2.5 Safety distance requirements (compliance boundaries)

To ensure public safety when installing base stations, take into account the following facts. This equipment generates radio frequency energy, which has a thermal effect when absorbed by the human body. For this reason compliance boundaries specific to this equipment have been established. The thermal effect of radio frequency energy can exceed safety levels when a person is inside the established compliance boundaries. By observing the compliance boundary, and ensuring the general public has no access to areas inside the established boundaries will ensure that the general public has no exposure to levels in excess of the safety limits.

To ensure installer safety when installing base stations, installation engineers need to be aware of the potential risk of the thermal effects of radio frequency energy and of how to protect him/herself against undue risk.

Warning

Do not go any closer to a live antenna than the compliance boundary. The radio frequency energy generated by the antenna poses a serious health risk.

Warning

If performing installation or maintenance procedures on the BTS, make sure that all transmitters in the area are switched off.

When assessing the applicable boundaries, the European standards EN 50383, EN 50384, EN 50385 and Council Recommendation 1999/519/EC for occupational and general public electromagnetic exposure limits - **see Annex A** - have been applied.

Note

The component specifications for 2100 MHz also apply to 1900 MHz products and can be used to demonstrate compliance with FCC guidelines for human exposure to radiofrequency electromagnetic fields contained in FCC document OET Bulletin 65 (August 1997).

Assessment applying SAR measurements

European standards EN 50383, EN 50384 and EN 50385 do not include specifications for whole body SAR measurement. Whole body SAR measurements are not required for transmitters that have maximum output power levels too low to result in exposure levels that can reach the whole body SAR compliance limits under any conditions. Whole body SAR exclusion power levels have been based on the worst case assumptions. For detail, see table below.

Table 12. Whole body SAR exclusion power levels

Exposure category	Maximum output power (rms)
General public	Max power [W] = general public whole body SAR limit 0.08 [W/kg] * 4-year old child mass 12.5 [kg] = 1 W
Occupational	Max power [W] = occupational whole body SAR limit 0.4 [W/kg] * 16-year old worker 42 [kg] = 16.8 W

Localised SAR measurement can only be used when:

1. The separation between the phantom and the outer surface of the energy generating element is 40 cm or less.
2. The surface area of the energy generating element is less than 60 cm by 30 cm.
3. The frequency is in the range of 800 to 3000 MHz.

For the reasons above, SAR measurements are not applicable to **Nokia UltraSite WCDMA Base Station Optima Compact Outdoor, Nokia UltraSite WCDMA Base Station Optima Indoor, Nokia UltraSite WCDMA Base Station Supreme Outdoor, Nokia UltraSite WCDMA Base Station Supreme Indoor** .

Assessment of compliance boundary

The compliance boundary is defined as the area around the antenna, shown in the first diagram below.The centre of the antenna is located at the origo. Distances from the antenna are shown. The top and side views are shown in the second diagram below, in picture 1 and picture 2.

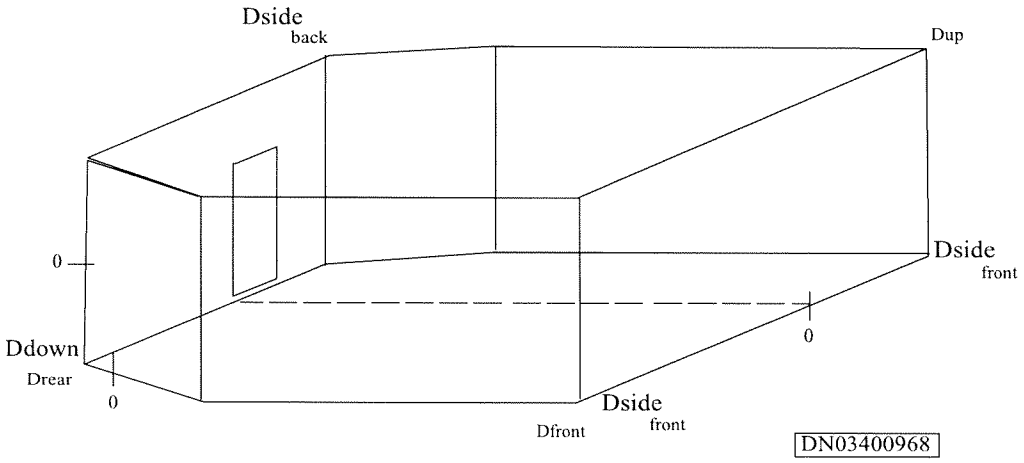

Figure 4. Area around the antenna

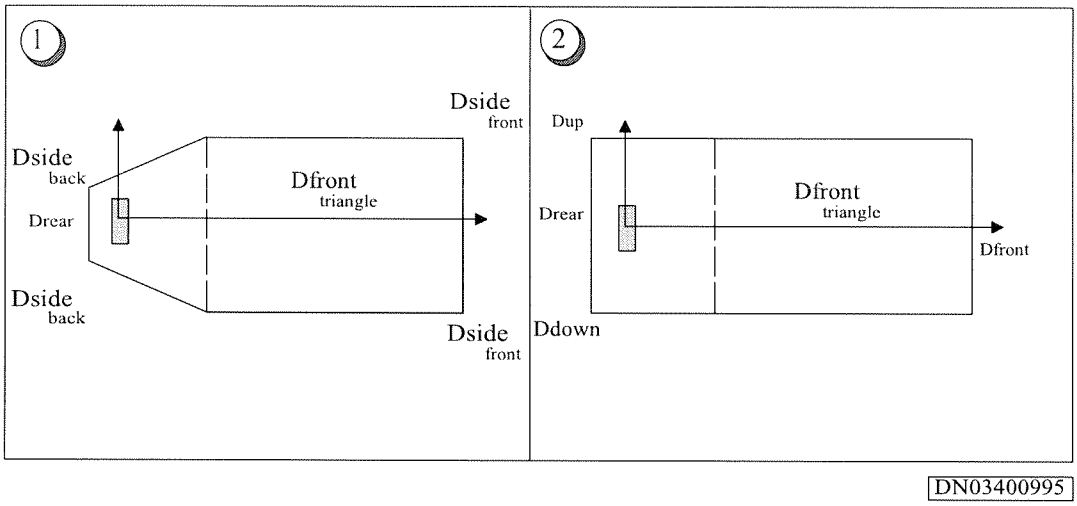

Figure 5. Antenna side and top view

The compliance boundaries for the Nokia UltraSite WCDMA Base Stations Optima Compact Outdoor, Optima Indoor, Supreme Outdoor and Supreme Indoor are given in table below for different power levels at the antenna input. Typical and worst case power level configurations for **general public (GP)** and **occupational (O)** exposure limits are included in the table.

Table 13. Dimensions of compliance boundary in meters for frequencies of 2000 MHz and above

Power at antenna input (W)	**Dfront**	**$Dfront_{triangle}$**	**Drear**	**$Dside_{back}$**	**$Dside_{front}$**	**Dup**	**Ddown**
5	GP: 1.2 O: 0.2	GP: 0.6 O: 0.2	GP: 0.1 O:0.1	GP: 0.25 O: 0.25	GP: 0.25 O:0.25	GP: 0.6 O:0.6	GP: 0.6 O: 0.6
10	GP: 2.3 O: 0.4	GP: 1.2 O: 0.2	GP: 0.1 O: 0.1	GP: 0.25 O: 0.25	GP: 0.6 O: 0.25	GP: 0.6 O: 0.6	GP: 0.6 O: 0.6

Table 13. Dimensions of compliance boundary in meters for frequencies of 2000 MHz and above (cont.)

Power at antenna input (W)	Dfront	$Dfront_{triangle}$	Drear	$Dside_{back}$	$Dside_{front}$	Dup	Ddown
15	GP: 2.9 O: 0.5	GP: 1.3 O: 0.2	GP: 0.1 O: 0.1	GP: 0.3 O: 0.25	GP: 0.85 O: 0.25	GP: 0.6 O: 0.6	GP: 0.6 O: 0.6
20	GP: 3.3 O: 0.6	GP: 1.35 O: 0.2	GP: 0.1 O: 0.1	GP: 0.3 O: 0.25	GP: 1.0 O: 0.25	GP: 0.6 O: 0.6	GP: 0.6 O: 0.6
25	GP: 3.7 O: 1.2	GP: 1.3 O: 0.2	GP: 0.1 O: 0.1	GP: 0.3 O: 0.25	GP: 1.2 O: 0.25	GP: 0.6 O: 0.6	GP: 0.6 O: 0.6
30	GP: 4.1 O: 1.55	GP: 1.3 O: 0.2	GP: 0.1 O: 0.1	GP: 0.35 O: 0.25	GP: 1.3 O: 0.25	GP: 0.6 O: 0.6	GP: 0.6 O: 0.6
35	GP: 4.4 O: 1.75	GP: 1.4 O: 1.2	GP: 0.1 O: 0.1	GP: 0.35 O: 0.25	GP: 1.4 O: 0.35	GP: 0.6 O: 0.6	GP: 0.6 O: 0.6
40	GP: 4.7 O: 1.95	GP: 1.5 O: 0-7	GP: 0.1 O: 0.1	GP: 0.4 O: 0.25	GP: 1.5 O: 0.5	GP: 0.6 O: 0.6	GP: 0.6 O: 0.6

Typical configuration

The antenna is connected through a connector and cable(s) to the base station as shown in diagram below.

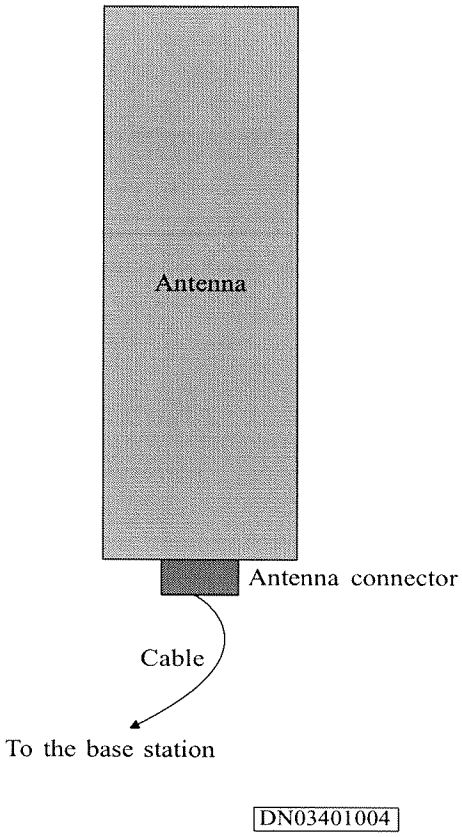

Figure 6. Antenna connection to the BTS

Table 14. A detailed description of the components

Power (P_{out})	20 W
Total connector loss	0.0 dB
Total cable loss	0.0 dB
Total Loss (L) = Total connector loss + Total cable loss	0.0 dB
Number of transmitter unit (N)	1
Power at antenna input = $P_{out}N10^{-L/10}$	20 W

The worst-case power level configuration is when *N* is 2 and there is no loss. In such a case the power at antenna input is 40 W.

Table 15. A typical antenna specification

Gain	18 dBi
Half-power beam width	H-plane: 60 deg. E-plane: 8 deg.
Electrical downtilt	0 deg.
Height/width/depth	1100 / 200 / 100 mm

When using different configurations

IMPORTANT:

- **In table 'Dimensions of compliance boundary in meters for frequencies of 2000 MHz and above' the compliance boundaries are given for different power levels, including the typical and worst case levels. If an exposure limit, antenna, and/or configuration is used which does not correspond to the levels or frequencies given in the two tables above, the compliance boundary must be recalculated according to EN 50383.**
- **The formula for calculating the compliance boundary using the far-field model, which is referenced in EN 50383, is given in ANNEX B later in this section. This model is applicable for calculating the compliance boundary for the far-filed region and over estimates the compliance boundary for the radiating near-field region, but is not applicable for calculating the compliance boundary for reactive near-field region where the distance from the antenna is less than or equal to λ / 4**

ANNEX A: Council recommendation 1999/519/EC for occupational and general public electromagnetic exposure limits

Table 16. Basic restrictions

Exposure characteris-tics	Frequency range	Whole body average SAR (W kg^{-1}	Localised SAR (head and trunk) W kg^{-1}	Localised SAR (limbs) W kg^{-1}

Table 16. Basic restrictions (cont.)

Occupational exposure	10 MHz - 10 GHz	0.4	10	20
General public exposure	10 MHz - 10 GHz	0.08	2	4

Note

All SAR values are to be averaged over any period of 6 minutes.

Note

Localised SAR averaging mass is any 10g of contiguous tissue: the maximum SAR so obtained should be the value used for the estimation of exposure.

Note

Basic restrictions between 10 GHz and 300 GHz are given in power densities. For occupational exposure it is 50 Wm^{-2} and for general public exposure it is 10 Wm^{-2}.

Table 17. Reference values calculated from basic restrictions

Exposure characteristics	Frequency range	Electric field strength V/m	Equivalent plane wave power density S ($W m^{-2}$)
Occupational exposure	10 - 400 MHz	61	10
	400 - 2000 MHz	$3f^{1/2}$	f/40
	2 - 300 GHz	137	50

Table 17. Reference values calculated from basic restrictions (cont.)

General public exposure	10 - 400 MHz 400 - 2000 MHz 2 - 300 GHz	28 $1.375f^{1/2}$ 61	2 f/200 10

- f is frequency in MHz
- For frequencies between 100 KHz and 10 GHz, S is to be averaged over any period of 6 minutes.
- For frequencies exceeding 10 GHz, S is to be averaged over any period of $68/f^{1.05}$ minutes (f in GHz).

ANNEX B: Far-field calculation method

This model is applicable for calculating the compliance boundary for the far-field region and over estimates the compliance boundary for the radiating near-field region, but is not applicable for calculating the compliance boundary for the reactive near-field region where the distance from the antenna is less than or equal to λ /4, which is 3.75 cm at 2000 MHz. Therefore, all the calculations are valid when the compliance boundary is greater or equal to the antenna dimensions plus λ /4.

When working close to transmitter antennas, the proper safety distances must be observed. The minimum safe distance from an antenna is measured in metres, and is stated as the value 'rmin'.

The minimum safety distance (compliance boundary) in metres from an antenna, or 'rmin', is calculated according to the following equation:

$$r_{min} = \sqrt{\frac{N10^{\frac{(G-L)}{10}} P}{4\pi S}}$$

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Figure 7. Formula for safety distances

The meaning of each formula component is as follows:

- N is the number of transmitters attached to the antenna
- G is the antenna gain (in dB) compared to isotropically radiating antenna
- L is the total loss (in dB) between the transmitter and the antenna input.
- P is the transmitter power (in W)
- S is the maximum allowed power density in air (in W/m^2)

Note

In the far-field, the field calculation does not tale into account the antenna size, which is assumed to be a point source. Therefore, when calculating the compliance boundary, the far-field data, antenna size and reactive field criteria have to be taken into account.
