Canadian Perspective on UV Drinking Water Disinfection and Impact of the US Environmental Protection Agency UV Disinfection Guidance Manual

Elia Edwards, M.A.Sc., P.Eng., Ian P.D. Wright, P.Eng., Associated Engineering
Suite 525, 21 Four Seasons Place, Toronto, Ont, M9B 6J8, Tel: (416) 622-9502, edwardse@ae.ca

INTRODUCTION

In Canada, drinking water standards are a provincial responsibility. There are no Federal regulations. However, a Federal/Provincial Subcommittee of Health Canada publishes the "Guidelines for Canadian Drinking Water Quality" (GCDWQ). The most recent guidelines (April 2003) are now available online in electronic form (www.hc-sc.gc.ca/hecs-sesc/water/dwgsup.htm). Each province is free to adopt as much or as little of the GCDWQ as it sees fit. As discussed in this article, while the GCDWQ form a foundation, the differences in drinking water regulations among the provinces are substantial.

This regulatory approach differs significantly from the approach used in the USA, where the Environmental Protection Agency (EPA) establishes Rules that are the basis for the standards in that country. Thus, in the USA, the Ultraviolet Disinfection Guidance Manual (UVDGM) will form a common reference for application across the entire country.

One difficulty with the GCDWQ is that specific treatment requirements for *Giardia* cyst and *Cryptosporidium* oocyst inactivation/removal based on source water quality characteristics have not yet been established. Within the GCWWQ, Health Canada has recommended that if past experience demonstrates that a particular raw water supply source could harbor pathogens for which E. coli are not good indicators (i.e., *Giardia* cysts and *Cryptosporidium* oocysts), then the source should receive treatment known to remove or inactivate these pathogens. This 'hands-off' approach places the onus on the owner of the public waterworks system to ensure that the necessary, yet undefined, level of treatment is provided. Both of these pathogens are found in many surface waters in Canada and so are of concern. Since the USEPA Surface Water Treatment Rule was promulgated in 1989, it has been used frequently as a reference standard in Canada by many engineers, municipal utilities and some provincial regulators. Following the *Cryptosporidium* outbreak in Milwaukee, Wisconsin (USA) and several smaller outbreaks in Canada, aspects of the USEPA Enhanced Surface Water Treatment Rule also were used as reference standards for Canadian applications.

Thus, the impetus to use UV disinfection has come substantially from the municipal utilities faced either with local regulations that draw, in part, upon the USEPA, or out of concern regarding public health or future regulations. This impetus is significant. Several large UV installations either are already in service or nearing completion and others are in design. Numerous other communities are evaluating UV disinfection. Table 1 is a summary of some of the UV disinfection systems in Canada.

IMPLEMENTATION OF UV TECHNOLOGY ACROSS CANADA

As previously noted, the differences between the various provincial drinking water regulations are substantial. In most cases, UV disinfection is not specifically addressed in the legislation. However, the regulators in some provinces have several provinces have recognized UV disinfection as an alternative disinfectant. The result is that application of UV disinfection is widespread across Canada.

QUEBEC EXPERIENCE

Within the Drinking Water Treatment Technologies Assessment Procedure, Environment Quebec has compiled information on the implementation of various leading-edge technologies such as UV from across the global waterworks industry into a single technology assessment protocol. This protocol provides a well-established and proven testing, monitoring and reporting framework for experimental technologies to transition from pilot-scale demonstration through full-scale validation through to becoming accepted as a 'mature' technology.

Environment Quebec specifically acknowledges UV as an acceptable alternate disinfection technology within the Regulation Respecting Drinking Water and its accompanying documents. The Design Guidelines identify the following effective doses for a given level of inactivation: 20 mJ/cm2 for 2.0-log (99%) inactivation of *Cryptosporidium* oocysts, 40 mJ/cm2 for 3.0-log (99.9%) inactivation of

Giardia cysts, and 80 mJ/cm2 for 4.0-log (99.99%) inactivation of viruses.

Environment Quebec mandates that for all proposed UV drinking water treatment systems, the equipment manufacturer must validate the performance of the UV equipment according to industry-acceptable standards across the range of site-specific operating conditions. In particular, validation must confirm the effective dose delivered by the UV reactor across the range of site-specific operating conditions and confirm sensor calibration on the basis of the effective dose delivered. The Design

Guidelines identify the following validation protocols as benchmarks: German (DVGW-W294), Austrian (ÖNORM 5873-1) or American (NWRI/AWWARF, Draft EPA -- UVDGM and NSF-55). If validation will be completed at the installation site and not one of the approved validation facilities, the protocol used must comply with one of the above protocols and approval must be obtained prior to commencing the testing. To obtain approvals, the equipment manufacturer must provide to the design engineer a copy of all test results, the validation procedure used, and the name of the independent agency that supervised the bioassay testing.

Partial List of Canadian UV Disinfection Systems

Location	Province/ Territory	Capacity	Status
Edmonton (EPCOR E.L. Smith)	Alberta	240 ML/d 63 MGD	Operational
Edmonton (EPCOR Rossdale)	Alberta	275 ML/d 73 MGD	On-line 2004?
Lethbridge	Alberta	150 ML/d 40 MGD	On-line 2003
Canmore	Alberta	11 ML/d 2.9 MGD	Operational
Camrose	Alberta	13 ML/d 3.4 MGD	Operational Victoria
(Capital Regional District)	B.C.	580 ML/d 153 MGD	On-line 2003 Vancouver
(Seymour/Capilano)	B.C.	1800 ML/d 475 MGD	On-line 2006 Sunshine
Coast Regional District	B.C. 32 ML/d	8.4 MGD On-line	2003
Swan River	Manitoba	5 ML/d 1.3 MGD	Operational
Winnipeg	Manitoba	490ML/d 129 MGD	On-line 2004
R.M. McDonald	Manitoba	6 ML/d 1.6 MGD	Operational
Iqaluit	Nunavut	9 ML/d 2.4 MGD	On-line 2003
St. John's	Nfld	20 ML/d 5.3 MGD	Operational
Deer Lake	Nfld	8 ML/d 2.1 MGD	
R.M.Waterloo (Mannheim)	Ontario	72 ML/d 19 MGD	Operational
North Bay	Ontario	11 ML/d 2.9 MGD	Operational
Owen Sound	Ontario	27 ML/d 7.1 MGD	On-line 2003
Brockville	Ontario	36 ML/d 9.5 MGD	On-line 2003
Eglin	Ontario	23 ML/d 6.1 MGD	Operational
Sudbury	Ontario	40 ML/d 10.6 MGD	On-line 2003
L'Epiphanie	Quebec	5 ML/d 1.3 MGD	On-line 2003
North Battleford	Sask.	6 ML/d 1.6 MGD	Operational

Ontario Experience

Within the Procedure for Disinfection of Drinking Water in Ontario, the Ministry of the Environment has provided some guidance with respect to the implementation of various leading-edge technologies such as UV irradiation. The Ministry of the Environment specifically acknowledges UV as an acceptable alternate disinfection technology within the Drinking Water Systems Regulation and its accompanying documents.

The Ministry of the Environment does not identify specific effective doses for a given level of inactivation of target organisms. However, as UV irradiation would be employed in conjunction with secondary chlorination for most surface water supplies and groundwater supplies under the direct influence of surface water, an effective dose of 40 mJ/cm2 has been acknowledged to provide the minimum 2.0-log (99%) inactivation of *Cryptosporidium* oocysts and the minimum 3.0-log (99.9%) inactivation of *Giardia* cysts, while secondary chlorination would address the minimum 4.0-log (99.99%) inactivation of viruses.

The Ministry of the Environment mandates that for all proposed UV drinking water treatment systems, the equipment manufacturer must validate the performance of the UV equipment according to industry-acceptable standards across the range of site-specific operating conditions. Similar to Quebec, the Ministry of the Environment has acknowledged the following validation protocols as benchmarks: German (DVGW-W294), Austrian (ÖNORM 5873-1) or American (NWRI/AWWARF, Draft EPA - UVDGM and NSF-55), and requires certified biodosimetry test results as part of the approvals process. The Ministry of the Environment also has prepared some internal documents as well as identified the 'Ten States Standards' as reference material for the design of UV systems. These documents provide additional guidance with respect to monitoring, control, alarming, and reporting of proposed UV systems.

Saskatchewan Experience

Although not specifically mentioned within the Water Regulations, Saskatchewan Environment regards UV irradiation as an acceptable alternate disinfection technology. An effective dose range of 24 - 45 mJ/cm2 has been identified within "A Guide to Waterworks Design" for the necessary level of *Giardia* cyst and *Cryptosporidium* oocyst inactivation. Similar to the approach taken by many of the other Provinces and Territories, Saskatchewan Environment envisions UV equipment validation based on industry-acceptable standards across the range of site-specific operating conditions.

Alberta Experience

At the time of preparing the existing Standards and Guidelines for Municipal Waterworks, Wastewater and Storm Drainage Systems (1997), UV irradiation was not included as an acceptable alternate disinfection technology. However, since then, Alberta Environment has been instrumental in assisting to develop much of the research that has lead to the widespread recognition and acceptance of UV technology in North America. In 2000, Alberta Environment issued a white paper on UV technology and acknowledged its acceptance as an alternate disinfection technology.

UV irradiation will be included in the suite of disinfection technologies in the revised 2004 Standards and Guidelines anticipated to be introduced in 2004. For successful implementation and approvals, Alberta Environment will continue to require full-scale validation of the proposed UV reactor based on one of the industry-accepted standards across the range of site-specific operating conditions. Alberta Environment has indicated that within the revised (2004) Standards and Guidelines, specific monitoring and reporting compliance requirements will also be identified for all drinking water UV systems.

British Columbia Experience

British Columbia has relatively few conventional water treatment plants. Many of the water sources in British Columbia have relatively low turbidity and, in some cases, well protected watersheds. Water treatment requirements are also substantially "outcome based" through negotiation with the local Drinking Water or Health Officer. As such, there is considerable interest in UV disinfection for both filtered and unfiltered drinking water applications. The regulators presently are relying on the design engineer in conjunction with the selected equipment manufacturer to demonstrate performance validation of the UV equipment according to industry-acceptable standards. These have been based largely on the current American and German standards with 40 mJ/cm2 being the common dose required to achieve 3.0-log (99.9%) *Giardia* cyst and 3.0-log (99.9%) *Cryptosporidium* oocyst inactivation.

Remaining Provinces and Territories

Although not specifically mentioned within the respective health acts or drinking water regulations, the regulatory agencies from Prince Edwards Island, Labrador and Newfoundland, Nova Scotia, New Brunswick, Manitoba, Yukon, Northwest Territories and Nunavut regard UV irradiation as an acceptable alternate disinfection technology in conjunction with secondary chlorination to ensure distribution system integrity maintenance for surface water supplies and groundwater supplies under the direct influence of surface water.

As the implementation of UV irradiation at public waterworks systems is predominantly still relatively new within all of these regions, the various regulatory agencies are approaching implementation and approvals on an individual and site-specific basis. The various regulatory agencies are relying on the design engineer in conjunction with the selected equipment manufacturer to demonstrate performance validation of the UV equipment according to industry-acceptable standards across the range of site-specific operating conditions.

USEPA UV DISINFECTION GUIDANCE MANUAL

Traditionally, there have been close ties between water supply practices in Canada and the USA. As already discussed, Canadian engineers, municipalities and regulators frequently draw upon the USEPA Rules to establish treatment objectives or standards. In addition, the American Water Works Association (AWWA) includes Canada in its area of service. Specific to UV disinfection of protozoans, a considerable amount of development work was carried out by Canadian companies and institutes that has contributed to the development of the UVDGM. Likewise, Canadians frequently have drawn upon US specialists and companies in the development of UV disinfection projects.

Therefore, the UVDGM is very much in line with practices in Canada and it is expected to become a fundamental design reference across Canada. The manual establishes the basic considerations and criteria for system location and design. Suggestions regarding design techniques such as the use of Computational Flow Dynamic (CFD) models will be valuable.

It is also expected that the UVDGM will be used to form the basis for at least some of the provincial regulations and design guidelines. The specifics pertaining to which validation protocol should be employed, or which design, monitoring and reporting standards should be considered, have yet to be established in the regulatory framework. For these criteria, the UVDGM will provide an excellent resource for many regulatory agencies as well as design engineers and waterworks personnel in assisting with the successful implementation of UV technology across Canada.

A common design basis for existing UV disinfection systems in Canada has been a validated 40 mJ/cm2 dose using at least the 95th percentile transmittance. This will bring most, if not all, current installations in line with the UVDGM "Tier 1" criteria with little or no change.

Possibly of more interest to some utilities and regulators will be the finalization of the UVDGM "Tier 2" approach. Larger utilities, in particular, may elect to use this approach where the additional costs of determining the site specific UV disinfection performance are offset by a more cost-effective end product along with greater knowledge of the performance of the system. Using this approach, some existing UV system owners may be able to demonstrate qualification for an increase in their permitted capacity by going through the "Tier 2" evaluation procedure.