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Best practices in regulating solar installations

 **TORONTO** Atmospheric Fund

## Technical Bulletin #2 : Inspecting Residential Solar Water Heating Systems

May 2010

### Introduction

The performance of a residential solar domestic hot water (SDHW) system is dependent on the design of the system, the performance and efficiency of the individual components and, of equal importance, the quality of the installation. Even “packaged” systems that come complete from a single manufacturer require a large amount of on-site design to maximize the system performance and to effectively integrate the SDHW system into the home’s hot water heating system.

Building codes are primarily focused on the safety of the product, which includes its installation on or in the building, its safe performance while in operation and, if it fails, that it fails safely. However product standards deal with a wider variety of issues, which can include safety, performance, and durability and industry best practices. For SDHW systems many of these issues (both codes and standard related) are highly dependent on the proper installation of the system.

One of the challenges that a building code regulator or a solar deployment agency faces is to identify what the critical elements are that need to be verified by inspection to ensure that the installation meets the requirements of codes, standards and — if involved — the objectives of the deployment agency.

The City of Toronto pilot SDHW deployment program — the Toronto Solar Neighbourhoods Initiative (TSNI) or Solar Neighbourhoods for short — has worked closely with the local regulator (Toronto Building) and various stakeholders to develop a number of forms and reports for the inspection of SDHW systems to meet code, standard, and program requirements.

### Installing to the Ontario Building Code

The Ontario Building Code requires that packaged SDHW systems be in conformance to CSA F379: *Packaged Solar Domestic Hot Water Systems*. This can be accomplished either through CSA certification (i.e. certified by CSA International) or through P.Eng stamped drawings (for the safety elements of F379).

Further, the Ontario Building Code requires that SDHW systems be installed in accordance to CSA F383: *Installation of Packaged Solar Domestic Hot Water Systems*.

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The Solar Permits Initiative has been developed by the Toronto Atmospheric Fund (TAF) to share knowledge gained through the largest single-city solar hot water project in Canada — Solar Neighbourhoods.

Solar Permits is made possible by an investment by the Government of Ontario and the Government of Canada.



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And finally there is the general requirement that a SDHW system meets the requirements for both plumbing safety in the building code, and, if the system is installed on a structure (i.e. installed on the roof of a house), that the installation is in compliance with the structural requirements of the code<sup>1</sup>.

In January 2010, there was a change to the Ontario Building Code to provide greater clarity on the backflow prevention requirements for SDHW systems (see Appendix 1).

## Installing to CSA F383

CSA F383: *Installation of Packaged Solar Domestic Hot Water Systems* provides a detailed outline of topics that the installer is required to follow or consider during the installation of a SDHW system. As well F383 provides a list of system site tests (see Table 1) that the installer must undertake as part of the system commissioning to ensure that the system is complete and that all components have been properly installed.

While this provides a good starting point for a regulator to determine areas to inspect to ensure compliance to F383, it does not verify that the product is installed in a way that meets other code requirements, such as backflow prevention, plumbing safety and structural compliance. Even for compliance to F383, it is generally inadequate as it does not provide precise inspection details. Descriptions such as “adequately sloped” in section 13.1c. are not definitive and hence do not provide the necessary level of detail for an inspector who must address what the “adequate slope” is.

## Inspection to Ensure Compliance to Code and Standard

One of the terms that most building inspectors in North America are familiar with is “inspection service level.” In most cases, it is not possible for building departments to fully inspect all elements of an installation to verify conformance to all elements of the building code due to budget restraints or because of employee health and safety policies. A certain level of trust must be placed in the professionalism of the installer or third-party verification from a P.Eng. or other “qualified” professionals stating that the installation is in compliance with the building code. Where a product is regularly installed in a jurisdiction, an inspection service level policy is often put in place defining what level of inspection for a particular project (or product) is expected from the building inspector.

In Canada the Canadian Solar Industries Association (CanSIA) has established a program to certify SDHW installers. A CanSIA certified SDHW System installer<sup>2</sup> is trained to install systems to meet CSA F383.

This provides a critical link in the regulatory inspection of a SDHW system as the building department can now require the installation to be inspected (or signed off) by a certified installer. Acceptance by the regulator of the use of CanSIA certified installers as a qualified professional is an important policy for the wider deployment of SDHW systems.

Toronto Building has developed a SDHW System Inspection Report (see Appendix 2) that uses the System Site Tests in CSA F383, but also integrates the requirements of the Ontario Building Code (primarily relating to backflow protection and structural requirements).

The SHDW System Inspection Report provides specific directions to the certified SDHW installer on areas that he or she needs to verify are correct. If the installation is not done by a certified SDHW installer, then a P.Eng must be engaged to sign this report. This report is then provided to the building inspector at the time of building permit inspection.

1 Much focus has been placed by the solar industry on the fact that solar collectors over 5m<sup>2</sup> are considered a “designated structure” in the Ontario Building Code. However if a solar system is installed on a structure, the installation is required to be in compliance with the structural requirements of the Code *regardless* of the size of the collectors.

2 <http://www.cansia.ca/training-employment/cansia-solar-hot-water-system-installer-certification>

Table 1: CSA F383 — Section 13: System Site Tests

13.1 System Visual Inspections	
This visual inspection shall include checks to ensure that:	
A	Collectors, pumps, heat exchangers, and other components have been connected properly, and not in reverse direction
B	Safety equipment, such as temperature and pressure-relief valves, is present, and installed in the correct manner. It shall be verified that an appropriate label has been affixed to the fill valve indicating that only the manufacturer's recommended heat transfer fluid must be added;
C	Pipes are adequately sloped to ensure complete draining of the system.
D	The correct amount of pipe insulation has been installed and that it is adequately secured and protected against water damage
E	Roof penetrations are adequately sealed;
F	Wiring meets applicable electrical codes and the manufacturer's instructions, and that it is properly fastened to protect it against mechanical damage;
G	Instrumentation and test points supplied with the system are installed properly;
H	Relief valves are plumbed to drains or catch basins
I	The system controller is properly located and in the automatic position
J	Labels are visible and completed as required by the CSA F379 Series
13.2 Pressure Leakage Tests	
13.2.1	Pressurized tanks and plumbing All liquid plumbing systems shall be pressure tested prior to system start-up and prior to insulating system piping.
13.2.2	Unpressurized tanks and piping Unpressurized tanks and piping shall be visibly tested for leaks by filling to overflow.
13.3 Flow Verification The establishment of fluid flow in the collector loop shall be verified.	
13.4 Freeze protection Tests <i>(The process to test freeze protection is outlined in this section)</i>	
13.4.3 Controller Test Solar heating systems shall have the controller operation verified by the method described in the manual supplied by the system manufacturer.	

## Providing Direction on Inspection to Building Inspectors

A second element in the building permit inspection involves the building inspector reviewing installation issues outlined in the service level bulletin (Inspection of SDHW Systems – see Appendix 2). The site inspection undertaken by the building inspector focuses on the three main areas of the building code that SDHW systems are covered under: installation on the roof; backflow prevention and plumbing safety. Table 2 below outlines the areas of inspection covered under the inspection bulletin.

**Table 2: Procedures to Follow on the Inspection of SDHW Systems**

	Procedure	Comment
1.1	The system has been installed.	
1.2	The location of the solar collector is as shown on the roof structure report.	To ensure that the roof has been evaluated at the location of the roof structure report. See Solar Permits Technical Bulletin #1 for more details.
1.3	The slope of the roof (either “flat” or “sloped” is adequate) is as indicated on the roof structure report. A flat roof is defined as having a slope of 1 in 10 or less.	SDHW collector racks are designed for sloped roofs or flat roofs. Different structural conditions exist for sloped and flat roofs.
1.4	Where required, a backflow prevention device has been installed and: (a) The direction of flow is correct; (b) A thermal expansion device has been installed downstream of the backflow preventer.	See Ontario Building Code Article 7.6.2.5
1.5	A mixing valve has been installed to limit the temperature of hot water to a maximum of 49°C, in accordance with Subsection 7.6.5. of the Ontario Building Code.	Normally installed after the backup water heater. Note some tankless water heaters need a regulated input water temperature so a mixing valve may be installed before a tankless heater.
1.6	Where structural alterations (as required by the permit) have been made, an inspection will be conducted to determine compliance. If the area of work is not accessible or accessibility is limited by the H&S policy, a report may be requested. The report may be provided by an Architect, P. Eng, or a person having a BCIN.	Installing solar collectors is not a structural alteration; only when the roof needs additional support (i.e. blocking) is there a need to evaluate compliance.
1.7	Fastening and securing of the roof-top equipment is not included in the Inspection Service Level, as reliance will be placed on the Certified Installer	Certified Solar DHW Installers are qualified to install the solar collectors.

## System Inspection to Ensure Best Practices

While the process outlined above provides assurances that the SDHW System is installed to meet codes and standards (as related to safety), solar deployment agencies are also concerned about the performance of systems installed with the support of the agency. In many areas in North America, SDHW deployment is in its infancy so there is a need to identify and provide assistance to solar installers to ensure installations meet industry “best practices.” The SDHW Inspection Form (see Appendix 4) was originally developed by Solar BC and modified slightly by the Toronto Solar Neighbourhoods program to allow deployment agency staff to provide a thorough inspection of the elements of a SDHW system that will affect the performance and longevity of the system.

## Appendix 1 — Ontario Building Code Requirements for Backflow Prevention for SDHW Systems

Ontario Regulation: OBC 503-09

*112. Article 7.6.2.5. of Division B of the Regulation is revoked and the following substituted:*

### 7.6.2.5. Backflow from Buildings with a Solar Domestic Hot Water System

**(1) Except** as permitted by Sentence (2) and as provided in Sentences (3) and (4), a potable water system shall be protected against backflow where the heat transfer loop of a solar domestic hot water system is directly connected to the potable water system.

**(2) Where** the heat transfer loop of the solar domestic hot water system consists of direct flow-through of potable water only, protection against backflow is not required.

**(3) A** potable water system that is directly connected to a solar domestic hot water system that serves a residential occupancy within the scope of Part 9, shall be provided with a backflow prevention device selected in accordance with CSA F379.1, "Packaged Solar Domestic Hot Water Systems (Liquid-to-Liquid Heat Transfer) for All-Season Use".

**(4) Where** a solar domestic hot water system includes a single wall heat exchanger and contains only a relatively harmless heat transfer fluid as described in CSA F379.1, "Packaged Solar Domestic Hot Water Systems (Liquid-to-Liquid Heat Transfer) for All-Season Use", the backflow prevention required in Sentence (1) is permitted to be a dual check valve backflow preventer conforming to CAN/CSA-B64.3, "Backflow Preventers, Dual Check Valve with Atmospheric Port Type (DCAP)".

**Appendix 2 — Toronto Building’s SDHW Inspection Report**



**SDHW System Inspection Report**

This site review report may be sent directly to an inspector or faxed directly to the **District Inspection Office**.

<input type="checkbox"/> North York	416-696-4179	<input type="checkbox"/> Toronto and East York	416-696-4151
<input type="checkbox"/> Scarborough	416-696-4166	<input type="checkbox"/> Etobicoke York	416-696-4169

Date			Permit No.
Day	Month	Year	

**Project Location**

Street No.	Street Name	Unit No.
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**Project Description**

**System Inspection**

Installers Name:	Professional Engineer:
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Signature \_\_\_\_\_

Note: Upon completion of the installation of the Domestic Hot Water Solar System the certified installer or a professional engineer must submit to the inspector the verification that the installation of the system is in conformance with CSA F-383-87 "Installation Code for Solar Domestic Hot Water systems".

**Commissioning**

- 1. Flow Verification Test – completed & passed
- 2. Pressure Leakage Test – completed & passed
- 3. Freeze Protection Test – completed & passed
- 4. Controller Test – completed & passed

**System Visual Inspection**

- 5. All plumbing connections to collectors, pumps, heat exchangers and other components have been connected properly
- 6. All safety equipment such as temperature and pressure relief valves are present and installed in the correct manner
- 7. All pipes are adequately sloped to ensure complete draining of the system
- 8. The correct amount of pipe insulation is installed and is adequately secured and protected against water damage
- 9. Structural conditions are as shown in roof report and structural attachments are in accordance with structural drawings and CSA-F383
- 10. Location of solar collectors and/or tank is as shown in the structural roof report
- 11. All wiring (AC and control) meets the Ontario Electrical Code and is properly fastened to protect it against mechanical damage
- 12. All instrumentation and test points are installed properly
- 13. System controller is properly located and in the automatic position

**Monitoring Equipment**

- 14. Monitoring equipment is present and operational

**System Manual**

- 15. Manual is complete
- 16. Operation instructions are complete

Appendix 3 — Toronto Building’s Policy on Inspection of SDHW Systems



**Inspection of Solar Domestic Hot Water Systems (SDHW)**

<b>Bulletin Number:</b>	<b>DRAFT</b>
<b>Date:</b> May 7, 2010	
<b>Authority:</b> None Required	
<b>Chief Building Official &amp; Executive Director</b>	
<b>Bulletin Prepared by:</b> Inspection Services Coordinating Team	

**PURPOSE:**

To establish a uniform process for the inspection of a SDHW system for all residential Part 9 buildings.

**POLICY:**

Following notification (inspection request) by the client, the inspector will attend the site where a permit has been issued for the installation of a solar domestic hot water system. The inspection will be conducted in accordance with the procedure outlined below to confirm that the system has been installed in accordance with the permit documents.

**PROCEDURE**

1. An on site inspection will be conducted to determine the following:
  - i) The system has been installed
  - ii) The location of the solar collector is as shown on the roof structure report.
  - iii) The slope of the roof (either “flat” or “sloped” is adequate) is as indicated on the roof structure report. A flat roof is defined as having a slope of 1 in 10 or less.
  - iv) Where required, a backflow prevention device has been installed and:
    - (a) The direction of flow is correct;
    - (b) A thermal expansion device has been installed downstream of the backflow preventer.
  - v) A mixing valve has been installed to limit the temperature of hot water to a maximum of 49°C, in accordance with Subsection 7.6.5. of the Ontario Building Code
  - vi) Where structural alterations (as required by the permit) have been made, an inspection will be conducted to determine compliance. If the area of work is not accessible or accessibility is limited by the H&S policy, a report may be requested. The report may be provided by an Architect, P. Eng, or a person having a BCIN.
  - vii) Fastening and securing of the roof top equipment is not included in the Inspection Service Level, as reliance will be placed on the Certified Installer
2. Only if a RP (reduced pressure principle) backflow preventer is installed then confirm the submission of the completed Backflow Prevention Device Test Report and attached it to the permit folder.
3. Review the completed SDHW System Inspection Report and attach to the permit folder.

**Appendix 4 — Toronto Solar Neighbourhoods Inspection Form**



**Solar Neighbourhoods**

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**SDHW System Inspection Form**

Project/Homeowner Name: \_\_\_\_\_  
 Project #: \_\_\_\_\_  
 Date: \_\_\_\_\_  
 Contractor: \_\_\_\_\_  
 Inspector: \_\_\_\_\_  
 In Attendance: \_\_\_\_\_  
 Approximate Installation Date: \_\_\_\_\_

**Type of System**

- Closed Loop
- Drain Back
- Drain Down
- Thermosyphon
- Other

**Type of Collectors**

- Flat Plate
- Evacuated Tube

**Roof Type**

- Flat
- Sloped
- On Ground

Municipal Water Pressure  
 \_\_\_\_\_ psi

**Site Conditions**

	In Application	Inspection
Solar collector azimuth from due south		
Solar collector tilt from horizontal		
Collectors unshaded, no new growth of trees or bushes		
Shade analysis done		

Item	Yes/OK	No/Repair	N/A	Comment	Action Required
<b>Collectors</b>					
Glazing unbroken, clean (do not clean when hot)					
Framing tight, no evidence of corrosion, square					
Seals and gasket not deteriorating, complete					
Interior insulation in place, dry, not deteriorating					
Mounting hardware secure to collectors and roof					
Roof penetrations sealed and tight					

Item	Yes/OK	No/Repair	N/A	Comment	Action Required
Lightning protection (if used) is secure					
Flow rate balanced throughout array					
Sensor wires secure					
Sensor secure, in good contact with absorber plate					
Type of collector is as specified					
# of collectors as specified					
Safe and easy access for repairs/maintenance					
No leakage from collectors					
Collectors are sloped for drainage					
<b>Exterior Piping (wall and roof)</b>					
Insulation complete, weather and wildlife proof, secure					
Pipes protected from mechanical damage if in traffic area					
Pipe runs on roof properly done and secured					
Hangers supporting piping properly without stress					
Pipe runs are sloped if required for drainage					
Wall penetration properly sealed and weather/animal proofed					
No evidence of leakage					
Adequate space for repairs/maintenance					
Corrosion protection between dissimilar metals					
Air vents at high points c/w loosened caps (Drain down/back only)					
Drain valves at low points and accessible (Drain down/back only)					
<b>Interior Piping</b>					
Insulation complete, secure - on solar loop					
Insulation complete, secure - solar to back up tank					
No evidence of leakage					
Check valves in correct position and orientation					
Hangers supporting piping properly without stress					
Anti-scald valve installed					
Drain valves at low points and accessible					
Expansion tank installed (closed loop only)					
Adequate space for repairs/maintenance					
Corrosion protection between dissimilar metals					
Valves correct type and direction					

Item	Yes/OK	No/Repair	N/A	Comment	Action Required
By-pass valves are piped correctly and clearly labeled					
If required - backflow preventer installed and has inspection test tag					
If BFP installed - expansion tank or TER valve installed					
<b>Pumps</b>					
Electrical connections secure					
Piping connections secure, no evidence of corrosion					
Pump properly supported					
Flow rate in appropriate range					
Adequate lubrication supplied (dry rotors only)					
Plumbed in proper direction					
<b>Heat Exchanger</b>					
No evidence of corrosion at fittings					
Piping connections secure					
Anode in water manifold present					
Temperature differences appropriate					
Water level is correct (drain down/back only)					
Heat exchanger visible leak detection					
Plumbed correctly					
<b>Heat Transfer Fluid</b>					
Pressure of heat transfer fluid (must be 10 psi below city pressure)					
No direct make up water supply					
Manual fill valve and drain have fittings so cannot be tampered with					
Relief valves discharge to appropriate location					
<b>Heat Transfer Fluid (Closed Loop Systems)</b>					
Glycol pH, alkalinity and concentration acceptable					
<b>Controls</b>					
Electrical connections secure					
Controls securely mounted					
On/off differential correct					
Sensor wire secure, unbroken, not shorted or kinked					
120/240 V wiring at least 1 ft from sensor wires					
Sensor resistance appropriate					
Cable shield (if used) grounded to cabinet only					
All electrical (including pump) is properly grounded					

Item	Yes/OK	No/Repair	N/A	Comment	Action Required
Outdoor instruments/controls are weatherproofed					
<b>Storage Tanks</b>					
Drain valve opens and closes properly					
Insulation complete, tight and dry					
No evidence of leakage					
Dielectric fittings where needed, no corrosion					
Sensor wires secure					
Sensor secure, in good contact with tank wall					
Heating element wiring (if used) is secure					
T&P not blowing off, load still using heat					
Adequate access for repairs/maintenance					
Safety All hot surfaces (+120F) labelled to prevent burns					
<b>Monitoring</b>					
Basic - pump run odometer					
Basic - tank temperature thermometer					
Advanced					
<b>Miscellaneous/Other</b>					
Photos taken					
Structural review					
Electrical review					
Installation/Operation/Maintenance manual on site					
Manufacturer's literature on site					
Homeowner instructed on system basics					
Homeowner comments					
Building permit on site					

For further information on solar system permitting issues, including recordings of our Spring 2010 webinar series, please visit [www.SolarPermits.ca](http://www.SolarPermits.ca)

