations, core cooling can be provided by different means such as forced circulation with the RCS pumps, natural circulation of the coolant or by the Residual Heat Removal System (RHRS). During certain abnormal conditions cooling must even rely on stationary boiling of the coolant.

It is important that plant operators have reliable information concerning the coolant conditions and inventory in the Reactor Pressure Vessel (RPV). This information is usually related to the core, expressed specifically as the coolant temperature, pressure, flow and water level relative to the top of the core. It is also important that plant operators have reliable information concerning subcooling of the coolant and its time history to assess abnormal conditions. The information must be available for all conditions, including cold shutdown since core cooling interruptions have occurred at several VVERs. Annex A, which lists some of these events, identifies conditions which should be considered in the design of core cooling monitoring instrumentation.

# NUCLEAR REACTOR INSTRUMENTATION – PRESSURIZED WATER REACTOR (PWR) OF VVER DESIGN – MONITORING ADEQUATE COOLING WITHIN THE CORE DURING SHUTDOWN

## 1 Scope and object

This International Standard applies to pressurized water reactors (PWRs) of VVER design with configurations similar to those shown in figures 1 and 2, and presents the requirements for monitoring adequate cooling within the core during hot and cold shutdown conditions. Annex B provides more information on VVER operating states.

Good international practices to be used when designing new or upgrading existing core cooling monitors for VVER systems are summarized in this standard. This standard does not consider the design details of the different VVER technological systems designs, except to the extent that the design affects the monitoring of core cooling.

Requirements are given for core cooling monitoring instrumentation to ensure the safe operation of VVERs during abnormal operation and during and after design basis accidents (DBA). Requirements for core cooling monitoring during conditions beyond a DBA, which could be a specific national requirement or consideration, are not covered here.

The core cooling monitoring instrumentation has to function under widely different conditions. The circumstances under which this instrumentation needs to function are described. Descriptions of diverse measuring principles and suitable devices are given along with requirements for the following:

- operational conditions;
- installation;
- operator displays;
- testing, calibration and maintenance;
- equipment qualification;
- documentation;
- redundancy.

## 2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this International Standard. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of IEC and ISO maintain registers of currently valid International Standards

IEC 60050(393):1996, *International Electrotechnical Vocabulary (IEV) – Chapter 393: Nuclear Instrumentation – Physical phenomena and basic concepts*

IEC 60737:1982, *In-core temperature or primary envelope temperature measurements in nuclear power reactors – Characteristics and test methods*

IEC 60770-1:1999, *Transmitters for use in industrial-process control systems – Part 1: Methods for performance evaluation*

IEC 60780:1998, *Nuclear power plants – Electrical equipment of the safety system – Qualification*

IEC 60880:1986, *Software for computers in the safety systems of nuclear power stations*

IEC 60911:1987, *Measurements for monitoring adequate cooling within the core of pressurized light water reactors*

IEC 60964:1989, *Design for control rooms of nuclear power plants*

IEC 60980:1989, *Recommended practices for seismic qualification of electrical equipment of the safety system for nuclear generating stations*

IEC 60987:1989, *Programmed digital computers important to safety for nuclear power stations*

IEC 61225:1993, *Nuclear power plants – Instrumentation and control systems important for safety – Requirements for electrical supplies*

IEC 61226:1993, *Nuclear power plants – Instrumentation and control systems important for safety – Classification*

IEC 61227:1993, *Nuclear power plants – Control rooms – Operator controls*

IEC 61343:1996, *Nuclear reactor instrumentation – Boiling light water reactors (BWR) – Measurements in the reactor vessel for monitoring adequate cooling within the core*

IAEA Safety Guide 50-SG-D8:1984, *Safety related instrumentation and control systems for nuclear power plants*

### 3 Definitions and abbreviations

For the purpose of this International Standard, the following definitions apply. For terms defined elsewhere, the source is given in square brackets.

#### 3.1

##### **ALARA**

as low as reasonably achievable

#### 3.2

##### **coolant**

water and/or steam for heat removal from the core

#### 3.3

##### **DBA**

design basis accident

#### 3.4

##### **diversity**

the existence of redundant components or systems to perform an identified function, where such components or systems collectively incorporate one or more different attributes

[IAEA 50-SG-D8]

#### 3.5

##### **downcomer**

annular volume between reactor vessel wall and internals that directs coolant flow to the bottom of the core

**3.6**

**ECCS**

emergency core cooling system

**3.7**

**LOCA**

loss of coolant accident

**3.8**

**monitoring**

means provided to indicate continuously the state or condition of a system, sub-system, equipment or assembly

[IEV 393-08-48]

**3.9**

**PAMS**

post-accident monitoring system

**3.10**

**pressurized water reactor (PWR)**

a nuclear steam supply system in which the pressurized coolant is heated by the reactor core, and process steam is generated in the steam generator by heat transfer from the coolant

**3.11**

**reactor containment**

the structure that encloses the reactor coolant system and parts of specific associated systems, including the pressure containment structures that enclose individual components in some nuclear power plant designs

**3.12**

**RCS**

reactor coolant system

**3.13**

**reactor pressure vessel (RPV)**

the vessel which contains the reactor core

**3.14**

**RPS**

reactor protection system

**3.15**

**reduced inventory condition**

an intentional condition that exists during specific maintenance operations whenever water level in the RPV is lower than the top of the RPV hot leg piping nozzle elevation, plus an allowance for water level measurement uncertainty

**3.16**

**redundancy**

provision of alternative (identical or diverse) elements or systems, so that any one can perform the required function regardless of the state of operation or failure of any other [IAEA 50-SG-D8]