EVALUATION OF HUMAN EXPOSURE TO ELECTROMAGNETIC FIELD USING DATA PROVIDED BY THE NATIONAL AUTONOMOUS ELECTROMAGNETIC FIELD MONITORING SYSTEM

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With the start of discussions about the implementation of 5G (fifth generation) technology, there were voices expressing reluctance, which is why monitoring the ambient electromagnetic field is a very useful measure these days. The present paper uses the data measured during one year by the sensor system developed at the national level by the National Authority for Administration and Regulation in Communications (ANCOM). The measured values were compared with the reference levels provided by the national legislation. The results show that the level of the ambient electromagnetic field is reduced compared to the reference levels.

Keywords: electromagnetic field, ANCOM, ICNIRP, human exposure

1. Introduction

In recent decades, technologies that enable wireless communications, such as cellular radio systems for mobile communications, have raised concerns about possible adverse effects on human health. Electromagnetic fields are generated by various sources, both natural and man-made; they are intangible, they cannot be seen with the naked eye, and sometimes they can produce biological effects, such as heating, but this biological effect is not always a health hazard. People's concerns about the possible health effects of the electromagnetic field have increased and, together with a poor public understanding of some scientific topics, have generated some erroneous ideas, increasing concerns about possible health risks.

In order to prevent potential effects on human health, international regulations and guidelines have emerged that set limits for the exposure of the general public and workers to radio frequencies. To verify compliance with the safety limits of the public and workers, measurements and evaluations of human exposure to electromagnetic fields are necessary. The demand for the monitoring

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of electromagnetic fields generated by communication systems and other radio frequency technologies, in order to assess compliance with existing legislation and prescribed reference levels is increasing more and more. To be able to have a technological development and progress from a scientific point of view, it is important how we present to people the dependence of risks on health in relation to technological evolution [1]. An important step in calming the population was the emergence of broadband or different frequency bands electromagnetic field monitoring systems that continuously measure the electromagnetic field from all surrounding sources and transmit the evaluation results to a platform accessible to the public.

2. Exposure limits

One of the first groups formed to study the problems related to protection against the electromagnetic field and the effects of non-ionizing radiation was founded in 1974, by the International Radiation Protection Association (IRPA). The group then became the International Non-Ionizing Radiation Commission (INIRC), within IRPA, and together with the World Health Organization, they created documents that include measurements and measuring devices, sources, applications and also, effects of non-ionizing radiation on organisms.

The successor of INIRC, formed by the separation of an independent organization from it, is the International Committee on Non-Ionizing Radiation Protection (ICNIRP), which was founded in 1992 with the aim of continuing in particular the investigation of the effects of radiation non-ionized on health. [2]

The limits imposed in most European states and other states of the world have adopted the limitations imposed by ICNIRP. On the other hand, a few countries, invoking the precautionary principle, have limitations that are much lower, for example China and Switzerland. [3]

The limitations published by ICNIRP are based on relevant studies. The procedures focus on the effects of short-term exposure, as there are insufficient studies of long-term effects to refer to. Studies have been conducted on animals exposed to extremely low frequencies and radio frequencies, and these showed no differences between short-term exposure and long-term exposure to fields whose level was within the limits of the ICNIRP standard. [4]

Reference levels for electric field proposed by ICNIRP and then accepted by the European Union for exposure of the general public to time-varying electromagnetic fields are shown in Table 1.

In Romania, the basic restrictions that regulate exposure to electromagnetic wave emissions for frequencies up to 300 GHz were established by means of Order of the Minister of Public Health 1007/2002, then supplemented

by Order 1193/2006, which fully took over recommendation 519/1999 drafted by the Council of Europe, which is based on the document published by ICNIRP [2].

Table 1

Reference levels for general public exposure

Frequency range	E [V/m]
65-150 kHz	87
0.15-1 MHz	87
1-10 MHz	87/ f 1/2
10-400 MHz	28
400-2000 MHz	1.375 f 1/2
2-300 GHz	61

3. Monitoring of the electromagnetic field at the national level

At the international level, there is the ITU-T K.83 recommendation "Monitoring the levels of the electromagnetic field" which shows how to perform and present the long-term measurements of the electromagnetic field in areas of public interest. [5]

In addition to the electromagnetic field measurement campaigns carried out by mobile communications network operators [6], the Romanian National Communications Administration and Regulation Authority provides the general public with an interactive map that presents the electromagnetic field levels measured in Romania and compares them with the reference levels imposed by the national regulations in effect. The values of the published field levels are obtained either by measurements with portable equipment or by measurements of the 150 fixed sensors arranged in 104 localities in the country, located in the vicinity of educational institutions, hospitals, public institutions, congested areas or public areas in the vicinity of which there are agglomerations from the point of view of electromagnetic field sources [7]. The development of a network for the monitoring of electromagnetic emissions by the regulatory authority aims to ensure the independence of the measurements performed, thus increasing citizens' confidence in the presented results. On the map we can see where the EMF sensors installed by ANCOM are located and you can search the results of the measurements made by them for different time intervals, the results of the measurements are displayed graphically and are compared with the reference levels for the general public. The presentation of the results, easy to understand by the general public, helps to manage the social acceptance of the development of mobile networks.

Monitoring stations with sensors use a triaxial isotropic probe for measuring the electric field intensity in 4 frequency bands [7]:

• broadband with the frequency range of 100 kHz – 7 GHz (band that covers including the bands used in Romania for 5G);
• three frequency bands from the mobile telephony spectrum: 925 MHz – 960 MHz, 1805 MHz – 1880 MHz, 2110 MHz – 2170 MHz;

The monitoring system consists of measuring stations equipped with NARDA AMB 8057 and AMB 8059 broadband sensors that permanently monitor the electromagnetic field [7].

Fig. 1 shows the map of the arrangement of fixed sensors at the national level, the highest density being in Bucharest.

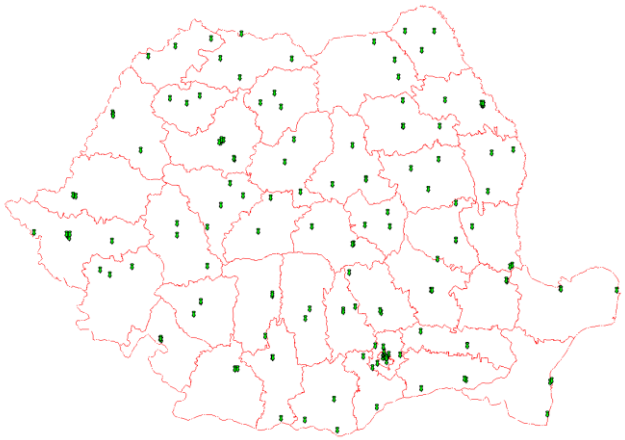

Fig. 1. Distribution of fixed sensors

4. Results and their interpretation

For the analysis of the exposure of the general public to the electric field, with the help of colleagues from the ANCOM Executive Division Monitoring and Control, the data measured by 150 fixed sensors were exported over the course of a year, between August 1, 2021 and July 31, 2022. For each frequency band (100 kHz – 7 GHz, 925 MHz – 960 MHz, 1805 MHz – 1880 MHz, 2110 MHz – 2170 MHz) the maximum and average hourly values of the electric field intensity (E) were exported. Electric field intensity (E) corresponds to the force exerted on of a charged particle, independent of its displacement in space. The database from which it started totaled over 10 million samples.

For each analysis band of each sensor, we calculated the annual average of the maximum measured values, as well as the annual average of the average measured values. The results were graphically represented by histograms and cumulative distributions for the 150 sensors. Although the standards provide for the measurement of the average value of the field for a duration of 6 minutes, we chose to also interpret the maximum values to see if the differences are considerable.

Fig. 2, Fig. 3, Fig. 4, respectively Fig. 5 shows, for the frequency bands 100 kHz - 7 GHz, 2110 MHz - 2170 MHz, 1805 MHz - 1880 MHz, respectively 925 MHz - 960 MHz, the histograms of the annual averages of the electric field maxima measured, as well as the cumulative distributions of the annual averages of the maximum values of the measured electric field.

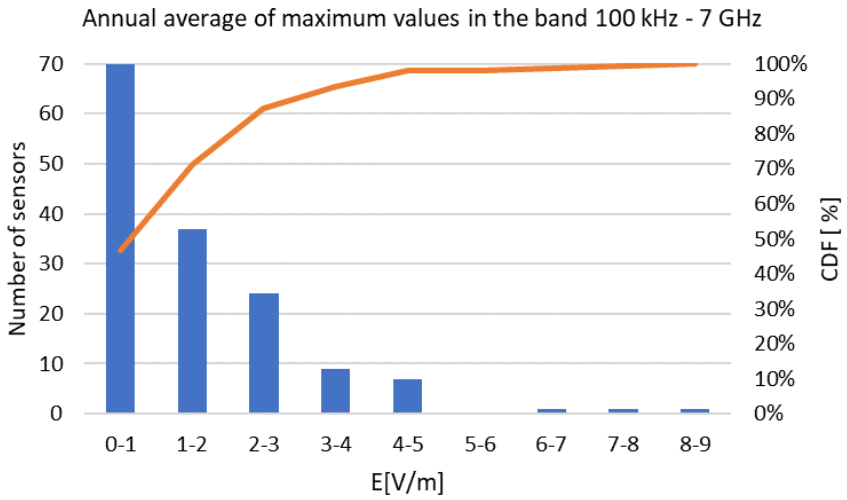

Fig. 2. Histogram of the annual averages of the maximum values of the electric field measured in the band 100 kHz - 7 GHz. The cumulative distribution of the annual averages of the maximum values of the electric field measured in the band 100 kHz - 7 GHz

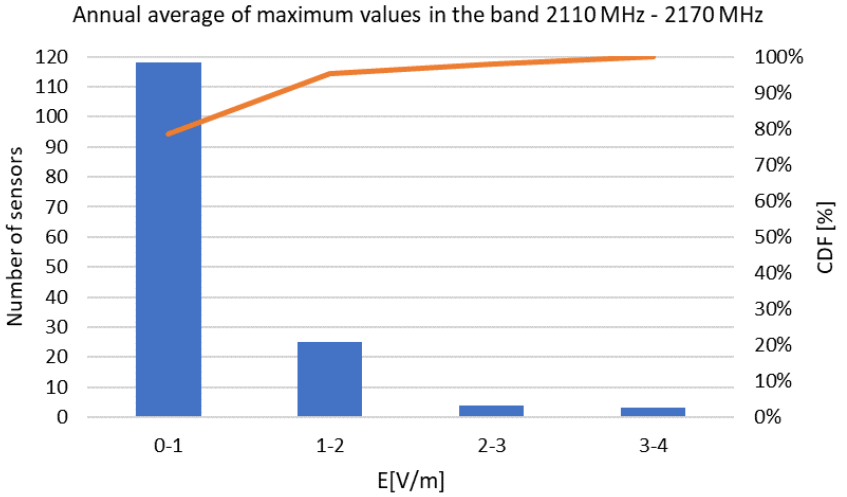

Fig. 3. Histogram of the annual averages of the maximum values of the electric field measured in the band 2110 MHz - 2170 MHz. The cumulative distribution of the annual averages of the maximum values of the electric field measured in the band 2110 MHz - 2170 MHz

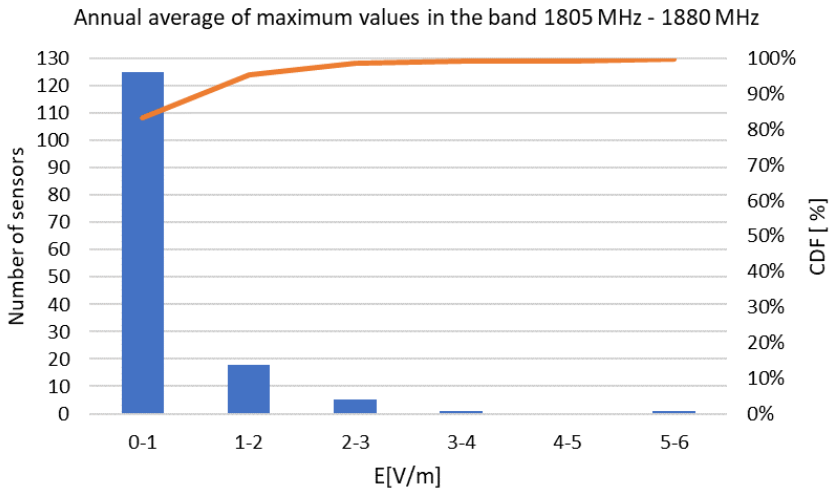

Fig. 4. Histogram of the annual averages of the maximum values of the electric field measured in the band 1805 MHz - 1880 MHz. The cumulative distribution of the annual averages of the maximum values of the electric field measured in the band 1805 MHz - 1880 MHz

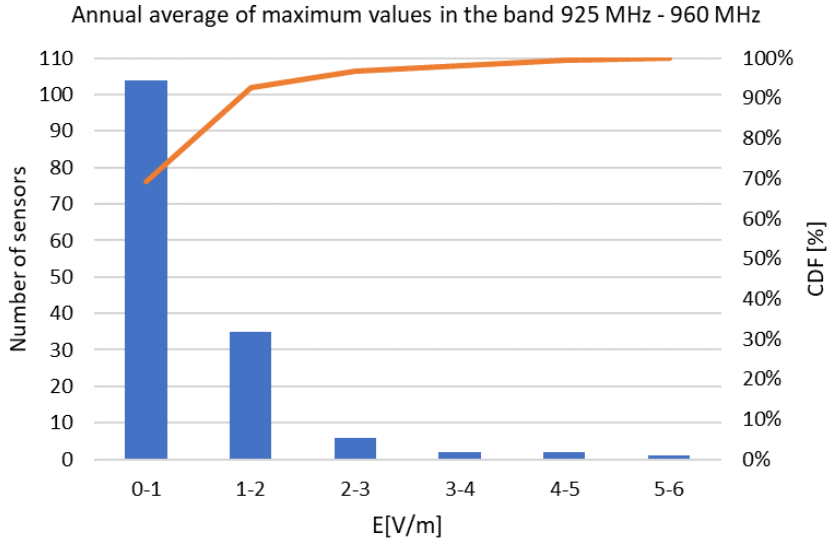

Fig. 5. Histogram of the annual averages of the maximum values of the electric field measured in the band 925 MHz - 960 MHz. The cumulative distribution of the annual averages of the maximum values of the electric field measured in the band 925 MHz - 960 MHz

It is observed that for 70 of the 150 sensors, the average of the electric field maxima measured in the 100 kHz - 7 GHz band, at hourly level for 365 days, is below 1 V/m, 90% of the values being below 4 V/m, which represents less than 15% of the reference level provided for the general public.

The annual averages in the 2110 MHz - 2170 MHz band show that 95% of the sensors have maximum field values below 2 V/m, while for the 1805 MHz - 1880 MHz band, with the exception of 2 of the sensors, the measured field was below 3 V/m.

For the frequency band 925 – 960 MHz, the reference level is 41.81 V/m, with 97% of the sensors reporting average annual maximum values below 7.2% of this level.

Fig. 6, Fig. 7, Fig. 8, respectively Fig. 9 shows, for the frequency bands 100 kHz - 7 GHz, 2110 MHz - 2170 MHz, 1805 MHz - 1880 MHz, respectively 925 MHz - 960 MHz, the histograms of the annual average values of the hourly averaged measured electric field, as well as the cumulative distributions of the annual averages of the hourly averaged measured electric field.

As expected, the annual averages obtained for the measured hourly average values are lower than the annual averages of the maximum hourly values.

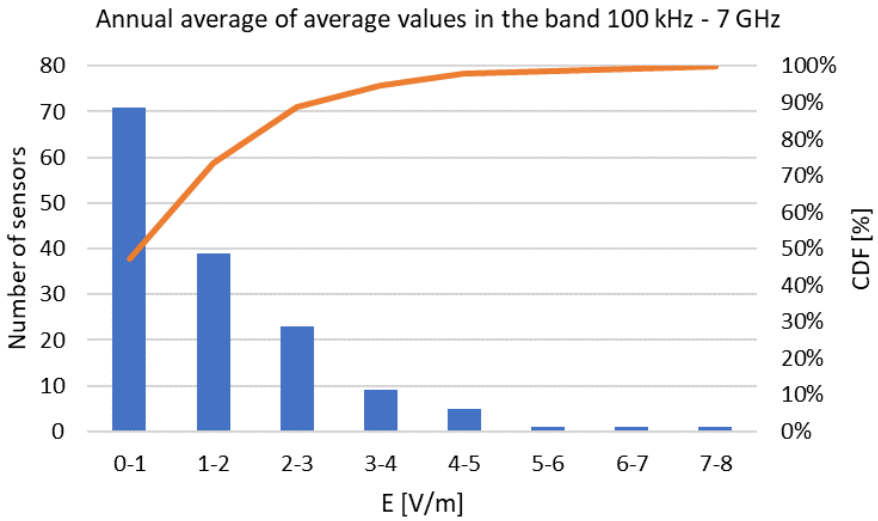

Fig. 6. Histogram of the annual averages of the average values of the electric field measured in the band 100 kHz - 7 GHz. The cumulative distribution of the annual averages of the average values of the electric field measured in the band 100 kHz - 7 GHz

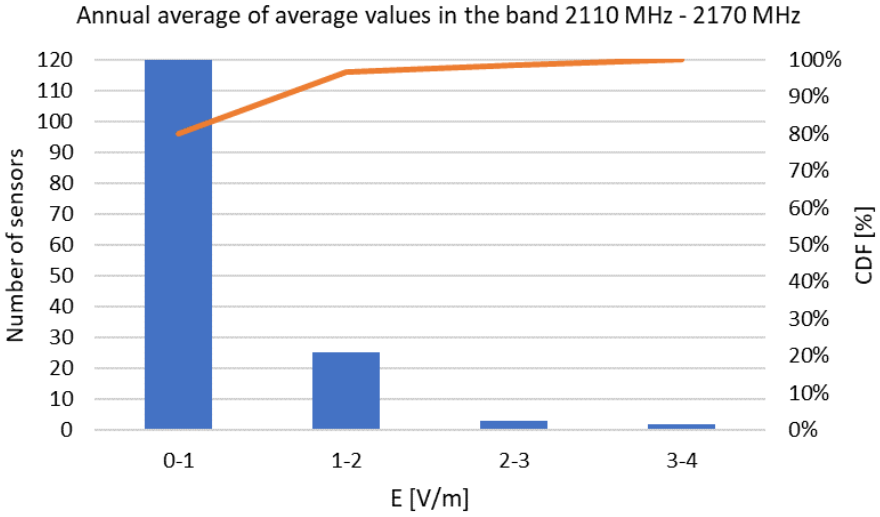

Fig. 7. Histogram of the annual averages of the average values of the electric field measured in the band 2110 MHz - 2170 MHz. The cumulative distribution of the annual averages of the average values of the electric field measured in the band 2110 MHz - 2170 MHz

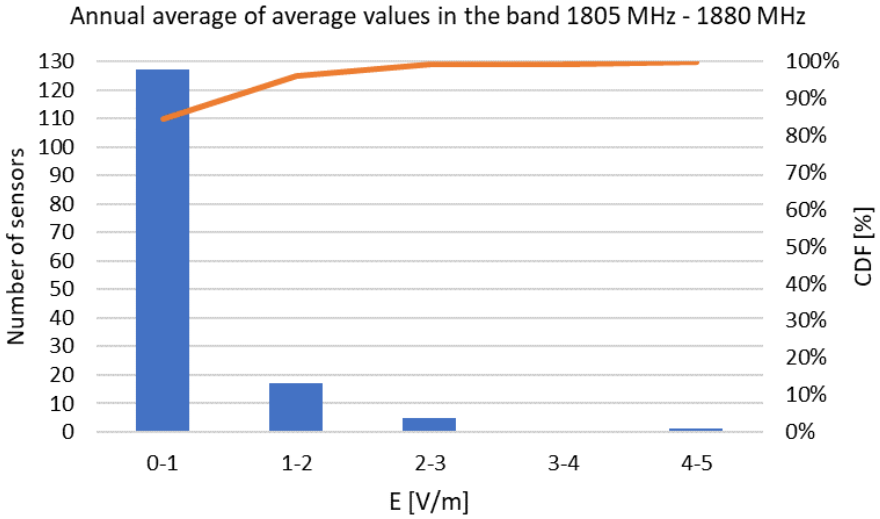

Fig. 8. Histogram of the annual averages of the average values of the electric field measured in the band 1805 MHz - 1880 MHz. The cumulative distribution of the annual averages of the average values of the electric field measured in the band 1805 MHz - 1880 MHz

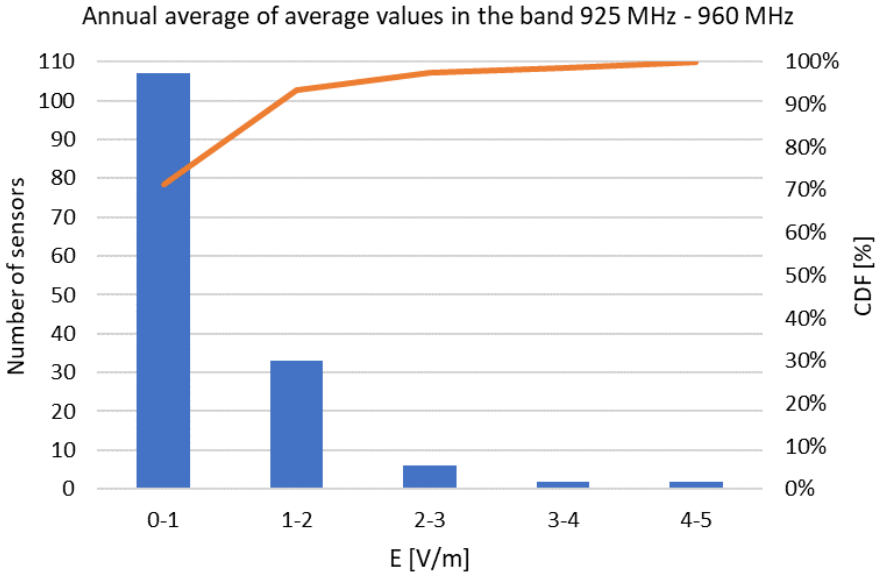

Fig. 9. Histogram of the annual averages of the average values of the electric field measured in the band 925 MHz - 960 MHz. The cumulative distribution of the annual averages of the average values of the electric field measured in the band 925 MHz - 960 MHz

Referring to the reference levels for general public exposure for each frequency band, the presented graphs show:

• for the 100 kHz - 7 GHz band - 97% of the annual averages obtained for the hourly average values are below 15.5% of the reference level for exposure to the general public

• for the band 2110 MHz – 2170 MHz - 97% of the annual averages obtained for the hourly average values are below 3.2% of the reference level for exposure to the general public

• for the band 1805 MHz – 1880 MHz - 97% of the annual averages obtained for the hourly average values are below 4.2% of the reference level for exposure to the general public

• for the band 925 MHz - 960 MHz - 97% of the annual averages obtained for the hourly average values are below 6.8% of the reference level for exposure to the general public

5. Conclusions

The measurements show that there are no reasons for concern regarding the effects on health caused by exposure to the ambient electromagnetic field. The annual average of the maximum values of the electromagnetic field recorded hourly, in the band 100 kHz - 7 GHz, by all 150 sensors is 1.57 V/m, representing

less than 6% of the reference level. The annual average of the maximum values of the electromagnetic field recorded hourly, in the band 2110 MHz - 2170 MHz, by all 150 sensors is 0.68 V/m, being almost 90 times lower than the reference value. Results similar to those in the 2100 MHz band were also obtained for the 1805 MHz - 1880 MHz band, the annual average of the maximum values of the electromagnetic field recorded at hourly level slightly exceeding the percentage of 1% of the reference level. For the frequency band 925 MHz - 960 MHz, allocated to the GSM system (Global System for Mobile Communications), where the reference level is 41.81 V/m, the annual average of the maximum values of the electromagnetic field recorded at hourly level was 0.86 V/m, which percentage means 2%. The highest values of the field were measured by the sensor located on the terrace of building A of the Faculty of Electronics, Telecommunications and Information Technology, from Iuliu Maniu Boulevard 1-3, Bucharest, where it is known that there are several broadcast stations, mobile telephony, data transmissions, radio relays, etc. Even for this location, the highest value of the electromagnetic field in the band 100 kHz - 7 GHz, recorded during the analyzed year was 12.24 V/m, being below 45% of the reference level. The data presented reflect the measurements made after August 1, 2021, but according to the data presented on the official page presenting the results of the measurements [7], from the installation of the sensors until April 2021, the measurements made by ANCOM did not reveal any exceeding of the limits provided by the national regulations in force.

R E F E R E N C E S

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