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Guide & Requirements for Harmonic Control for Entities Connected at Voltages above 35 kV

Original title was:

"Guide & Requirements for Harmonic Control for Entities Supplied at a Voltage Level from 69kv to 287kv"

November 1993

Prepared
by

Regional System Planning Department
System Planning Division
B.C. Hydro

January 1999

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1. INTRODUCTION

1.1 Scope

This document provides guidance and requirements on the limits of harmonic distortions that may be introduced into the B.C. Hydro system by entities connected at a voltage below 35kv. The purpose is to establish a rational procedure for the control of harmonic distortions shared between B.C. Hydro and connected entities. This document also defines the responsibilities of B.C. Hydro in providing and administering interconnections for harmonic-producing entities.

1.2 Definitions

(1) *Point of common coupling (PCC)*: The point of common coupling is defined as the B.C. Hydro point electrically nearest to the entity installation. This point is normally the primary bus of the entity supply transformer.

(2) *Individual harmonic distortion (IHD)*: The individual harmonic distortion value of a waveform is defined as the RMS value of a harmonic component expressed as a percentage of the RMS value of the fundamental frequency component. In the case of harmonic voltage distortion, the nominal operating voltage shall be used as the RMS value of the fundamental frequency component. In the case of harmonic current distortion, the maximum fundamental frequency load current under normal operating conditions shall be used as the RMS value of the fundamental frequency component.

(3) *Total harmonic distortion (THD)*: The total harmonic distortion value of a waveform is the root-sum-square of individual harmonic distortion values, as defined in Equations (1.1) and (1.2). B.C. Hydro requires that harmonics up to fortieth (40th) shall be included in the THD calculation:

$$THD(voltage) = \frac{\sqrt{V_2^2 + V_3^2 + \ \dots \ + V_{40}^2}}{V_{1(nominal)}} \qquad (1.1)$$

$$THD(current) = \frac{\sqrt{I_2^2 + I_3^2 + \ \dots \ + I_{40}^2}}{I_{1(maximum)}} \qquad (1.2)$$

(4) *Total harmonic current*: Total harmonic current of a current waveform is defined as the root-sum-square of the RMS magnitudes of individual harmonic currents:

$$Total\ harmonic\ current \ = \ \sqrt{I_2^2 + I_3^2 + \dots + I_{40}^2} \qquad (1.3)$$

(5) *Residual I*T product*: The residual I*T is the root-sum-square value of the zero sequence RMS harmonic currents multiplied by the TIF weighting factors. The values of TIF weighting factor can be found in reference [1] or [6].

(6) *Noise Metallic (Nm)*: Noise metallic, which is also referred to as telephone circuit noise, is defined

as a metallic voltage impressed between tip and ring of a telephone set and measured as a power level across a 600W load. Nm is expressed mathematically as 10´log (unit: dBrn) of the square of the difference between the tip-to-ground and the ring-to-ground voltages divided by the metallic circuit impedance. The metallic voltage is normally weighted with certain factors at different frequencies. This guideline uses C-message weighted voltage (dBrnC) [6].

(7) *Noise to Ground (Ng)*: Noise to ground, which is a measurement of the influence of power system currents on a telephone circuit, is the average of tip-to-ground and ring-to-ground voltages measured as a power level across a 600W load. Ng is expressed mathematically as 10´log (dBrn) of the square of the average voltage divided by the reference impedance of 600W. This guideline uses C-message weighted average voltage (dBrnC) [6].

(8) *Cable (longitudinal) Balance*: Cable balance, which is a measurement of the susceptibility of a telephone cable, is the difference between noise to ground and noise metallic expressed in dBrnC [6].

(9) *Background Voltage Harmonics*: Background voltage harmonics are the harmonic voltages that exist at PCC when the entity connection is not connected to the supply system or is connected but not drawing load current from the supply system.

(10) *Total Plant Load*: Total plant load is the calculated total plant MVA demand, without subtracting entitie's co-generation capacity if any, for normal plant operation.

(11) *Harmonic Loads:* Harmonic loads in a plant are those primary industrial loads that can cause more than 5% of total harmonic distortion in the load currents when supplied with a sinusoidal 60Hz voltage. In most cases, harmonic loads are Arc furnaces, DC drives, variable frequency AC drives, rectifiers, and possibly uninterruptible power supplies.

1.3 References

This guideline makes reference to the following documents:

[1] IEEE Std.-519: "IEEE Recommended Practices and Requirements for Harmonic Control in Electric Power Systems", 1992.

[2] CSA-C22.2 No.0.16-M92: "Measurement of Harmonic Currents", 1992.

[3] CSA-C22.2 No.3: "Inductive Co-ordination", 1954 and No.3.1: "Inductive Coordination Handbook", 1974. (This standard is currently under revision.)

[4] CIGRE JTF 36.05.01/14.03.01 Report: "Connection of Harmonic Producing Installations in High-Voltage Networks with Particular Reference to HVDC", 1991.

[5] UK Engineering Recommendation G.5/3: "Limits for Harmonics in the United Kingdom Electricity Supply System", 1976.

[6] CEA&TCEC Joint Report: "Electrical Coordination Guide", 1989.

2. GENERAL PROCEDURE

This guideline deals with harmonic-producing installations in categories, according to the size of an installation and the capacity of its supply system.

Category 1 (small) installations can be accepted by B.C. Hydro without performing detailed harmonic analysis in the plant design stage[1].

Category 2 (large) installations are required to perform and submit for B.C. Hydro's inspection harmonic study at the plant design stage. The study shall demonstrate that B.C. Hydro's harmonic design limits are met.

At B.C. Hydro's sole discretion, certain entities are required to demonstrate, through field measurements, that their installations comply with B.C. Hydro's harmonic measurement limits during the plant commissioning stage and/or normal operation.

2.1 Criteria for Category 1 Installation

A entity installation is considered as category 1 if

(1) The ratio of total harmonic load MVA in the plant with respect to the total plant load MVA, in percentage, is below the curves shown Figure B.1. The total harmonic load MVA shall be estimated according to the following formula:

$$\begin{gathered}\textit{Total harmonic load MVA} = \\ \textit{0.85x(total MVA of harmonic loads configured in more than 6 pulses)} + \\ \textit{1.00x(total MVA of other harmonic loads in the plant)}\end{gathered} \qquad (2.1)$$

(2) The entity capacitors should not cause harmonic resonances, namely the following condition is satisfied for every harmonic number h:

$$|h_{resonance} - h| > \begin{cases} 0.35 & h = 5,7,11,13,17\ldots \\ 0.1 & h = 2,4,6,8,10\ldots. \\ 0.15 & h = 3,9,21,27\ldots.. \end{cases} \qquad (2.2)$$

In the above equation, $h_{resonance}$ is the (parallel) resonance frequency in multiples of 60Hz. This frequency

[1] If any category 1 installation causes harmonic problems, B.C. Hydro is entitled to apply harmonic design and measurement limits to the installation.

is normally obtained by a frequency scan analysis of the plant. This equation needs to be checked only for the two harmonics adjacent to h resonance. If there is only one capacitor location in the plant, the frequency may be estimated according to Equation (2.3):

$$h_{resonance} = \sqrt{MVA_{sys} / MVA_{cap}} \tag{2.3}$$

where MVA_{sys} is the system fault MVA seen at the capacitor bus. This MVA shall include the contribution of non-harmonic-producing loads such as motors in the plant. MVA_{cap} is the installed capacitor MVA calculated at normal operating voltage. It shall be noted that both MVA_{sys} and MVA_{cap} may vary with the operating conditions of the supply system and the plant. The limits of Equation (2.3) shall be satisfied for all conditions.

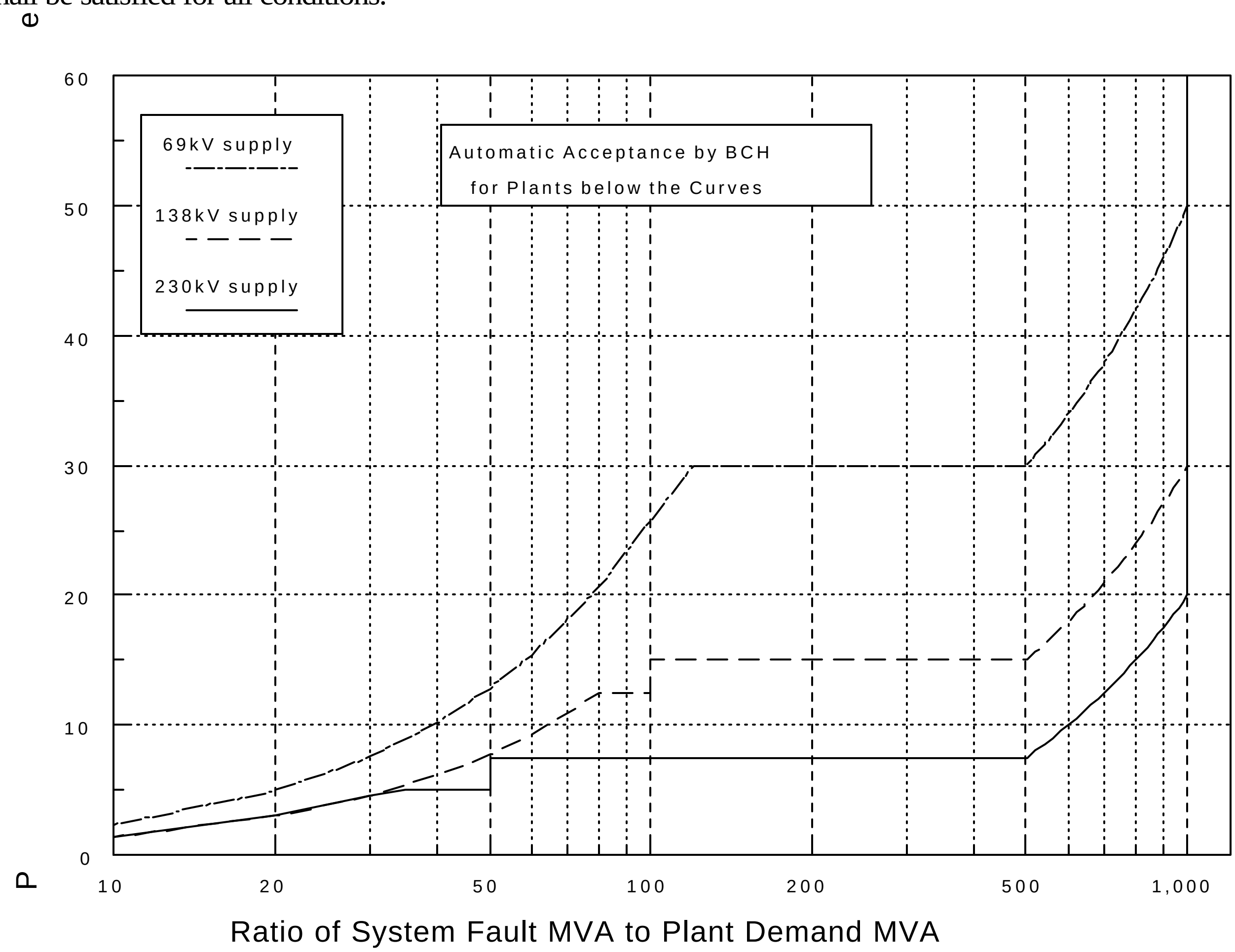

Figure B.1 Criteria for Category I Installation.

2.2 Criteria for Category 2 Installation

Any installations not belonging to category 1 are considered as category 2. These installations shall satisfy B.C. Hydro that the harmonic design and/or measurement limits as specified in Sections 3 and 4 are complied with.

2.3 Engineering Information Required from Entities

Entities in either category shall provide B.C. Hydro with the following data:

(1) Single-line diagram of the installation.
(2) All non-harmonic-producing industrial loads (for most entities this means the load with demand greater than 500 kW).
(3) All harmonic producing industrial loads, **and power sources** (demand greater than 500 kW for most entities) and their harmonic spectrums.
(4) Supply transformers and other transformers for primary industrial application purpose.
(5) Distribution cables and lines that cannot be neglected for harmonic analysis.
(6) Power factor correction capacitors and harmonic filters, if any.
(7) A harmonic assessment report based on the above information. For category 1 installation, the report shall demonstrate that the installation can be considered as category 1. For category 2 installation, the report shall demonstrate that the B.C. Hydro harmonic design and/or measurement limits are satisfied.

2.4 Examples

Example 1

- The total plant load is 100 MVA
- Utility supply is at 287 kV
- The system fault level a PCC is 5000 MVA

Therefore the ratio of system fault MVA to demand MVA is 50 (=5000/100)

Harmonic producing loads in the plant are as follows:

- 6.0 MVA of 12 pulse DC drives
- 5.0 MVA of other harmonic loads

Total harmonic load is then 10.1 MVA (=1.00x5.00+0.85x6.00), as per Eqn. (2.1)

Therefore percentage total harmonic load is 10.1% (=10.1/100)

Conclusion:

As per Figure B.1, point (50, 10.1%) falls above the 287kv curve. The installation is a category 2 type and requires harmonic studies at the plant design stage.

Example 2

- The total plant load is 30 MVA
- Utility supply is at 69 kV
- The system fault level at PCC is 1700 MVA

Therefore ratio of system fault MVA to plant demand MVA is 57 (=1700/30)

Harmonic producing loads in the plant are as follows:

- 2.0 MVA 12 pulse adjustable speed drives
- 3.2 MVA other harmonic loads, including a 2 MVA 6 pulse DC drive

Total harmonic load is then 4.9 MVA (=1.00x3.2+0.85x2.00), as per Eqn. (2.1)

Therefore percentage total harmonic load is 16.3% (=4.9/30)

Conclusion:
As per Figure B.1, point (57, 16.3%) falls below the 69kv curve. The installation passes the harmonic chart requirement.

Harmonic resonance check is as follows:

- The plant capacitor banks installed in one location are 1.2 MVAR
- The fault level at the capacitor bus is 150 MVA

Therefore h resonance is 11.18 $(=\sqrt{(150/1.2)})$

|hresonance -h| =0.18 < 0.35 for h =11 not okay
=0.82 > 0.10 for h =12 okay

Conclusion:
Although satisfying the harmonic chart requirements, the plant fails the harmonic resonance check. The installation is a category 2 type, and requires harmonic analysis in the plant design stage.

Example 3

- The total plant load is 30 MVA
- Utility supply is at 69 kV
- The system fault level at PCC is 1700 MVA

Therefore ratio of system fault level to demand MVA is 57 (=1700/30)

Harmonic producing loads in the plant are as follows:

- 2.0 MVA 12 pulse adjustable speed drives
- 3.2 MVA other harmonic loads, including a 2 MVA 6 pulse DC drive.

Total harmonic load is them 4.9 MVA (=1.00x3.2+0.85x2.0), as per Eqn (2.1) Therefore percentage total harmonic load is 16.3% (=4.9/30)

Conclusion:

As per Figure B.1, point (57, 16.3%) falls below the 69 kV curve. The installation passes the harmonic chart requirement.

Harmonic resonance check is as follows:

- The plant capacitor banks, installed in one location, are 2.1 MVAR
- The fault level at the capacitor bus is 190 MVA

Therefore hresonance is 9.51 (=√(190/2.1))

|hresonance -h|	= 0.51 > 0.15	for h=9 okay
	= 0.49 > 0.10	for h=10 okay

Conclusion:

The installation meets the requirements for the harmonic chart as well as the harmonic resonance check. The installation is a category 1 type, and can be accepted without performing detailed harmonic analysis in the plant design stage.

3. HARMONIC LIMITS FOR DESIGN PURPOSE

3.1 General

At the plant design stage, category 2 entities shall satisfy B.C. Hydro that the calculated current and voltage distortions at the point of common coupling shall not exceed the design limits. Worst case normal operating conditions shall be used in the calculation of harmonic distortions. For entities with transformer arrangements that result in zero sequence current injections into B.C. Hydro system, the amount of zero sequence harmonic current injections must be calculated. For those entities whose loads are unbalanced among three phases and can result in a voltage imbalance[2] greater than 1.5% at PCC, three-phase harmonic analysis is required.

3.2 Harmonic Current Limits

Limits for harmonic current distortion are shown in Tables 3.1A, 3.1B and 3.1C. These limits apply to each phase current individually at the point of common coupling. Harmonic current distortion shall be calculated using two sets of system impedance data:

(1) The supply system harmonic impedance as seen from the point of common coupling is zero at all harmonic frequencies. This assumption is needed since the system harmonic impedance can be zero at any frequency due to resonances in the B.C. Hydro system. Using zero harmonic impedance also ensures that the entity plant contains their own harmonic currents and the

[2] Voltage imbalance is defined as the ratio of negative sequence voltage to the positive sequence voltage.

harmonic currents escaping into B.C. Hydro system are minimized.

(2) The supply system harmonic impedances are the same as those provided by B.C. Hydro. The purpose is to determine if there is any excessive harmonic current injection into B.C. Hydro system caused by the harmonic resonance between the system impedance and the entity capacitor banks.

It must be noted that the limits shown in Tables 3.1 apply only to the harmonic currents introduced by entity installations. A zero background harmonic distortion shall be assumed in the calculation therefore. The results are the harmonic currents exclusively due to entity installations. Since problems may be caused by the amount of harmonic current injections into supply systems irrespective to the magnitude of fundamental frequency current at the PCC, this guide also imposes ampere limits on the total harmonic current injection. For most B.C. Hydro connected entities, satisfying the percentage harmonic current limits generally results in the satisfaction of the ampere limits.

Table 3.1A: Harmonic Current Distortion Limits (35kV to 69 kV)

I_{sc}/I_L	h<11	11≤h<17	17≤h<23	23≤h<35	35≤h	THD
£20	4.0	2.0	1.5	0.6	0.3	5.0
(20 50]	7.0	3.5	2.5	1.0	0.5	8.0
(50 100]	10.0	4.5	4.0	1.5	0.7	12.0
(100 1000]	12.0	5.5	5.0	2.0	1.0	15.0
>1000	15.0	7.0	6.0	2.5	1.4	20.0

Limits for total harmonic current: 20 A

Note: 1. Even harmonics are limited to 25% of the IHD limits above.
2. Triple order harmonics are limited to 35% of the IHD limits above.

Where I_{sc} = Maximum system short circuit current at PCC.
I_L = Maximum average fundamental frequency total load current at PCC.
h = Harmonic order.

Table 3.1B: Harmonic Current Distortion Limits (138 kV)

I_{sc}/I_L	h<11	11≤h<17	17≤h<23	23≤h<35	35≤h	THD
£20	2.0	1.0	0.75	0.3	0.15	2.5
(20 50]	2.5	1.75	1.25	0.5	0.25	4.0
(50 100]	5.0	2.25	2.0	0.75	0.35	6.0
(100 1000]	6.0	2.75	2.5	1.0	0.5	7.5
>1000	7.5	3.5	3.0	1.25	0.7	10.0

Limits for total harmonic current: 10 A

Note: 1. Even harmonics are limited to 25% of the IHD limits above.
2. Triple order harmonics are limited to 35% of the IHD limits above.

Where I_{sc} = Maximum system short circuit current at PCC.
I_L = Maximum average fundamental frequency total load current at PCC.
h = Harmonic order.

Table 3.1C: Harmonic Current Distortion Limits (above 138 kV)

I_{sc}/I_L	h<11	11£h<17	17£h<23	23£h<35	35£h	THD
<50	2.0	1.0	0.75	0.3	0.15	2.5
³50	3.0	1.5	1.15	0.45	0.22	3.75
Limits for total harmonic current: 6 A						
Note: 1. Even harmonics are limited to 25% of the IHD limits above. 2. Triple order harmonics are limited to 35% of the IHD limits above.						
Where I_{sc} = Maximum system short circuit current at PCC. I_L = Maximum fundamental frequency total load current at PCC. h = Harmonic order.						

3.3 Harmonic Voltage Limits

Limits for harmonic voltage distortion at the point of common coupling are listed in Table 3.2. Reducing harmonic voltage distortion is the responsibility shared between B.C. Hydro and the entity. A first-come-first-served policy is adopted in this guide. While B.C. Hydro is responsible to maintain the voltage distortion within the limits of Table 3.2, a new entity installation is limited to add certain harmonic voltage distortion at the PCC such that the combined voltage harmonics of background and entity contribution is within the limits of Table 3.2:

$$IHD_{customer} + IHD_{background} \le IHD\ Limits$$

$$\sqrt{\sum_{h=2}^{h=40} (IHD_{h\text{-}customer} + IHD_{h\text{-}background})^2} \le THD\ Limits \qquad (3.1)$$

The harmonic voltage limits apply to each phase voltage individually at the point of common coupling. The supply system harmonic impedance data provided by B.C. Hydro shall be used to determine the harmonic voltage distortions caused by the entity plants.

Table 3.2: Harmonic Voltage Distortion Limits

PCC Voltage	Voltage IHD (%)	Voltage THD (%)
35kV to 69 kV	3.0	5.0
138 kV	1.5	2.5
230	1.0	1.5

~~3.4 Engineering Information Provided by B.C. Hydro~~

B.C. Hydro will provide, **upon request**, the necessary engineering information required **for harmonic analysis of the entity connection .** If the information is considered to be critical to the equipment design, the entity can request B.C. Hydro to supply more **detailed** technical data, at the entity's expense, based on dedicated field measurements or harmonic studies on B.C. Hydro system.

The engineering information provided by B.C. Hydro includes:

(1) System fault level for harmonic studies:

The system fault level for harmonic studies may not be the same as those used to determine the breaker rating and protection setting of the entity plant. B.C. Hydro will specify what fault levels shall be used for harmonic analysis.

(2) Supply system harmonic impedance:

This information may be determined from field measurements and/or computer simulations by B.C. Hydro. It shall include various operating conditions, network configurations and future system expansions. Depending on the location and size of the plant, the harmonic impedance may take different forms:

- Impedances calculated from several system fault levels.
- A curve of system impedance as a function of frequency.
- A family of impedance-frequency curves.
- A range of harmonic impedances at each harmonic frequency.

(3) Background harmonic voltage distortion:

This information will be supplied in the form of harmonic voltage spectrums (magnitude). The data may be estimated according to B.C. Hydro's power quality survey data bank, measured at the point of common coupling, or calculated from harmonic analysis.

(4) Supply voltage imbalance:

B.C. Hydro is responsible to supply a voltage at the point of common coupling **with < 1.5 % voltage unbalance, 95 % of the time.** A voltage unbalance is defined as the ratio of negative sequence voltage with respect to the positive sequence voltage. Since the generation of harmonic currents is very sensitive to the supply voltage unbalance, the effects of voltage unbalance must be considered in entity's harmonic studies. For those entities with balanced three-phase loads, this means that the harmonic current spectrums representing the harmonic-producing loads must be determined assuming that there exists a 2% unbalance at the supply voltage. Under such a condition, a twelve-pulse DC drive is expected to produce 5th and 7th harmonic currents. As long as the harmonic source spectrums are modified to take into account the unbalance effects, harmonic analysis with a single-phase network representation is acceptable. For those entity plants with unbalanced three-phase loads (see Section 3.1 for the criteria), three-phase harmonic analysis is required. A **B.C. Hydro system** voltage unbalance of 1.5% at the PCC shall be used in the study.

3.5 Other Considerations

(1) Telephone interference due to harmonics

This guideline imposes no specific design limits on the calculated I*T values. This is because that the telephone interference is, in the majority of cases, caused by residual (zero sequence) harmonic currents. For those entities whose supply transformers are connected with primary in delta or ungrounded-star form, the calculated residual current flowing into B.C. Hydro system is always zero, and therefore, no direct telephone interference is expected. It shall be noted, however, that indirect harmonic-telephone interference is still possible. These interferences may be caused by the interaction of non-residual harmonic currents with the equipment of the supply system. Since the indirect interference is impossible to predict in most cases, the philosophy adopted in this guideline is to limit the total harmonic current in ampere value and the triple order harmonic current distortion, in addition to the IEEE limitations on IHD and THD.

For those entities supplied by transformers with grounded-star primary, three-phase harmonic and telephone interference studies are recommended. These studies can reduce the likelihood of the installation violating B.C. Hydro's telephone interference measurement limits specified in Section 4. As an approximate guide, the limit on calculated residual I*T product can be determined according to Equation (3.2). More accurate methods to assess the interference are described in [6].

$$\text{Maximum Residual } I*T\ (A) < \frac{1450\ (A*km)}{\text{Length of parallel explosure } (km)} \qquad (3.2)$$

(2) Effects of background harmonics on entity capacitors **and harmonic filters.**

While trying to meet B.C. Hydro's harmonic limits at the point of common coupling, entities may also keep in mind that their capacitors a**nd/or harmonic filters** may become a sink for the harmonic currents **originating** from outside their plants. This problem is normally caused by the parallel resonance between the capacitors and the system impedance (including the supply transformer impedance). Adherence to Equation (2.2) of Section 2.1 may reduce the likelihood of resonance and capacitor overload. **However, detailed harmonic studies are recommended for capacitor sizing and harmonic filter design.**

4. HARMONIC LIMITS FOR MEASUREMENT PURPOSE

4.1 General

Either B.C. Hydro or the entity can be responsible to perform harmonic measurement tests, depending on the purpose of the tests. Harmonic tests and limit check shall be conducted during the normal plant operating cycles. Conditions that require harmonic measurements may include:

(1) Harmonic problems are reported;
(2) New entity plant is commissioned; and
(3) Major system changes, either in B.C. Hydro system or in entity plant, are implemented.

4.2 Limits on Current and Voltage Distortions

The limits for measured harmonics are based on the design harmonic limits. However, factors such as time-varying nature of harmonics and entity plant start-up conditions are taken into account. For example, short time bursts of harmonic distortions higher than the design limits are generally acceptable. Two indices shall be used to measure the degree of harmonic bursts:

(1) Maximum Duration of Harmonic Burst ($T_{maximum}$): This is the maximum time interval in which the harmonic distortion exceeds a specified IHD or THD level during a 24 hour measurement period.

(2) Total Duration of Harmonic Burst (T_{total}): This is the summation of all the time intervals in which the harmonic distortion exceeds a specified IHD or THD level during a 24 hour measurement period.

The 24 hour measurement period shall be established on a calendar day basis. B.C. Hydro requires that, for 95% of the measurements (namely, 95 days out of 100 days), the measured IHD and THD levels must be limited according to the maximum and the total duration of harmonic burst $T_{maximum}$ and T_{total}, as shown in Table 4.1.

4.3 Limits on Telephone Interference

Telephone interference due to harmonics is a complex problem that involves three major factors: the existence of source of influence, the coupling between the source and telephone cable, and the susceptibility of telephone equipment. I*T product only addresses the problem of source of influence and therefore is incomplete. On the other hand, the complexity of the problem makes it impossible to accurately calculate the interference level with all three factors included. As a result, this guideline relies on measurements to check compliance.

The telephone interference measurement will be performed on any telephone set vulnerable to the entity plant harmonics. Two values, the noise to ground (Ng) and the noise metallic (Nm) will be measured. B.C. Hydro requires that, subject to cable balance (Ng-Nm) greater than 60.0 dBrnC, the noise to ground level shall be lower than 80.0 dBrnC.

Table 4.1: Limits for Measured Harmonic Distortions

Maximum Duration of Harmonic Burst ($T_{maximum}$)	Acceptable harmonic distortion level THD and IHD
1 sec. < $T_{maximum}$ ≤ 5 sec.	3.0 x (design limits)
5 sec. < $T_{maximum}$ ≤ 10 min.	2.0 x (design limits)
10 min. < $T_{maximum}$ ≤ 30 min.	1.5 x (design limits)
30 min. < $T_{maximum}$	1.0 x (design limits)
Total Duration of Harmonic Burst (T_{total})	**Acceptable harmonic distortion level THD and IHD**
15 sec. < T_{total} ≤ 60 sec.	3.0 x (design limits)
60 sec. < T_{total} ≤ 40 min.	2.0 x (design limits)
40 min. < T_{total} ≤ 120 min.	1.5 x (design limits)
120 min. < T_{total}	1.0 x (design limits)

4.4 Instrumentation Requirement

Instruments, which may include PT's and CT's, used for harmonic distortion and telephone interference measurements must be certified by B.C. Hydro. If there is any dispute over the accuracy of an instrument, CSA standard C22.2 [2,3] shall be used to resolve the dispute.

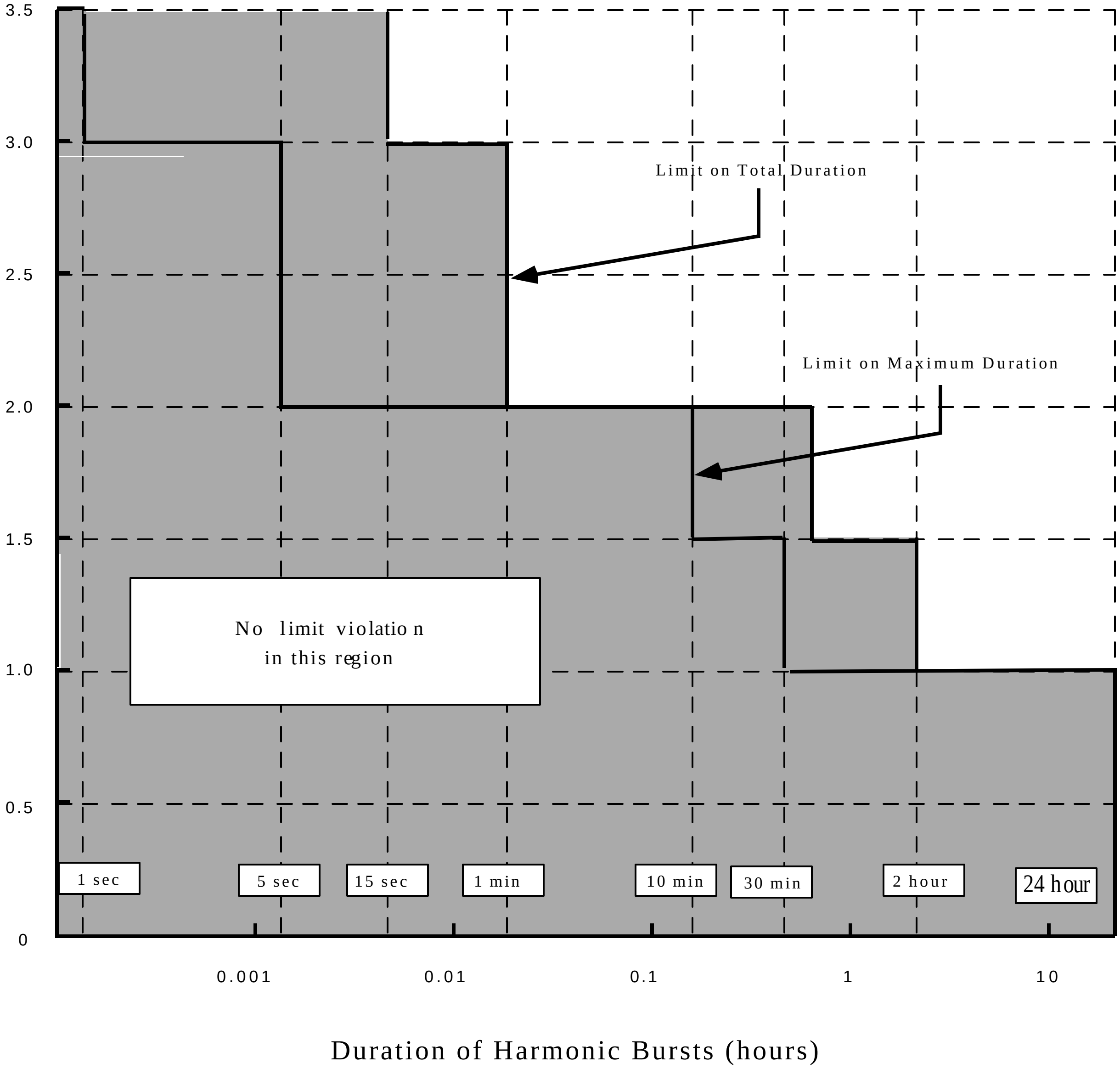

Figure 4.1 BC Hydro's limits on measured harmonics.

5. RESPONSIBILITIES FOR MITIGATION OF HARMONIC PROBLEMS

Adherence to the recommended limits of this guideline should reduce the risks of damage to, or malfunctioning of other entity's or B.C. Hydro's equipment. But there is no guarantee that this can completely prevent trouble arising. This section defines the responsibilities of each involved party to mitigate harmonic problems.

5.1 Harmonic Limits Exceeded

B.C. Hydro is responsible to ensure that the background harmonic voltage distortion **(before the entity connection is in service),** at the point of common coupling, is within the voltage distortion limits jointly specified in Table 3.1 and Table 4.1.

The entity is responsible to ensure that its portion of harmonic current distortion (**after the entity connection is in service),** at the point of common coupling, is within the voltage distortion limits jointly specified in Table 3.1 and Table 4.1.

If, after the entity connection is in service, the harmonic voltage distortion at the point of common coupling to B.C. Hydro exceeds voltage distortion limits, the entity is responsible to reduce the harmonic voltage. However, if the actual supply system harmonic impedances and background voltage distortions are outside the ranges specified by B.C. Hydro, B.C. Hydro is responsible to reduce the harmonic voltage distortion.

Telephone interference limits shall be complied with only if there is a harmonic-caused telephone interference problem. Subject to (1) noise to ground level greater than 80.0 dBrnC and telephone cable balance greater than 60.0 dBrnC or (2) noise to ground level greater than 90.0 dBrnc, the entity is responsible to mitigate the telephone interference problem. However, if the actual supply system harmonic impedances are outside the range determined by B.C. Hydro , B.C. Hydro is responsible to mitigate the problem.

5.2 Harmonic Limits not Exceeded

Problems caused by harmonics may arise even if harmonic limits are not violated. Under these circumstances, all involved parties may be responsible to mitigate the problems. **B.C.Hydro will co-operate with all parties involved to determine the most appropriate technical solution. Exact sharing of responsibilities shall be negotiated on a case by case basis.**

5.3 Determination of Limit Violation

B.C. Hydro is responsible to demonstrate the violation of harmonic voltage and current limits and identify the entity that causes harmonic problem. The telephone companies, with B.C. Hydro's co-operation, are responsible to demonstrate the violation of telephone interference limits and identify the entity that causes the interference problem.