[2022 KEPIC-Week]

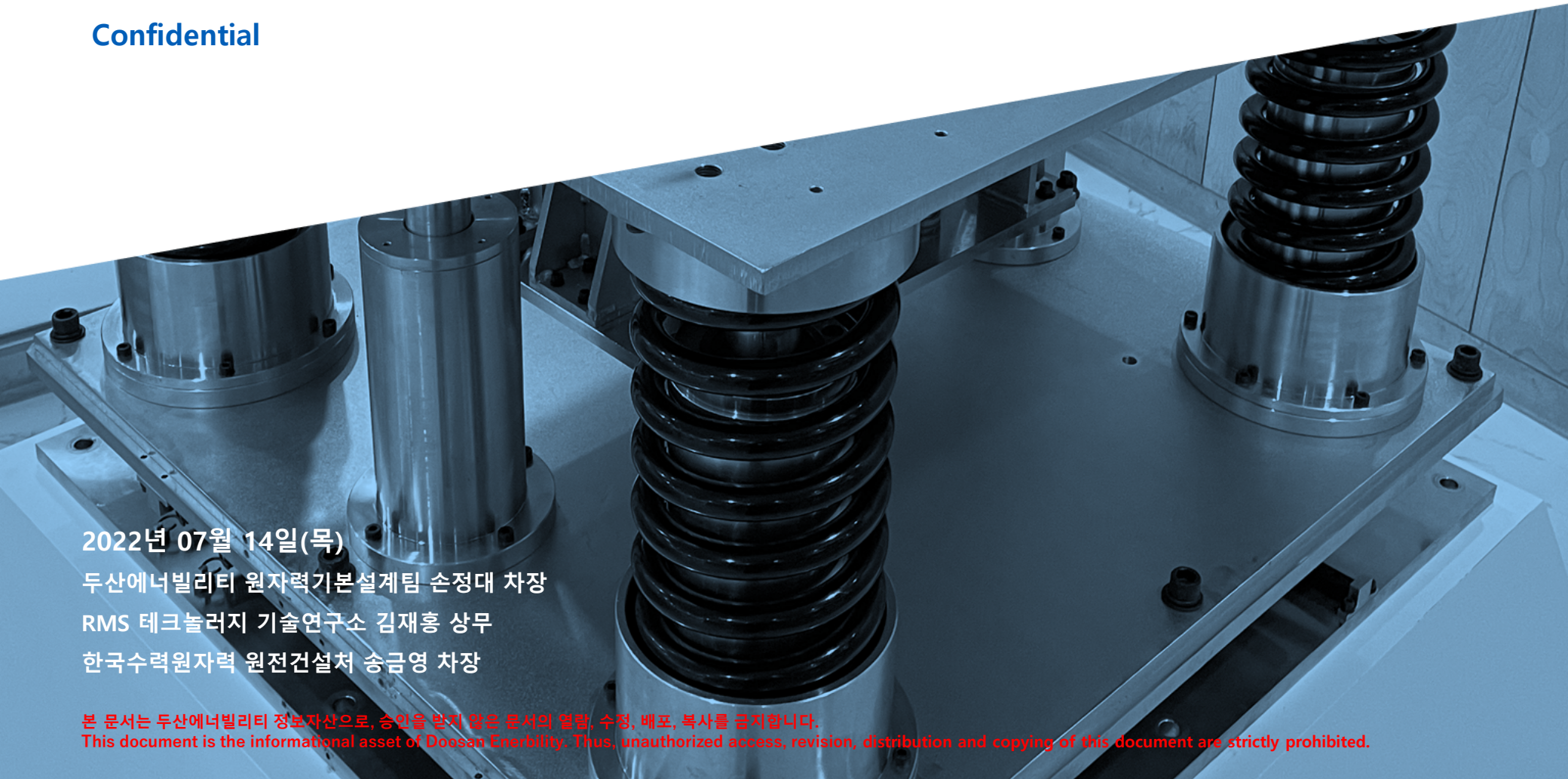
원자력발전소 축전지 연결 케이블 동특성시험

DOOSAN

RMS

KHNP
KOREA HYDRO & NUCLEAR POWER CO., LTD

Confidential



2022년 07월 14일(목)

두산에너빌리티 원자력기본설계팀 손정대 차장

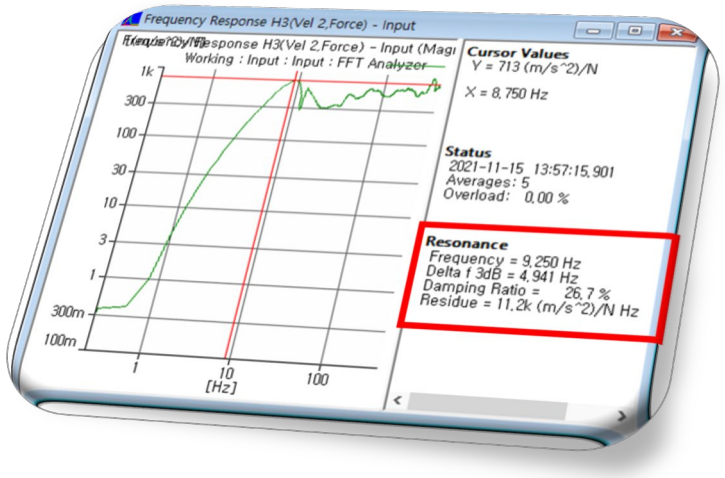
RMS 테크놀러지 기술연구소 김재홍 상무

한국수력원자력 원전건설처 송금영 차장

Contents

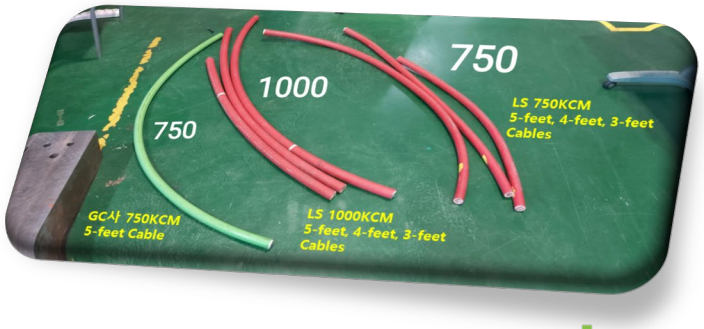
1. Introduced

- APR1400 축전지 연결 케이블이 축전지에 영향을 주는지 확인 필요
- 축전지에 영향이 있는지 확인 하기 위해서는 연결케이블의 감쇠비 확인이 필요
- 따라서, 본 시험은 연결케이블의 동 특성을 아래와 같이 수행 하였음.
  - ✓ Free Vibration Damping Ratio Test
  - ✓ Cable Internal Damping Ratio Test
  - ✓ Cable External Stiffness Test
  - ✓ Cable External Damping Coefficient Test

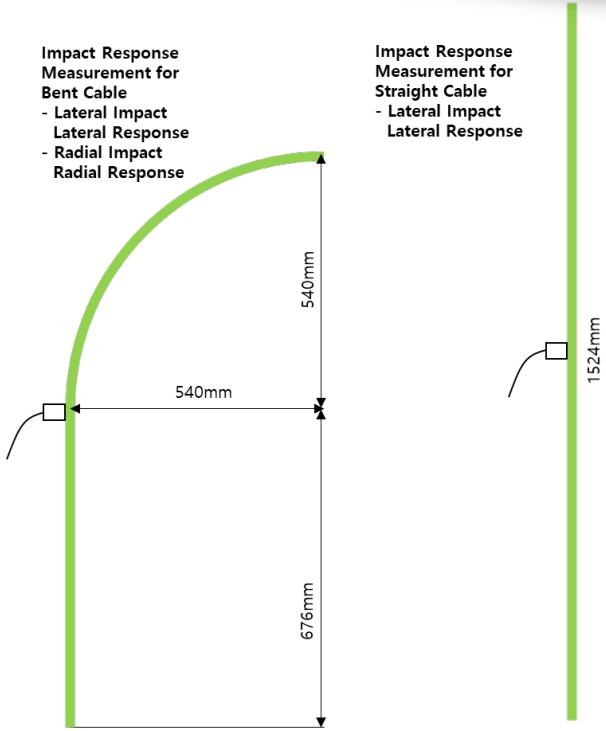


2. Test Specimens

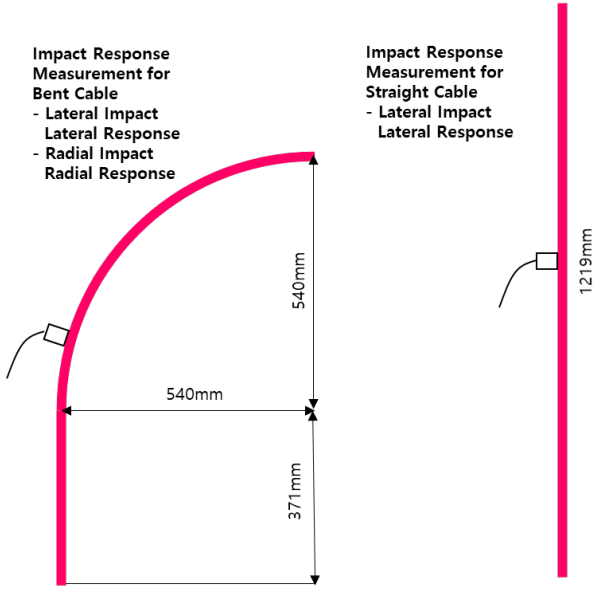
➢ Internal Damping Ratio Test Specimens



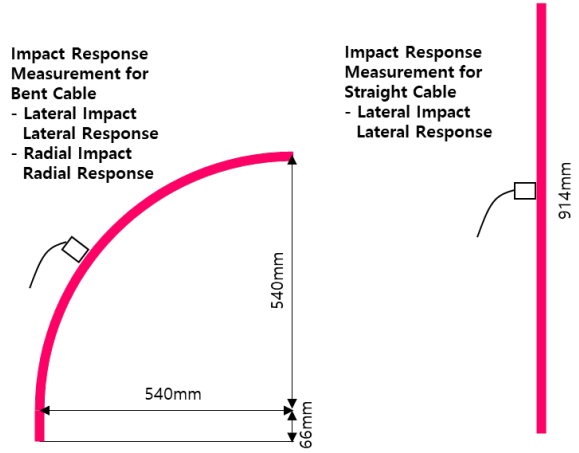
No	Cable Company	Cable	길이 [ft / mm]
1	GC	750KCM	5 / 1524
2	LS	750KCM	5 / 1524
3	LS	750KCM	4 / 1219
4	LS	750KCM	3 / 914
5	LS	1000KCM	5 / 1524
6	LS	1000KCM	4 / 1219
7	LS	1000KCM	3 / 914



<Test Specimens 5ft>



<Test Specimens 4ft>

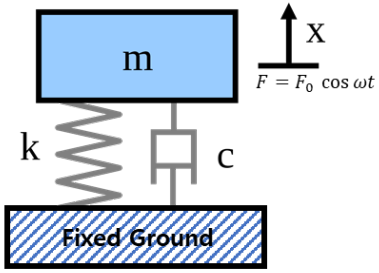


<Test Specimens 3ft>

3. Test Methods

➢ MCK System

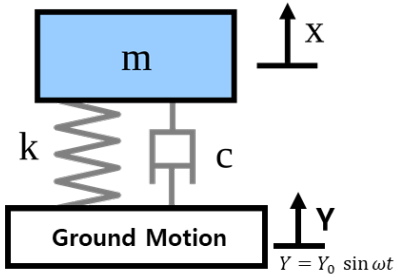
[Internal Excitation System]



$$m\ddot{x} + c\dot{x} + kx = F_0 \cos \omega t$$

$$X = \frac{F_0}{\sqrt{(k - m\omega^2)^2 + c^2\omega^2}}$$

[Ground Excitation System]

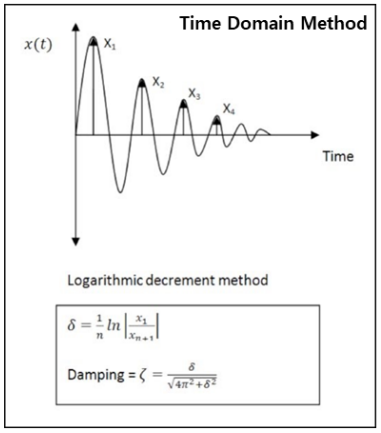


$$m\ddot{x} + c\dot{x} + kx = c\dot{y} + ky$$

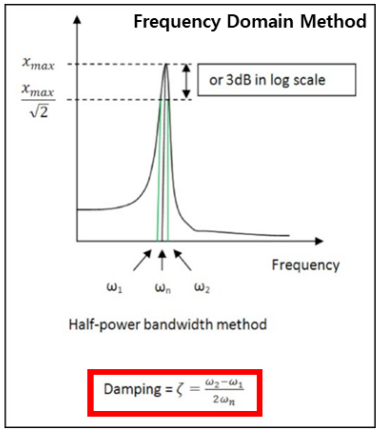
$$\frac{X}{Y} = \frac{k^2 + c^2\omega^2}{\sqrt{(k - m\omega^2)^2 + c^2\omega^2}}$$

$$\omega_n = \sqrt{\frac{k}{m}} \qquad \zeta = \frac{c}{c_c} = \frac{c}{2m\omega} = \frac{c}{2\sqrt{mk}}$$

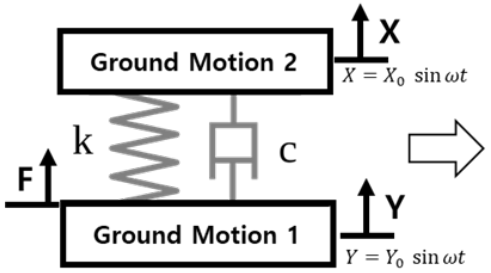
Experimental Methods for Damping Ratio ζ



or

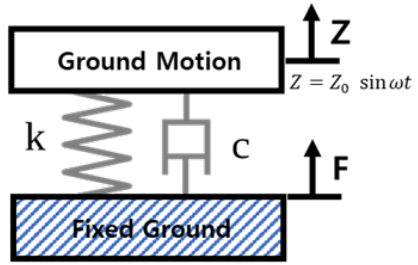


[Actual Cable System]



$$c(\dot{x} - \dot{y}) + k(x - y) = F \xrightarrow[z = x - y]{\dot{z} = \dot{x} - \dot{y}} c\dot{z} + kz = F$$

[Equivalent System for Test]



Stage 1 : Stiffness Measurement

$$\dot{z} = 0, z = \Delta, F = F_\Delta$$

$$\Rightarrow \boxed{k = \frac{F_\Delta}{\Delta}}$$ **Cable External Stiffness**

Stage 2 : Damping Coefficient Measurement

$$\dot{z} = \omega\delta, z = \delta, F = F_{\omega\delta} = F_\omega + F_\delta$$

$$\Rightarrow c\omega\delta + k\delta = F_{\omega\delta}$$

$$c\omega + k = \frac{F_{\omega\delta}}{\delta} = \frac{F_\omega}{\delta} + \frac{F_\delta}{\delta}$$

$$c = \frac{1}{\omega}\left(\frac{F_{\omega\delta}}{\delta} - k\right) = \frac{1}{\omega}\left(\frac{F_\omega}{\delta} + \frac{F_\delta}{\delta} - \frac{F_\delta}{\delta}\right)$$

$$\boxed{c = \frac{F_\omega}{\omega\delta} \qquad F_\omega = F_{\omega\delta} - k\delta}$$

Cable External Damping

z : Relative Displacement
Δ : Forced Displacement in Static Load Test
F_Δ : Measured Force in Static Load Test
δ : Dynamic Displacement in Dynamic Load Test
ω = 2πf : Cycle Speed of Test Machine (rad/s)
$F_\delta = k\delta$: Spring Force in Dynamic Load Test
$F_{\omega\delta}$: Measured Dynamic Load
F_ω : Damping Force = $F_{\omega\delta} - F_\delta$
c : Damping Coefficient
→ Input value in Cable Element Property in FE-Model

Q&A

감 사 합 니 다.

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