INTERNATIONAL NUCLEAR SAFETY PROGRAM

EMERGENCY OPERATING INSTRUCTION ANALYSIS PROJECT

SOVIET-DESIGNED PRESSURIZED WATER REACTOR SYMPTOMATIC EMERGENCY OPERATING INSTRUCTION ANALYTICAL VALIDATION PROCEDURE: APPROACH, METHODOLOGY DEVELOPMENT AND APPLICATION

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A systematic approach to the analytical validation of symptom-based EOPs includes:

1. Identification of critical safety functions essential to the maintenance of fission product barrier integrity;
2. Identification of the symptoms which manifest an impending challenge to critical safety function maintenance;
3. Development of a symptomatic methodology to delineate bounding plant transient response modes;
4. Specification of bounding scenarios;
5. Development of a systematic calculational approach consistent with the objectives of the methodology;
6. Performance of thermal-hydraulic computer code calculations implementing the analytical methodology;
7. Interpretation of the analytical results on the basis of information available to the operator;
8. Application of the results to the validation of the proposed operator actions
9. Production of a Technical Basis Document justifying the proposed operator actions.

Probability Safety Analysis Results for NPP "Kozloduy" – VVER 1000

Initial Event	Probability , 1/ry
1.Large break LOCA	10^{-5}
2. Middle break LOCA	$5{,}5.10^{-4}$
3.Small break LOCA	10^{-3}
4.Very Small break LOCA	$3{,}7.10^{-3}$
5. RPS control rod ejection	5.10^{-4}
6. SBLOCA outside containment	10^{-5}
7.SG collector rupture	10^{-5}
8.SG tube rupture	5.10^{-3}
9.RPS actuation	3
10.Loss of steam dump capabilities	$1{,}2.10^{-1}$
11.Containment isolation	7.10^{-2}
12.Loss of off-site power	3.10^{-2}
13.Loss of technical water system	10^{-3}
14.Steamline break in containment	10^{-3}
15. Steamline break outside containment	4.10^{-2}
16.Loss of feed water	10^{-3}

CALCULATIONAL PROCEDURE

A calculational strategy is developed and implemented to determine the timing and effectiveness of operator actions in averting loss of the CSF.

1.Perform Base Case Calculation

- for a specific bounding scenario
- non-degraded automatic system response without operator actions
- best-estimate plant response as a basis from which to compare failed system response
- establishing success criteria in validating the CSF Response Tree Green Path.

2.Perform Failed System Calculation

•for a successful base case transient sequence

•failure of the supporting ESF system without operator action

•Running the calculation out to the loss of critical safety function and/or onset of FPB damage

•recording all pertinent plant transient parameters available to the operator to diagnose event and/or recognize loss of critical safety function.

•comparison to the base case:

1) key symptoms that are unique to the required actions;
2) parameter values to be used to initiate/abandon action;
3) time available to take action;
4) insights into potential actions.

•establishing the limiting time to loss of the CSF and onset of FPB damage.

3.Analyze Loss Of Critical Safety Function

•Identifying the information available to the operator in the control room that can be used to specifically determine the loss of CSF and at what time into the event this determination could be made.

•Identifying the time at which the critical safety function is lost and the time of FPB damage.

•Estimation of the time when the operator must perform some manual action to prevent the loss of the critical safety function.

4.Perform Operator Action Sensitivity Calculation

•Running a new failed system calculation but with an operator action at the selected time to verify that this action has restored the critical safety function, thus preventing the onset of FPB damage.

•Comparison to the failed case:

1) key symptoms that are unique to successful recovery;
2) parameter values to be used to determine return to normal procedures.

•determination of the efficacy of the functional recovery strategies in averting loss of the

5.Perform Alternative Action Sensitivity Calculation

•Running a new calculation proposing an alternative operator action subsequent to the time after which the first course of action would no longer be effective in averting FPB damage

• Verifying that this action has restored the critical safety function thus preventing the onset of FPB damage

•Evaluating the efficacy of alternative recovery strategies.

THE REGULATORY BODY HAS DEFINED THE FOLLOWING STAGES OF EOP DEVELOPMENT AND APPROVAL:

- DEFINING THE BASIC PRINCIPLES TO BE APPLIED IN THE EOP DEVELOPMENT PROCESS
- DEFINING THE STRUCTURE AND SCOPE OF THE SYSTEM OF EOP
- DEVELOPMENT OF DETAILED LIST OF EOPS AND THEIR UNIQUE STRATEGIES
- DEVELOPMENT OF INDIVIDUAL PROCEDURES
- VERIFICATION OF THE PROCEDURES
- ANALYTICAL VALIDATION
- INDEPENDENT REVIEW OF EOPS AND APPROVAL
- OPERATOR TRAINING
- IMPLEMENTATION OF THE PROCEDURES IN THE CONTROL ROOM
- DEVELOPMENT OF LONG TERM MAINTENANCE PROGRAM

No.	NAME	Scenario developed by
1.	RG ESS ejected	ZNPP
2.	Uncontrollable movement of RG SS	BNPP
3.	Maximum secondary steam loss	ZNPP
4.	Primary make-up with distillate at maximum possible make-up rate	BNPP
5.	Primary LOCA with worst core cooling conditions	ZNPP
6.	Momentary shutdown of one RCP	BNPP
7.	Maximum possible loss of steam removal from SG	ZNPP
8.	Loss of SG makeup	BNPP
9.	Secondary LOCA leading to maximum primary cooldown rate	ZNPP
10.	Primary LOCA from steam portion of pressurizer leading to maximum temperature stratification's in equipment	BNPP
11.	Primary cooling at Pprimary>35kgf/sm2	ZNPP
12.	Connection of RCP in hard loop	BNPP
13.	Loss of steam leak (closure of pressuruzer impulse relief valve) at maximum feedwather ECCS flow rate	ZNPP
14.	Maximum primary LOCA to box	BNPP
15.	Maximum secondary LOCA to box when SG feedwather isolation fails	ZNPP
16.	Maximum primary LOCA to box if box ventilation system isolation is delayed	BNPP
17.	Loss of spent fuel pool cooling	ZNPP
18.	Maximum primary LOCA outside box through pressurize discharge line	BNPP
19.	Maximum primary-to secondary LOCA	ZNPP
20.	Maximum primary LOCA into intermediate	BNPP
	ADDITIONAL BOUNDARY CONDITION	
21.	Full unit blackout	ZNPP

Approach for developing Kozloduy EOPs structure and contend

1. Connecting separate instructions in system for both design and beyond design accidents

2. Developing particular instructions in step form for the operators

3. Use of thermal-hydraulic and probability analysis for instruction developing and V&V

4. Use of the available international experience and knowledge for Kozloduy EOPs development

Kozloduy EOPs Developing Principles

1.EOPs include all design basis accidents .

2.EOPs include accidents with multiple failures and errors .

3.EOPs include instructions for protection of radioactivity barriers in no concern of the initial events .

4.EOPs are based on symptoms recognized by control room operators .

5.EOPs include instructions for the whole time period of accident - from protection actuation till establishing safe and steady reactor state .

6.EOPs include instructions for transition to severe accident guideline .

7.For design accidents are used design devices , for beyond design accidents are used all available devices .

8.EOPs are based on best estimate and probability analysis.

NEC - EAD , NPP – KOZLODUY , ENERGYPRODUCTION - 2

CURRENT STATUS OF EOIs DEVELOPMENT FOR VVER-1000

1.Developed First revision 38 EOIs
   a. Beaver Valley , Zaporijie and Balakovo EOIs used
   b. First Revision written by 17 Unit and Shift Supervisors

2.Verified 38 EOIs
   a. Verification for technical correctness by 10 senior departmental staff
   b. About 2 400 notes , deficiencies and recommendations found

3.Developed Users' Guideline , Writers' Guideline , Verification Guideline
   a. Writers' Guide developed by PNNL sponsored seminar
   b. Writers' guide and Users' guide submitted to Bulgarian Nuclear Regulatory Body CUAEPP

4. EOIs analyses started by "Energoproject"-Sofia and BNSA-INRNE
   a. EGP - 70% of the work done
   b. INRNE – 50% of the work done

5. Analyses supporting activities :
   a. Development of database
   b. Verification of the models
   c. Education of KNPP staff for analyses
   d. Installation of RELAP5mod3.2 on KNPP PC and SGI work station

Future activities:

a. Completion of EOIs analyses
b. Evaluation of Modernization Program measures – equipment changes and SAR improvements and incorporation of the appropriate changes in EOIs
c. Accomplishment of independent review of EOIs structure and content
d. Development of CSF status trees
e. Development of Second Revision EOIs
f. Participation in Modernization Program activities concerning Severe Accident Analyses:
-Synthesis of available information about severe accidents for VVER-1000
-Study of H_2 generation in the containment and instalation of H_2 recombination system
-Instalation in the containment of ventilation system for severe accidents
-Beyond design bases accidents analyses
•Total loss of feedwater
•total loss of electrical power supply
•Small break LOCA in coincedence with loss of MHSI pumps
•Interfacing system LOCA
•Steam generator header break
•SGTR with steam line break
•ATWS
•Evaluation of design for beyond design accident management
•PSA Level 2 and 3
•SAR upgrading

DOCUMENTS TO BE SUBMITTED FOR REVIEW DURING THE DIFFERENT DEVELOPMENT STAGES:

- GUIDELINES FOR EOPs DEVELOPMENT, DESCRIBING THE BASIC PRINCIPLES TO BE APPLIED, THE STRUCTURE AND SCOPE OF THE PROCEDURES, CSFs DEFINITION ETC.

- QUALITY ASSURANCE PROGRAM FOR THE DIFFERENT DEVELOPMENT STAGES, INCLUDING V&V

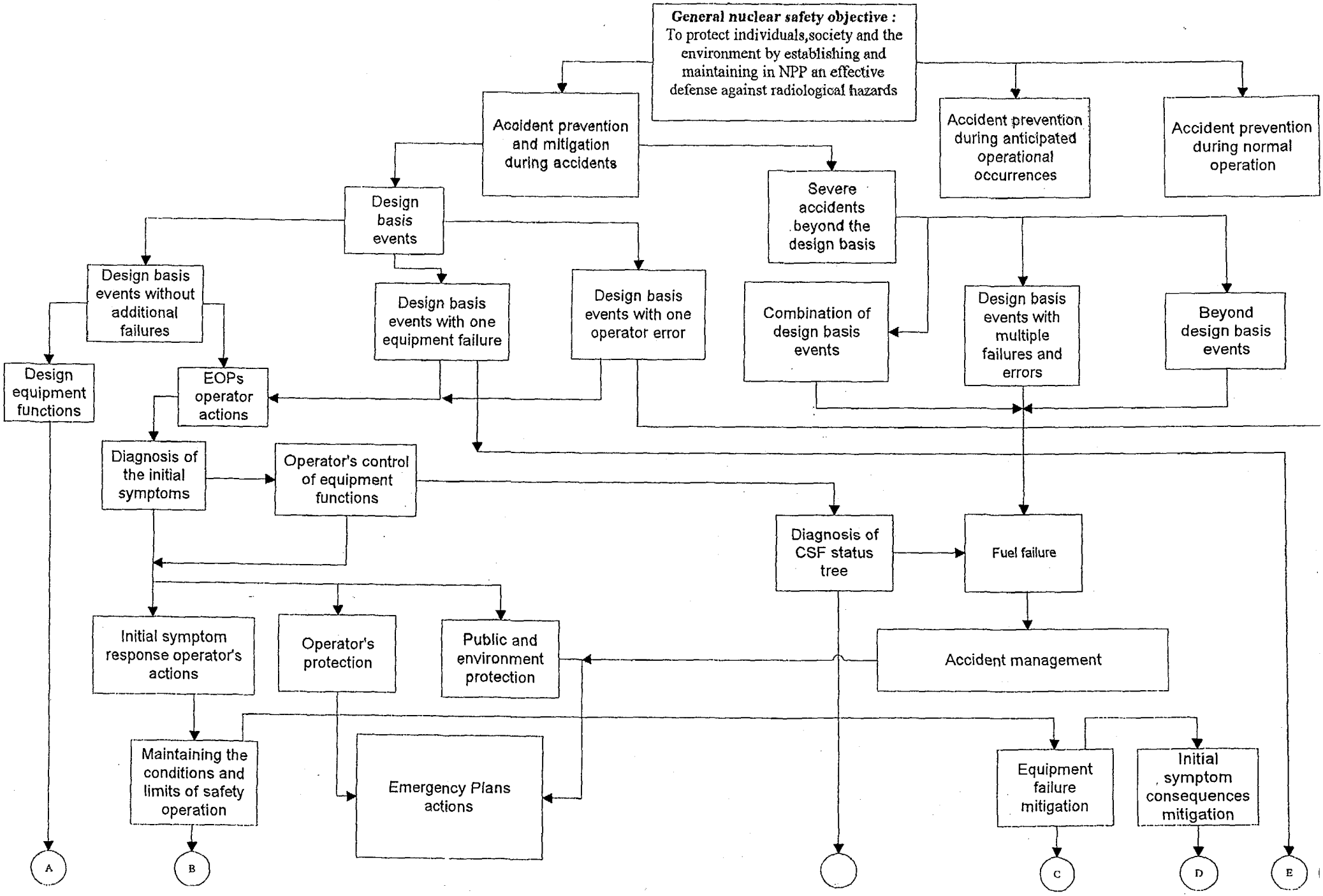
- PROGRAM FOR VERIFICATION AND VALIDATION. DOCUMENTATION OF THE RESULTS OBTAINED

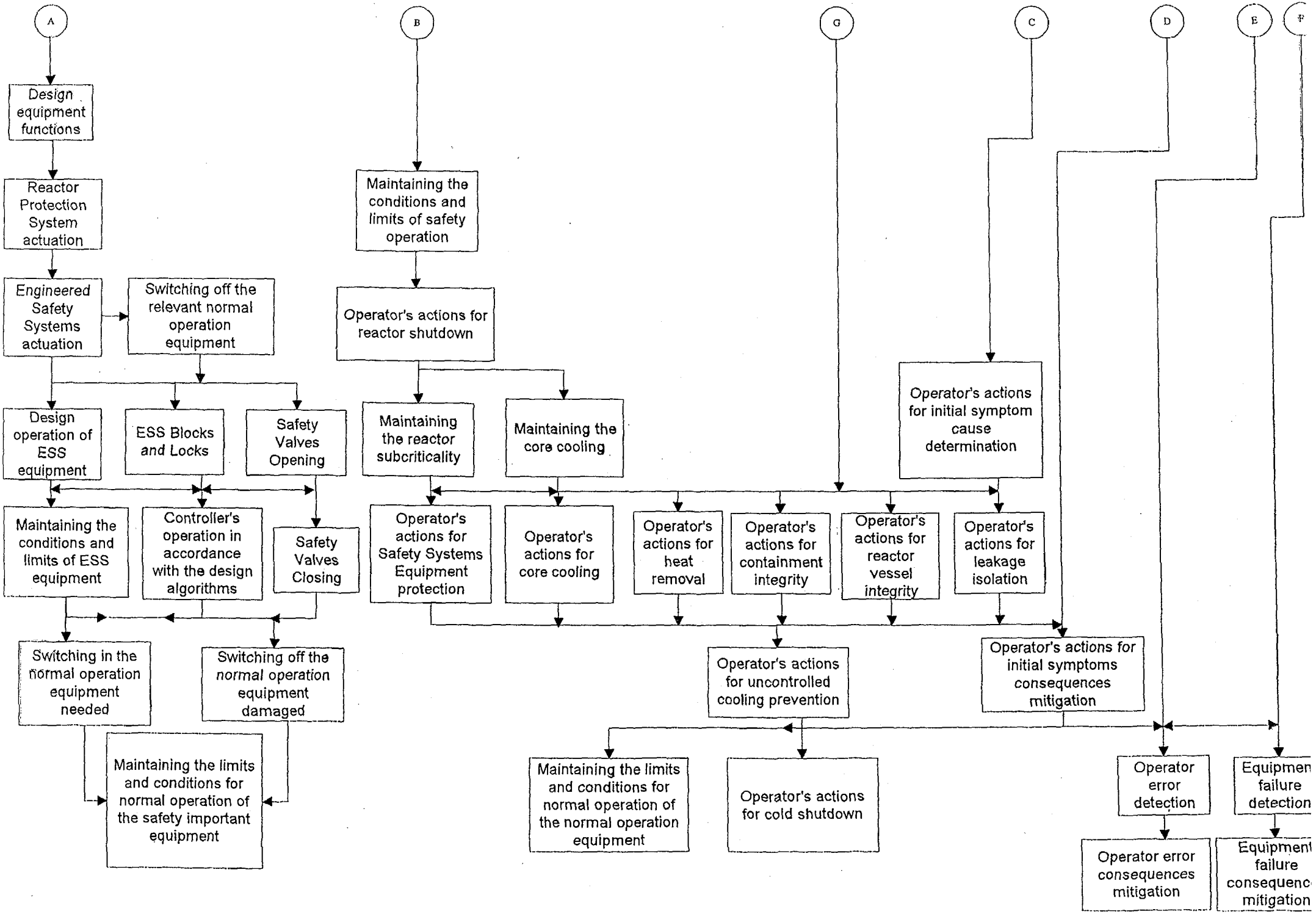
- TECHNICAL SUBSTANTIATION REPORT ON THE T/H ANALYSES PERFORMED, INCLUDING ACCIDENT SCENARIOS, METHODOLOGY FOR ANALYTICAL VALIDATION, RESULTS

- OPERATORS TRAINING PROGRAM BEFORE AND AFTER EOP IMPLEMENTATION

- LONG TERM MAINTENANCE PROGRAM OF THE SET OF EOPs.

Specific objectives and principles for EOPs




A
B
G
C
D
E
F
Design equipment functions
Reactor Protection System actuation
Engineered Safety Systems actuation
Switching off the relevant normal operation equipment
Design operation of ESS equipment
ESS Blocks and Locks
Safety Valves Opening
Maintaining the conditions and limits of ESS equipment
Controller's operation in accordance with the design algorithms
Safety Valves Closing
Switching in the normal operation equipment needed
Switching off the normal operation equipment damaged
Maintaining the limits and conditions for normal operation of the safety important equipment
Maintaining the conditions and limits of safety operation
Operator's actions for reactor shutdown
Maintaining the reactor subcriticality
Maintaining the core cooling
Operator's actions for Safety Systems Equipment protection
Operator's actions for core cooling
Operator's actions for heat removal
Operator's actions for containment integrity
Operator's actions for reactor vessel integrity
Operator's actions for leakage isolation
Operator's actions for uncontrolled cooling prevention
Maintaining the limits and conditions for normal operation of the normal operation equipment
Operator's actions for cold shutdown
Operator's actions for initial symptom cause determination
Operator's actions for initial symptoms consequences mitigation
Operator error detection
Operator error consequences mitigation
Equipmen failure detection
Equipment failure consequenc mitigation

Symplified Operator Cognitive Task Model