

Ozone Laundry – Safety Issues



NGTC Project no. 138311,2

The Natural Gas Technologies Centre (NGTC) was founded in 1992 and is Canada's only independent Canadian technology centre dedicated to natural gas, from its distribution to its utilization. Through the development of advanced technologies and methods, we are promoting the use of natural gas as a mean to facilitate the transition from a fossil-based economy to a low-carbon energy economy.

Context and approach

In 2010, NGTC assisted Union Gas in the development of DSM measures related to ozone laundry treatment for hospitality and health care facilities. Linen services were also considered since they serve some of the hospitality and health care establishments that outsource their laundry.

It was determined that the use of ozone for light and medium soils laundry can reduce the energy consumption for water heating by approximately 86%, electricity consumption by 10%, water consumption by 29%, and energy costs by 70% for natural gas at 0.19\$/m³ and electricity at 0.10\$/kWh.

Union Gas has now given NGTC the mandate to investigate some safety issues of commercial ozone laundry systems. Issues of concern relate to potential ozone leakage into the laundry room and worker exposition to this gas, as well as ozone cleaning effectiveness for hospital laundry.

NGTC researched the web for information on those issues, and then contacted the people listed in Table 0-3¹. The main contacts are from PG&E, a California utility who has set up an incentive program for ozone laundry systems, and Barry L. Loeb, Editor-in-Chief of "Ozone News", a publication from the International Ozone Association (IOA), and Paul Overbeck, President of the International Ozone Association.

NGTC's objective was to find answers to the questions listed in Table 0-1 below.

In general, ozone laundry treatment is considered to be a **safe** and **reliable** technology. Ozone leakage in laundry room is not an issue for **properly designed systems**, with proper equipment maintenance and adequate worker training.

Major design issues:

There are two means of injecting ozone in water:

1. By **venturi- injection**. **Low risk** : Venturi-injection is very efficient in diluting ozone into water, such that concentration of remaining ozone in the air inside the washer is very small.
2. By **bubble diffusion**. **Risk dependent on system design**: Efficiency of bubble diffusion depends on the system design. With bubble diffusion, ozone is blown

¹ Success rate in reaching through contacts of approximately 25%.

into water in a sump tank. Mass transfer efficiency depends on the water height in the tank: if this height is not sufficient, not all ozone will be diluted into water, which will result in higher concentration of ozone in the air inside the washer. Ideally such systems should extract the gas from the machine and destroy the ozone before the doors of the machine are opened. There could also be potential risks of ozone leakage in the case defective machine door seals (proper maintenance required).

In any case, all systems should include an **ozone monitor to detect ozone before unsafe level is reached**, and laundry room ventilation. Proper equipment maintenance and proper worker training are also necessary.

Note that PG&E presently has an incentive program to encourage the implementation of commercial ozone laundry systems.

Also of potential interest to Union Gas:

- “Handbook of Ozone use in Laundries”, will be available later this month².
- Conference in Toronto in September 2011: <http://www.io3a.org/toronto2011.php>.

² On Amazon.com.

Table 0-1. Ozone laundry safety issues Q&A.

Questions and answers	Source
Q1. Are there or have there been risks of ozone leakage with ozone laundry systems?	
<p>If the systems are engineered properly, there should be no risk. Systems have to be maintained properly, otherwise there may be leakage. Note that Mr. Loeb is more familiar with water treatment industry. Track record in that industry is good.</p>	<p>Barry L. Loeb, Editor-in-Chief, Ozone News</p>
<p>Leakage risks should be a concern, since uncontrolled ozone concentrations could cause serious problems. However, the risk is minimal if the systems are engineered properly, well operated, maintained adequately and with proper worker training.</p> <p>«Misapplication and poor operation and maintenance of any product will cause issues not just ozone!»</p>	<p>Paul Overbeck, International Ozone Association</p>
<p>Ozone laundry systems are considered as safe. Has not heard anything of the contrary.</p>	<p>Quess Ellis, Energy efficiency liaison at PG&E</p>
Q2. If yes, are there technologies that are less prone to ozone leakage?	
<p>Ozone has to be injected into the water either by bubble diffusion (ozone bubbled directly into the sump of the wash) or venturi injection (ozone injected in the water before entering the washer).</p>	<p>PG&E Ozone laundry fact sheet³</p>

³ «PG&E Ozone laundry fact sheet», http://www.pge.com/includes/docs/pdfs/mybusiness/energysavingsrebates/rebatesincentives/ozonate_laundry_factsheet_announcement.pdf, page visited April 6, 2011.

Table 0-1. Ozone laundry safety issues Q&A.

Questions and answers	Source
<p>Ozone has to be injected into the water either by bubble diffusion or venturi injection. A technology where the ozone would be blown into the machine would be more risky in terms of ozone leaks.</p>	<p>Barry L. Loeb , Editor-in-Chief, Ozone News.</p>
<p>The risk is less with venturi-injection because the mass transfer efficiency (ozone dilution in water) is very high (not much ozone remaining in gaseous form).</p> <p>The risk is higher with bubble diffusion because the mass transfer efficiency is dependent on the system design. Hence, the system has to be well designed. With bubble diffusion, ozone is blown into water in a sump tank. Mass transfer efficiency depends on the water height in the tank: if this height is not sufficient, mass transfer efficiency will be less, which will result in higher concentration of ozone in the air inside the washer. Ideally such systems should extract the gas from the machine and destroy the ozone before the doors of the machine are opened. There could also be potential risks of ozone leakage in the case defective machine door seals.</p> <p>All ozone laundry systems should come with an ozone monitor.</p> <p>Mr. Overbeck emphasizes the need for proper design, operation, maintenance and worker training. Reference «Ozone safe work practices » by Worker’s Compensation Board of BC⁴.</p>	<p>Paul Overbeck, International Ozone Association</p>
<p>PG&E has a list of approved manufacturers (Trade Alliance Network</p>	<p>Quess Ellis, Energy efficiency liaison at PG&E</p>

⁴ «Ozone safe work practices», WorkSafeBC, http://www.worksafebc.com/publications/health_and_safety/by_topic/assets/pdf/ozone_bk47.pdf, web page visited April 8, 2011.

Table 0-1. Ozone laundry safety issues Q&A.

Questions and answers	Source
Q3. Has the technology improved in the recent years to eliminate those risks if they ever existed? How has it improved?	
The technology has been in the market for more than 20 years. In the past, there have been problems related to ozone generators ⁵ , but latest case studies indicate that this is not an issue anymore.	PG&E Emerging Technologies Program Report ⁶
Q4. Is the presence of ozone easily detectable in laundry rooms ? What measures are taken in the presence of ozone?	
Ozone has a pungent smell that is detectable at concentrations as low as 0.02 ppm to 0.05 ppm.	Ozone MSDS
All laundry rooms should be well ventilated because ozone smells.	PG&E Emerging Technologies Program Report
All ozone laundry systems should include an ozone monitor that detects ozone before it reaches unsafe levels. The monitor should control a ventilation system that would extract air from the laundry room in the case the monitor would sound an alarm.	Paul Overbeck, International Ozone Association
Local authorities will ask for an ozone detector that will sound an alarm when the concentration in the room is higher than 0.1 ppm.	Barry L. Loeb , Editor-in-Chief, Ozone News.
Q5. What are the regulations or guidelines pertaining to maximum levels of ozone in indoor environments?	
In Canada, the maximum level of 0.12 ppm for a maximum of one hour is the recommended maximum exposure for residences. See Table 0-2, which contains regulatory and recommended maximum exposure values for various countries.	ASHRAE Standard 62-1 - 2004 ⁷

⁵ Note: ozone generator problems are unrelated to ozone leakage. They are related to reduced capacity of ozone production.

⁶ Erik Kolderup, John Arent, Asim Tahir, « Pacific Gas and Electric Company- Emerging Technologies Program – Supplement to Application Assessment Report #0609 – Laundry Ozone Generators», September 10, 2007, 20p.

⁷ «ANSI/ASHRAE Standard 62.1 – Ventilation for Acceptable Indoor Air Quality », 2004, 120 p.

Table 0-1. Ozone laundry safety issues Q&A.

Questions and answers	Source
Q6. What are the potential effects of ozone exposition above recommended limits on human health?	
A prolonged exposure by humans to ozone has produced no apparent ill effects at 0.2 ppm. A one hour exposure at 50 ppm is generally considered fatal.	PG&E Emerging Technologies Program report
Ozone inhalation can result in dry mouth, coughing, irritation of nose, throat and chest, difficulty in breathing, headache and fatigue. Ozone exposure also causes irritation of the eyes and mucus membranes.	Ozone MSDS
«Ozone has been reported to mimic the effects of ionizing radiation, and may cause damage to chromosomal structures»	Ozone MSDS
Q7. Do all systems come with ozone detectors?	
All ozone laundry systems should come with an ozone monitor. Ozone detectors from major manufacturers are quite reliable.	Barry L. Loeb , Editor-in-Chief, Ozone News.
All ozone laundry systems should include an ozone monitor.	Paul Overbeck, International Ozone Association
Q8. Is ozone cleaning effectiveness ok for hospital laundry? What concentration of ozone is required?	
The concentration required depends on the application. With the right concentration, ozone is very effective for bacteria. Papers on this topic had been published by Dr. Rip Rice ^{8,9} .	Barry L. Loeb , Editor-in-Chief, Ozone News.

⁸ Rip G. Rice, Marc BeBrum, Jacqueline Hook, Dick Cardis and Cameron Tapp, «Microbiological Benefits of Ozone in Laundering Systems», pp 357-368
 Kyle Allison, Jacqueline Hook, Dick Cardis and Rip G. Rice. «Quantification of the Bactericidal, Fungicidal, and Sporocidal Efficacy of the JLA Ltd. Ozone Laundering System» .

⁹ NGTC tried to contact Dr. Rice but did not get any return call or e-mail.

Table 0-1. Ozone laundry safety issues Q&A.

Questions and answers	Source
Ozone is very effective if used properly. Some soils require only ozone and cold water while with other soils, ozone has to be combined with some wash chemicals. In the past, the role of wash chemicals has been neglected, which led to conclusions of bad effectiveness. Recent studies indicate that ozone is extremely effective, in addition to generating significant energy and water savings.	PG&E Emerging Technologies Program Report
Bacteriostatic test results show no decrease in laundry cleanliness due to the use of ozone at a hospital (North Mississippi Medical Center) .	EPRI ¹⁰ Ozone fact sheet ¹¹
The public health departments of the States of Missouri and New Hampshire have formally approved one of the four ozone laundry approaches, and other states are evaluating ozone laundering	International Ozone Association web site
Q9. Is there any Canadian standard relating to laundry sterilization in hospitals?	
The Canadian Standards Association offers standards dealing with decontamination, sterilization, and infection prevention and control in health care facilities ^[1] . One of those standards,«CAN/CSA-Z314.10 ^[2] » deals with laundry of some hospital textiles (reusable wrappers, surgical gowns and drapes).	NGTC

¹⁰ Electric Power Research Institute. NGTC called EPRI for additional information but since NGTC is not an EPRI paying member, NGTC's request for information could not be transferred to the institute's ozone system specialists.

¹¹ «EPRI Pressurized Ozone Hospital Laundry System Fact Sheet», 2005, <http://vonguntenuzone.com/application/ozone%20for%20laundry/hospital.pdf>, web page visited on April 6, 2011.

Table 0-2. Regulations and guidelines pertaining to indoor environments

	Enforceable and/or Regulatory Levels			Non-Enforced Guidelines and Reference Levels			
	NAAQS/EPA ¹²	OSHA	MAK ¹³	Canadian ¹⁴	WHO/Europe ¹⁵	NIOSH ¹⁶	ACGIH ¹⁷
Ozone	0.12 ppm [1 h] ¹⁸ 0.08 ppm	0.1 ppm	No max. value established (carcinogen)	0.12 ppm [1 h] 0.064 ppm	120 µg/m ³ [8 h]	0.1 ppm [C]	0.05 ppm ¹⁹ 0.08 ppm ²⁰ 0.1 ppm ²¹ 0.2 ppm ²²

¹² Outdoor air standard (USA).

¹³ For industrial environments (Germany).

¹⁴ For residential environments (Canada).

¹⁵ Non-industrial. For indoor and outdoor exposure (Europe).

¹⁶ For industrial environments (USA).

¹⁷ For industrial environments (USA).

¹⁸ Not to be exceeded more than once a year.

¹⁹ TLV @for heavy work; TLVs@ represent maximum acceptable 8-hour, time-weighted average,

15-minute short-term exposure limit and instantaneous (ceiling) case limits. They are to be applied for workers in industrial workplace.

²⁰ TLV for moderate work

²¹ TLV for light work

²² TLV for any work (maximum 2 hours)

Table 0-3. Contacts.

Name	Company	Field	Contact information
Quess Ellis,	PG&E	Utility	San Francisco, CA Tel: 1-559-263-5560 E-mail: qxe1@pge.com
Christine Tanner	PG&E	Utility	Northern Region, CA Tel: 1-707-299-7551 E-mail: cdt1@pge.com
Paul Overbeck (Executive Director)	International Ozone Association	Not-for-profit educational association made up of academics, consultants, manufacturers, regulatory staff, end users and interested parties with a charter to support the safe and effective use of ozone in global application	Tel: 1.480.529.3787 Fax: 1.480.473.9068 E-mail: pauloverbeck@io3a.org
Ami Patel ²³ (Program Director)	PG&E	Utility	Program Director, PG&E Tel: 415-973-8727 E-mail: abp6@pge.com
Barry Loeb (Editor-in Chief)	Ozone News and OS&E (Cincinnati, Ohio)	Publication	Tel : 1-513 385-3906 E-mail : blloeb@fuse.net

²³ Additional information from PG&E still to come.