

**'22 원자력학회 추계 워크숍 발표**

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**운영기술지침서 운전지원시스템**  
**(Technical specifications Operator Support System)**

**2022.10.19**

**KHNP CRI**

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# I. Introduction



# I. Introduction

## ■ Research Background

- A Technical Specification(Tech Spec) establishes requirements for items such as safety limits, limiting safety system settings, limiting control settings, limiting conditions for operation, surveillance requirements, design features, and administrative controls. **Limiting Conditions for Operation(LCO)** that identify the lowest functional capability or performance level of equipment required for safe operation for the facility [1].

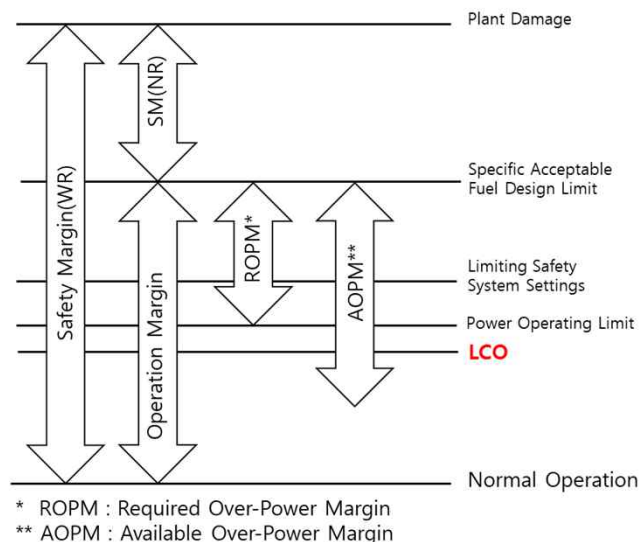


Fig. Range of LCO in safety margin[3]

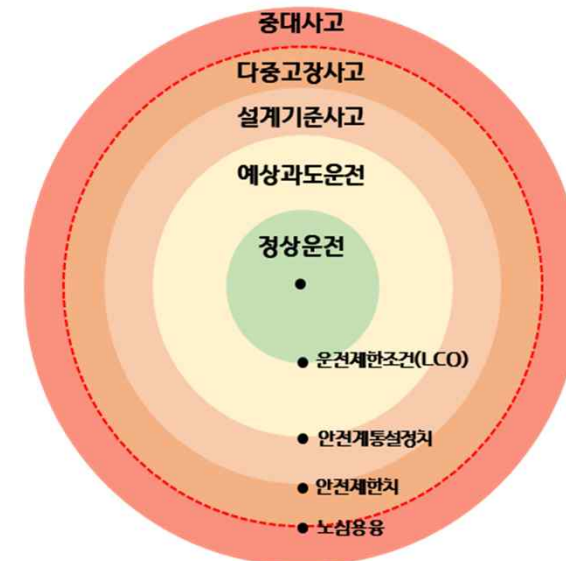
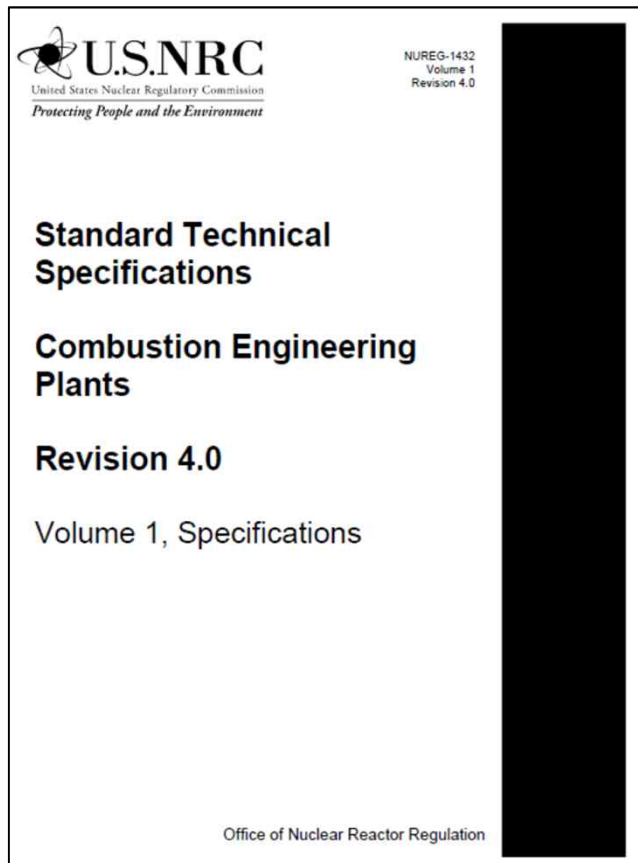


Fig. LCO in plant operation range

# I. Introduction

## ■ Research Background



3.7.2 Main Steam Isolation Valves (MSIVs)		
LCO 3.7.2 [Two] MSIVs shall be OPERABLE.		
APPLICABILITY: MODE 1, MODE 2 and 3 except when all MSIVs are closed [and de-activated]		
ACTIONS		
CONDITION	REQUIRED ACTION	COMPLETION TIME
A. One MSIV inoperable in MODE 1.	A.1 Restore MSIV to OPERABLE Status	[8] hours
B. Required Action and Associated Completion Time of Condition A not met.	B.1 Be in MODE 2.	6 hours
⋮		
SURVEILLANCE REQUIREMENTS		
SURVEILLANCE		FREQUENCY
SR 3.7.2.1 -----NOTE----- Only Required to be performed in MODE 1 and 2. Verify the isolation time of each MSIV is within limits.		In accordance with the Inservice Testing Program

Fig. '3.7.2 MSIV' of NRC standard TS [2]

# I. Introduction

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## ▪ Research Background

- Compliance with LCO can be defined as performing the following 6 procedures.

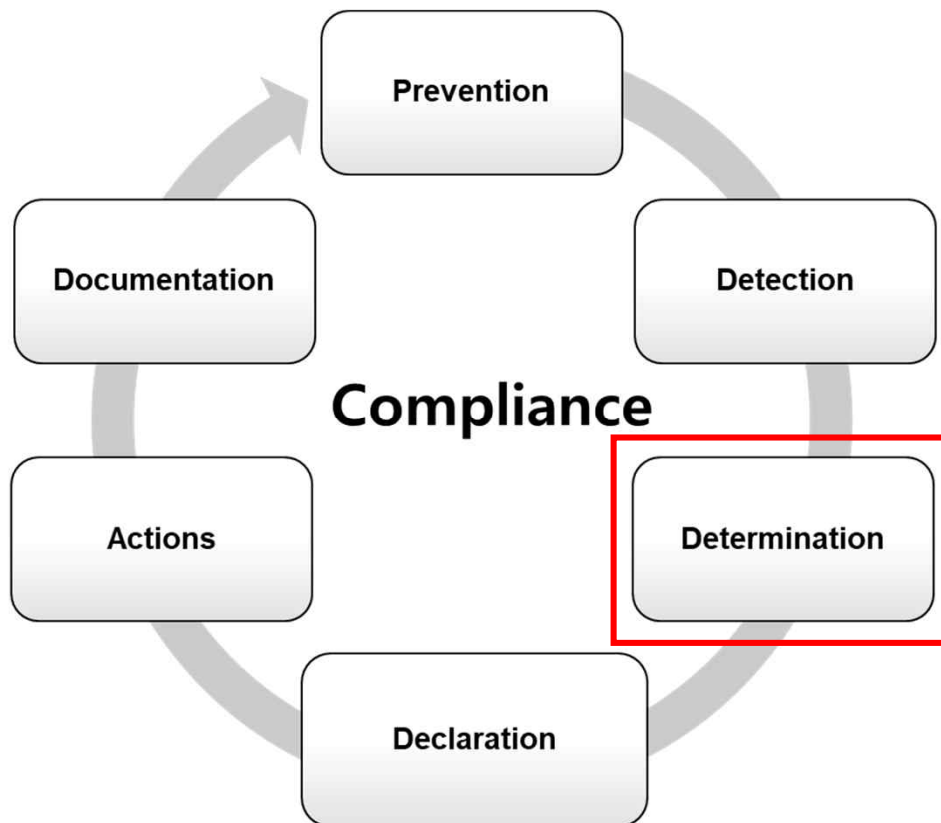


Fig. Compliance cycle with LCO of TS

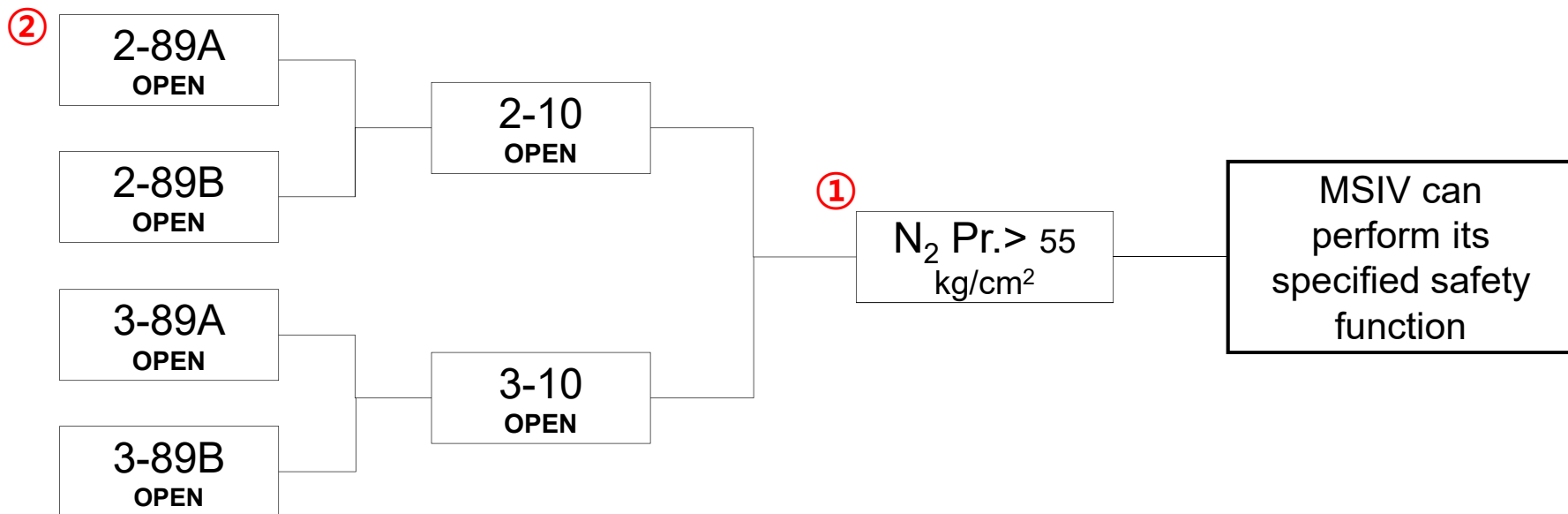
- **To prevent** that LCO is not met
- **To detect** that the abnormal status of LCO
- **To determine** that LCO is met or not met
- **To declare** the entry into the action statement of the LCO
- **To take required actions** within the completion time
- **To document** related LCO process

# I. Introduction

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## ▪ Research Background

- The below figure is a simplified block diagram for determining operability of LCO 3.7.2 'MSIV shall be **OPERABLE**'

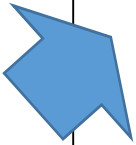


- The determination of operability in case 1 & case 2 may be different.

# I. Introduction

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## ▪ Project Overview

- ❖ 과제명 : 운영기술지침서 검색 및 감시시스템 개발
  - ❖ 연구목표
    - 운전제한조건(LCO) 연관 데이터베이스(DB) 구축
    - 운영기술지침서 디지털화를 통한 검색 기능 강화(연관 오더 사전 알림)
    - 운전제한조건 감시 및 평가 논리 개발
  - ❖ 연구기간 : 2020.7 ~ 2023.3 (33개월)
  - ❖ 활용부서(대상발전소) : 본사 발전처(신월성 1발전소)
  - ❖ 수행부서 : 중앙연구원 계전연구소 운전기술그룹
  - ❖ 위탁기관 : (주)지엔피시스템, 한국전력기술(AE, SD)
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### • Phase 1 research project

- Shin-Wolsong Unit 1&2
- Digitalization of Tech Spec.
- Compliance Support for LCO

### • Phase 2 research project

- Plants based on OPR1000 & APR1400
- Digitalization of Tech Spec.
  - ✓ Retrieval based on NLP
- Determination guidelines of safety functions
- Compliance
  - ✓ **Actions**



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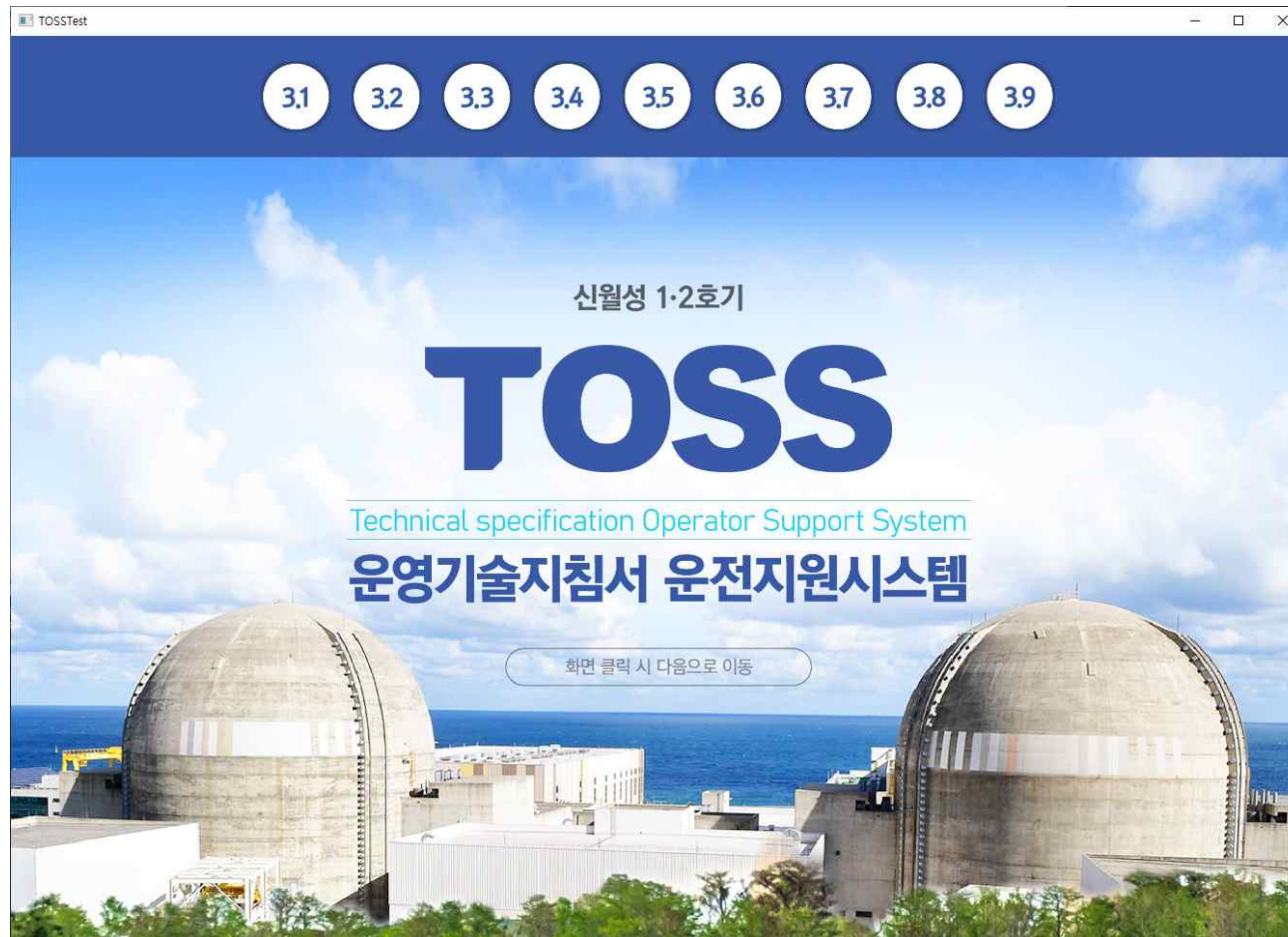
## **II. Digitalization of Tech Spec.**

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## II. Digitalization of Tech Spec.

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- Technical specification Operator Support System(TOSS)



## II. Digitalization of Tech Spec.

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## II. Digitalization of Tech Spec.

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## II. Digitalization of Tech Spec.

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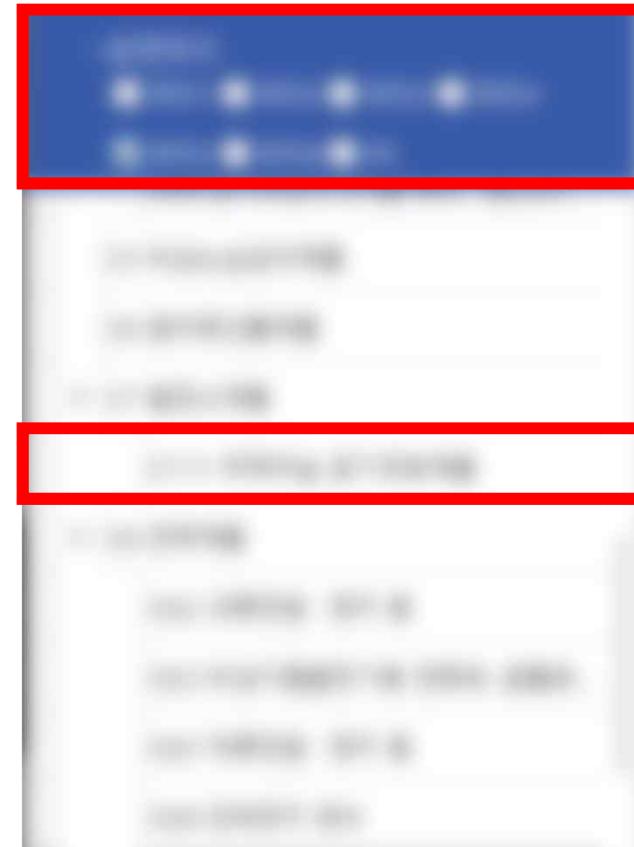
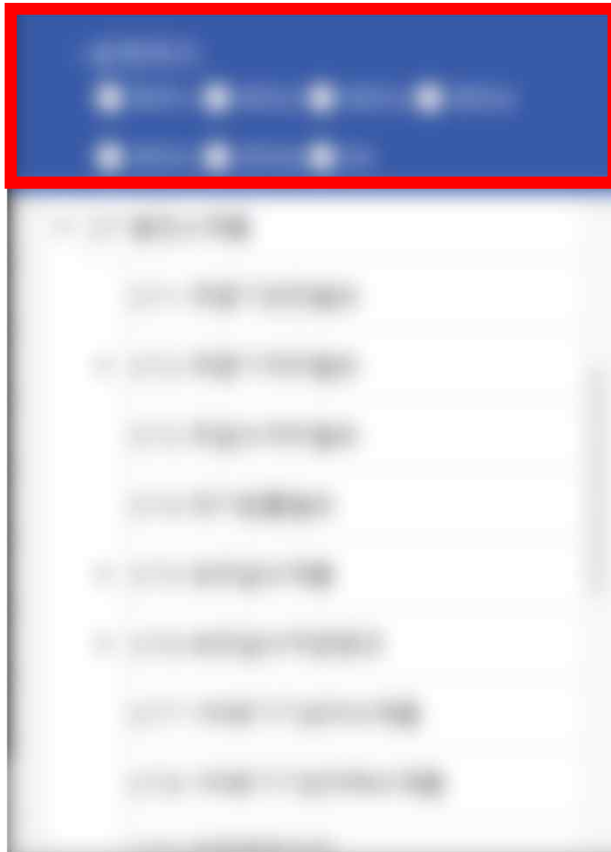
- Technical specification Operator Support System(TOSS)



## II. Digitalization of Tech Spec.

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- Technical specification Operator Support System(TOSS)





## II. Digitalization of Tech Spec.

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- Technical specification Operator Support System(TOSS)-phase 2

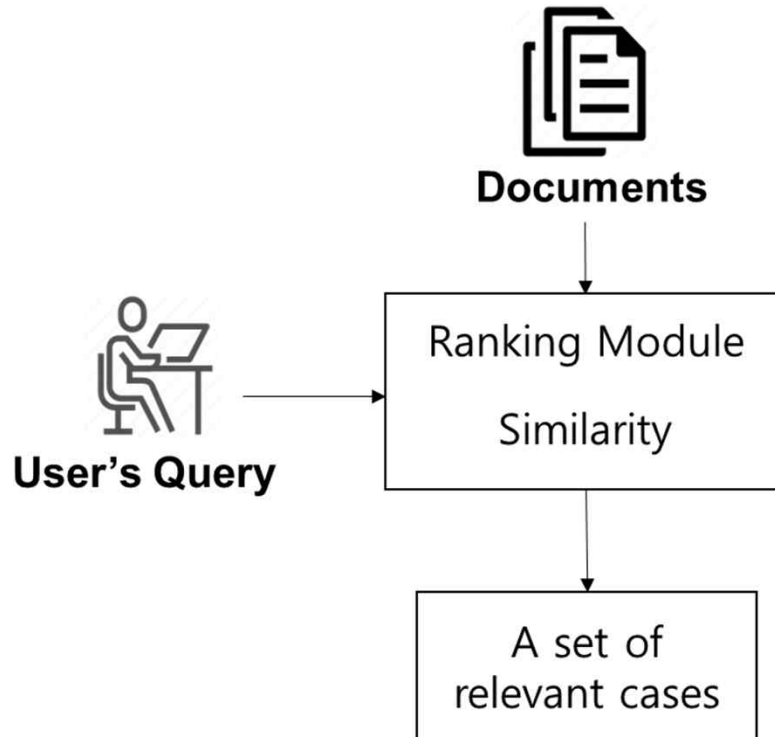


Fig. Structure of retrieval process

- LCO Case 1

*“EDG 01A 기동용 공기 공급라인 누설  
부위 점검으로 인한 LCO 적용”*

- LCO Case 2

*“MSIV-154 SOV 2-89A Fuse 교체”*

- LCO Case 3

*“Ch. A 원자로 용기수위 지시계 중  
2번 그룹 히터 온도상승으로 Ch. A 히터  
제어전원 차단됨”*

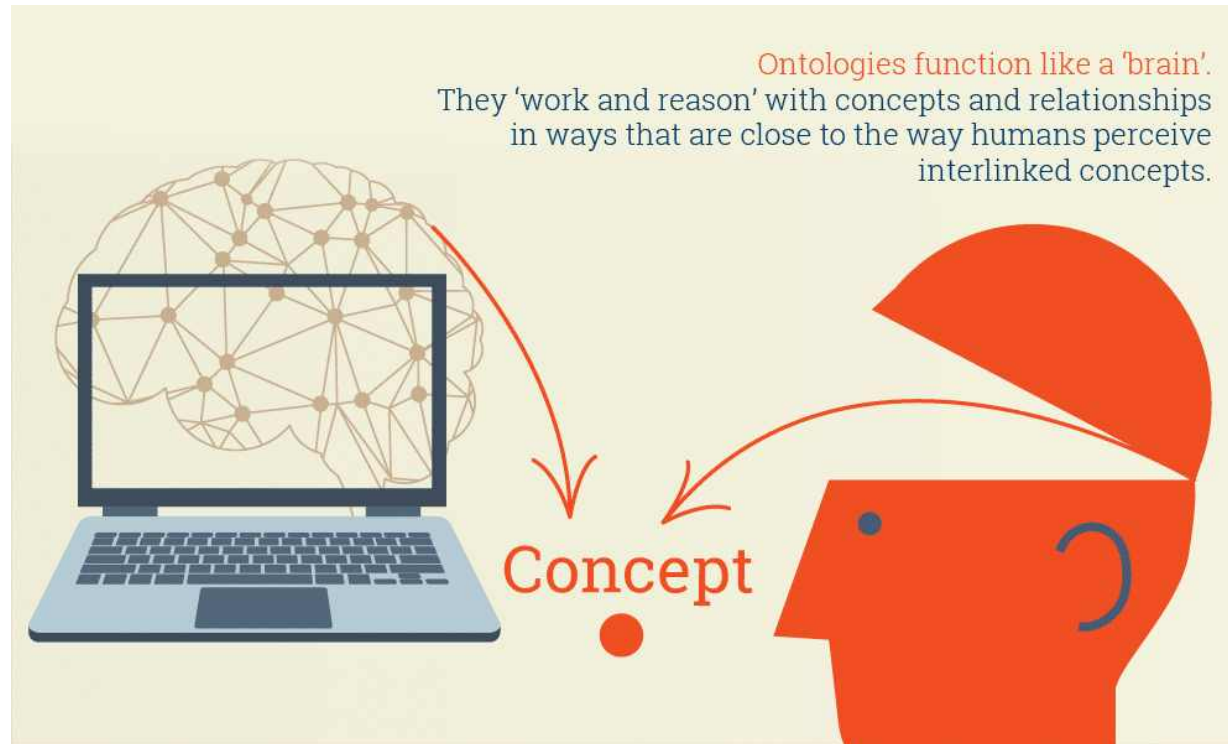


## II. Digitalization of Tech Spec.

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- Technical specification Operator Support System(TOSS)-phase 2

**“An ontology is a formal, explicit specification of a shared conceptualization”**



## II. Digitalization of Tech Spec.

- **Technical specification Operator Support System(TOSS)-phase 2**

Properties	MSIV 151	RCB Air Rad Mon. RE-039
Mode	1, 2, 3, 4	1, 2, 3, 4
Function Location	2235-521-V-0151	2235-761-J-RE-0039
Type	Valve	Instrumentation
Power Source	N/A	2235-827-E-MC03A-C3, E3
Control Cabinet	2235-771-J-PA03A-07	2235-761-J-CA14
Control AC Power	2235-842-E-IN01A-CB24	2235-842-E-IN01B-CB36
Control DC Power	2235-841-E-MC01A-C1-CB09	N/A
Root Valve	N/A	2235-761-V-0431/0432/0434
Transmitter	N/A	2235-761-J-RT-0039
Controller	N/A	N/A
Converter	N/A	N/A
Hand SW	2235-521-J-HS-0151AA	2235-761-J-HS-0431/0432/0434
Indicator	N/A	2235-761-J-UI-0971
Recorder	N/A	2235-761-J-RR-0039
Parts	2235-521-J-PS-0151-16A, 16B	N/A

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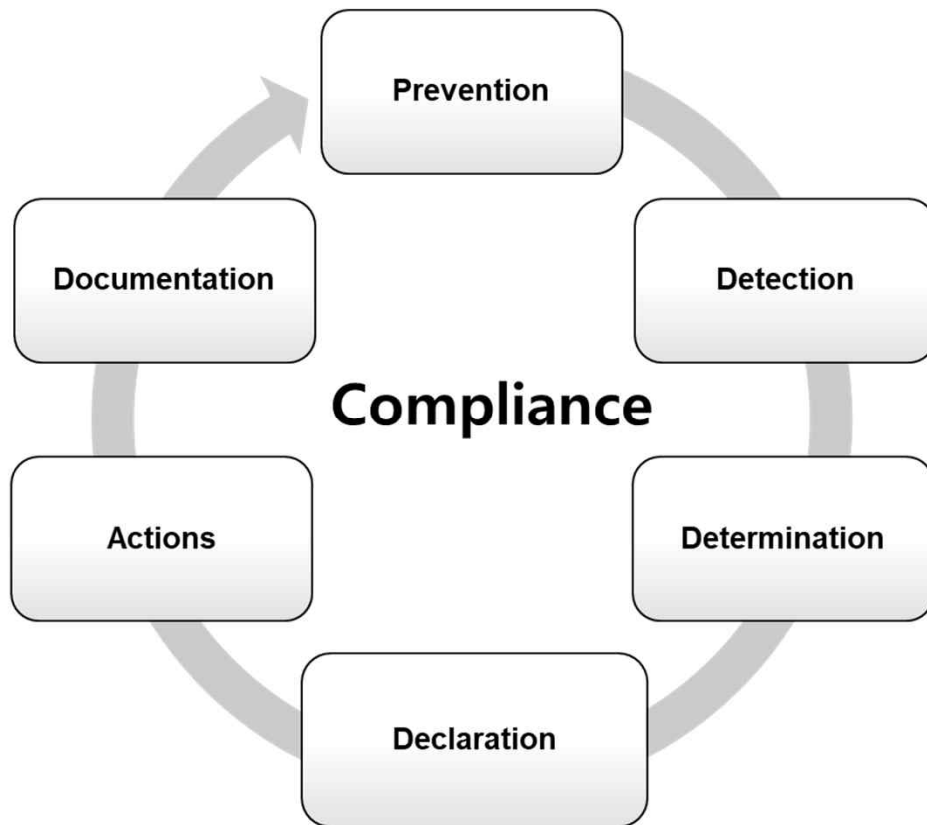


## **III. Compliance Support for LCO**

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### III. Compliance Support for LCO

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- **To prevent** that LCO is not met
- **To detect** that the abnormal status of LCO
- **To determine** that LCO is met or not met
- **To declare** the entry into the action statement of the LCO
- **To take required actions** within the completion time
- **To document** related LCO process

Fig. Compliance cycle with LCO of TS

## II. Monitoring Methodology for LCO

- 1), 2) and 3) process are related to Prevention.
- 4) process is related to Detection.

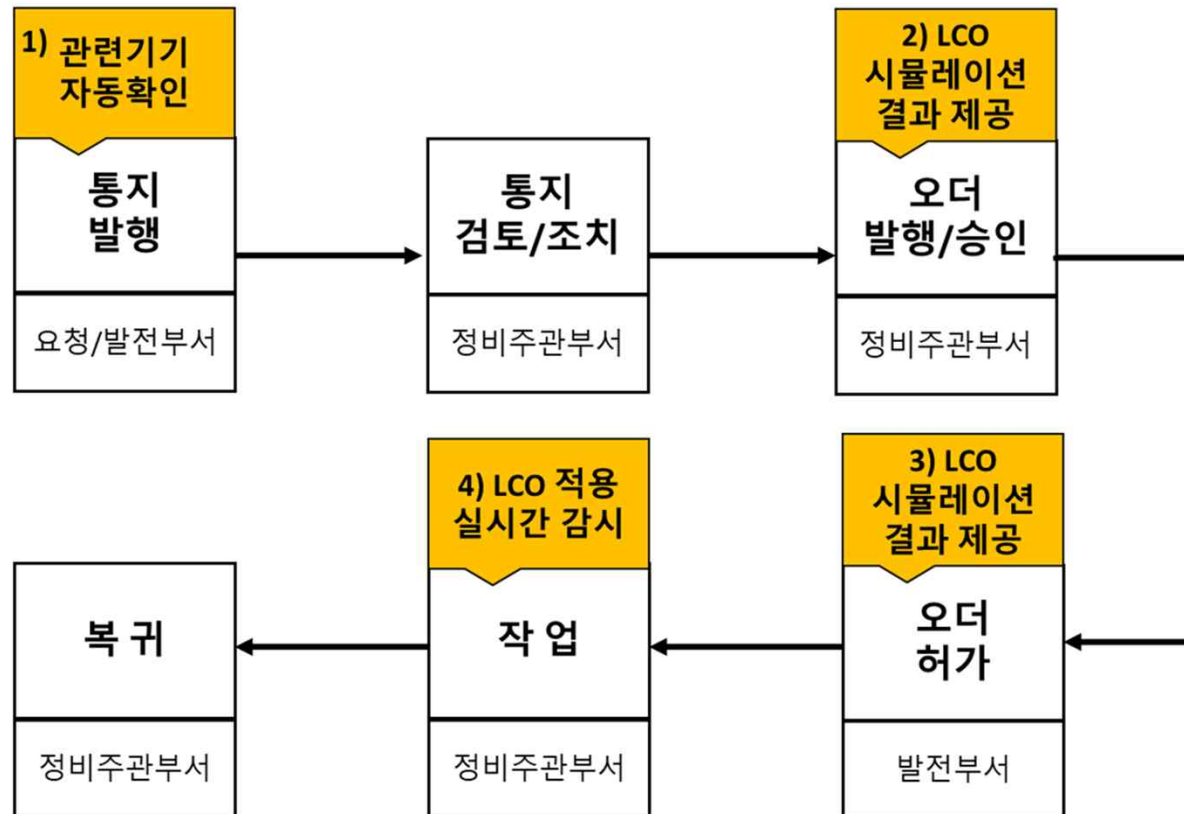


Fig. Prevention and Detection

## II. Monitoring Methodology for LCO

- Detection of abnormal conditions for LCO



Fig. Detection logic diagram of LCO 3.3.1

## II. Monitoring Methodology for LCO

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- Determination of whether LCO is met or not met



Fig. Evaluation logic diagram of LCO 3.3.1

## II. Monitoring Methodology for LCO

- Declaration of the entry into LCO
- Actions of this LCO

LCO 적용관리 시스템												
순번	LCO No.	공정제명/조건	LCO	적용	적용시간	제제	제제시간	완료	제정시간	TS	TS	GAP
1	3.7.2	주공기처리장치	예	적용	2019/1/24 17:20	제제	2019/1/24 18:40	완료	2시간	TS	TS	예
2	3.3.1	정기보조작업 정확도: 중간 등	예	적용	2019/1/24 13:20	제제	2019/1/24 14:10	완료	1시간	TS	TS	예
3	3.4.1	배기압력, 온도, 유량 제정	예	적용	2019/1/24 08:10	제제	2019/1/24 12:10	완료	7일	TS	TS	예

공작 시 해당 LCO 보기로 LNAK →  
 공작 시 및 현재 불만족사항에 대한 일정 일정 Pre-up  
 일정시간 이내로 공작 능력, 조공 시 능력, 제제 시 능력  
 공작 시 및 현재 불만족사항에 대한 일정 일정 Pre-up  
 공작 시 GAP GAP이 해당 LCO 적용 항목으로 LNAK



## II. Monitoring Methodology for LCO

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- Documentation



Fig. Digitalized TS of LCO 3.3.1



Fig. Typical window of LCO case

## II. Monitoring Methodology for LCO

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- The usability test results



## II. Monitoring Methodology for LCO

### ▪ The usability test results

	1	2	3	4	5	6	7	8	평균
○ 사용자 인터페이스									
1. 시스템에 대한 첫 인상은 어떠한가?	4	4	5	5	5	5	5	5	4.75
2. 검색기능									
2.1 전체적인 구성	4	3	5	4	5	5	4	4	4.25
2.2 정렬기능	3	3	4	4	5	5	4	4	4.00
2.3 관련문서 호출기능	4	4	5	4	5	5	4	3	4.25
2.4 LCO 연관기기	3	3	5	4	5	5	4	4	4.13
2.5 동일어 처리를 통한 검색	3	3	3	3	5	5	4	3	3.63
3. 감시기능									
3.1 전체적인 구성	4	3	5	4	5	5	5	4	4.38
3.2 LCO 중합 페이지	3	3	4	4	5	5	4	4	4.00
3.3 LCO 계통별 페이지	3	3	4	4	5	5	5	4	4.13
3.4 감지논리	4	3	5	4	5	5	5	3	4.25
3.5 평가 논리	3	3	5	5	5	5	5	4	4.38
○ Task 기반 평가 - 공통질문									
1. 이상 상황 감지에 대한 인지는 용이하였는가?	5	3	5	4	5	5	5	5	4.63
2. 이상 상황 감지 팝업 메시지의 인터페이스는 적절한가?	5	3	5	4	5	5	5	4	4.50
3. 감지 논리의 인터페이스는 적절한가?									
3.1 발생 원인에 대한 인지가 용이하였는가?	5	4	4	4	4	5	4	5	4.38
3.2 감지 논리 내에 페이지 이동은 용이하였는가?	5	4	3	4	4	5	4	3	4.00
3.3 평가 논리로의 진입은 용이하였는가?	5	4	5	4	5	5	4	4	4.50
4. 평가논리의 인터페이스 적절성									
4.1 사용자 평가는 직관적이고 그에 따른 시스템 반응은 적절한가?	5	3	5	4	5	5	4	4	4.38
4.2 평가 논리의 Block 중 부연설명을 위한 팝업 메시지는 적절한가?	5	3	4	4	5	5	4	3	4.13
4.3 LCO 적용을 위한 진입은 용이한가?	5	3	5	4	5	5	5	4	4.50
○ Task 기반 평가 - 시나리오별 질문									
1. 적용버튼 클릭 이후 관련 LCO를 확인하는 팝업의 적절성	4	4	5	5	5	5	5	4	4.63
2. G4 통지 발행 팝업의 인터페이스 적절성	5	4	5	5	5	5	5	4	4.75
3. 미적용 버튼 팝업의 인터페이스 적절성	5	3	5	5	5	5	4	4	4.50
○ 조사항목									
1. 운영기술지침 감시의 전반적인 흐름은 기존 직무를 적절히 반영하였는가?	4	5	5	5	5	5	5	5	4.88
2. TOSS 시스템 도입시 운영기술지침 검색 및 감시에 도움이 될 것이라고 생각하는가?	5	5	5	5	5	5	5	5	5.00

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## **IV. Summary & Conclusion**

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## IV. Summary & Conclusion

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- The limiting conditions for operation(LCO) of technical specification(TS) that are the lowest functional capability of performance shall be conformed while the power plant is in operation.
- Tech Spec. has been digitized and provides many search functions by taking advantage of the digitalization such as sort functions, synonym processing, multi-windows etc.
- 6 procedures for LCO compliance were explained.  
(Prevention, Detection, Determination, Declaration, Actions, Documentation)
- TOSS under development is expected to be of the creative solution for difficulties related to LCO in domain NPPs.

**Thank you for listening**

