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技術報告書

계측제어 시험검증설비 오동작 원인/결과

I&C Functional Test Facility Malfunction Cause & Effect

韓國原子力研究所

提　　出　　文

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이 보고서를 1997년도 "계측제어 시험검증 기술 개발" 과제의 기술보고서로 제출합니다.

제목 : 계측제어 시험검증설비 오동작 원인/결과

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요 약

계측제어 시험검증설비는 원자력발전소 계측제어계통 개발시 개발 초기단계부터 개발될 계통의 기능 및 성능을 시험검증하기 위한 설비이다. 따라서 시험검증설비는 제어 및 감시신호를 정상 및 비정상상태때는 물론이고, 사고상태때에도 제공할 수 있고 다양한 하드웨어 인터페이스 방법을 제공할 수 있어야 한다.

시험검증설비에서 비정상 및 사고상황을 재현하기 위해서는 오동작을 삽입하여 그 결과가 실제 원자력발전소에서 일어나는 상황과 유사하여야 한다. 본 기술보고서에서는 시험검증설비에서 구현된 79개의 오동작에 대해서 각각이 속하는 Group, 오동작 번호, 오동작의 제목, 입력하여야 하는 선택사양, 권고하는 선택사양, 이 오동작이 프로그래밍된 다이나믹 루틴명, 오동작 입력시의 제한사항, 오동작의 원인, 마지막으로 오동작 입력시 나타나는 영향 또는 결과에 대해서 기술하였다.

Summary

The objective of I&C functional test facility (FTF) is to validate newly developed digital control and protection algorithm, alarm reduction algorithm and the function of operator support system and so on. To realize transient and accident situation in the FTF, the result of the activation of malfunction should be similar to the situation of real nuclear power plants. In this technical report, describe the Group, Malfunction No., Description, Option, Recommendations, Considered in Subroutine, Limitations, Cause, and Effect of the malfunctions implemented in FTF.

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1. 序論

계측제어 시험검증설비는 원자력발전소 계측제어계통 개발시 개발 초기단계부터 개발될 계통의 기능 및 성능을 시험검증하기 위한 설비이다. 개발될 계측제어계통의 prototype은 원자력발전소의 정상운전 및 비정상 상태의 신호를 입력으로 받아 적절한 요구 출력신호를 발생하여 원전의 상태가 정상상태 또는 운전원이 요구하는 상태로 전환되는지를 확인할 수 있어야 한다. 이와 같은 요구조건에 부합하는 제어 및 감시신호를 정상 및 비정상상태때는 물론이고, 사고상태때에도 제공할 수 있고 다양한 하드웨어 인터페이스 방법을 제공할 수 있는 설비이다.

시험검증설비에서 비정상 및 사고상황을 재현하기 위해서는 오동작을 삽입하여 그 결과가 실제 원자력발전소에서 일어나는 상황과 유사하여야 한다. 본 기술보고서에서는 시험검증설비에서 구현된 79개의 오동작에 대해서 각각이 속하는 Group, 오동작 번호 (Malfunction No.), 오동작의 제목 (Description), 입력하여야 하는 선택사양 (Option), 권고하는 선택사양 (Recommendations), 이 오동작이 프로그래밍된 다이나믹 루틴명 (Considered in Subroutine), 오동작 입력시의 제한사항 (Limitations), 오동작의 원인 (Cause), 마지막으로 오동작 입력시 나타나는 영향 또는 결과 (Effect)에 대해서 기술하였다.

제 2 장 오동작 (Malfunction) Cause & Effect

Group	Rod control system
Malfunction No.	1
Description	Drop of all control rods in CBA
Option	0 : Normal 1 : Dropped
Recommendations	
Considered in Subroutine	RODMVD
Limitations	
Cause	Blown stationary gripper at 100% at 100% and 228 steps

Effects

- CBA drops to 0 step
- Nuclear power decreases to 20%
- PRZ pressure decreases
- Generator power decrease
- T_{ref}/T_{avg} Hi/Lo alarm
- PRZ pressure Lo alarm
- Backup heater ON
- Power range high flux Rx trip
- FW isolation
- Turbine trip

Group	Rod Control System
Malfunction No.	2
Description	Drop of single control rod in CBB
Option	0 : Normal Number on dropped rod (1-8)
Recommendations	
Considered in Subroutine	RODMVD
Limitations	
Cause	CRD failure

Effects :

- Nuclear power drops to 70%
- CBD starts withdrawal
- PRZ pressure drop
- Nuclear power increase
- PRZ pressure drop
- Backup heater ON

Group	Rod Control System
Malfunction No.	3
Description	Stuck control rod in CBC
Option	0: Normal Number on stuck rod (1-8)
Recommendations	
Considered in Subroutine	RODMVD
Limitations	
Cause	Open breaker at decreasing power

Effects:

- Control bank D not moving
- T_{avg} small increase
- T_{ref}/T_{avg} Hi/Lo alarm

Group	Rod Control System	
Malfunction No.	4	
Description	Overlap failure	
Option	0: Normal 1: Failure	
Recommendations		
Considered in Subroutine		RODMVD
Limitations		
Cause	Defective detector Load increase or decrease time ??	

Effects:

- No overlap between banks

Group	Rod Control System
Malfunction No.	5
Description	Position indication failure
Option	0: Normal 1-4: Control Bank A,B,C,D 5-8: Shutdown Bank A,B,C,D
Recommendations	
Considered in Subroutine	PACLED
Limitations	
Cause	Digital rod position indication failure

Effects:

- CBA to SBD position indication is different from the actual value

Group	Rod control system	
Malfunction No.	6	
Description	Minimal rod speed	
Option	0: Normal 1: Active	
Recommendations		
Considered in Subroutine	RODMVD	
Limitations		
Cause	Speed change signal lost when power decreases	

Effects:

- Control rod movement speed is slower than normal operation (8 steps/min)
- Large gap between nuclear power and generator power
- T_{ref}/T_{avg} Hi/Lo alarm

Group	Rod control system	
Malfunction No.	7	
Description	Control rod speed malfunction	
Option	0: Normal 1: Active	
Recommendations		
Considered in Subroutine	RODMVD	
Limitations		
Cause	Speed change signal lost at power decrease	

Effects:

- Rod control system works less well
- Generator power decrease and stable
- T_{ref}/T_{avg} Hi/Lo alarm

Group	Rod control system
Malfunction No.	8
Description	Rod bank uncontrolled out
Option	0: Normal Bank number (1-8)
Recommendations	
Considered in Subroutine	RODMVD
Limitations	
Cause	Rod control logic failure at 100%

Effects:

- Specified control bank is continuously withdrawn without demand to 228 steps
- Control bank D full rod withdrawal alarm (if option #4 selected)
- Average temperature increase
- Nuclear power small increase then decrease, maintains stable state

Group	Rod control system
Malfunction No.	9
Description	Rod bank uncontrolled in
Option	0: Normal 1: Bank number (1-8)
Recommendations	
Considered in Subroutine	RODMVD
Limitations	
Cause	T_{ref} fails low ??

Effects: - Specified control bank is continuously inserted without demand
- Control bank lo-lo limit alarm
- Average temperature decrease
- PRZ pressure/level decrease
- Control bank D withdrawal
- Nuclear power decrease
- T_{ref}/T_{avg} Hi/Lo alarm
- Turbine trip
- Reactor trip

Group	Rod control system
Malfunction No.	10
Description	Operation blocked
Option	0: Normal 1: Active
Recommendations	
Considered in Subroutine	RODMVD
Limitations	
Cause	Complete collapse of rod control system

Effects: - Rod control mode select is not working
- Group select is not working
- Rod control In/Out is not working
- At power decrease
  - Generator power decrease (fast)
  - Nuclear power decrease (slow)
  - Average temperature increase
  - PRZ level increase
  - T_{ref} / T_{avg} increase
  - T_{ref} / T_{avg} Hi/Lo alarm

Group	Rod control system
Malfunction No.	11
Description	Anticipated transient without scram (failure to scram)
Option	0: Normal 1: Activate
Recommendations	
Considered in Subroutine	RODMVD
Limitations	The ATWS event is a physically complicated event. It requires an expert level of understanding and for the simulator it is outside the usual scope. That is why it is recommended to use the malfunction only in special training. In some situations the pressure rise may be so rapid that 185 bar is exceeded - then SMABRE stops the calculation. The simulation time step 0.2s is in such situations too long for ATWS simulation and calculation problems can not be prevented. Use Max 0.2s as time step for ATWS although no LOCA malfunctions are activated. The following disturbances are typically combined with ATWS: - Turbine trip - RCP trip - Loss of feedwater - Loss of electricity - Small break LOCA - Steam line break - Rupture of a steam generator tube
Cause	Scram signal lost. Caused by Rx protection logic circuit failure at any power J.M. Control rods are not moving down on scram signal

Effects:

- Reactor trip signal but not scram of control rods
- The effects are depending on the cause of the reactor trip
- Control bank D is inserted at normal speed in AUTO mode
- Turbine trip
- Average temperature increase sharply
- PRZ pressure small increase then decrease
- PRZ level same as pressure

J.M.

- Reactor trip is activated but the control rods are not moving down
- If the reactor is operating in AUTO mode the control rods are moving slowly down and the transient is milder than in MANUAL mode
- The event combined with the ATWS-malfunction defines the continuation.
- At main coolant pump trip the primary pressure and temperature rise reduce the reactor power and excess energy is removed through the PRZ safety valve
- At loss of feedwater the energy is removed through the turbine bypass valves until the secondary side is empty After that the primary pressure and temperature rise so high that the core power controlled by the core temperatures and void fraction corresponds to the energy release through the pressurizer safety valve
- At turbine trip the secondary pressure rises so high that the core power is removed through the turbine bypass valves and partially through the atmospheric dump valves
- At steam line break the chain of events is quite complicated. It includes periods like emptying of the broken steam generator energy removal through the intact steam generator, rise of primary pressure and opening of the pressurizer safety valves.
- At LOCA the ATWS has a minor effect because in any case void fraction is generated in the core and borated water is injected into primary loop.

Group	Loss of coolant Accident
Malfunction No.	12
Description	Leakage of primary coolant into containment. Break areas up to 10% of the area of the primary tube. (A special malfunction #13 for leakages into the secondary system)
Option	0: Normal Break node * 10000 + leak size in cm^2 Primary node number 1-34, see locations in the primary loop from the nodalization scheme
Recommendations	The recommended break size is 0-500 cm^2. 100% corresponds to 3800 cm^2 break area. Examples: 80100, 80200, 80500 for a cold leg break in node 8, having size 100, 200, 500 cm^2 The recommended nodes are (examples for a 200 cm^2 break) - loop #1 cold leg : 1 (10200) - loop #2 cold leg : 8 (80200) - loop #3 cold leg : 14 (140200) - loop #1 hot leg : 7 (70200) - loop #2 hot leg : 33 (330200) - loop #3 hot leg : 20 (200200) - vessel top : 31 (310200) - vessel bottom : 23 (230200) - pressurizer (top) : 34 (340200)
Considered in Subroutine	SMABRE/LINK
Limitations	LOCA is physically a quite complicated event. That is why the malfunction is recommended to be used only for special training. Use Max 0.2 s for the time step for LOCA calculation.
Cause	A break is assumed in the primary loop as a partial rupture of the pipe itself or as a rupture of the smaller pipes connected into the primary loop.

Effects:

- The primary coolant inventory will be reduced.
- The pressurizer level drops
- The primary pressure drops and the boiling in the pressurizer partly prevents the pressure decrease
- The reactor is scrammed from the low pressure
- The pressure continues to drop remarkably fast until the boiling starts in the core and upper plenum
- The high pressure injection is activated from the low pressure signal
- The pressure drops slower due to boiling between the core and steam generator and due to injections
- When the primary pressure drops below the secondary pressure, heat is transferred from the secondary side to the primary side, steam is generated in the steam generator primary side too, until the tubes are empty from water.
- In the beginning only water is leaking through the break, later on both water and steam
- The operator may reduce the steam generator pressure during the event. The safety signal actuation may be prevented. Quite early in the transient the operator should switch off the main coolant pumps. All these actions have a significant effect on standard LOCA curve can be presented.

Group	Loss of coolant Accident
Malfunction No.	13
Description	Rupture of steam generator tubes
Option	0: Normal Loop# * 10000 + leak size in cm^2
Recommendations	The event is one variation of the SBLOCA. thus see the comments for malfunction #12. In reality the flow area of a single tube is about $2cm^2$ and a double ended break means a total flow area of $4cm^2$ for a single tube. Thus for realistic training it is recommended to use flow area of $4cm^2$ for a single tube, $8cm^2$ for two tubes. $12cm^2$ for tree etc. Thus a double ended tube break for the different loops is selected by: Loop #1 10004 Loop #2 20004 Loop #3 30004 ***Use Max 0.2 s for the time step.***
Considered in Subroutine	SMABRE/LINK
Limitations	
Cause	As a consequence of thermal stresses on the tube material one or several steam generator tubes are broken opening a flow connection between primary and secondary loops.
Effects:	- On the primary side the event behaves like a small break LOCA until the primary pressure drops down to the level of the secondary pressure. After that the flow in the break is controlled by small pressure differences between the primary and the secondary side - In the broken steam generator the secondary water level rises filling the secondary side gradually. - Operator actions are expected for the isolation of the broken steam generator and for reducing the primary injection . The selected operator actions are very important for how the event continues.

Group	Loss of coolant Accident
Malfunction No.	14
Description	Reactor coolant pump stop transients
Option	0: Normal 1: RCP #1 2: RCP #2 3: RCP #3
Recommendations	
Considered in Subroutine	RCPPBO
Limitations	
Cause	Reactor coolant pump trip is activated by a faulty signal. The operator cannot restart the pump before the malfunction is inactivated.

Effects:
- As a consequence of the trip signal the selected RCP is stopped. The stopping time depends on the pump inertia and the status of other pumps
- The reactor is scrammed
- The turbine is scrammed
- The flow in the loop having the pump stopped is balanced to a negative value and the flow rate in loops having operating pumps is balanced to a higher level than originally.

Group	Loss of coolant Accident
Malfunction No.	15
Description	PRZ PORV stuck open
Option	0: Normal opening (1-100%) Example: A fully open PRZ PORV is selected by parameter 100.
Recommendations	
Considered in Subroutine	PRZCON
Limitations	The PRZ - PORV stuck open transient corresponds to a small break LOCA. See comments for malfunction #12 Use Max 0.2 s for the time step.
Cause	PRZ PORV control mechanism fails J.M. Due to a faulty signal the PRZ PORV is opened and it remains in an open position. The valve can be closed after releasing the malfunction.

Effects:

- PV445 (PORV) open lamp on
- PRZ pressure decrease
- PRZ level decrease
- PRT temperature increase
- PRT pressure increase
- Back-up heater on
- PRT temp/press Hi alarm
- PRZ level increase
- Rx trip caused by PRZ press low

J.M.

- The primary pressure is reduced corresponding to the released amount of steam
- The reactor is scrammed from the low pressure
- When the saturation pressure in the upper plenum drops below the upper plenum pressure steam is generated in the upper plenum and it is collected to the upper head.
- The high pressure injection (HPI) is activated
- As a consequence of HPI-activation and boiling in the upper plenum the pressurizer level rises and finally both water and steam are leaking out through the PORV
- The pressure relief tank (PRT) is filled with the leaking coolant, gradually the tank pressure is increased and the break disc is broken in the PRT.
- The containment pressure rises activating the containment spray after the break disc in the PRT is broken.

Group	Loss of coolant Accident
Malfunction No.	16
Description	PRZ SV stuck open
Option	0: Normal opening (1-100%) Example: A fully open PRZSV is selected by parameter 100
Recommendations	
Considered in Subroutine	PRZCON
Limitations	See malfunction # 15.
Cause	PRZ safety valve drive mechanism fails J.M. Due to a faulty signal the PRZSV is opened and it remains in an open position. The valve can be closed after releasing the malfunction.

Effects: - PSV10 ON
- PRT temp & press increase
- Average temperature decrease
- PRZ press & level decrease
- Back-up heater ON
- PRT temp/press hi alarm
- PRT level increase
- Rx trip
- Turbine trip
- SI actuated

J.M.
- The primary pressure is reduced corresponding to the released amount of steam
- The reactor is scrammed from the low pressure
- When the saturation pressure in the upper plenum drops below the upper plenum pressure, steam is generated in the upper plenum and it is collect to the upper head
- The high pressure injection (HPI) is activated
- As a consequence of HPI-activation and boiling in the upper plenum the pressurizer level rises and finally both water and steam are leaking out through the SV
- The pressure relief tank (PRT) is filled with the leaking coolant, gradually the tank pressure is increased and the break disc is broken in the PRT.
- The containment pressure rises activating the containment spray after the break disc in the PRT is broken

Group	Loss of Coolant Accident	
Malfunction No.	17	
Description	Non-isolable FW line leak	
Option	0: Normal Loop # * 10000 + leak size in cm^2 Recommended leak size 1-100 cm^2	
Recommendations		
Considered in Subroutine	SMABRE/LINK	
Limitations	The event is a variation of the LOCA. See comments for malfunction # 12. Use Max 0.2 s for the time step	
Cause	The non-isolable FW line leak is modeled as a leak from the steam generator downcomer volume. The leak elevation corresponds to the elevation of the feedwater pipeline. The coolant is leaking into the containment.	

Effects:

- In the broken steam generator the feedwater injection and the steam flow are not balancing.
- For small leakages (20 cm^2)
  unbalance leads gradually to lacking inventory in gradually system.
- The leak inside the containment activates the containment isolation signal
- Reactor scram due to containment isolation signal (or low S/G level?)

Group	Loss of Coolant Accident	
Malfunction No.	18	
Description	Steam line rupture (isolable)	
Option	0: Normal Loop # * 10000 + leak size in cm^2	
Recommendations		
Considered in Subroutine	SMABRE/LINK	
Limitations	The event is a variation of the SBLOCA. See comments for malfunction # 12. Use Max 0.2 s for the time step	
Cause	The steam line is assumed to be broken in the isolable part inside the turbine hall. The instructor defines the break no fixed size has been assumed.	

Effects:

* Small leak sizes (100 cm^2)
  - At small leak sizes the only effect can be seen as an unbalance between feedwater flow and steam flow to the turbines, as well as between reactor power and generator power

* Large leak sizes (Max 2000 cm^2)
  - At larger leak sizes the secondary pressure drops
  - Steam generator levels drop due to insufficient feedwater capacity
  - Turbine trip from low S/G level
  - Reactor trip from turbine trip
  - Strong cooling on primary side due to decreased secondary pressure
  - S/G isolation from low S/G pressure, after that no leak any more and the S/G pressure rises again
  - Strong cooling may have started HPIS injection on the primary side
  - Primary pressure and PRZ level increase due to primary heating and HPIS injection

Group	Pressurizer	
Malfunction No.	19	
Description	PRZ pressure high/low indication failure (Wide range and narrow range)	
Option	0: Normal 11: High failure (W) 12: Low failure (W) 21: High failure (N) 22: Low failure (N)	
Recommendations		
Considered in Subroutine	PACINS	
Limitations		
Cause	Indication transmitter produces wrong signal	
Effects: Instrument indication is wrong when the system is working properly		

Group	Pressurizer
Malfunction No.	20
Description	PRZ level high/low indication failure
Option	0: Normal 1: High failure 2: Low failure
Recommendations	
Considered in Subroutine	PACINS
Limitations	
Cause	Indication transmitter produces wrong signal J.M. : PRZ level display shows low or high level

Effects: Instrument indication is wrong when the system is working properly

J.M. : No effect on the physical behavior

Remark : The proper way should be:

- At low level the primary charging system tends to increase the Pressurizer level
- At high level the letdown system tends to reduce the pressurizer level and the pressurizer heaters are switched on inorder to keep the primary pressure.

Group	Pressurizer
Malfunction No.	21
Description	Loss of pressurizer proportional heater
Option	0: Normal 1: Loss of heaters
Recommendations	
Considered in Subroutine	PRZCON
Limitations	
Cause	Proportional heater breaker open
Effects:	- PRZ pressure decrease - In heater control AUTO mode back-up heater ON - Recover PRZ pressure

Group	Pressurizer
Malfunction No.	22
Description	PRZ spray valve open, fails to close or jammed shut
Option	0: Normal 1: Fully open 2: Fails to close 3: Stuck in position
Recommendations	
Considered in Subroutine	PRZCON
Limitations	
Cause	- Valve close : Loss of valve driving compressed air - Valve open : Valve driving mechanism failure - Valve stuck in position : Driving mechanism failure

Effects:

* Valve open
  - PRZ spray flow decrease
  - PRZ pressure decrease
  - Proportional heater fully ON
  - PRZ level small decrease
  - Backup-heater ON
  - PRZ pressure low alert alarm
  - PRZ level increases sharply

J.M. :

* At fully open
  - Primary pressure drops
  - Boiling marging is reduced
  - Reactor scram from low pressure
* At fails to close
  - Whenever the spray has reduced the primary pressure continues to drop
  - Boiling marging is reduced
  - Reactor scram from low pressure

At stuck in position:
  - Whenever the spray valves are needed for reducing a pressure rise, they have no effect. The effect can be seen in transients where primary pressure is rising like turbine trip or excess charging flow into the primary system

Group	Pressurizer
Malfunction No.	23
Description	Failure in PRZ pressure controller (to maximum or minimum)
Option	0: Normal 1: Maximum failure 3: Minimum failure
Recommendations	
Considered in Subroutine	PRZCON
Limitations	
Cause	Controller circuit failure

Effects:

* High failure
  - PRZ spray valve open, spray flow increase
  - PRZ pressure decrease
  - PRZ pressure low alert alarm
  - Rx trip
* Low failure
  - PRZ proportional heater fully ON
  - Back-up heater ON
  - PRZ pressure Hi alert alarm
  - PV445 (PORV) opens
  - PRZ pressure decrease

Group	Reactor Coolant Pumps
Malfunction No.	24
Description	1 RCP seal return flow high
Option	0: Normal 1: RCP # 1 2: RCP # 2 3: RCP # 3
Recommendations	
Considered in Subroutine	RCPPBD
Limitations	
Cause	#1 seal rupture (?)
Effects: - RCP seal return flow increases	

Group	Reactor Coolant Pumps	
Malfunction No.	25	
Description	1 RCP seal return flow low & high temperature	
Option	0: Normal 1: RCP #1 2: RCP #2 3: RCP #3	
Recommendations		
Considered in Subroutine	RCPPBD	
Limitations		
Cause	#1 seal rupture	
Effects: - RCP seal return flow low		

Group	Reactor Coolant Pumps
Malfunction No.	26
Description	Reactor coolant pump trip
Option	0: Normal 1: RCP # 1 2: RCP # 2 3: RCP # 3
Recommendations	
Considered in Subroutine	RCPPBD
Limitations	
Cause	RCP breaker open

Effects:
- RCP trip
- S/G to RCP loop flow decrease
- Reactor trip at RCS flow low at Hi power
- Turbine trip

J.M. : Finally the flow direction in the tripped loop becomes negative and the flow in the operating loops increases from the normal level.
The decay heat is removed through the steam generators in the operating loops

Group	Reactor Coolant Pumps	
Malfunction No.	27	
Description	RCP seal injection valve fails to close	
Option	0: Normal 1: Fails to close	
Recommendations		
Considered in Subroutine		SEALSD
Limitations		
Cause	Valve moving power fails	

Effects:
- HV50 closed
- RCP seal injection flow decreases to 0.0 kg/s
- RCP seal delta pressure decreases to 0.0 kg/cm^2
- RCP seal return flow decreases to 0.0 kg/s

Group	Reactor Coolant Pumps
Malfunction No.	28
Description	RCP shaft break
Option	0: Normal 1: RCP #1 2: RCP #2 3: RCP #3
Recommendations	
Considered in Subroutine	SMABRE/LINK
Limitations	
Cause	RCP shaft break J.M. : The shaft of the selected RCP is broken causing loss of electrical torque on the RCP' s and a partial loss of the pump inertia

Effects: See RCP trip procedure

J.M.: - The control system interprets the situation as a RCP trip.
- The pump speed drops faster than in a normal RCP trip
- Else see malfunction #26 RCP trip

Group	Reactor Coolant Pumps
Malfunction No.	29
Description	RCP rotor seizure
Option	0: Normal 1: RCP #1 2: RCP #2 3: RCP #3
Recommendations	
Considered in Subroutine	SMABRE/LINK
Limitations	
Cause	J.M. : Due to a mechanical failure the pump shaft of the selected RCP is seized

Effects:
- In one time step the pump speed of the selected RCP is stopped.
- The negative flow in the loop having the stopped pump is stabilized faster than in a normal RCP trip.
- Else see malfunction #26 RCP trip

Group	Steam Generator
Malfunction No.	30
Description	S/G level high/low indication failure (wide range & narrow range)
Option	0: Normal 11: S/G #1 high failure (W) 12: S/G #1 low failure (W) 13: S/G #1 high failure (N) 14: S/G #1 low failure (N) 21: S/G #2 high failure (W) 22: S/G #2 low failure (W) 23: S/G #2 high failure (N) 24: S/G #2 low failure (N) 31: S/G #3 high failure (W) 32: S/G #3 low failure (W) 33: S/G #3 high failure (N) 34: S/G #3 low failure (N)
Recommendations	
Considered in Subroutine	PACINS
Limitations	
Cause	Indication transmitter produces wrong signal
Effects: Instrument indication is wrong when the system is working properly	

Group	Steam Generator	
Malfunction No.	31	
Description	S/G pressure high/low indication failure	
Option	0: Normal 11: S/G #1 high failure 12: S/G #1 low failure 21: S/G #2 high failure 22: S/G #2 low failure 31: S/G #3 high failure 32: S/G #3 low failure	
Recommendations		
Considered in Subroutine	PACINS	
Limitations		
Cause	Indication transmitter produces wrong signal	
Effect: Instrument indication is wrong when the system is working properly		

Group	Steam Generator
Malfunction No.	32
Description	Loss of S/G level signal (to level controller)
Option	0: Normal 1: S/G #1 2: S/G #2 3: S/G #3
Recommendations	
Considered in Subroutine	SGLECD
Limitations	
Cause	S/G level controller failure

Effects:
- Loss of level signal to FW flow regulator
- FW valve opening in order to increase S/G level - i.e. away from setpoint (bypass valve opens)
- SMABRE : large injection
- S/G level increases
- Trip on high S/G level after about 10s

Group	Chemical and Volume Control System
Malfunction No.	33
Description	Boron concentration high/low (auto mode)
Option	0: Normal 1: High 2: Low
Recommendations	
Considered in Subroutine	MUSYSD
Limitations	
Cause	Auto flow distribution signal fault in AUTO make-up mode

Effects:
* Boron concentration high
  - RCS boron concentration increases
* Boron concentration low
  - RCS boron concentration decreases

Group	Chemical and Volume Control System
Malfunction No.	34
Description	VCT level control failure
Option	0: Normal 1: Level high failure 2: Level low failure
Recommendations	
Considered in Subroutine	NORLSD
Limitations	
Cause	LV614 or 616 control logic failure

Effects: * Level high failure (85%)

- LV614 is diverting to hold-up tank when VCT level is greater than 74%
- VCT level will decrease

* Level low failure (15%)

- Auto make-up mode start
- VCT level increase

Group	Chemical and Volume Control System
Malfunction No.	35
Description	Loss of charging pump
Option	0: Normal 1: Charging pump #1 2: Charging pump #2 3: Charging pump #3
Recommendations	
Considered in Subroutine	NORLSD
Limitations	
Cause	Charging pump breaker open

Effects:
- Charging pump trip
- Charging flow decrease
- Seal injection flow decrease
- PRZ level decrease

Group	Chemical and Volume Control System	
Malfunction No.	36	
Description	Regen. Heat exchanger leak	
Option	0: Normal Leak in % (1-100)	
Recommendations		
Considered in Subroutine	NORLSD	
Limitations		
Cause	Regen heat exchanger tube rupture	

Effects:
- RHX outlet temperature decreases
- Charging line out temp tube decreases
- L/D HX outlet flow decreases and flow-low alarm
- L/D HX outlet temp also decreases
- VCT level decreases

Group	Chemical and Volume Control System	
Malfunction No.	37	
Description	Letdown heat exchanger leak	
Option	0: Normal Leak in % (1-100)	
Recommendations		
Considered in Subroutine	NORLSD	
Limitations		
Cause	Letdown heat exchanger tube rupture	

Effects:
- L/D HX outlet flow decreases
- L/D HX outlet temp decreases
- VCT level decreases
- L/D back pressure will decreases

Group	Chemical and Volume Control System	
Malfunction No.	38	
Description	Charging line rupture (isolable)	
Option	0: Normal 1: Rupture	
Recommendations		
Considered in Subroutine	NORLSD	
Limitations		
Cause	- Line break - Lost 50% of charging flow after RHX	

Effects:
- PRZ level decreased
- Charging flow increases

Group	Chemical and Volume Control System	
Malfunction No.	39	
Description	Make-up Water Blocked	
Option	0: Normal 1: Fault	
Recommendations		
Considered in Subroutine	MUSYSD	
Limitations		
Cause	Make-up water (demi. water) supply system failure	

Effects:
- If make-up start is no make-up water only boric flow
- RCS boron concentration increase in AUTO mode
- VCT level decrease if in AUTO mode

Group	Residual Heat Removal System
Malfunction No.	40
Description	Pump breaker trip
Option	0: Normal 1: Trip
Recommendations	
Considered in Subroutine	RHRSYD
Limitations	
Cause	Breaker mechanism failure as SI mode or cool down stage

Effects:
- RHR pump trip
- No RHR flow to RCS
- If in cooldown stage, average temp dose not decrease

Group	Residual Heat Removal System
Malfunction No.	41
Description	RHR HX discharge valve position failure
Option	0: Normal 1: Fully open 2: Fails close 3: Stuck in position
Recommendations	
Considered in Subroutine	RHRSYD
Limitations	
Cause	* High failure - Loss of valve driving compressed air * Low failure or stuck in position - Valve driving mechanism failure

Effects : * High failure
- Discharge valve fully open
- Can not control RHR return flow and temperature
* Low failure
- Discharge valve fully closed
- Bypass valve fully open
- RHR return flow decreases
- RHR return temperature increases
- Can not control RHR return flow and temperature
* Stuck in position
- Can not control discharge valve, RHR return temperature and flow

Group	Residual Heat Removal System
Malfunction No.	42
Description	Bypass valve position failure
Option	0: Normal 1: Fully open 2: Fails close 3: Stuck in position
Recommendations	
Considered in Subroutine	RHRSYD
Limitations	
Cause	Loss of valve driving compressed air or valve driving mechanism failure

Effects:

* Fully open

- If the discharge valve is fully open the RHR return flow increases

* Fully closed

- If the discharge valve is fully closed the RHR return flow decreases

* Stuck in position

- RHR return temperature and are not working properly

Group	Residual Heat Removal System	
Malfunction No.	43	
Description	RHR heat exchanger leak	
Option	0: Normal 1: Leak in % (1-100)	
Recommendations		
Considered in Subroutine	RHRSYD	
Limitations		
Cause	RHR heat exchanger tube rupture	
Effects: If the RHR discharge valve is open the RHR return flow and temperature decrease		

Group	Residual Heat Removal System
Malfunction No.	44
Description	Loss of RHR pump
Option	0: Norma 1: Loss
Recommendations	
Considered in Subroutine	RHRSYD
Limitations	
Cause	RHR pump shaft seizure

Effects: See malfunction #40

Group	Steam Dump System	
Malfunction No.	45	
Description	Steam dump valve closed undemanded	
Option	0: Normal 1: Closed	
Recommendations		
Considered in Subroutine	STMVLV	
Limitations		
Cause	Valve are closed because of loss of pressure signal before turbine reset	

Effects:
- System pressure increase
- No steam flow
- Steam generator level increase because of Aux. feedwater flow
- Turbine trip by S/G level high if Aux. feedwater exists

Group	Steam Dump System
Malfunction No.	46
Description	
Option	0: Normal 1: Open
Recommendations	
Considered in Subroutine	STMVLV
Limitations	
Cause	Valves are not closed because of malfunction of controller when STMDMP valves open
Effects:	- Main steam pressure decrease - Main steam flow is not controlled by the steam dump valves

Group	Steam dump System
Malfunction No.	47
Description	Steam dump valves open undemanded
Option	0: Normal 1: Open
Recommendations	
Considered in Subroutine	STMVLV
Limitations	
Cause	Valves are open because of malfunction of the controller at 100%

Effects:
- Steam flow increase
- S/G level decreases
- Generator power decreases
- Turbine trip

Group	Main Steam System
Malfunction No.	48
Description	Steam flow indication failure high/low
Option	0: Normal 1: High failure 2: Low failure
Recommendations	
Considered in Subroutine	PACINS
Limitations	
Cause	Indication transmitter produces wrong signal

Effects: Instrument indication is wrong when the system is working properly

Group	Main Steam System
Malfunction No.	49
Description	Steam pressure indication failure high/low
Option	0: Normal 1: High failure 2: Low failure
Recommendations	
Considered in Subroutine	PACINS
Limitations	
Cause	Indication transmitter produces wrong signal
Effects: Instrument indication is wrong when the system is working properly	

Group	Main Steam System
Malfunction No.	50
Description	MSIV closure
Option	0: Normal 1: MSIV #1 2: MSIV #2 3: MSIV #3
Recommendations	
Considered in Subroutine	SGPRCD
Limitations	
Cause	MSIV driving mechanism failure J.M. An inadvertent S/G isolation signal causes isolation of the selected S/G. The isolation is caused by fast acting valves, then no delay can be seen for the isolation.

Effects:
- MAIV close
- Steam line flow decreases to 0
- S/G pressure increases
- S/G PV open
- S/G PSV open
- Reactor trip

J.M.
- The pressure in the isolated S/G rises and the S/G safety valves are opened in the loop. Due to higher pressure the isolated S/G removes less heat from the primary system than the nonisolated S/G-s
- The nonisolated S/G-s remain in normal conditions but meanwhile the heat flux from the primary loop is increased due to increased primary temperature.
- Primary temperature is increased causing an increase in the pressurizer level and primary pressure.
- Reactor power is reduced due to the increased primary temperature.

Group	Main Steam System	
Malfunction No.	51	
Description	MSIV fails to shut	
Option	0: Normal 1: MSIV #1 2: MSIV #2 3: MSIV #3	
Recommendations		
Considered in Subroutine		SGPRCD
Limitations		
Cause	J.M. MSIV isolation takes place in the case of a low S/G pressure When malfunction #51 is active the selected S/G cannot be isolated	

Effects: (Test : Set malfunction 51 to 1

Set KMISO =1

0.1x real time

- MSIV 2 and 3 close but not 1)

J.M. - In the case of an isolable steam line break the selected S/G cannot be isolated. Then the event corresponds to the malfunction #52, main steam line break, nonisolable outside or inside containment.

- In the case of a steam generator tube rupture the operator cannot isolate the broken S/G for reducing the leakage from the primary side

Group	Main Steam System
Malfunction No.	52
Description	Main steam line break, nonisolable (inside or outside containment)
Option	0: Normal 110000: Loop #1 (inside) 120000: Loop #2 (inside) 130000: Loop #3 (inside) 210000: Loop #1 (outside) 220000: Loop #2 (outside) 230000: Loop #3 (outside) add leak size in cm^2 Example : A $1000cm^2$ main steam line rupture for the different loops is selected by : Loop #1 inside containment : 111000 Loop #2 inside containment : 121000 Loop #3 inside containment : 131000 Loop #1 outside containment : 211000 Loop #2 outside containment : 221000 Loop #3 outside containment : 231000
Recommendations	
Considered in Subroutine	SMABRE/LINK
Limitations	The event is a variation of a LOCA. See comments for malfunction #12. Max time step 0.2 s.
Cause	The whole main steam line pipe or a part of it is assumed broken. Because the secondary isolation valves are located in the turbine hall the possible combinations are - nonisolable leak inside containment - nonisolable leak outside containment

Effects: * Small leakages

- For small leak sizes (<100 cm^2) the transient is quite mild showing only an unbalance between the feedwater injection and steam flow to the turbines. The unbalance may be seen in the steam flow measurement for the broken loop, too In a longer time interval the smaller leak empties the feedwater inventory in the condenser and this cause turbine trip. The rest of the consequences are corresponding to a larger steam line break.

* Large leakage (Max 2000 cm^2)

- The secondary pressure drops
- The steam flow to the turbines is reduced due to lowered secondary pressure
- The primary side is cooling down dropping the pressurizer level and the primary pressure
- The reactor control tries to increase the core power but the upper limitation prevents the rise from getting too high
- If the leak is located inside the containment, containment pressure is increased starting the containment isolation signal
- In case of containment isolation signal the reactor is tripped causing turbine trip
- In case of leak outside containment the turbine is tripped on low secondary pressure causing reactor trip (?)
- The secondary pressure continues to drop causing activation of S/G isolation signal. All S/G-s are isolated by fast acting valves.
- After isolation the intact S/G-s remain on pressure level, a slight pressure increase is caused by the heat form the primary side
- The broken S/G cools the primary loop where the HPIS may be started from low pressure. This may gradually cause an overpressure.
- The decay heat from the core gradually empties the broken S/G
- When the broken S/G is empty the primary loop starts to heat up again. The heat-up may be so large that the spray is needed in order to limit the pressure rise
- If the operator has stopped the RCP's the cold leg of the broken S/G cools down much below the temperature in the intact loops.

Group	Main Steam System
Malfunction No.	53
Description	Stuck S/G safety valve
Option	0: Normal 1: #1 2: #2 3: #3
Recommendations	
Considered in Subroutine	SGPRCD
Limitations	
Cause	Valve operation mechanism failure

Effects: Does not open on demand

(Function can be tested by :

Set malfunction 53 to 1(-3)

(safety valve)

Make direct change CPSAFE (1)

(0.816E7) to lower than S/G

pressure eg to o.5E7

- The other valves open (red lamp on)
- The chosen valve does not open

(red lamp not on))

Group	Main Steam System
Malfunction No.	54
Description	MSR (reheater) steam supply control valve closed
Option	0: Normal 1: Closed
Recommendations	
Considered in Subroutine	CNTVLV
Limitations	
Cause	MSR steam supply control valve controller is failed at 100% LOAD

Effects:
- Generator power decreases
- Feedwater temperature decreases
- Control valve (CV70) closes

Group	Turbine System	
Malfunction No.	55	
Description	Turbine trip	
Option	0: Normal 1: Trip	
Recommendations		
Considered in Subroutine		LTURBS
Limitations		
Cause	Turbine trip button has malfunction	

Effects: - Turbine trip as turbine manual trip at 100% load (<10% LOAD)
- Reactor trip at < 10% LOAD only turbine trip

Group	Turbine System
Malfunction No.	56
Description	Undemanded turbine control valve movement
Option	0: Normal 1: Activate
Recommendations	
Considered in Subroutine	CNTVLV
Limitations	
Cause	Wrong signal to controller

Effects:
- Control valves close
- Generator power decreases to zero quickly
- Turbine trip
- Reactor trip

Group	Turbine System
Malfunction No.	57
Description	Turbine control valve stuck
Option	0: Normal 1: Stuck
Recommendations	
Considered in Subroutine	CNTVLV
Limitations	
Cause	Controller fails
Effects: - Generator power can not be decreased using LOAD setpoint or LOAD rate setpoint	

Group	Turbine System
Malfunction No.	58
Description	Failure of auto turbine runback
Option	0: Normal 1: Failure
Recommendations	
Considered in Subroutine	LTURBS
Limitations	
Cause	Loss of flow decreases temporarily

Effects:
- Feedwater flow decreases temporarily and then increases again
- One more pump stop makes turbine trip from low S/G level due to lack of feedwater

Group	Condenser and Condensate System
Malfunction No.	59
Description	Air leaking into the condenser
Option	0: Normal Leak area
Recommendations	
Considered in Subroutine	CONDEN
Limitations	
Cause	Condenser tank is cracked
Effects:	- Condenser vacuum pressure decreases - Generator power decreases

Group	Condenser and Condensate System	
Malfunction No.	60	
Description	Loss of air ejector	
Option	0: Normal 1: Activate	
Recommendations		
Considered in Subroutine	CONDEN	
Limitations		
Cause	Air ejector failure	

Effects:
- Air ejector trip
- Vacuum pressure decreases
- Generator power decreases
- Reactor power decreases

Group	Condenser and Condensate System	
Malfunction No.	61	
Description	Condenser tube leak	
Option	0: Normal 1: Flow rate	
Recommendations		
Considered in Subroutine	CONDEN	
Limitations		
Cause	Condenser tube is broken	

Effects:
- Condenser level increases
- Condensate water temperature decreases

Group	Condenser and Condensate System
Malfunction No.	62
Description	Loss of condenser circulating water pump
Option	0: Normal 1: Trip
Recommendations	
Considered in Subroutine	CONPMP
Limitations	
Cause	Pump breaker trip
Effects:	- Cooling water pump trip - Condenser temperature increases - Condenser vacuum pressure decreases - Generator power decreases - Reactor power decreases

Group	Condenser and Condensate System
Malfunction No.	63
Description	Condensate pump breaker trip
Option	0: Normal 1: Pump #1 2: Pump #2 3: Pump #3
Recommendations	
Considered in Subroutine	CONPMP
Limitations	
Cause	Loss of electric power
Effects:	- Condensate pump trip - Condensate pump outlet pressure decreases - Condenser temperature increases - Feedwater flow decreases - Steam generator level decreases

Group	Feedwater System
Malfunction No.	64
Description	HP feedwater heater high - high level
Option	0: Normal 1: High - high level
Recommendations	
Considered in Subroutine	SGLECD
Limitations	
Cause	HP FW heater Drain valve is uncontrollable

Effects:
- LV103, LV203 open
- Condenser level increases slowly
- Because of hot water from HP heater, condenser vacuum pressure decreases
- FW flow rate increases slowly and is settled again by FW control system after few minutes

Group	Feedwater System
Malfunction No.	65
Description	Loss of feedwater heaters
Option	0: Normal 1: Loss of heaters
Recommendations	
Considered in Subroutine	HEATER
Limitations	
Cause	Loss of extraction steam from turbine
Effects: - FW temperature increases - Generator power increases for a while and decreases again	

Group	Feedwater System	
Malfunction No.	66	
Description	Bypass of feedwater preheaters	
Option	0: Normal 1: Bypass	
Recommendations		
Considered in Subroutine	FWVALV	
Limitations		
Cause	Bypass valves fail to open	

Effects:
- FW temperature decreases
- Steam generator pressure decreases because of colder water
- Generator power decreases because of less steam flow by less steam header pressure

Group	Feedwater System	
Malfunction No.	67	
Description	FW pump trip	
Option	0: Normal 1: Pump #1 2: Pump #2 3: Pump #3	
Recommendations		
Considered in Subroutine	FWPUMP	
Limitations		
Cause	FW pump breaker trip at 100% load	

Effects:
- FW pump stops
- Load runback actuates
- Load decrease
- Steam flow and feedwater flow decreases

Group	Feedwater System
Malfunction No.	68
Description	Open all FW valves
Option	0: Normal 1: Activate
Recommendations	
Considered in Subroutine	SGLECD
Limitations	
Cause	Controller failure ?

Effects:
- Full FW flow to S/G
- S/G level increases
- Reactor trip on high level after some time
- SMABRE : large injection

Group	Feedwater System
Malfunction No.	69
Description	FW line break inside containment
Option	0: Normal 1: Line break
Recommendations	
Considered in Subroutine	FWFLOW
Limitations	
Cause	FW line is broken

Effects:
- FW flow increases because of low pressure on FW line
- S/G level decreases
- Turbine and reactor trip because of S/G level low

Group	Feedwater system	
Malfunction No.	70	
Description	Close all FW valves	
Option	0: Normal 1: Activate	
Recommendations		
Considered in Subroutine	SGLECD	
Limitations		
Cause	Controller failure ?	

Effects:
- FW valves closed i.e. no FW to S/G-s
- S/G level decrease
- Trip on low S/G level

Group	Feedwater System
Malfunction No.	71
Description	Failure in FW controller (loss of steam flow signal)
Option	0: Normal 1: Loop #1 2: Loop #2 3: Loop #3
Recommendations	
Considered in Subroutine	SGLECD
Limitations	
Cause	Signal error or instrument error

Effects: Explanation :

- Loss of the steam flow signal results in a large flow deviation signal to the controller for the main FW valve.
- The major signal to the controller is however S/G level deviation
- The main FW valve will try to give a S/G level deviation from the setpoint in order to compensate the error in the flow deviation
- The bypass valve controller will, however, try to maintain S/G level
- The magnitude of the effect depends on the flow error factor (CWFWCE)

Description :

- The main FW valve closes and flow goes down
- S/g level down first then returns
- Main and bypass valves open on low S/G level
- S/G level returns towards setpoint

Group	Auxiliary Feedwater System
Malfunction No.	72
Description	Loss of auxiliary feedwater
Option	0: Normal 1: Loss of AFW
Recommendations	
Considered in Subroutine	FWPUMP
Limitations	
Cause	All Aux. FW pumps trip. When steam flow exists after turbine trip

Effects:
- All aux. FW pumps trip
- NO aux. FW
- S/G level increases
- Turbine and reactor trip by S/G level low signal

Group	Auxiliary Feedwater System
Malfunction No.	73
Description	Auxiliary FW flow uncontrollable
Option	0: Normal 1: Uncontrollable
Recommendations	
Considered in Subroutine	FWPUMP
Limitations	
Cause	AFW flow controllers are stuck
Effects:	- Aux. FW flow doesn't change by charging aux. FW flow set point. But the flow can be charged by S/G pressure. If S/G pressure decreases the Aux. FW flow might be increased

Group	Auxiliary Feedwater System
Malfunction No.	74
Description	Auxiliary FW pump trip (AFWP1)
Option	0: Normal 1: Trip
Recommendations	
Considered in Subroutine	FWPUMP
Limitations	
Cause	Pump breaker trip

Effects:
- Aux. FW pump #1 trip
- Aux. FW flow rate decreases
- The increment of S/G level decreases.

Group	Auxiliary Feedwater System	
Malfunction No.	75	
Description	Service water pump breaker trip	
Option	0: Normal 1: Trip	
Recommendations		
Considered in Subroutine	FWPUMP	
Limitations		
Cause	SWP breaker open when BHV301, BHV302 are closed and S/G level is low or the turbine is tripped.	

Effects: Aux. feedwater is not supplied S/G level decreases

If the turbine is not tripped yet it will be tripped from low S/G level

Group	Miscellaneous System
Malfunction No.	76
Description	Nuclear instrumentation system (NIS) failure
Option	0: Normal 1: SRM 2: IRM 3: PRM
Recommendations	
Considered in Subroutine	PACINS
Limitations	
Cause	Indication transmitter produces wrong signal
Effects: Instrument indication is wrong when the system is working properly	

Group	Miscellaneous System
Malfunction No.	77
Description	Axial tilt
Option	0: Normal 1-8 Bank choice
Recommendations	
Considered in Subroutine	RODMVD
Limitations	
Cause	Rod bank insertion Bank number must be selected Stopped at suitable tilt with Malfunction #77 reset to 0
Effects: - Selected rod bank in - Axial offset increases - Notice that the axial offset can be stopped by the instructor at a suitable value by resetting the malfunction to 0	

Group	Miscellaneous System
Malfunction No.	78
Description	Load rejection
Option	0: Normal 1: Activate
Recommendations	
Considered in Subroutine	GENELD
Limitations	
Cause	

Effects:
- Generator power decreases to 0
- Generator breaker open
- Turbine speed increases
- Turbine trip
- Reactor trip

Group	Miscellaneous System	
Malfunction No.	79	
Description	Loss of off-site power	
Option	0: Normal 1: Activate	
Recommendations		
Considered in Subroutine	GENELD	
Limitations		
Cause	System low frequency, low voltage	

Effects:
- Net breaker open
- 4 . 16 KV bus failure
- CCWS, fan cooler, charging pump, condensate pumps, RCP, Heater drain pump, cooling water pump trip
- Reactor trip, turbine trip
- D/G start
- FW pumps trip
- Start 2 ea. charging pump
- Start RHR pump
- Start CCW pump
- Start Aux. FW pump
- Start Fan cooler (2 ea.)

서 지 정 보 양 식

수행기관 보고서번호	위탁기관 보고서번호	표준 보고서번호	INIS 주제코드
KAERI/TR-0869/97			

제목/ 부제	첨단 계측제어 기술 개발
	계측제어 시험검증기술 개발
연구책임자 및 부서명	권 기춘 / MMIS Lab.
연 구 자 및 부서명	권 기춘

발 행 지	대전	발 행 기 관	한국원자력 연구소	발 행 일	97. 6
페 이 지	87P	도 표	유 ( ), 무 (O)	크 기	19*26 cm.
참고사항					

비밀여부	공개(O), 대외비( ), __급비밀	보고서종류	기술보고서
연구 위탁기관		계약 번호	

초록 (300단어 내외)

계측제어 시험검증설비는 원자력발전소 계측제어계통 개발시 개발 초기단계부터 개발될 계통의 기능 및 성능을 시험검증하기 위한 설비이다. 따라서 시험검증설비는 제어 및 감시신호를 정상 및 비정상상태때는 물론이고, 사고상태때에도 제공할 수 있고 다양한 하드웨어 인터페이스 방법을 제공할 수 있어야 한다.

시험검증설비에서 비정상 및 사고상황을 재현하기 위해서는 오동작을 삽입하여 그 결과가 실제 원자력발전소에서 일어나는 상황과 유사하여야 한다. 본 기술보고서에서는 시험검증설비에서 구현된 79개의 오동작에 대해서 각각이 속하는 Group, 오동작 번호, 오동작의 제목, 입력하여야 하는 선택사양, 권고하는 선택사양, 이 오동작이 프로그래밍된 다이나믹 루틴명, 오동작 입력시의 제한사항, 오동작의 원인, 마지막으로 오동작 입력시 나타나는 영향 또는 결과에 대해서 기술하였다.

주제명 키워드 (10단어 내외

확인 및 검증, 시험검증설비, 시뮬레이션, 오동작 원인/결과

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Abstract(About 300 Words)

The objective of I&C functional test facility (FTF) is to validate newly developed digital control and protection algorithm, alarm reduction algorithm and the function of operator support system and so on. To realize transient and accident situation in the FTF, the result of the activation of malfunction should be similar to the situation of real nuclear power plants. In this technical report, describe the Group, Malfunction No., Description, Option, Recommendations, Considered in Subroutine, Limitations, Cause, and Effect of the malfunctions implemented in FTF.

Subject Keyword (About 10 Words)

Verification and Validation, Simulation, Functional Test Facility, Malfunction