Revision 0

Knowledge and Abilities Catalog for Nuclear Power Plant Operators: Pressurized Water Reactors Westinghouse AP1000

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ABSTRACT

The Knowledge and Abilities Catalog for Nuclear Power Plant Operators: Westinghouse AP1000 Pressurized-Water Reactors (NUREG-YYYY, Revision 0) provides the basis for the development of content-valid licensing examinations for reactor operators (ROs) and senior reactor operators (SROs). The examinations developed using this Catalog along with the Operator Licensing Examination Standards for Power Reactors (NUREG-1021) will sample the topics listed under Title 10, Code of Federal Regulations, Part 55 (10 CFR 55).

The catalog is organized into six major sections: Catalog Organization, Generic Knowledge and Ability Statements, Plant Systems, Emergency and Abnormal Operating Procedures, Components and Theory.

This is a new Knowledge and Abilities catalog developed specifically to address the passive nature of the Westinghouse AP1000 design.

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1.0 ORGANIZATION OF THE CATALOG

1.1 INTRODUCTION

The Knowledge and Abilities Catalog for Nuclear Power Plant Operators: Westinghouse AP1000 NUREG-*YYYY*, provides the basis for development of content-valid written and operating licensing examinations for reactor operators (ROs) and senior reactor operators (SROs). The Catalog is designed to ensure equitable and consistent examinations.

1.2 PART 55 OF TITLE 10 OF THE CODE OF FEDERAL REGULATIONS

The catalog is used in conjunction with NUREG-1021 "Operator Licensing Examination Standards for Power Reactors." NUREG-1021 provides policy and guidance and establishes the procedures and practices for examining licensees and applicants for RO and SRO licenses pursuant to Part 55 of Title 10 of the Code of Federal Regulations (10 CFR 55). All knowledge and abilities (K/As) in this catalog are directly linked by item number to 10 CFR 55.

1.3 RO WRITTEN EXAMINATION ITEMS

The guidance for preparation of the RO written examination is presented in NUREG-1021, ES-205, and ES-401. The specific items for RO written examinations are presented in 10 CFR 55.41(b).

1.4 SRO WRITTEN EXAMINATION ITEMS

The guidance for preparation of the SRO written examination is presented in NUREG-1021, ES-401. In addition to the RO items specified in 10 CFR 55.41(b), additional items for SRO written examinations are presented in 10 CFR 55.43(b).

1.5 RO AND SRO OPERATING TEST ITEMS

The items for operating tests for ROs and SROs are presented in 10 CFR 55.45(a). The guidance for preparation of the operating tests is presented in NUREG-1021, ES-301. The operating test should include a representative selection of K/As derived from those items listed in 10 CFR 55.45(a).

1.6 SENIOR OPERATORS LIMITED TO FUEL HANDLING

The specifications for examinations for Senior Operators Limited to Fuel Handling (LSRO) are provided in Examination Standard, NUREG 1021, Section ES-701. The LSRO examination process includes both a written examination and an operating test. This examination and test include, but are not limited to, items associated with 10 CFR 55.43(b) items 5 through 7, and 10 CFR 55.45(a) items 5 and 6.

1.7 ORGANIZATION OF THE CATALOG

This catalog is organized into 6 major sections. K/As are grouped according to the major section to which they pertain. This organization is shown schematically below:

1 ORGANIZATION OF THE CATALOG

2 GENERIC KNOWLEDGE AND ABILITIES
Conduct of Operations K/As
Equipment Control K/As
Radiation Control K/As
Emergency Procedures / Emergency Plan K/As

3 PLANT SYSTEMS
Knowledge Categories (K1 - K6)
Ability Categories (A1 - A4)

4 EMERGENCY AND ABNORMAL PLANT EVOLUTIONS
Knowledge Categories (EK/AK 1 - EK/ AK3)
Ability Categories (EA/AA 1 - EA/AA 2)

5 COMPONENTS
Component Knowledge Categories

6 THEORY
Reactor Theory Knowledge Categories
Thermodynamics Knowledge Categories

1.8 GENERIC KNOWLEDGE AND ABILITIES

Generic knowledge and abilities are generally administrative knowledge and abilities with broad application across systems and operations. They are listed in Section 2 of the catalog. The categories of generic K/As are listed below:

1) Conduct of Operations K/As
2) Equipment Control K/As
3) Radiation Control K/As
4) Emergency Procedures /Emergency Plan K/As

The generic K/As for "Conduct of Operations" are used to evaluate the applicant's knowledge of the daily operation of the facility. The types of information covered under this category may include shift turnover or temporary modification procedures.

The generic K/As for "Equipment Control" are used to evaluate the administrative issues associated with the management and control of plant systems and equipment. Examples of the types of information evaluated under this topic include maintenance and temporary modifications of systems. Fuel handling and refueling K/As are organized into this topic area because of the equipment control aspect of fuel handling.

The generic K/As for "Radiation Control" are used to evaluate the applicant's knowledge and abilities with respect to radiation hazards and protection (personnel and public). Examples of the

types of information that should be evaluated under this topic are knowledge of significant radiation hazards or radiation work permits.

The generic K/As for "Emergency Procedures / Emergency Plan" are used to evaluate the applicant's general knowledge of emergency operations. The K/As are designed to evaluate knowledge of the emergency procedures use. The emergency plan K/As are used to evaluate the applicant's knowledge of the plan, including, as appropriate, the RO's or SRO's responsibility to decide whether it should be executed and the duties assigned under the plan.

1.9 PLANT SYSTEMS

1.9.1 Plant System Organization by Safety Function

Nine (9) major safety functions must be maintained to ensure safe nuclear power plant operation. The safety function groups are:

SF 1	Reactivity Control
SF 2	Reactor Coolant System Inventory Control
SF 3	Reactor Pressure Control
SF 4	Heat Removal From Reactor Core
SF 5	Containment Integrity
SF 6	Electrical
SF 7	Instrumentation
SF 8	Plant Service Systems
SF 9	Radioactivity Release

Plant systems have been included in this catalog based on their relationship and importance to 9 safety functions. Table 1 contains a list of these plant systems, arranged within safety function. Three plant systems (Reactor Coolant System, Chemical and Volume Control System, and Passive Core Cooling System) each contribute to several safety functions.

Table 1
Plant Systems by Safety Functions

3.1 Safety Function 1: Reactivity Control

SF1 CVS	Chemical and Volume Control System
SF1 DRCS	Digital Rod Control System
SF1 RPIS	Rod Position Indication System

3.2 Safety Function 2: Reactor Coolant System Inventory Control

SF2 CVS	Chemical and Volume Control System
SF2 ESAS	Engineered Safeguards Actuation System
SF2 PLCS	Pressurizer Level Control System
SF2 PXS	Passive Core Cooling System
SF2 RCS	Reactor Coolant System

3.3 Safety Function 3: Reactor Pressure Control

SF3 ADS Automatic Depressurization System
SF3 PPCS Pressurizer Pressure Control System

3.4 Safety Function 4: Heat Removal From Reactor Core

PRIMARY SYSTEMS

SF4 PRHR Passive Residual Heat Removal
SF4 RCP Reactor Coolant Pumps
SF4 RCS Reactor Coolant System
SF4 RNS Normal Residual Heat Removal System
SF4 SGS Steam Generator System

SECONDARY SYSTEMS

SF4 CDS Condensate System
SF4 CMS Condenser Air Removal System
SF4 FWS Main and Startup Feedwater System
SF4 MSS Main Steam System
SF4 MTS Main Turbine and Main Turbine Control Systems
SF4 SDCS Steam Dump Control System
SF4 SWS Service Water System

3. 5 Safety Function 5: Containment Integrity

SF5 CNS Containment System
SF5 PCS Passive Containment Cooling
SF5 VLS Containment Hydrogen Control System

3. 6 Safety Function 6: Electrical

SF6 ECS AC Electrical Distribution
SF6 IDS Class 1E and Non 1E DC and UPS Systems
SF6 ZOS Onsite Standby Power System

3.7 Safety Function 7: Instrumentation

SF7 DAS Diverse Actuation System
SF7 IIS Incore Instrumentation System
SF7 NIS Nuclear Instrumentation System
SF7 RMS Area Radiation Monitoring System
SF7 RTS Reactor Trip System

3.8 Safety Function 8: Plant Service Systems

SF8 CAS Compressed Air System
SF8 CCS Component Cooling Water System
SF8 CWS Circulating Water System
SF8 FHS Fuel Handling System
SF8 FPS Fire Protection System
SF8 SFS Spent Fuel Pool Cooling System
SF8 VES Main Control Room HVAC
SF8 VFS Containment Air Filtration System

3.9 Safety Function 9: Radioactivity Release

SF9 WGS Gaseous Radwaste System
SF9 WLS Liquid Radwaste System

1.9.2 Plant System K/A Stem Statements

The information delineated within each plant system is organized into 6 different types of knowledge and 4 different types of ability. If there are no knowledge or ability statements following a stem statement, there is no applicable K/A; these are marked N/A.

The applicable 10 CFR 55.41 / 43 / and 45 item numbers are included with each stem statement. In most cases the K/As associated with the stem statements can be used for both the written examination and the operating test. See Table 2 below:

Table 2
Knowledge and Ability Stem Statements for Plant Systems

Knowledge Stem Statements

K1. Knowledge of the physical or control/protection logic relationship between the [system] and the following systems:
(CFR: 41.2 to 41.9 / 45.7 to 45.8)

K2. Knowledge of bus or division power supplies to the following:
(CFR: 41.7)

K3. Knowledge of the effect that a loss or malfunction of the [system] will have on the following systems or system parameters:
(CFR: 41.7 / 45.6)

K4. Knowledge of [system] design feature(s) and/or interlock(s) which provide for the following:
(CFR: 41.7)

K5. Knowledge of the operational implications or cause and effect relationships of the following as they apply to the [system]:
(CFR: 41.5 / 45.7)

K6 Knowledge of the effect of the following plant conditions, system malfunctions, or component malfunctions on the [system]:
(CFR: 41.7 / 45.7)

Ability Stem Statements

A1. Ability to predict and/or monitor changes in parameters associated with operation of the [system] including:
(CFR: 41.5 / 45.5)

A2. Ability to (a) predict the impacts of the following malfunctions or operations on the [system] and (b) based on those predictions, use procedures to correct, control, or mitigate the consequences of those malfunctions or operations:
(CFR: 41.5 / 43.5 / 45.3 / 45.5 / 45.13)

A3. Ability to monitor automatic operation of the [system], including:
(CFR: 41.7 / 45.5 / 45.13)

A4. Ability to manually operate and monitor in the control room:
(CFR: 41.7 / 45.5 to 45.8)

1.10 EMERGENCY AND ABNORMAL PLANT EVOLUTIONS

1.10.1 EPEs and APEs

Section 4 of the catalog contains the AP1000 specific Emergency Operating Procedures (EOPs) and Abnormal Operating Procedures (AOPs) to address emergency and abnormal plant evolutions.

An emergency plant evolution is any condition, event or symptom which leads to entry into Emergency Operating Procedures. An abnormal plant evolution is any degraded condition, event, or symptom which leads to entry into Abnormal Operating Procedures.

Table 3 contains a list of AP1000 Emergency and Abnormal Operating Procedures included in the AP1000 K/A Catalog. The EOPs and AOPs each have a unique evolution designator.

Table 3
Emergency and Abnormal Operating Procedures

4.1 Emergency Operating Procedures

E-0	Reactor Trip or Safeguards Actuation
ES-0.1	Reactor Trip Response
ES-0.2	Natural Circulation Cooldown
E-1	Loss of Coolant Accident
ES-1.1	Passive Safety System Termination
ES-1.2	Post Loss of Coolant Accident Cool Down and Depressurization
ECA-1.1	Loss of Coolant Accident Outside Containment
E-2	Faulted Steam Generator Isolation
E-3	Steam Generator Tube Rupture
FR-S.1	Response to Nuclear Power Generation – ATWS
FR-C.1	Response to Inadequate Core Cooling
FR-C.2	Response to Degraded Core Cooling
FR-C.3	Response to Saturated Core Cooling
FR-H.1	Response to Loss of Heat Sink
FR-H.2	Response to Steam Generator Overpressure
FR-I.1	Response to High Pressurizer Level
FR-P.1	Response to Imminent Pressurized Thermal Shock Condition
FR-Z.1	Response to High Containment Pressure
FR-Z.2	Response to High Containment Flooding
FR-Z.3	Response to High Containment Radiation

SDP-1 Response to Loss of RCS Inventory During Shutdown
SDP-2 Response to Loss of Normal Residual Heat Removal System During Shutdown
SDP-4 Response to Rising Nuclear Flux During Shutdown
SDP-5 Response to Reactor Coolant System Cold Overpressure During Shutdown
SDP-6 Response to Unexpected Reactor Coolant System Temperature Changes During Shutdown

4.2 Abnormal Operating Procedures

A-301 Rapid Power Reduction
A-302 Emergency Boration
A-304 Steam Generator Tube Leak
A-306 Evacuation of Control Room
A-308 Loss of Control Room Air Conditioning
A-311 Rod Control System Malfunction
A-313 Uncontrolled Cooldown
A-314 Fuel Handling Incident
A-317 Loss of Component Cooling Water
A-318 Condensate System Malfunctions
A-320 Loss of Circulating Water
A-321 Loss of Data Display and Processing System
A-323 Loss of 6.9KV or 480 Volt Bus Power
A-327 Startup Feedwater System Malfunctions
A-328 Malfunction of Feedwater Heaters and Extraction Steam
A-329 Loss of Instrument Air
A-332 Turbine Trip Without Reactor Trip
A-333 Main Turbine Malfunction
A-336 Malfunction of Protection and Safety Monitoring System
A-337 Passive Residual Heat Removal Heat Exchanger Leak
A-340 Reactor Coolant Leak
A-342 Reactor Coolant Pump Malfunctions
A-343 Loss of Normal Residual Heat Removal
A-345 Loss of Service Water

1.10.2 K/A Stem Statements for EOPs and AOPs

The information delineated within each emergency plant evolution is organized into 3 different types of knowledge and 2 different types of ability. If there are no knowledge or ability statements following a stem statement, there is no applicable K/A; these are marked N/A.

The applicable 10 CFR: 55.41 / 43 / and 45 item numbers are included with each stem statement. In most cases the K/As associated with the stem statements can be used for both the written examination and the operating test. See Table 4 below:

Table 4
Knowledge and Ability Stem Statements for
Emergency and Abnormal Procedures

Knowledge Stem Statements

EK1 Knowledge of the relationship between the [event] and the following systems or components:
(CFR: 41.8 / 41.10 / 45.3)

EK2. Knowledge of the operational implications or cause and effect relationships of the following as they apply to [event]:
(CFR: 41.5 / 41.7 / 45.7 / 45.8)

EK3. Knowledge of the reasons for the following actions as they apply to [event]:
(CFR: 41.5 / 41.10 / 45.6 / 45.13)

Ability Stem Statements

EA1. Ability to operate and monitor the following as they apply to a [event]:
(CFR: 41.5 / 41.7 / 45.5 to 45.8)

EA2. Ability to evaluate the following parameters and/or conditions as they apply to [event]:
(CFR: 41.7 / 43.5 / 45.6)

1.11 COMPONENTS

Basic components such as valves and pumps are found in many systems. NUREG-1021, section ES-205, lists 8 categories of components. The 8 categories of components for which additional knowledge statements are necessary are listed below and delineated in Section 5 of this catalog.

The component knowledge statements are more detailed than those provided in the system listing, yet at the same time they are generic to the component types. Each component has a unique 6-digit code number identified in NUREG-1021, and 10 CFR 55.41(b) item number. See Table 5, below.

Table 5
Components

191001	Valves (CFR: 41.3)
191002	Sensors and Detectors (CFR: 41.7)
191003	Controllers and Positioners (CFR: 41.7)
191004	Pumps (CFR: 41.3)
191005	Motors and Generators (CFR: 41.7)
191006	Heat Exchangers and Condensers (CFR: 41.4)
191007	Demineralizers and Ion Exchangers (CFR: 41.3)
191008	Breakers, Relays, and Disconnects (CFR: 41.7)

1.12 THEORY

NUREG-1021, Section ES-205, lists theory items. General fundamental knowledge which underlies safe performance on the job is delineated in Section 6 of this catalog. These theory topics represent general fundamental concepts related to plant operation. Each theory topic has the same 6-digit code number identified in NUREG-1021. The applicable 10 CFR 55 item number is provided for Reactor Theory and Thermodynamics Theory.

Reactor Theory (CFR: 41.1)

192001	Neutrons
192002	Neutron Life Cycle
192003	Reactor Kinetics and Neutron Sources
192004	Reactivity Coefficients
192005	Control Rods
192006	Fission Product Poisons
192007	Fuel Depletion and Burnable Poisons
192008	Reactor Operational Physics

Thermodynamics Theory (CFR: 41.14)

193001	Thermodynamic Units and Properties
193003	Steam
193004	Thermodynamic Process
193005	Thermodynamic Cycles
193006	Fluid Statics and Dynamics
193007	Heat Transfer
193008	Thermal Hydraulics
193009	Core Thermal Limits
193010	Brittle Fracture and Vessel Thermal Stress

1.13 IMPORTANCE RATINGS

Importance, in this context, considers direct and indirect impact of the K/A on safe plant operation in a manner ensuring personnel and public health and safety. Importance Ratings of the K/As are given next to each knowledge and ability in the catalog. These ratings reflect average ratings of respondents. The rating scale is presented in Table 6, below:

Table 6
RO and SRO Importance Ratings

Rating	Importance for safe operation
5	Essential
4	Very important
3	Fairly important
2	Of limited importance
1	Insignificant Importance

Therefore, the rating of 2.0 or below represents a statement of limited or insignificant importance for the safe operation of a plant. Such statements are generally considered as

inappropriate content for NRC licensing examinations. (See below for qualifications of importance ratings related to variability of the ratings and plant specific data.)

1.14 Rules of Use

To ensure consistency in applying this catalog the following

- “Parameters” include any characteristic of a system/component that is measured.
- “Actuation” includes actuation logic, signals, blocks, bypasses, permissives, interlocks, and resets.

1.15 AP1000 ACRONYMS AND TERMS

AFD	Axial Flux Difference
ASS	Auxiliary Steam System
BDS	Steam Generator Blowdown System
CAS	Compressed and Instrument Air Systems
CCS	Component Cooling Water System
CDS	Condensate System
CES	Condenser Tube Cleaning System
CFS	Turbine Island Chemical Feed System
CMS	Condenser Air Removal System
CNS	Containment System
COLR	Core Operating Limits Report
CPS	Condensate Polishing System
CVS	Chemical and Volume Control System
CWS	Circulating Water System
DAS	Diverse Actuation System
DNBR	Departure From Nucleate Boiling
DOS	Standby Diesel and Aux Boiler Fuel Oil System
DRCS	Digital Rod Control System
DWS	Demineralized Water Transfer and Storage System
ECP	Estimated Critical Position
ECS	Main AC Power System
EDI	Electrodeionization Package
EDS	Non Class 1E DC and UPS System
EHS	Special Process Heat Tracing System
EOL	End-of-Life
ESAS	Engineered Safeguards Actuation System
FHS	Fuel Handling System
FPS	Fire Protection System
FWS	Main and Startup Feedwater System
GSS	Gland Seal System
HCS	Generator Hydrogen and CO2 Systems
HDS	Heater Drain System
HPA	High Pressure Air
HSS	Hydrogen Seal Oil System
HVAC	Heating, Ventilation, and Air Conditioning
IDS	Class 1E DC and UPS System
IIS	Incore Instrument System
MES	Meteorological and Environmental Monitoring System

MFCV	Main Feedwater Control Valve
MFIV	Main Feedwater Isolation Valve
M-G	Motor Generator
MSIV	Main Steam Isolation Valve
MSR	Moisture Separator/Reheater
MSS	Main Steam System
MTC	Moderator Temperature Coefficient
MTS	Main Turbine System
NIS	Nuclear Instrumentation System
OE	Operating Experience
PAMS	Post Accident Monitoring System
PCS	Passive Containment Cooling System
PGS	Plant Gas Systems
PLS	Plant Control System
PMS	Protection and Safety Monitoring System
PRA	Probabilistic Risk Assessment
PRHR	Passive Residual Heat Removal
PSS	Primary Sampling System
PXS	Passive Core Cooling System
PPCS	Pressurizer Pressure Control
PLCS	Pressurizer Level Control
QPTR	Quadrant Power Tilt Ratio
RCS	Reactor Coolant System
RMS	Radiation Monitoring System
RNS	Normal Residual Heat Removal System
RTS	Reactor Trip System
RXS	Reactor System
SDCS	Steam Dump Control System
SFCV	Startup Feedwater Control Valve
SFS	Spent Fuel Pool Cooling System
SG PORV	Steam Generator Power Operated Relief Valve
SGS	Steam Generator System
SJS	Seismic Monitoring System
SMS	Special Monitoring System
SSS	Secondary Sampling System
SUR	Startup Rate
SWS	Service Water System
TCS	Turbine Building Closed Cooling Water System
TOS	Main Turbine Control and Diagnostics System
VAS	Radiologically Controlled Area Ventilation System
VBS	Nuclear Island Nonradioactive Ventilation System
VCS	Containment Recirculation Cooling System
VES	Main Control Room Emergency Habitability System
VFS	Containment Air Filtration System
VLS	Containment Hydrogen Control System
VTS	Turbine Building Ventilation System
VWS	Central Chilled Water System
VXS	Annex/Aux Building Nonradioactive Ventilation System
VYS	Hot Water Heating System
VZS	Diesel Generator Building Heating and Ventilation System
WGS	Gaseous Radwaste System

WLS	Liquid Radwaste System
ZAS	Main Generation System
ZBS	Transmission Switchyard and Offsite Power System
ZOS	Onsite Standby Power System
ZRS	Offsite Retail Power System
ZVS	Excitation and Voltage Regulation System