

# Radiation Leakage Of Before-Sale and Used Microwave Ovens

by Artnarong Thansandote, David W. Lecuyer and Gregory B. Gajda

*This paper presents data from surveys of both before-sale and used microwave ovens in the greater Ottawa area. A survey of a total of 60 before-sale ovens was carried out to determine their compliance with the requirements of the Canadian Radiation Emitting Devices Regulations for microwave ovens. Similarly, over 100 used ovens were inspected to determine their microwave leakage levels and compare them to the maximum allowed leakage given in the regulations. None of the before-sale ovens were found to emit microwave radiation in excess of the maximum allowed leakage, and only one used oven leaked in excess of the maximum allowed leakage. A total of six before-sale ovens from three different manufacturers were found to be non-compliant with the labeling requirements.*

## Key Words:

Microwave radiation leakage, microwave ovens

**B**ecause of potential hazards, Health Canada introduced regulations for microwave ovens on October 23, 1974, and later amended them on December 12, 1979 [Health Canada, 1994].

The regulations were promulgated under the Radiation Emitting Devices (RED) Act and are referred to as "Microwave Ovens, part III, Schedule II in Chapter 1370 of the Consolidated Regulations of Canada, 1978." They governed the design, construction and functioning of microwave ovens sold, leased or imported into Canada. Some of regulatory requirements are indicated as follows:

- Oven doors must have at least two independent interlocks to ensure that the microwave power is turned off when the door is open and that the microwave power generator cannot be turned on while the door is open. If a door interlock fails, the oven must automatically be rendered inoperable.
- Microwave radiation leakage at 5 cm from any outer surface of the oven must not exceed 1 mW/cm<sup>2</sup> with a test load in the cavity, and 5 mW/cm<sup>2</sup> without a test load. For an oven that is designed for cooking and has a total microwave power-generating capacity not greater

than 1.5 kW, the test load must be 275 ± 15 ml of water at an initial temperature of 20 ± 5°C. The 1 and 5 mW/cm<sup>2</sup> allowable limits have been established to protect oven users and are at least 10 times lower than the threshold for adverse health effects that is generally accepted by scientific consensus [Health Canada, 1999].

- Ovens must have permanently affixed labeling on the external surface showing the name of the manufacturer, model number, serial number, date and place of manufacture, type of microwave generator, normal operating voltage and frequency and the normal maximum output power.
- A warning sign, clearly visible from a distance of at least 1 m, must be on the external surface of the oven. This sign must be a two-contrasting-color, inverted triangle containing a symbolic representation of a microwave generator and must contain the words "CAUTION — MICROWAVES" and "ATTENTION — MICRO-ONDES."

In Canada, the Radiation Protection Bureau (RPB) of Health Canada is responsible for the regulatory compliance of before-sale microwave ovens. Manufacturers intending to import, sell or lease microwave ovens voluntarily submit to RPB technical information showing that their oven models are in compliance with the regulations. However, after-sale (used) microwave ovens are not covered by these regulations. As ovens age, there



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is a possibility that the effectiveness of the door interlocks, hinges and seals could deteriorate with use and may consequently result in excessive leakage.

Over the past two decades, several surveys were carried out in order to evaluate radiation leakage levels from used microwave ovens. Based on the survey conducted at the US Fermi National Accelerator Laboratory between 1974 and 1985, the mean maximum leakage within 5 cm of the oven surface was  $0.2 \pm 3.1$  mW/cm<sup>2</sup> [Miller, 1987]. Annual surveys investigated in the UK from 1980 to 1987 showed that only a small number of the inspected ovens leaked in excess of 5 mW/cm<sup>2</sup> at 5 cm from the surface [Moseley and Davison, 1989], while none of the inspected appliances in Germany emitted microwave radiation exceeding 1 mW/cm<sup>2</sup> [Matthes, 1992].

After the Canadian microwave oven regulations were introduced, there was a marked improvement in the leakage levels [Stuchly, et al., 1978]. Despite the available data on microwave oven leakage, Canadian consumers remain concerned.

Advancement in microwave oven technology has resulted in lower oven prices, thus increasing use and ownership of ovens in Canada. Microwave ovens are now common in most Canadian homes as well as in restaurants and in commercial and industrial establishments. According to data published by Statistics Canada, Canadian households that have a microwave oven increased from 10.2% in 1982 to 86.3% in 1997. Because of low prices in the last few years, many Canadians have expressed concerns whether current generation microwave

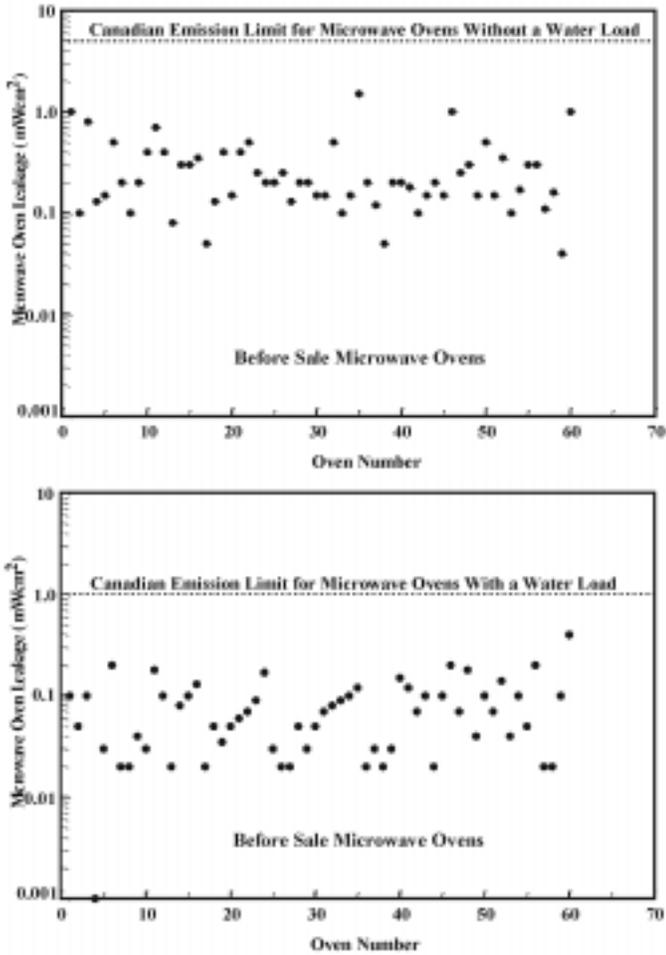
ovens are made as safe as older models. Some have even questioned whether their present ovens, which have been in use for several years, leak excessive microwave radiation. In order to address the issue, two separate surveys were conducted in the greater Ottawa area for both before-sale and used ovens. A total of 60 before-sale microwave ovens, representing 14 manufacturers, were inspected in eight retail outlets in the greater Ottawa area in the spring of 1997.

Subsequently, with the cooperation of oven owners, a survey of 103 used ovens representing 17 manufacturers was carried out. The age of the used ovens varied from less than a year to 23 years, with an average of eight-and-a-half years. This paper gives a summary of measurement data from these surveys and compares the measured leakage levels with the emission standards specified in the regulations.

### Methods

Prior to carrying out microwave leakage measurements, all surveyed models of before-sale and used microwave ovens were inspected for labeling, interlock functioning and the integrity of the door, hinges and seals. Other relevant information such as oven age, manufacturer and maximum output (microwave) power was also recorded.

Measurements of maximum microwave leakage, in terms of power density, emanating from all external surfaces of the ovens were conducted at 5 cm from all external surfaces with the cavity empty and with the cavity containing a 275 ml water load in a low form beaker. All the inspected ovens were adjusted to operate at maximum output power. The measurements were made using an electromagnetic radiation monitor (Narda 8110B) together with the following probes: (1) NARDA 8120A, rated for a



**Figure 1:** Graph showing leakage data of before-sale ovens with and without load.

maximum power density of 2 mW/cm<sup>2</sup> and a minimum sensitivity of 0.01 mW/cm<sup>2</sup> (2) NARDA 8121A, rated for a maximum power density of 20 mW/cm<sup>2</sup> and a minimum sensitivity of 0.1 mW/cm<sup>2</sup>.

**Results and Discussion**

**Before-Sale Ovens**

None of the before-sale units showed any visible damage other than minor enamel abrasions.

However, a total of six before-sale ovens from three different manufacturers were found to be in non-compliance with the labeling requirements. All manufacturers whose ovens were labeled incorrectly were contacted and were required to implement correct labeling on new oven models offered for sale, lease or importation into Canada. In all cases, affected manufacturers took

immediate corrective action to comply with the Radiation Emitting Devices Regulations. The microwave power of these units ranged from 580 W to 1000 W.

The results of radiation leakage measurements of before-sale ovens with and without load are shown in Figure 1. Each point on these plots represents the maximum microwave emission from one oven. Descriptive statistics with respect to radiation

leakage are listed in Table 1. It may be seen that the average levels of radiation leakage with and without a water test load were 0.08 and 0.3 mW/cm<sup>2</sup>, respectively. These levels are well below the respective limits of 1 mW/cm<sup>2</sup> and 5 mW/cm<sup>2</sup>, as specified in the regulations. Based on data in Table 2, a higher percentage of the surveyed ovens show a maximum leakage at the center of the door screen.

**Table 1:** Descriptive statistics on radiation leakage from the surveyed ovens

**Before-Sale (60 models)**

Statistics	No Load (mW/cm <sup>2</sup> )	Load (mW/cm <sup>2</sup> )
Maximum	1.5	0.4
Minimum	0.04	0.001
Average	0.3	0.08
Std. Dev.	0.28	0.07
Regulatory Limit	5	1

**Used (103 models)**

Statistics	No Load (mW/cm <sup>2</sup> )	Load (mW/cm <sup>2</sup> )
Maximum	5	4.5
Minimum	0.03	0.01
Average	0.52	0.17
Std. Dev.	0.77	0.45
Regulatory Limit	5	1

## Used Ovens

In the case of used ovens, some of the labels were no longer affixed to external surfaces due to age. The microwave power of these ovens ranged from 400 W to 1400 W, with an average value of 667 W.

The results of radiation leakage measurements of used ovens with and without load are shown in Figure 2. Each point on these plots represents the maximum microwave emission from one oven. Descriptive statistics with respect to radiation leakage are listed in Table 1. It may be seen that the average levels of radiation leakage with and without a water test load were 0.17 and 0.52 mW/cm<sup>2</sup>, respectively. These average levels are well below the microwave radiation leakage limits specified in the regulations. Similar to the case for before-sale ovens, the majority of used ovens shows a maximum leakage at the center of the door screen. As shown in Figure 2, one oven model was observed to have a maximum leakage of 4.5 mW/cm<sup>2</sup> when tested with a water load. The oven was 23 years old at the time of the survey. In contrast, a 22-year-old used oven emitted leakage well within the regulatory limit when



**Table 2:** Positions of maximum leakage around the surveyed ovens expressed in percentage of ovens.

Leakage Positions	Before-Sale Water Load	Used Water Load	Before-Sale No Load	Used No Load
<b>Door Frame</b>				
Right	11.7 %	10.6 %	8.3 %	1.0 %
Top	1.7 %	15.4 %	1.7 %	18.6 %
Bottom	11.7 %	7.7 %	11.7 %	8.3 %
<b>Door Screen</b>				
Top	5.0 %		5.0 %	1.0 %
Bottom	13.3 %	1.9 %	15.0 %	4.1 %
Center	51.7 %	38.5 %	51.7 %	43.3 %
<b>Cabinet</b>				
Top	3.3 %	1.9 %		
Timer	1.6 %	17.3 %	3.3 %	10.3 %
Door Release		6.7 %	3.3 %	13.4 %
Sum	100 %	100 %	100 %	100 %

tested with and without a water load. Thus, age is not the primary factor for excessive microwave leakage.

### Conclusions and Recommendation

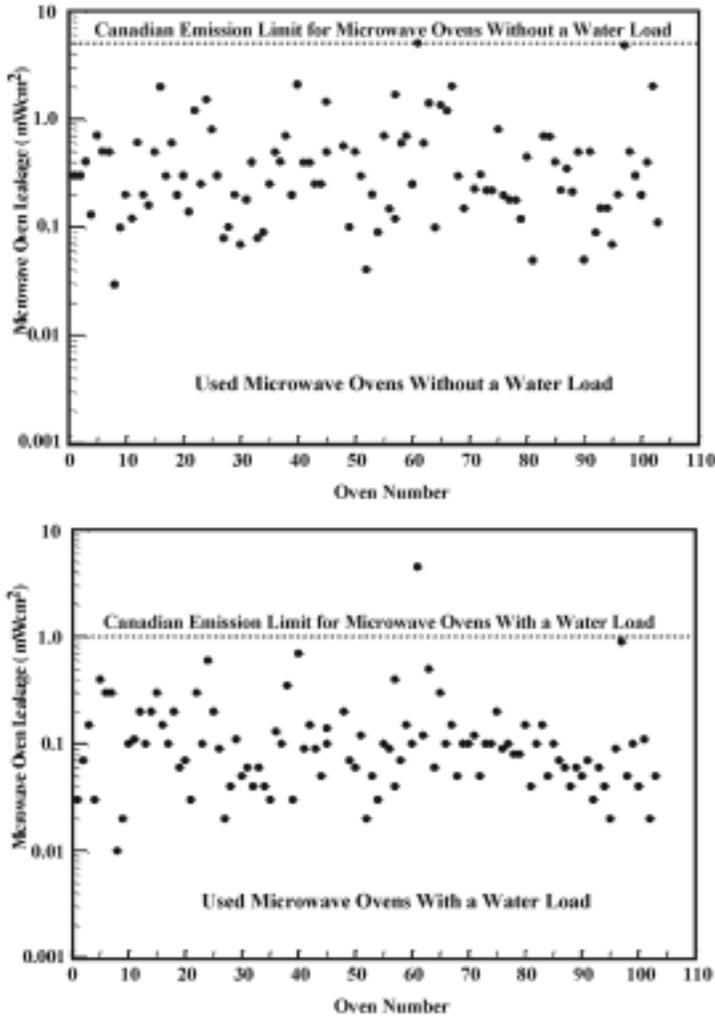
There is a continuing public concern about possible health hazards that may be caused by exposure to radiation emitted from microwave ovens. In order to protect people who are using these appliances, Health Canada promulgated regulations,

under the Radiation Emitting Devices Act, to deal with microwave ovens. The regulatory leakage limits are based on the scientific knowledge about health-related effects of microwaves, and considerable safety margins were incorporated to derive the safety limits.

Based on our recent surveys, all before-sale domestic microwave ovens were found to be in compliance with the regulations. Therefore,

exposures to microwave radiation during cooking with these ovens would, in general, be very low, and no detrimental health effects should occur. Of the 60 microwave ovens surveyed, there were six models which were incorrectly labelled. The manufacturers were notified of the deficiencies; rapid response was made to bring the product labels into compliance.

The microwave leakage levels from all



**Figure 2:** Graph showing leakage data of used ovens with and without load.

but one of the 103 used ovens were found to be within the limits specified in the regulations. Only one unit was found to emit microwave radiation in excess of the limit when tested with a water load. This unit was 23 years old at the time of the survey. However, excessive leakage was not observed on another oven of a similar age, and as such age cannot be taken as the definitive

consideration for excessive leakage.

Low radiation leakage levels can be maintained by keeping the microwave ovens in good working order, and this responsibility rests with the microwave oven owner. The most frequent causes of leakage from microwave ovens are mechanical abuse of doors and door seals, build-up of dirt around door seals,

improper servicing, and, with older ovens, failure to replace or repair worn-out door hinges and latches. If excessive leakage is suspected, microwave oven owners should contact the product manufacturer, distributor or service person to have the oven professionally inspected.

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### References

Health Canada. 1994. Radiation Emitting Devices Regulations. Available from Health Canada's Web site at: [www.hc-sc.gc.ca/rpb](http://www.hc-sc.gc.ca/rpb)

Health Canada. 1999. Limits of Human Exposure to Radiofrequency Electromagnetic Fields in the Frequency Range from 3 kHz to 300 GHz: Safety Code 6. Catalogue No. H46-2/99-237. Available from Health Canada's web site at: [www.hc-sc.gc.ca/rpb](http://www.hc-sc.gc.ca/rpb)

Matthes, R. 1992. Radiation Emission From Microwave Ovens. *J. Radiological Protection* 12: 167-172.

Miller, T. M. 1987. Results of Microwave Oven Radiation Leakage Surveys at Fermilab. *American Ind. Hyg. Assoc. J.* 48: 77-80.

Moseley, H., and Davison, M. 1989. "Radiation Leakage Levels From Microwave Ovens." *Annals of Occupational Hygiene* 33: 653-654.

Stuchly, M. A., Repacholi, M. H., and Lecuyer, D. 1978. "The Impact of Regulations on Microwave Ovens in Canada." *Health Physics* 37: 137-144.