TEN YEARS OF HARMONIC AND FLICKER CONTROL BY IEC NORMALISED MEASUREMENTS IN BUENOS AIRES DISTRIBUTION SYSTEM

Pedro ISSOURIBEHERE
IITREE-UNLP – Argentina
pedroi@iitree-unlp.org.ar

Alejandro GALINSKI
ENRE – Argentina
agalinski@enre.gov.ar

Diego BIBÉ
ENRE – Argentina
dbibe@enre.gov.ar

Gustavo BARBERA
IITREE-UNLP – Argentina
gbarbera@iitree-unlp.org.ar

ABSTRACT

The electricity distribution service in Buenos Aires – Argentina – was privatised in the early nineties. This service is provided by three different Utilities and the control is carried out by a Regulatory Agency (ENRE). The IITREE of La Plata University provides technical assistance to the Regulatory Agency.

Since the beginning of the privatisation, extensive Monitoring Programs regarding Power Quality have been carried out.

The control of harmonics and flicker, which is detailed in [1] and [2], began in 1997. For this reason, a decade of permanent control has been achieved so far. The three Utilities – called A, B and C in the present paper – perform 45 weekly measurements per month. Therefore, several thousands of measurements have been collected.

By the time this control began, the existing limits in IEC standards for both harmonics and flicker were adopted in order to obtain a starting point for the local regulation. In addition, the equipment employed to perform the measurements also meets IEC standards [3] [4].

In every site in which the limits established for harmonics and flicker in voltage quality are exceeded, the Utility is penalised. The fine, applied only to this site, continues until a new measurement proves that the problem has been solved.

The aim of the article is to show the results obtained over the first 10 years of control. The carried out studies mainly consisted of processing the data gathered during the whole decade with the purpose of obtaining: disturbance trends over the years, comparisons of the levels measured in different Utilities as well as disturbance behaviours throughout the day. In addition to this, the degree of fulfilment achieved by the Utilities was also assessed.

In the next sections the results obtained in the control of both types of disturbances are presented.

INTRODUCTION

The control of harmonics requires measuring the THD (***Total Harmonic Distortion***) and all the individual harmonics up to the 40th, as well. However, only the THD was used to assess harmonic behaviour in several analyses carried out in the present article.

Regarding flicker control, the Pst (***Short-term Flicker Severity***) is employed. In all the studies carried out in the article concerning flicker phenomenon, the Pst parameter was used.

Each normalised weekly measurement consists of 1008 10-minute intervals. To represent each measurement, either the mean value or the Percentile 95 (P95) of all the 10-min intervals was employed. This P95 represents that value exceeded by only 5 % of all the 10-min intervals. This parameter is widely used in Argentinian regulations since it is the one to be compared to the established limits in order to determine whether a measurement is penalised or not.

Recent reports such as [5] of CIGRE recommend using either P95 or P99 for each site in order to characterise the system. Since the P99 is not normally employed in Argentina, such a parameter was not used in this paper. Naturally, it would also be possible to represent the analysed data by the P99 parameter.

The normalised equipment is normally installed at the secondary of MV/LV transformers. These points are not randomly chosen but are selected from the results obtained through a previous, massive survey that leads to localise those sites of the network which are more likely to have high levels of disturbances. This previous survey is carried out by using a large number of low-cost disturbance recorders that only provide the THD and a parameter similar to the Pst.

COMPARISON BETWEEN THE LEVELS RECORDED IN THE THREE UTILITIES

In Figure 1 a comparison of the THD levels recorded in the three Utilities is shown. The values were represented by both the average value and the P95 of all the weekly averages.

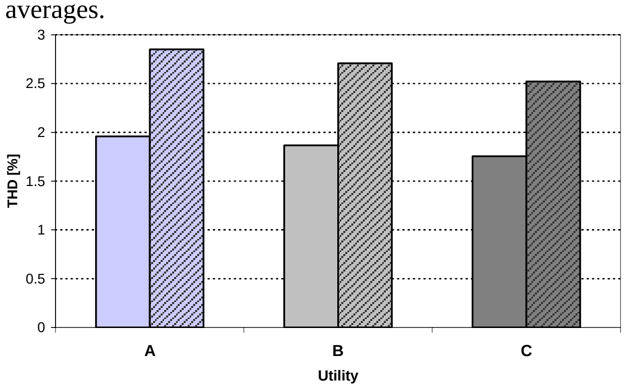

Fig. 1. Comparison of harmonic levels in the three Utilities.

The values reached in the three Utilities were quite similar. The highest levels were observed in Utility A, while the lowest ones were measured in Utility C.

Similarly to what was presented above for harmonics, the comparison of flicker levels is depicted in Figure 2.

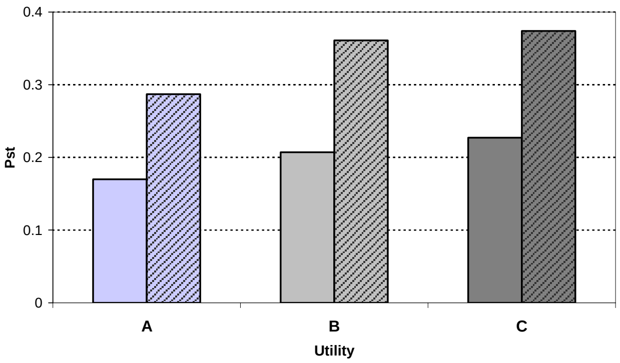

Fig. 2. Comparison of flicker levels in the three Utilities.

The values recorded in the three Utilities were also similar. Nevertheless, in this case the highest values were observed in Utility C whereas the lowest ones in Utility A. That is to say, the opposite to what occurred in harmonic control.

DISTURBANCE BEHAVIOUR THROUGHOUT THE YEARS

The trends of both disturbances over the last 10 years were also obtained considering the results in the three Utilities. The THD trend is illustrated in Figure 3. This parameter was represented by the mean value and the Percentile 95 of the average values of all the weekly measurements belonging to each year.

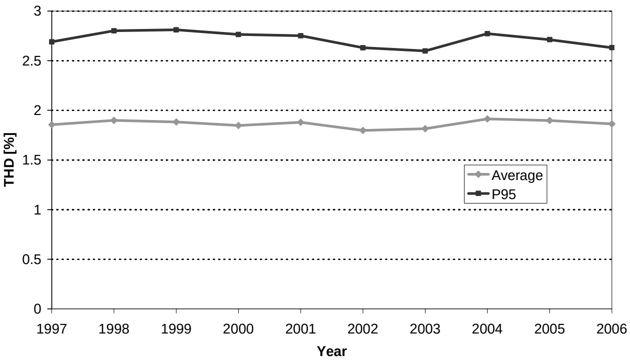

Fig. 3. THD trend throughout the last 10 years.

The trend did not show significant changes in different years. It is remarked the fact that the degree of fulfilment regarding harmonics was quite high.

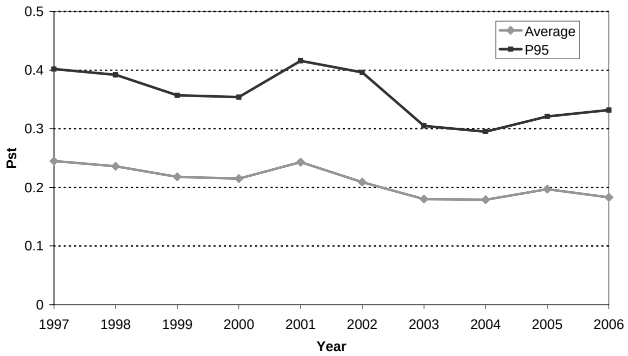

Fig. 4. Pst trend throughout the last 10 years.

As regards flicker behaviour over the years, the trend appears in Figure 4. Although the levels recorded in different years were also similar, the trend showed a slight decrease. Probably, the reason of this issue lies in the fact that the fulfilment of flicker requirements was not as high as that for harmonics. Therefore, throughout all these years the Utilities have had to mitigate flicker in different points of the network. As a result, the system may have become more powerful and less sensitive to distorting loads.

DISTURBANCE BEHAVIOUR IN THE DIFFERENT MONTHS

In order to obtain the behaviour of disturbances throughout a typical year, all measurements were classified according to the month they belong to, regardless of the year in which they were carried out. Thus, the graph shown in Figure 5 was obtained.

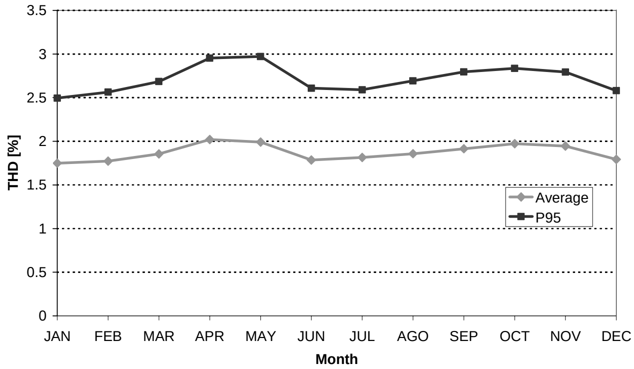

Fig. 5. THD behaviour during the year.

Even though there were not significant differences in the THD values throughout the year, for both parameters – i.e. mean value and P95 – it was observed that the lowest levels of harmonics were reached in winter and summer. Since harmonic levels in the network depend heavily on customers' emissions, it would be worth correlating this harmonic trend with users' habits (use of diverse household appliances in different seasons, holidays, etc.).

When it comes to flicker behaviour, the results are depicted in Figure 6. As it can be observed, the Pst values have remained steady and therefore no correlation between this disturbance and the period of the year was achieved.

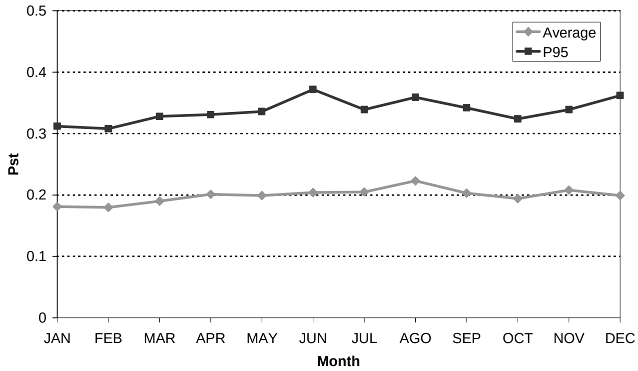

Fig. 6. Pst behaviour during the year.

DISTURBANCE BEHAVIOUR THROUGHOUT THE DAY

The profiles of both disturbances throughout the day were achieved. In order to do so, all the data gathered over the last decade were divided into the 24 hours corresponding to a complete day.

The THD daily profile is illustrated in Figure 7. This graph looks like the load curve of residential customers. For this reason, it was concluded that such customers are thought to be prone to cause harmonics.

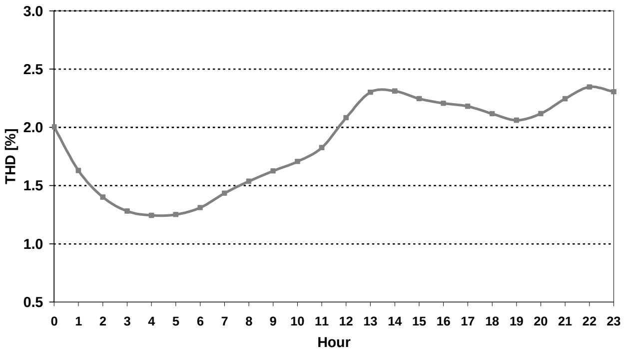

Fig. 7. THD behaviour during the day.

On the other hand, the Pst daily profile is illustrated in Figure 8. On this occasion, the graph was similar to the load curve of general customers. Consequently, these customers, who consist mainly of industrial and commercial users, appear to be in part responsible for the flicker existing in the distribution system.

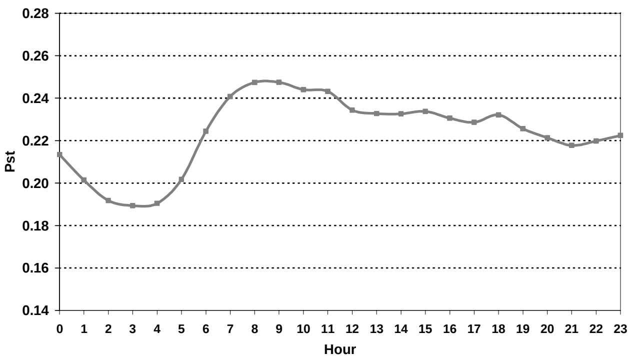

Fig. 8. Pst behaviour during the day.

DEGREE OF FULFILMENT IN EACH UTILITY

Ordinary Monitoring Programme

This section is about the assessment of the established disturbance limit fulfilment.

To begin with, the fulfilment of harmonic levels is discussed. In Figure 9, a bar chart shows the percentage of penalised measurements in each Utility. As it can be observed, since the percentage of penalised sites was below 2 % in the three companies, it is concluded that the degree of fulfilment was high. Besides, the proportion of penalised sites in the three Utilities reached 1.2 %.

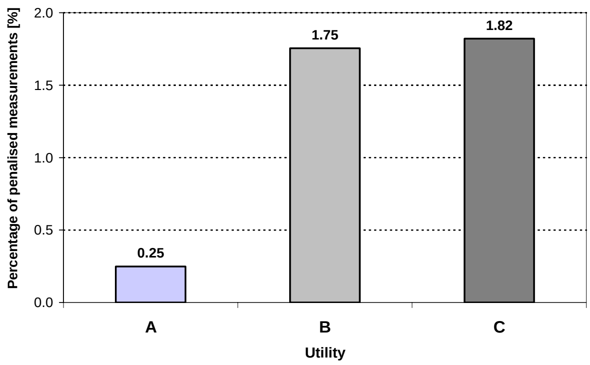

Fig. 9. Penalised sites for harmonics in each Utility.

When it comes to which harmonics are more likely to appear in the distribution system, it was found that from the 2nd to the 14th all of them appeared with the same occurrence. In contrast, it was observed that practically in half of the penalised cases, the harmonic that was above the limits was the 15th.

The bar chart in Figure 10 appears to be useful in order to compare the measurement results with the established limits. There, the P95 of all the P95s of each weekly measurement was represented for all the harmonics up to the 15th. This parameter is close to the maximum value to be found in the network.

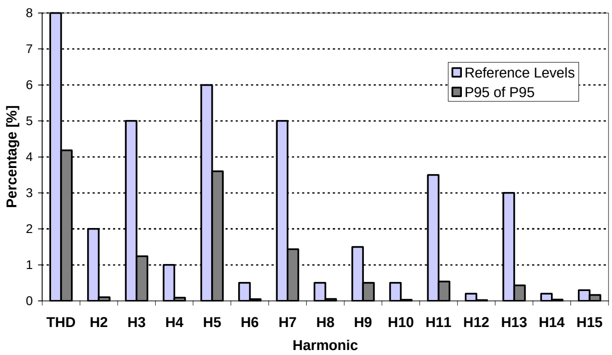

Fig. 10. Reference levels and measured values at different harmonics.

In the worst case (5th harmonic), this parameter was slightly higher than the half of the reference level. Therefore, it is concluded that the degree of fulfilment regarding harmonics was high. Nevertheless, it is important to point out the fact that the measurements are normally made at the point with highest short-circuit power of the whole LV network. This point has the maximum capacity of absorbing the disturbances present in the current and, consequently, the harmonics in the voltage waveform are supposed to be the lowest of the LV network.

In connection with the fulfilment of flicker levels, the results for each Utility appear in Figure 11. On this occasion, the proportion of penalised sites is not as low as in the case of harmonics. The highest number of penalised measurements was reached in Utility C, in which more than 4 % of the sites resulted fined. Considering the three Utilities together, 2.5 % of all the flicker measurements were penalised.

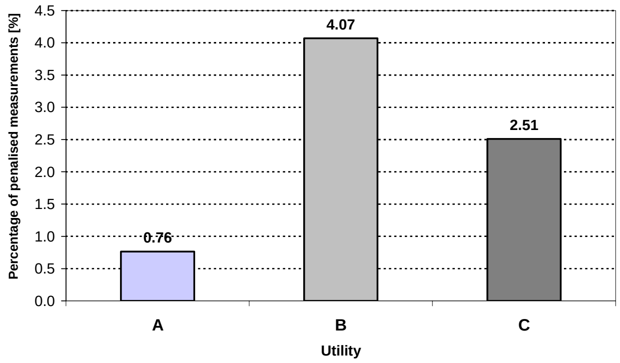

Fig. 11. Penalised sites for flicker in each Utility.

The comment made above about the points where the measurements are normally made is also applicable here.

Complaint treatment

Apart from the ordinary monitoring programme, whose results were discussed in the previous section, the Utilities are also required by the Regulatory Agency to deal with special cases. These cases are when customers complain about disturbances existing in the supplied voltage. In most of them, such complaints are connected with flicker phenomenon since customers notice some fluctuation in the luminance of their bulbs.

The same IEC normalised equipment is employed to assess the flicker level directly in the houses whose owners have claimed to notice the annoying fluctuation. So far, more than 300 complaints have been dealt with. Obviously, with the purpose of not affecting the results, these measurements were not included in all the previous analyses.

In this case, taking into account the three companies, almost 60 % of the analysed complaints resulted in flicker levels above the established limits. That is to say, the results were completely different from those in the ordinary monitoring programme; the flicker levels were far higher.

Finally, in Figure 12 the histogram of Pst values – representing each measurement by its P95 – for all the complaint sites is depicted. The addition of all the bars with Pst values higher than 1 represents the proportion of penalised sites.

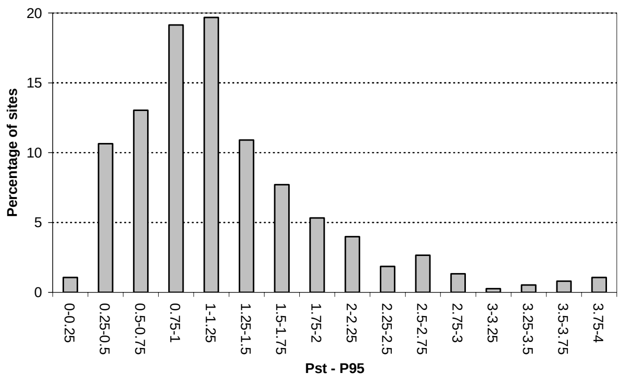

Fig. 12. Histogram of Pst values – Complaint cases.

From this parallel campaign it is possible to conclude that although the flicker levels measured at the secondary of MV/LV transformers were in general within the established limits, in certain points of the LV network – with less short-circuit power – the Quality of Service provided was not so satisfactory.

CONCLUSIONS

- The degree of fulfilment regarding harmonic and flicker control was high.
- The disturbance levels recorded in the three Utilities were similar. However, the company with the highest levels of harmonics showed the lowest levels of flicker and vice versa.
- The harmonic levels throughout the 10 years have remained practically steady. Nevertheless, a slightly decreasing tendency has been observed in flicker levels.
- The lowest levels of harmonics have taken place during the periods of the year in which residential customers are normally on holiday. In addition, no correlation between flicker levels and periods of the year has been found.
- The harmonic daily profile was similar to the load curve of residential customers, whereas the flicker daily profile resembled the load curve of general customers.
- The degree of fulfilment in harmonics was higher than in flicker.
- The treatment of complaints about flicker led to the awareness of the presence of this phenomenon in the LV network.

REFERENCES

[1] Anexo a la Resolución ENRE 184/2000. Base Metodológica para el Control de la Calidad del Producto Técnico. Etapa 2.

[2] Anexo a la Resolución ENRE 99/97. Base Metodológica para el Control de la Emisión de Perturbaciones. Etapa 2.

[3] IEC 61000-4-7. Part 4: “Testing and measurement techniques. Section 7: General guide on harmonics and interharmonics measurements and instrumentation, for power supply system and equipment connected thereto”.

[4] IEC 61000-4-15. “Flickermeter. Functional and design specification”.

[5] “Power Quality Indices and Objectives”. CIGRE C4 WG 07, March 2004.