# Reliability Program of Switchyard in PPS

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## 1. Introduction

Began to study regularly from continuous conference at 2006, among NRC (Nuclear Regulation Commission), INPO (Institute of Nuclear Power Operations), FERC (Federal Energy Regulation Commission) and NERC (North America Electric Reliability Corporation), to accomplish stability and reliability evaluation since North America area Blackout in 2003 about switchyard analysis in NPP

## 2. Analysis and Results

### *2.1 General*

US nuclear have 19.3 % preliminary power source, but domestic occupies more than 39.0 % by load rapidly increase and demand of stability electric power need. Reliability evaluation must carry out to prevent problem that probability/predictable by power industry, on trip element of Non-Class 1E equipment give directly an affect to safety system

### *2.2 PPS (priority power system)*

Power system consists of independence circuit more than 2 and reflects multi, diversification concept to supply electric power to safety system. But, switchyard (Non-Class 1E) is not reflected design concept of safety system

### *2.3 Reliability Analysis*

#### *2.3.1 Domestic*

Switchyard is complexity in maintenance and management side by owner and administrator duality since power industry structural reform (2002).

Table 1 Stop state

| Division | Gen | Ex | Tr | Ry | PT | H-M | Grid | Etc | total |
|---|---|---|---|---|---|---|---|---|---|
| KSNP(8) | 5 | 1 | 4 | 2 | - | 3 | 1 | - | 16 |
| W.H(6) | 1 | 4 | 2 | 2 | 2 | 2 | 2 | 3 | 18 |
| PHWR(4) | 2 | 2 | 3 | - | - | - | 5 | 2 | 14 |
| F.M(2) | 5 | 1 | 2 | 1 | - | - | 1 | - | 10 |
| total | 13 | 8 | 11 | 5 | 2 | 5 | 9 | 5 | 58 |

* Source: 11th technical information meeting

Table 2 Maintenance time

| Division/year | | | 2004 | 2005 | 2006 | 2007.7 | Total | Hour |
|---|---|---|---|---|---|---|---|---|
| kepco | Tr | 71(MT) | 367(0.041) | | 488(0.056) | | 955 | 0.0308 |
| | | 72(SB) | 128(0.014) | 153(0.017) | | 122(0.014) | 403 | 0.0130 |
| | | 73(SB) | 120(0.013) | | 132(0.015)/ 27(0.003) | | 252 | 0.0081 |
| | | 74(MT) | 368(0.042) | 552(0.063) | | 331(0.038) | 1251 | 0.0404 |
| khnp | Tr | 7B(MT) | | | 64(0.007) | 152(0.017) | 216 | 0.0069 |
| | | 7C(SB) | | | 792(0.090) | 296(0.034) | 1088 | 0.0351 |
| | | 7D(SB) | | 8(0.001) | 496(0.056) | | 504 | 0.0163 |
| | | 7E(MT) | | 8(0.001) | 304(0.347) | | 312 | 0.0101 |

* 18/43 month, power system reliability: 0.5day/year (12/8760 = 0.00136)

Table 3 Reactor shutdown number of item

| Division | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | total |
|---|---|---|---|---|---|---|---|
| W | 0/2 | 0/3 | 1/4 | 0/2 | 0/2 | 0/2 | 1 |
| K | 1/2 | 4/6 | 0/3 | 1/6 | 1/2 | 1/4 | 8 |
| Y | 3/9 | 2/9 | 0/4 | 2/2 | 2/6 | 1/4 | 10 |
| U | 3/8 | 2/5 | 0/7 | 0/8 | 1/9 | 3/5 | 9 |
| total | 7/21 | 8/23 | 1/18 | 3/18 | 4/19 | 5/15 | 28 |

* Source: Http:// opis.kins.re.kr/latest accident

#### *2.3.2 United States*

Table 4 LOOP event

| Date | site | LOOP cause |
|---|---|---|
| 1995. 2. 6 | Palo Verde | plant system regulation voltage loss |
| 1997. 7.22 | Clinton Power | Offsite power stability not discussion |
| 1998. 9. 1 | Pickering | Power grid under voltage not indicate, LOCA |
| 2003. 7. | Palo verde | electric power system net distortion, harmonic resonance |
| 2003. 8.14 | North American | Link system large scale power failure accident, PSA not include |
| 2004. 5. 5 | Dresden Unit2,3 | switchyard breaker |
| 2004. 7. | Palo verde | relay point of contact badness, t/l grounding (25 seconds), |
| 2006. 6.20 | Catawba | PCB CT breakdown f, LOOP occurrence |
| 2006. 7.25 | Forsmark-1 | switchyard short accidents, safety system (AC, DC) loss |

* Source: NRC RIS 04-05, 24, IN 00-06, 06-06, KPX, SOER 99-01

Table 5 LOOP causes

| Division | ex | hard | human | | system | weather | total | Percent (%) |
|---|---|---|---|---|---|---|---|---|
| | | | on | stop | | | | |
| Plant | - | 11 | 8 | 12 | - | 3 | 34 | 23 |
| switchyard | - | 42 | 3 | 21 | 1 | 8 | 75 | 51 |
| Grid | - | 3 | 1 | - | 14 | - | 18 | 12 |
| Weather | 6 | - | - | - | - | 15 | 21 | 14 |
| total | 6 | 56 | 12 | 33 | 15 | 26 | 148 | 100 |

* Source: NUREG/CR-6890 Vol.1

### *2.4 Reliability Result*

NRC proposed to carry out next 4 items to strengthen reliability through opinion harmony and information sharing between licenser, and FERC chooses NERC for reliability regulatory agency and PPS switchyard may cause LOOP and SBO, important influence on voltage stability

1) Protocol use among Plant, transmission and independence system operator
2) RTCA (Real-Time Contingency Analysis) program use between NPP (Nuclear Power Plant) and TSO (Transmission System Operator)
3) RG 1.155 2 (offsite power) recovery procedure establishment
4) RG 1.155 protocol of p-f change control

NRC is analyzing probability risk assessment on LOOP that can cause big effect to CDF (Core Damage Frequency) about all probability conditions that classify by Plant, Weather and Grid. Also, is accomplishing by Feedback correction, Audit, and Maintenance Rule (10CFR50.65). Neighbor power system suddenly may use when offsite power use is impossible.

1) Power grid low/loss and collapse
2) Power loss by abnormal weather

3) loss of essential switchgear bus

Domestic may considers loss rate, recovery time, effect of system etc. may analyze and collect LOOP experience data about power system.

1) Continuous information meeting between operator
2) cooperation TSO and NPP
3) Analysis past hysterics (maintenance, repair and accident etc.)
4) Construct of accident prevention program
5) Continuous reliability improvement effort
6) Operation experience reflection
7) Corrective action

*2.4.1 Reliability evaluation by NUREG-1784*

NRC is not regulation target about offsite power system, but in safety side, system grid reliability improvement plan over little year cooperation continuing.

1) Coordination with EDG and transmission system at uncertain time
2) Evaluation Electric power system grid alteration and voltage fluctuation
3) NPP and TSO work technical activity real-time to keep system stability and reliability about power system and protection
4) Review LOOP trip element (under Q power, device/equipment aging)
5) Review RCP low voltage and low-frequency by voltage and frequency wave in RCP flow and fuel control rod operation
6) Consideration Main transformer tap changer change and master exciter Protective Relay [V/㎐] setting

*2.4.2 Reliability evaluation by INPO SOER (Significant Operating Experience Report) 99-01*

Switchyard accident use to simulation on TSO and RTO (Regional Transmission Operator) education to unsatisfactory accident prevention, protector, human mistake etc. and to release time increases gradually about essential factor and system grid voltage

1) Protocol founding Between NPP and operator
2) Establishment recovery procedure for power system grid loss
3) Prevention program operation for grid and equipment (Exciter, Governor, OLTC)
4) Analysis safety system when use impossible urgent power by device trip that do not expect
5) Operator education
6) Plan of response facility meet to power system operation standard, NPP safety and grid
7) Communication status for non-essential power loss
8) Evidence operation experience and recording

## 3. Conclusion

Analysis data based on with afterworlds it proposes the reliability construction plan of domestic. The fact is executed as the immediacy safety of the nuclear power plant with the fact that it will contribute.

1) Without delay, Need periodic and interface active by power industry deregulation and replace or maintenance difficulty
2) Strengthen accident analysis and corrective action
3) Plan review that can increase efficiency and effect by graded quality activity
4) Probability reliability and Maintenance Rule concept should be examined.
5) Expert Pool position that can analyze problem of power industry and unexpected accident

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