Chapter 3

3.0 Standards & Regulations

3.1 Why Standards?

This chapter will be concentrated on standards governing the problem of phase unbalances and neutral currents. This is the only way a restriction can be imposed on consumers to make sure power distribution quality is maintained. The levels are given only to maintain an acceptable power quality. But how much a large consumer is loosing due to not maintaining at least the levels when he can easily do is the main concern of this whole research study.

In a Sri Lankan context I have never come across a situation where the consumer is blamed of low power quality. The only charge which can be closest based on power quality issue is the maximum demand charge which in turn is the power factor of the load centre for large consumers. Therefore large consumers invest on power factor correction capacitor banks to keep the maximum demand low, because the financial payback is acceptable in this case. But other than that no other low power quality penalties exist in the tariff structure.

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Due to the above fact that low power quality is not penalized, we could see many issues in the power system of Sri Lanka. Many power quality problems in the system are due to the load centres being of low quality concern. One side of the story is that consumers are not at all concern over balancing their power system. They are unaware of the losses due to unbalance system. Balancing is only during the design which the electrical design engineer will take care of and after that it has not been of concern to anyone. The system under operation is entirely different from what it was installed after few years.

On the other hand various non standardised components are used across different consumers. Low quality fluorescent ballasts, low quality drives and computers and other equipment manufactured without standards are flooding the market. The whole issue of importing low quality components has caused the power system of Sri Lanka to suffer.

For an example from my personal experience the feeder line reaching to Batticloa all the way through Polonnaruwa is full of power quality problems. Power sags, harmonics, voltage variations are just to name a few issues. This line is feeding rice mills with huge motors and the quality has not been anyone's concern.

3.2 Relevant Standards

Several standards of different international standard organizations and professional bodies were studied for this research. Unfortunately there exist neither Sri Lankan standard for power quality nor an adopted stringent rule for any international standard. Some of the major governing bodies of power quality standard are given below.

- International Electrotechnical Commission (IEC) of London, England
- Institute of Electrical and Electronics Engineers (IEEE) of USA
- British Standard (BS)
- European Standard (EN)
- National Electrical Manufacturers Association (NEMA)

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I had visit to several libraries and standard organizations to study these standards. Unfortunately these are not available free of charge. These are sold not at a nominal price. This could be a reason for not adopting standard due to limitation in accessibility. A summary of standards is given below.

3.2.1 IEC

- The ratio of the negative or zero sequence to the positive sequence is given as the imbalance percentage.

$$U_u = (U_i / U_d) *100 \%$$

$$U_u = (U_h / U_d) *100 \%$$

$$I_u = (I_i / I_d) *100 \%$$

$$I_u = (I_h / I_d) *100 \%$$

Where,

U_u is the voltage unbalance

U_i is the voltage inverse(negative) sequence

U_d is the voltage direct(positive) sequence

U_h is the voltage homopolar(zero) sequence

I_u is the current unbalance

I_i is the current inverse (negative) sequence

I_d is the current direct (positive) sequence

I_h is the current homopolar (zero) sequence

- Limits for the unbalance ratio defined by above equation is less than 2 % for LV and MV systems and less than 1 % for HV, measured as 10-minute values, with an instantaneous maximum of 4 %.

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- Standard 61000-3-2 and 61000-3-3 describes harmonics and their tolerable limits. Equipments are divided into different classes as class A, B, C and D. Following is the table for class D equipment.

Harmonic	Maximum permissible harmonic current per watt (mA/W)
3	3.4
5	1.9
7	1.0
9	0.5
13	0.35
Other odd up to 39	3.85/n

Table 1 : Harmonics regulations on IEC

94555

3.2.2 BS EN 50160

- Imbalance standard is given as negative sequence RMS to be 2% of the positive sequence RMS as the described testing method in the standard.

- This standard also gives the limitations for the harmonics levels. The harmonic order is divided into multiple harmonic, odd and even harmonics. U_n is the RMS value of the harmonic as a percentage of the fundamental.

Odd Harmonic				**Even Harmonic**	
Not a multiple of 3		**Multiple of 3**			
Order	**U_n(%)**	**Order**	**U_n(%)**	**Order**	**U_n(%)**
5	6.0	3	5.0	2	2.0
7	5.0	9	1.5	4	1.0
11	3.5	15	0.5	6 to 24	0.5
13	3.0	21	0.5		
17	2.0				
19	1.5				
23	1.5				
25	1.5				

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Table 2 : Harmonics regulations on BS EN

3.2.3 IEEE

In contrast IEEE describes the standards of the harmonic levels as below. This is a much simpler categorization and description of the similar standard. This is described in IEEE519 standard.

- The utility is responsible for maintaining quality of voltage waveform

- The customer is responsible for limiting harmonic currents injected onto the power system.

Bus voltage	Maximum individual harmonic component	Maximum THD (%)
69 kV and below	3.0%	5.0%

69 to 161kV	1.5%	2.5%
Above 161kV	1.0%	1.5%

Table 3 : Voltage regulations on IEEE

3.2.4 NEMA Standards

On NEMA standards maximum deviation of voltage is defined as below.

Voltage Unbalance = Maximum Deviation from mean of (Va,Vb,Vc)/Mean of Va,Vb,Vc

Realising that voltage unbalance causes extra losses, in order to safeguard motors from overloading NEMA has developed a derating curve as shown by Figure 13. This curve assumes that the motor is already delivering the rated load. According to this curve it is required that any motor should be built to handle 1% unbalance and thereafter it should be derated depending on the level of unbalance. For example if the unbalance is 3% a 10kW motor should be loaded up to only 9kW. If 10kW of power is to be developed with 3% unbalance the motor should be rated to about 12kW or should have a service factor of 1.15. Operation of an induction motor above 5% voltage unbalance is not recommended.

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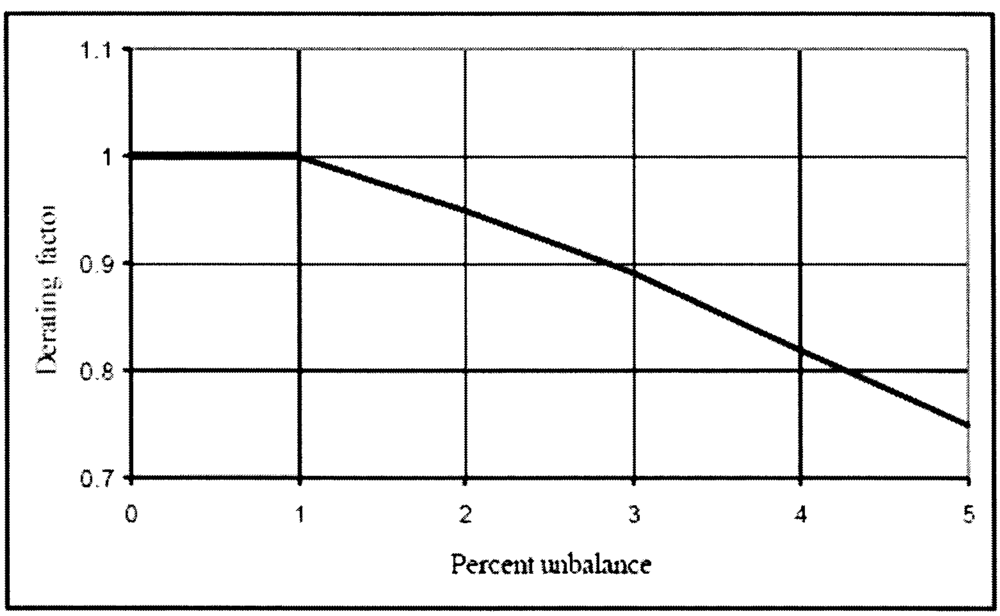

Figure 13 : Motor derating with percentage unbalance