韓電 765 kV 2回線 送電線路의 電氣環境障害 特性

論 文
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Environmental Impact on the KEPCO 765-kV Double Circuit Transmission Line

李 東 一* · 申 玖 容** · 金 正 夫***
(D. I. Lee · K. Y. Shin · J. B. Kim)

Abstract - The environmental impact of the KEPCO 765-kV transmission line was studied using a full scale test line in order to develop the design technology. Therefore this paper describes an environmental design summary of the audible noise, hum noise, wind noise, radio interference, TV interference and electric field measurement from the KEPRI 765-kV double circuit transmission test line with a bundle of 6-480㎟ conductors per phase. The analysis of the test results shows that 6-Rail and 6-Cardinal conductors bundle satisfy the audible noise criterion & TV interference under the stable rainy weather condition and the radio interference level under the fair weather. And the other items are also agreed with the design level criterion for KEPCO 765-kV transmission line.

Key Words : Environmental impact, Corona, Audible noise, Radio and TV interference

1. Introduction

Conductor selection is the most important decisions faced by a transmission line designer. The conductor size is often established by corona performance rather than current-carrying capacity, and bundle-conductor configurations are usually necessary to attain this performance.

Therefore KEPRI(Korea Electric Power Research Institute) has been studying the use of double circuit 765-kV transmission line to meet the need for economical bulk power transmission over the limited right-of-way with the least environmental impact to the people who live in the vicinity of these line. After studying the audible noise(AN), Radio Interference(RI) and TV Interference(TVI) of 8 kinds of conductor bundle using the corona cage where the average maximum bundle gradient of a 765-kV line could be simulated with a lower voltage and artificial rain[1]., KEPRI found that a bundle of 6-480 ㎟ conductors is the minimum one which meets the AN criterion of 50 dB(A) in residential area according to Korean Environmental Protection Act and any large 4-conductor bundle can not meet this criterion. The 480 ㎟ conductor has been selected in KEPCO(Korea Electric Power Corporation) 345-kV transmission lines. There are two kinds of conductors, Rail and Cardinal, whose cross section area is 480 ㎟. The diameters of Rail and Cardinal conductor are 29.61㎜ and 30.4 ㎜ respectively.

After the test in the corona cage was conducted, KEPRI tentatively selected the Rail conductor for 765-kV transmission in Korea[1]. In 1989, before the decision was made to upgrade the system voltage from 345-kV to 765-kV, KEPRI decided to build a full scale test line with a bundle of 6-Rail conductors to compare the results from a full-scale line with those from the corona cage and to evaluate the environmental impact of all the corona phenomena in the vicinity of a 765-kV line. The test line also offered the opportunity to gain the experience with the electrical and mechanical performance

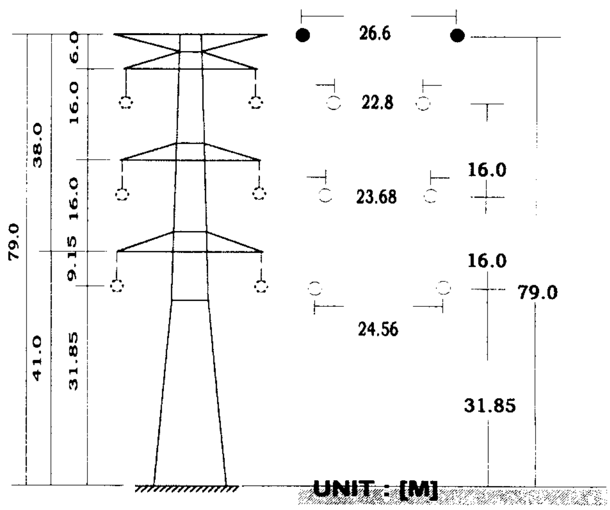

Fig. 1 The configuration of a suspension tower in the test transmission line

*正 會 員 : 韓電電力研究院 電力系統研究室 송변전技術그룹 先任研究員
**正 會 員 : 韓電電力研究院 電力系統研究室 송변전技術그룹 先任보研究員
***正 會 員 : 韓電電力研究院 電力系統研究室長
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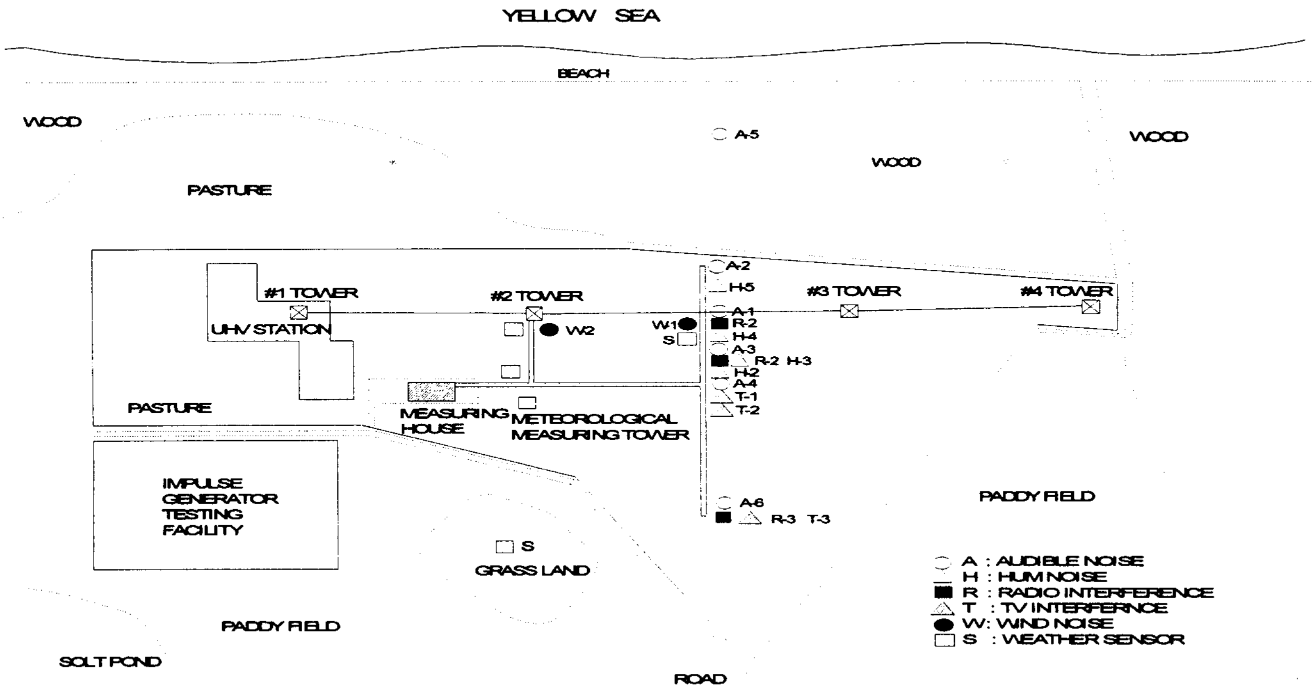

Fig. 2 The layout at Kochang 765-kV Test Line

of localized equipment such as line hardware, prior to the use in the commercial lines.

Rail conductor bundle was tested until March, 1995, and Cardinal conductor bundle has been testing since May, 1995. However Cardinal conductor was selected as an actual 765-kV transmission line conductor for KEPCO instead of Rail conductor due to the stronger ultimate strength of Cardinal conductor than that of Rail. Therefore, the corona phenomena of both conductors being measured at the test line on a long term basis are AN, Hum Noise(HN), Wind Noise(WN), RI, TVI and electric field intensity (EF).

2. Test Facility

Kochang 765-kV test line was designed as a full scale double circuit transmission line from both electrical and mechanical standpoints. Fig.1 shows the geometry of one of the suspension tower in the test line. The height of the tower is 79 m. The spacing of the subconductors which gives the minimum conductor surface gradient is 40 ㎝.

The test line consists of two dead end towers, two suspension towers and three spans. The span lengths are 200, 300 and 200 m respectively. Three 3 MVA 23/765-kV single-phase transformers energize the test line through 8-Rail conductor bus supported by dead-end & transposition tower and 5 overhead bus-supporting towers. The phases are arranged in a low reactance configuration.

The voltage of the test line is controlled by a 1500 kVA on-load tap changing transformer. Six line traps are installed between the bus conductors and the line conductors to attenuate RI from the transformers and insulator string hardware in the overhead bus[12]. Most of the measurement sensors are installed on relatively flat terrain transverse to the line at midspan as shown in Fig. 2 [2].

3. Instrumentation and Data Recording System

The data acquired from the capacitor voltage transformers, the rain gauge, and the sensors located at midspan and on the meteorological towers, were recorded every 3 minutes by a DEC (Digital Equipment Corporation) workstation. The weather parameters included wind speed and direction, relative humidity, temperature, barometric pressure, rain rate and other parameters.

Several sensors for AN, RI, TVI and hum noise were installed along a lateral profile at midspan and were connected to their appropriate instruments located in the measuring house by long coaxial cables. To measure AN, Bruel & Kjaer type 4184, ½″ weatherproof microphone units were located at 0 m (AN1 reference point), 15 m (AN3 evaluation point), 60 m (AN4), and 178 m (AN6 ambient noise) from the ground level point directly under the outmost phase conductors as shown in Fig. 2. The outputs of the microphone units were fed into B&K type 4435 noise level analyzers. Even though the microphones were covered with windscreens, a microphone height of 0.34 m above ground was adopted instead of the IEEE standard height of 1.5 m [2] to further minimize wind-generated noise [3].

To measure WN, the same measuring system as AN has been used with C-weighting filter due to the impulsive noise characteristics. Two microphones of the wind noise are installed directly under the outmost phase conductors and in front of No. 2 tower to measure conductor noise (CN) and tower noise (TN), respectively. The electric field strength at 1 m above ground was measured with a 60 Hz free body type meter(model HI-3604). According to the ANSI/IEEE standard of the electric field measurement technique, the meter must be separated at least 2.5 m from the human body.

RI data have been collected with the test receivers, Rohde & Schwarz (R/S) type ESHS 30 using Quasi Peak (QP) detectors. Active loop antennas, R/S type HFH2-Z2 are installed at above 2 m above ground. The frequency set for long-term measurement of RI is 0.475 MHz. Six line traps connected in series with the jumper lines of No. 1 dead-end tower would cut off the unwanted radio frequency noise current from the test transformers and hardwares of the insulator strings. The shield rings was attached to the hardware of the insulator string at the dead-end tower(#4) to suppress corona discharges. The line filters were installed to block the noise from uninterruptible power supply(UPS)[4].

To measure television interference (TVI), biconical antennas, R/S type HK116 are installed at 3 m above ground. The test receivers using QP detectors, R/S type ESVS30 are tuned to 75 MHz according to CISPR standards [5].

4. The result of data analysis

The long term data measured from August 1993 to March 1996 have been statistically analyzed to evaluate the environmental impact due to the corona phenomena of the test line.

Especially the AN, HN and TVI analysis of the foul weather condition and RI analysis of the fair weather condition were emphasized. The test results were compared with the calculated value and the simulated results in the corona cage. The total and selected numbers of records for fair and rainy weather conditions are shown in Table 1.

4.1 Audible Noise

Only data that met the criteria described below were selected for analysis. The total and selected numbers of records for fair and rainy weather conditions are shown in Table 1.

The selected data were the measured AN data that satisfied the following conditions. If these conditions were not satisfied, the data were discarded.

Table 1. Summary of Data Collection

Rail / Cardinal

Items	No. of Raw Data		No. of Selected Data (Acquisition Rate)	
	Fair	Rainy	Fair	Rainy
AN	158,902 / 47,844	5,831 / 2,408	83,429(52.5%) / 25,541(53.3%)	3,198(54.8%) / 628(26.1%)
HN	158,902 / 41,093	5,831 / 2,236	132,826(83.6%) / 25,981(63.2%)	4,951(84.9%) / 1,246(55.7%)
WN	165,036 / 63,781		30,501(18.5%) / 4,926(7.7%)	
RI	134,037 / 32,511	4,468 / 1,642	113,213(71.2%) / 11,417(35.1%)	3,666(62.9%) / 1,802(65.9%)
TVI	158,902 / 51,484	5,831 / 2,700	89,313(56.2%) / 8,318(16.2%)	3.328(57.1%) / 1,948(72.1%)

a) Wind velocity should be less than 5 m/s

b) Test voltage should be within ±1.5 % tolerance

c) The measured value should be greater than the ambient noise level (ANL) by 4 dB(A)

The following additional corrections were applied to the selected AN data. These corrections are according to IEEE Std. 656-1992 [2], KSA0701-1987 [4], JIS Z8731-1983 [5].

a) If AN - BGN ≥ 10 dB(A), then AN = AN

b) If 6 ≤ AN - BGN ≤ 9, then AN = AN -1

c) If 4 ≤ AN - BGN ≤ 5, then AN = AN -2

Where, BGN means background noise.

All of these correction criteria eliminate the data that were contaminated by high ambient noise and extraneous induced wind noise. As can be seen in Table 1, $\frac{52.5\%}{53.3\%}$ and $\frac{54.8\%}{26.1\%}$ of the data met these criteria during fair and rainy weather, respectively. However, the selected fair weather data must be used with a great deal of care because the test line was very quiet for the majority of the fair weather.

Fig.3 shows the AN probability distributions of the selected data for rainy weather at location AN3 15 m from the outside conductor. Table 2 shows a comparison of the measured L_5 and L_{50} levels with those predicted by the Bonneville Power Administration (BPA) AN empirical formula [6].

As can be seen in Table 2, the stable rain and heavy rain measurements are in very close agreement with the levels predicted by the BPA formula. The results of fair

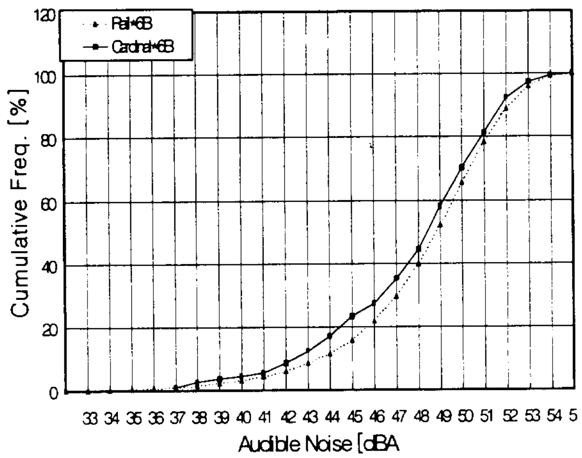

Fig 3. Cumulative distribution of AN in rain at 15 m from outer conductor

Table 2 Comparison between measured and predicted A-weighted ANs at the 15 m from the outmost phase [dB(A)]

Weather	Measured			Predicted BPA	
	Test Line		Corona Cage		
	Rail	Cardinal	Rail	Rail	Cardinal
Stable Rain L_{50}	48.8	48.4	44.9	48.5	48.2
Heavy Rain L_5	52.8	52.5	52.2	52.0	51.7
Fair L_{50}	42.1	40.9	42.7	23.5	23.2

weather measurements are much higher than the predictions, but this phenomenon is not surprising since the ambient level at this test site was relatively high due to the proximity of the Yellow Sea. It is our opinion that the fair weather AN is much lower than the 42.1 dB(A) level shown in Table 2. It is very difficult to measure the true fair weather AN from most test lines and operating lines because for the large majority of time, they are very quiet.

The median level (L_{50}) during stable rain is very close to that predicted by the BPA AN empirical formula, but is about 3.9 dB(A) higher than the value predicted from the corona cage measurement. We feel that the difference of 3.9 dB(A) is probably takes place because the wet conductor test used to determine the L_{50} level [1] in the corona cage does not adequately simulate the L_{50} rain rate experienced by the test line.

4.1.1 Audible Noise Frequency Spectrum

Fig. 4 shows the characteristic shape of the 1/3 octave band acoustic noise spectra of the test line during fair and rainy weather conditions. This illustrates the influence of rain which will be discussed in more detail in the following section. It was observed that the higher part of the AN frequency spectrum is formed by frequency components between 800 and 10,000 Hz which are due to random noise created by the conductor corona during rainy weather. The spectral distribution was found to be relatively independent of meteorological conditions such as rainfall intensity and humidity.

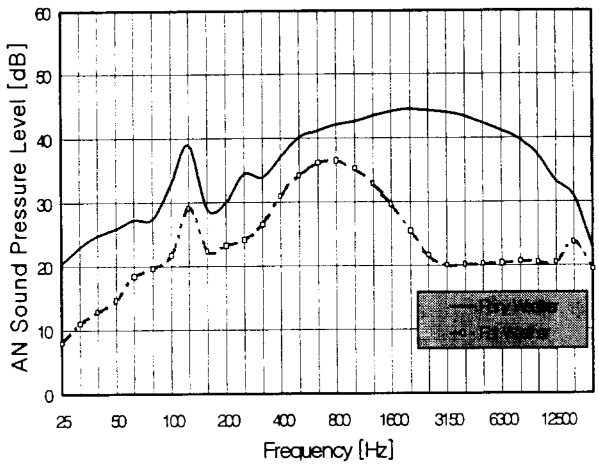

Fig. 4 Frequency spectrum of audible noise of Cardinal

The low frequency (63-125Hz) hum noise level is higher than other part.

4.1.2 Influence of Rainfall Intensity

The relationship between rainfall intensity and AN is summarized in Table 3 and plotted in Fig 5. As can be seen in Fig. 3 and Table 3, the 95 % and 5 % exceedance level are 41.3 dB(A) and 52.8 dB(A) for the AN3 microphone where as the same exceedance levels for the AN6 microphone are 30.3 dB(A) and 48.1 dB(A). Therefore, the differences between the 95 % and 5 % exceedance levels for the two microphones which are 11.5 dB(A) and 17.8 dB(A), respectively weren't constant.

The difference between the 5 % exceedance levels for AN3 and AN6 locations is only 4.7 dB which indicates that at the higher rainfall intensities, the nuisance effect of corona noise for residents living near the line will be lower because of the higher noise created by the falling rain. On the other hand the measurements on the test line and in the corona cage indicate that the AN reaches a saturation point at a rain intensity of about 30 mm/hr.

Table 3. Variation of AN with rainfall intensity at 15m (AN3) and 178m (AN6) from outer conductor (Rail Conductor Case).

		Exceedance Level [%]					
		0.1	5	25	50	75	95
Rainfall Intensity [mm/hr]		31.9	6.6	2.3	0.9	0.5	0.1
Audible Noise [dB(A)]	AN3	55.0	52.8	50.7	48.8	46.4	41.3
	AN6	52.0	48.1	44.9	42.2	39.2	30.3

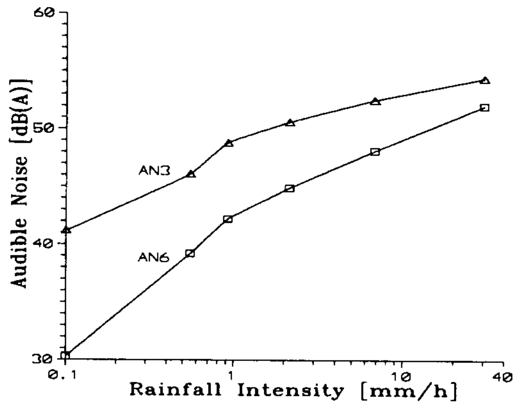

Fig. 5 AN characteristic curve on rainfall intensity

4.1.3 Lateral Profiles of Audible Noise

Table 4 shows the exceedance levels for each microphone location for fair weather and rainy weather. The L_5 and L_{50} exceedance levels during rain for each microphone location is plotted in Fig. 6 as a function of the lateral distance from the center of the line. An analysis of this data shows that the L_{50} (rain) AN decreases by approximately 5 dB(A) in Rail and 6 dB(A) in Cardinal each time the distance is doubled whereas the L_{50} (fair) decreased about 2.5 dB(A). Tests conducted at BPA [6], Hydro-Quebec [7] and EPRI [8] indicate that the A-weighted AN attenuates between 3 and 4 dB per doubling of the radial distance. The theoretical attenuation rate is 3 dB per doubling of distance for a line source. The additional attenuation is due to atmospheric absorption, refraction, shielding, scattering, ground interference, etc. The statistical measurements during rain indicate a slightly higher attenuation rate whereas the fair weather results indicate a slightly smaller attenuation rate. The slightly higher attenuation rate isn't completely understood, but it is within the accuracy of conducting AN measurements. Because the test line is so quiet during fair weather, the fair weather data is highly affected by ambient noise, therefore the data were corrected using a background noise microphone.

4.1.4. Effect of Test Voltage (Conductor Surface Gradient)

The rate the AN increases below 765-kV (nominal voltage) is much lower compared to the rate above ominal voltage. In Table 5 and Fig. 7, the 135-kV (17.6%) difference between 630-kV and 765-kV gives only a 2.2 dB (4.5%) difference in the AN whereas the 35-kV difference between 765-kV and 800-kV(maximum voltage) gives a 2.8 dB (5.7%) difference. The data at the lower voltage was obviously affected by background noise, but we know the system operating voltage for the 6-Rail conductor bundle must not be allowed to exceed the nominal voltage for very long periods of time in order to keep the AN below the design criteria.

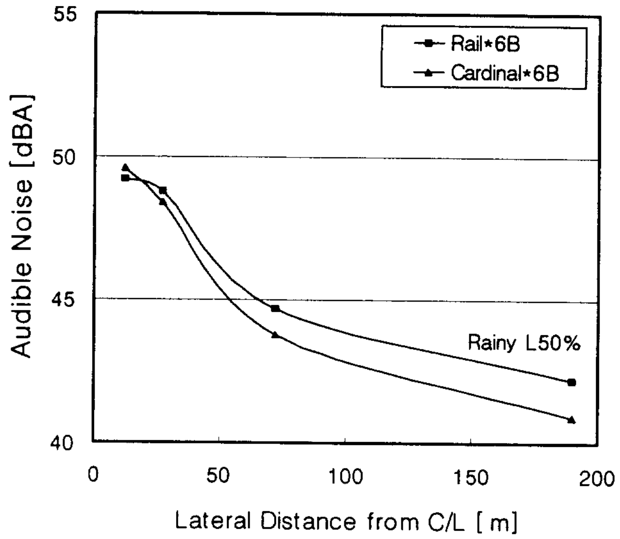

Fig. 6 AN lateral profiles in rain from KEPRI 765-kV double circuit test line

4.1.5 Effect of Bundle Subconductor Spacing

The effect of bundle subconductor spacing on AN was tested in the corona test cage, and the results are shown in Fig. 8. A spacing of 40 cm for the heavy rain condition and 35 cm for the case of wet conductor condition produced the minimum AN levels. However, the difference in AN between 35 and 40 cm spacings for the wet conductor condition was only 0.4 dB(A). Therefore, KEPRI selected a 40 cm spacing between the subconductors for the test line, considering AN level and the practice of 40 cm in 345-kV quadruple conductor bundle.

Table 4 Lateral profile data

Mic. No.	Lateraldist. from the Refer. Point [m]	mean Radial Distance from Microphone to Conductors [m]	Rainy Weather [dB(A)]				Equivalent Rainfall Intensity [mm/hr] Rail/Card.		Fair Weather [dB(A)]	
			Rail		Cardinal				Rail	Cardinal
			L_5	L_{50}	L_5	L_{50}	R_5	R_{50}	L_{50}	
AN1	0	52	53.0	49.2	52.9	49.6	6.6 /13.4	0.9 /0.5	41.9	41.2
AN3	15	58	52.8	48.8	52.5	48.4			42.1	40.8
AN4	60	88	49.6	44.7	52.0	43.8			39.9	41.1
AN6	178		48.1	42.2	46.7	40.9			38.9	38.6

Table 5. AN characteristic data of Rail Conductor on test voltages

		630kV		765kV		783kV		800kV		Equi., Rainfall Intensity	
		RL_5	RL_{50}	RL_5	RL_{50}	RL_5	RL_{50}	RL_5	RL_{50}	RL_5	RL_{50}
TEST	KEPRI	51.1	46.6	52.8	48.8	53.5	50.5	53.8	51.6	5.2 ~ 8.5	0.8 ~ 1.6
	Data No.	131		3198		interpolation		322			
*	BPA	42.0	38.5	52.0	48.5	53.4	49.9	54.4	50.9	7.0	1-2
	GE	45.4	35.8	54.9	49.1	56.0	50.7	56.8	51.8	9.4	0.4
	CRIEPI	43.2	-	52.7	-	53.9	-	54.7	-	30.0	-
Absolute Error		7.6	9.5	1.0	0.3	1.0	0.4	1.5	0.5	-	-

- RL_5 : Rain L_5%
- RL_{50} : Rain L_{50}%
- * : The results of calculation by formulas of BPA, GE and CRIEPI [9].

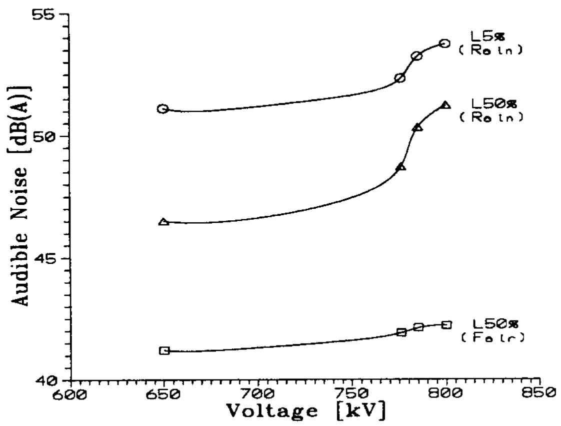

Fig. 7 Characteristic curve as a parameter of test voltage parameter

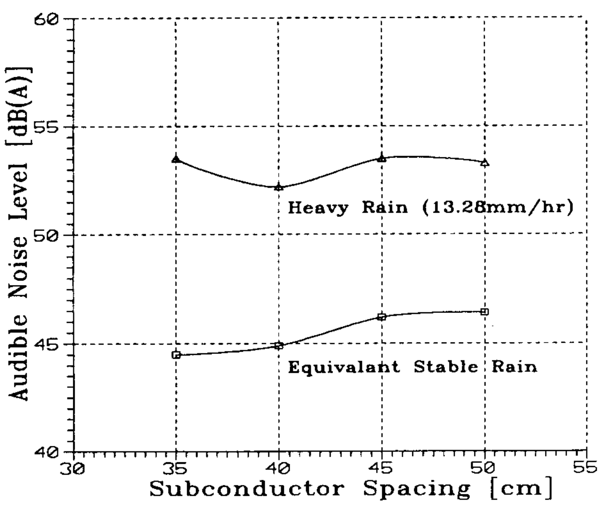

Fig. 8 Characteristic curve of audible noise level with subconductor spacing

4.2 Hum Noise

The average hum noise levels(L_{50}) at 18m from the reference point in the rainy weather show in Table 6. The L_s (spacing average value) was calculated from Lt_i(Time average value) using the equation(1)[11]. The typical frequency spectrum of HN in rainy weather is shown in Fig. 4.

$$L_s = 10\log\left\{\frac{\sum_{i=1}^{N}(10^{\frac{L_{ti}}{20}})^2}{N}\right\}\ [dB] \qquad (1)$$

where L_{ti} : L_{t50i} at i th measuring point
N : Number of measuring points
L_{t50} : 50% exceedance time average level

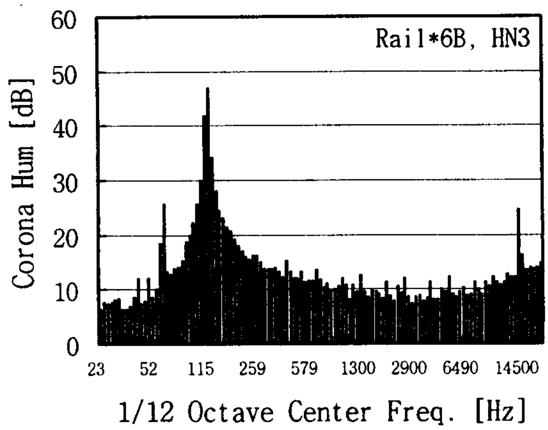

Fig. 9 HN frequency spectrum in rain

Table 6. Hum noise level [dB(A)]

	Rail	Cardinal
L_{s5}	38.8	40.5
L_{s50}	31.0	30.1

4.3 Aeolian(Wind) Noise

The average CN(Conductor Aeolian Noise) and TN (Tower Aeolian Noise) levels in windy weather show in Table 7. These values are measured by C-weighting and converted to the A-weighting using eq.(2)[11]. The average wind speed and wind direction in the measurements were 5~7 m/s and 45~55°, respectively.

Table 7. Aeolian noise level [dB(A)]

	Rail				Cardinal			
	CN	TN	Wind Speed	Wind Direction	CN	TN	Wind Speed	Wind Direction
L_5	49.5	62.9	13.0	84.6	48.8	52.2	7.0	63.4
L_{50}	32.8	45.5	7.2	53.8	40.2	42.4	4.9	46.7

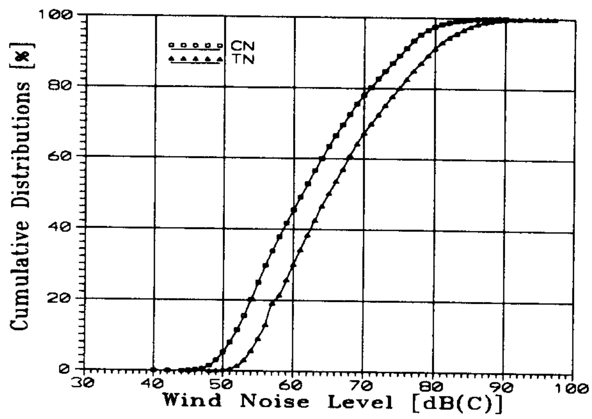

Fig. 10 WN distributions in windy weather

$$V_A\ [dB(A)] = V_M\ [dB] + 30 \log f - 79 \quad (2)$$

where,

V_A [dB(A)] : Converted A weighting value

V_M [dB] : Measured with C weighting value

f : Dominant frequency (≤250Hz)

4.4 Radio Interference

4.4.1 RI Frequency Spectrum

In order to get correction factor for converting the test line data into the data of a long actual transmission line, manual measurements of RI frequency spectrum were conducted, and the correction factor was measured as 6 dB[μV/m]. The shape and form of the spectrum depends on line length and the distances of applied point from the line, respectively[8].

In the 765-kV test line, the regularly spaced resonant peaks and nulls by standing waves appear in the spectrum along the frequency as shown in Fig. 11.

Generally, a long transmission line exhibits only minor irregularities in its frequency spectrum, a radio noise decreases as the frequency increases. And it was known that the geometric mean between maximum noise peaks and nulls in the frequency spectrum of the short line represents very closely the noise spectrum of the long line[10]. Although the measured peaks and nulls differ from theoretical ones above 500 kHz due to the AM broadcasting and unwanted signals, the geometric mean by the peak and null below 500 kHz can be represented as in Fig.11. The conversion value which is the difference between the geometric mean and the measured value is 6 dBμV/m at 475 kHz(measurement frequency) in Fig. 11.

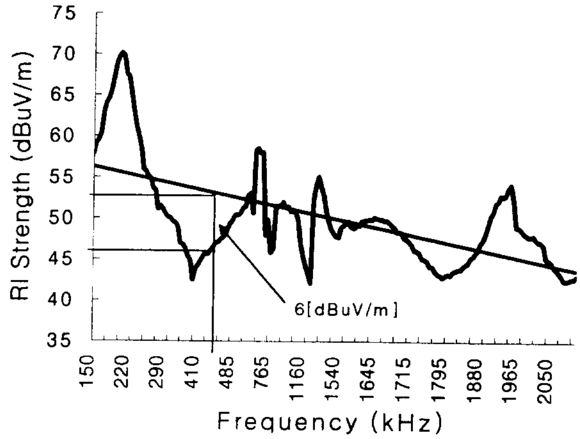

Fig. 11 RI Frequency Spectrum of 6-Cardinal Conductors Bundle

4.4.2 RI Lateral Profile

A lateral profile describes how the noise level falls off with becoming distant from the line as in Fig. 12.

In Fig. 12, the values of 6-Rail conductors bundle were converted by about 5 dBμV/m result from height pattern measurements. The antenna height above ground in 6-Rail measurement is about 7 m, but the antenna

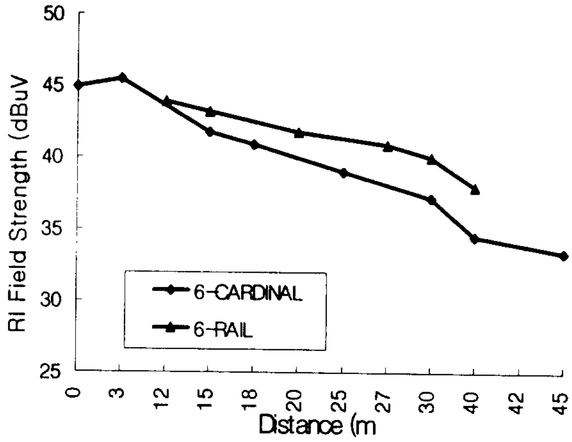

Fig. 12 RI Lateral profile for 6-Cardinal conductors bundle

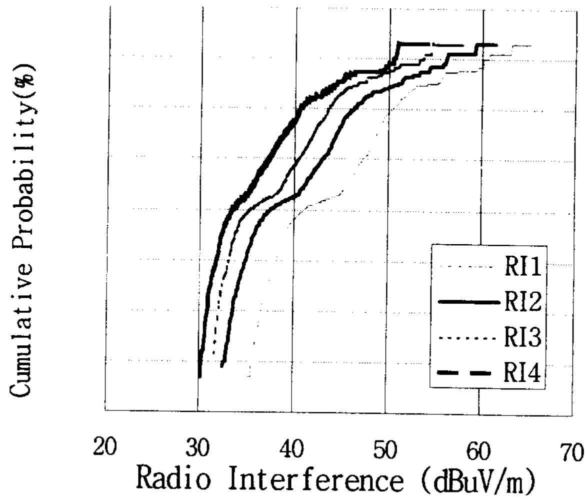

Fig. 13 A cumulative frequency distribution curve of RI for 6-Cardinal conductors bundle under fair weather.

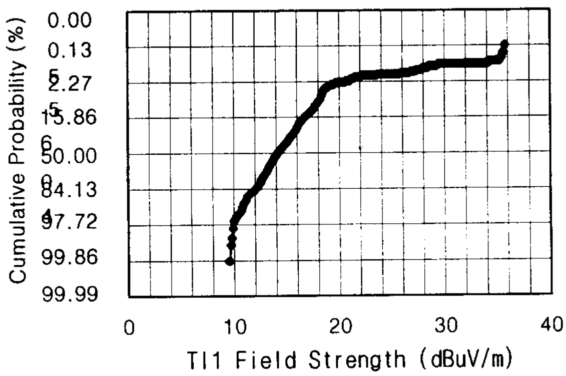

Fig. 14 TVI(QP) distribution in rainy weather

height in 6-Cardinal measurement is 2 m. The differences between 6-Rail and 6-Cardinal are about 1 to 3 dBμV/m. Considering RI differences(1 dBμV/m) from Table 8, this variation was caused by the measurement error with antenna height pattern.

A radio interference varies with time, primarily owing to the variations in the weather conditions. From conditions of heavy rain to fair weather, levels may change by as much as 20 ~ 30 dB. Thus it is possible to describe noise variation in statistical terms only, for cexample, by cumulative frequency distribution curves. These curves show the percentage of time that the noise level is below a certain value.

Fig. 13 shows the cumulative frequency distribution curve for 6-Cardinal conductors bundle under fair

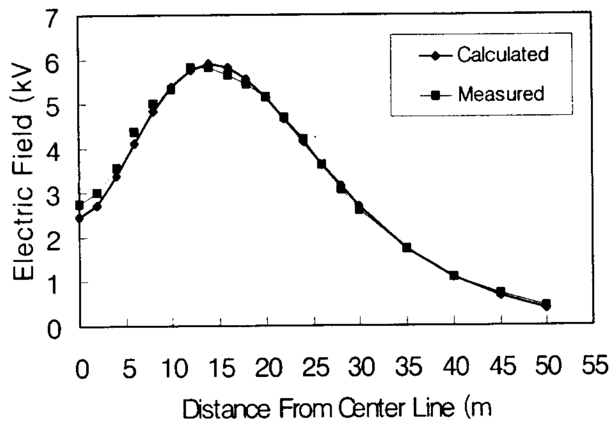

Fig. 15A Lateral electric field strength profiles

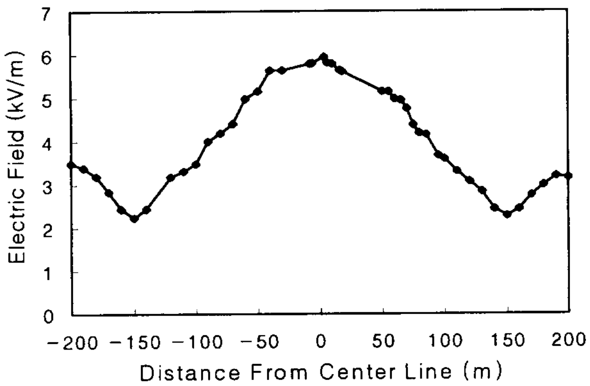

Fig. 15B Longitudinal electric field strength profile

Table 8. The analysis results of long-term measurement for 6-Rail and 6-Cardinal conductors bundle.

Items		RI1[dBμV/m]		RI2[dBμV/m]		RI3[dBμV/m]		RI4[dBμV/m]		R3[dBμV/m]	
		L_5	L_{50}	L_5	L_{50}	L_5	L_{50}	L_5	L_{50}	L_5	L_{50}
Fair Weather	Rail	53.4	49.6	50.0	46.3	-	-	-	-	34.2	28.4
	Cardinal	55.0	48.6	51.3	45.3	49.8	43.6	49.9	44.0	-	-
Rainy Weat-her	Rail	76.8	72.7	73.8	69.6	-	-	-	-	33.5	29.7
	Cardinal	70.6	61.3	66.9	56.9	63.8	55.0	67.3	55.5	-	-
Antenna position from the reference point		15[m]		30[m]		42[m]		57[m]		188[m]	

* Background level of the test line site is about 30 dBμV/m.

Table 9. The analysis results of long-term measurements for 6-Rail and 6-Cardinal conductors bundle

Items		TI1[dBμV/m]		TI2[dBμV/m]		TI3[dBμV/m]		T2[dBμV/m]		T3[dBμV/m]	
		L_5	L_{50}	L_5	L_{50}	L_5	L_{50}	L_5	L_{50}	L_5	L_{50}
Fair Wea- ther	Rail	-	-	-	-	18.2	15.6	20.5	14.8	17.2	14.2
	Cardinal	19.4	13.8	18.6	13.3	18.5	11.4	-	-	-	-
Rainy Wea-ther	Rail	-	-	-	-	21.5	18.2	19.5	17.0	17.2	15.1
	Cardinal	18.5	14.2	18.9	14.8	18.6	14.7	-	-	-	-
Antenna position from the reference point		27[m]		37[m]		52[m]		80[m]		188[m]	

weather condition.

The analysis results of long-term measurements for 6-Rail and 6-Cardinal conductors bundle based on Fig. 12 are summarized in Table 8.

In Table 8, the difference between 6-Rail and 6-Cardinal is 1 dBμV/m. This result almost coincide with BPA's calculation one(0.6 dBμV/m).

The background level is an important consideration in RI measurement. The investigation of the frequencies around 0.5 ㎒ led to the choice of 475 ㎑ as measuring frequency reasonably free of background during the daytime at the test line site. This level during the daytime is about 30 dBμV/m. In the night, the background level is increased about 7 dBμV/m.

In Table 8, both 6-Rail and 6-Cardinal conductors meet KEPCO's 765-㎸ line design criteria in Table 11.

4.5 TV Interference

Television Interference like audible noise is mostly a foul weather phenomenon. The rainy weather, QP TVI cumulative frequency distribution at 75 MHz is shown in Fig 14.

The analysis results of long-term measurements for 6-Rail and 6-Cardinal conductors bundle using statistical term are summarized in Table 9. In Table 9, TVI level for 6-Cardinal conductor bundle under fair weather is about 3 dBμV/m higher than estimated one due to unwanted noise. Generally, estimated TVI levels under fair weather equal background levels, which is about 10 dBμV/m.

In Table 9, 6-Cardinal conductors bundle meets KEPCO's 765-㎸ line design criteria.

4.6 Electric Field Strength

The electric field along the lateral line was measured and compared with the calculated data as shown in Table 10. Very good agreement was obtained between the measured and calculated performances, shown in Fig. 15A. Also Fig.15B shows the longitudinal electric field strength profile direct under phase conductor between #2 tower and #3 tower in the test line.

Table 10. The Comparison of EF with the calculated

Item	Measured		Calculated	
	765kV	800kV	765kV	800kV
Strength[kV/m]	5.6	5.8	5.9	6.2

5. KEPCO Design Criteria of Transmission Line.

When line design criteria are determined, it is the most important that the equilibrium of the construction cost and constraint level of the environmental impact must be considered. Under the above concept, KEPCO determined 765-㎸ line design criteria considering domestic regulations, corona cage and test line experiences, the rules, design guide and experiences of foreign countries. The design criteria for 765-kV transmission line are summarized in Table 11.

6. Conclusions

KEPRI(Korea Electric Power Research Institute) have studied the environmental impact on the KEPCO(Korea Electric Power Corporation) vertical,

Table 11. Environmental Design Criteria of KEPCO 765-㎸ Transmission Line

Items	Area	Criteria	Conditions
AN	Residential Area	below 50dB(A)	• measurement value : L_{50}% under rainy weather • Measuring point : 15 m from outmost phase • Microphone height above ground :1.5 m
	Quasi-Residential Area	below 55dB(A)	
	other Area	below 60dB(A)	
RI	All Area	above SNR 24dB	• measurement value : L_{50}% under fair weather • Measuring point : 15 m from outmost phase • Antenna height above ground : 2 m • Measuring frequency : 0.475 ㎒ • Signal strength : 71 dBμV/m(the signal strength of broadcast area at low noise area)
TVI	Residential Area	above SNR 40dB	• measurement value : L_{50}% under rainy weather • Measuring point : 15 m from outmost phase • Antenna height above ground : 3 m • Measuring frequency : 75 ㎒ • Signal strength : 54 dBμV/m(the signal strength of broadcast area at low noise area)
Electric Field	Residential Area	below 3.5kV/m	• Direct under conductor phase • Meter height above ground : 1 m
	Other Area	below 7.0kV/m	

double circuit 765-kV transmission line by testing them first in a corona test cage and testing them second on a full scale test line. After testing 6-Rail and 6-Cardinal conductor bundle using the 765-kV test line for 28 months, we have the following results

(1) From the results of our research until now, we evaluated the environmental impact of test line with KEPCO's 765-KV transmission line design criteria

(.2) The L_{50} AN of Rail and Cardinal Conductor in rainy weather at 15 m from the outermost phase are 48.8 dB(A) and 48.4 dB(A), respectively. These conductor bundles satisfy with our design criteria of 50 dB(A) at this location.

(3) A 40 cm subconductor spacing was selected from the viewpoint of AN and the practice of 345-kV line design.

(4) In order to minimize the effect of high ambient and extraneous wind induced noise, the AN data selected for analysis were corrected comparing with background noise.

(5) Both 6-Rail and 6-Cardinal Conductors bundles meet RI design criteria of KEPCO's 765-KV transmission line.

(6) 6-Cardinal conductors bundle meets TVI design criteria of KEPCO's 765-KV transmission line.

Later, we will present the research results of TV ghost and magnetic induction.

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저 자 소 개

이 동 일 (李 東 一)

1958년 3월 15일생. 1996년 한양대 대학원 전기공학과 졸업(공박). 1978년 한국전력 입사. 현재 한전전력연구원 전력계통연구실 송변전기술그룹 선임연구원. IEEE Member. CIGRE WG 22-14 Member.

신 구 용 (申 玖 容)

1967년 7월 8일생. 1993년 경남대 대학원 전기공학과 졸업(석사). 1988년 한국전력 입사. 현재 한전전력연구원 전력계통연구실 송변전기술그룹 선임보 연구원.

김 정 부 (金 正 夫)

1943년 11월 14일생. 1990년 서울대 대학원 전기공학과 졸업(공박). 1995년 전기학회 방전 및 고전압연구회 간사장 역임. 1980년 발송배전, 전기기계 기술사 취득. 1971년 한국전력 입사. 현재 한전전력연구원 전력계통연구실장. IEEE Senior Member. CIGRE SC22 Member.