

Section P	Public Safety
ES54 P0	
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Public Safety and Restricted Access

BC Hydro assumes responsibility for public safety related to the limits of approach for the underground power distribution system. This requirement is well documented in the WorkSafeBC regulations, as well as the BC Hydro Work Methods procedures. Accordingly, a solid metal lid on an underground concrete vault, bolted down with a BC Hydro security bolt ("puzzle bolt"), provides the necessary safety protection barrier. Similarly, large BC Hydro underground vaults, such as manholes and switchgear vaults, fitted with a cast-iron frame and cover, with a provision for installing security bolts and bolting down a removable access cover, meet the same requirements for restricted access.

In the past, the BC Hydro standards for restricted access to underground concrete vaults involved using industry standard penta bolts, based on established utility practices. However, in response to break-in fatalities and increased security requirements for the 2010 Olympics, BC Hydro introduced a new puzzle bolt. One of the deciding factors was the widespread use of penta bolts in the public domain, with penta bolt sockets readily available from regular hardware stores.

In addition to the requirement for restricted access to underground facilities, BC Hydro carried out extensive research and development work to mitigate the threat to public safety resulting from a possible explosion inside BC Hydro underground vaults. Although BC Hydro has only experienced a few explosions, other utilities with large underground distribution assets have experienced numerous documented cases of such incidents.

BC Hydro blastproofing design is built into the engineered assembly of underground vaults, based on simple pressure relief provisions, which require very little or no regular maintenance. Most importantly, in the event of an explosion there are no lethal flying projectiles to cause injury or damage. In the event of a smaller explosion inside a vault covered with a metal lid, back hinges would allow the back end of the lid to move up and open an exhaust cavity for the relief of explosive gases. However, a large explosion would lift the entire concrete collar and bolted lid assembly until it separates from the concrete box below, allowing a larger exhaust cavity around the perimeter to open up and act as an effective pressure relief device.

BC Hydro's largest underground vaults, such as manholes, are considered as a potential source for the largest explosions. To contain such explosive energy, to restrain the cast iron cover from "flying" and to control the pressure relief cavity, BC Hydro has developed an effective and simple design based on a fluted cast-iron frame, anchor rods and bolted down cast-iron cover. During an explosion, the anchored cast-iron frame and bolted frame-cover assembly would push the pavement up slightly and create a pressure relief cavity to exhaust explosive gases under the pavement. For further information and details of operation, see P1-02.

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	DISTRIBUTION STANDARDS 				ISSUED: MAR 2016 REPLACES: N/A ORIGINALLY ISSUED: MAR 2016	PAGE 1 OF 1	ES54 P0-02

Security Bolt Installation

The BC Hydro proprietary security bolt, the “puzzle bolt”, is slightly more difficult to install and remove than the penta bolt because of the unique driving pattern. This pattern on the puzzle bolt head is shown in Figure 1 and depicted on the attached drawing G-U08-A823. Once the driving patterns on the bolt and the socket are engaged, the installer slides the shroud onto the bolt and turns it clockwise to tighten the shroud. This prevents the driver from spinning, which could cause damage to the driving patterns – see Figure 2.



Figure 1 – Puzzle bolt unique driving pattern and outer thread with socket shroud pulled back for alignment of two matching patterns



Figure 2 – Puzzle bolt engaged

The engaged socket/bolt assembly becomes a long handle for the installer to use, to easily locate and centre the captive brass nut below, and screw in the puzzle bolt by hand. Details of the light-weight lid, large hinge links and bolt-down provisions are shown on the attached drawing G-U08-A828.

Once threading by hand becomes difficult, the installer inserts a socket wrench or an impact driver and tightens the puzzle bolt to 65 lb-ft (88 N-m) torque – see Figure 3.



Figure 3 – Puzzle bolt tightened by torque wrench

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Control of Puzzle Bolt Sockets

Control of BC Hydro proprietary puzzle bolt sockets, which each have a unique serial number, is administered in accordance with the rules explained in Forms V4, V5 and V6, which were developed by Corporate Security and Asset Management. Copies of these forms are contained in this standard: Form V4 – Stores Process; Form V5 – PLT Process, and Form V6 – Contractor Process.

Shipping

Each lightweight aluminum lid is shipped with two bolts. Figure 4 below shows a standard BC Hydro lightweight aluminum lid fastened with a reusable penta bolt, catalogue ID 97000514. A BC Hydro proprietary puzzle bolt, catalogue ID 96005175, is strapped to the underside of the lid, as shown in Figure 5. This is done to mitigate a situation where a contractor does not have the BC Hydro proprietary socket, such as has happened in the past, where they are unable to access the vault and complete the civil or electrical installation contract.



Figure 4 – Aluminum lid with penta bolt



Figure 5 – Puzzle bolt attached to underside

The contractor uses the penta bolt during the construction phase, up until the completion of the contract, to provide necessary safety protection. During commissioning and acceptance, the BC Hydro crew then removes the penta bolts from all aluminum lids and puts them in a return bucket. The BC Hydro crew retrieves the puzzle bolts from the underside of the aluminum lids and installs them as shown in Figure 6. The crew then slips on the vinyl cap, as shown in Figure 7 (BC Hydro catalogue ID 96005355).



Figure 6 – Aluminum lid with puzzle bolt



Figure 7 – Puzzle bolt with vinyl cap

The BC Hydro crew is responsible for ensuring safety protection and shall take as much time as necessary for correct installation of the puzzle bolts.

All penta bolts removed from the aluminum lids shall be returned to BC Hydro stores, so they can be shipped-back and reused by the concrete vault fabricators. Used penta bolts have the BC Hydro catalogue ID 97000514.

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SEE NOTE 4

SEE DETAIL 2 ON PAGE 3

70+0/-3

5

5

1

2

3

4

4

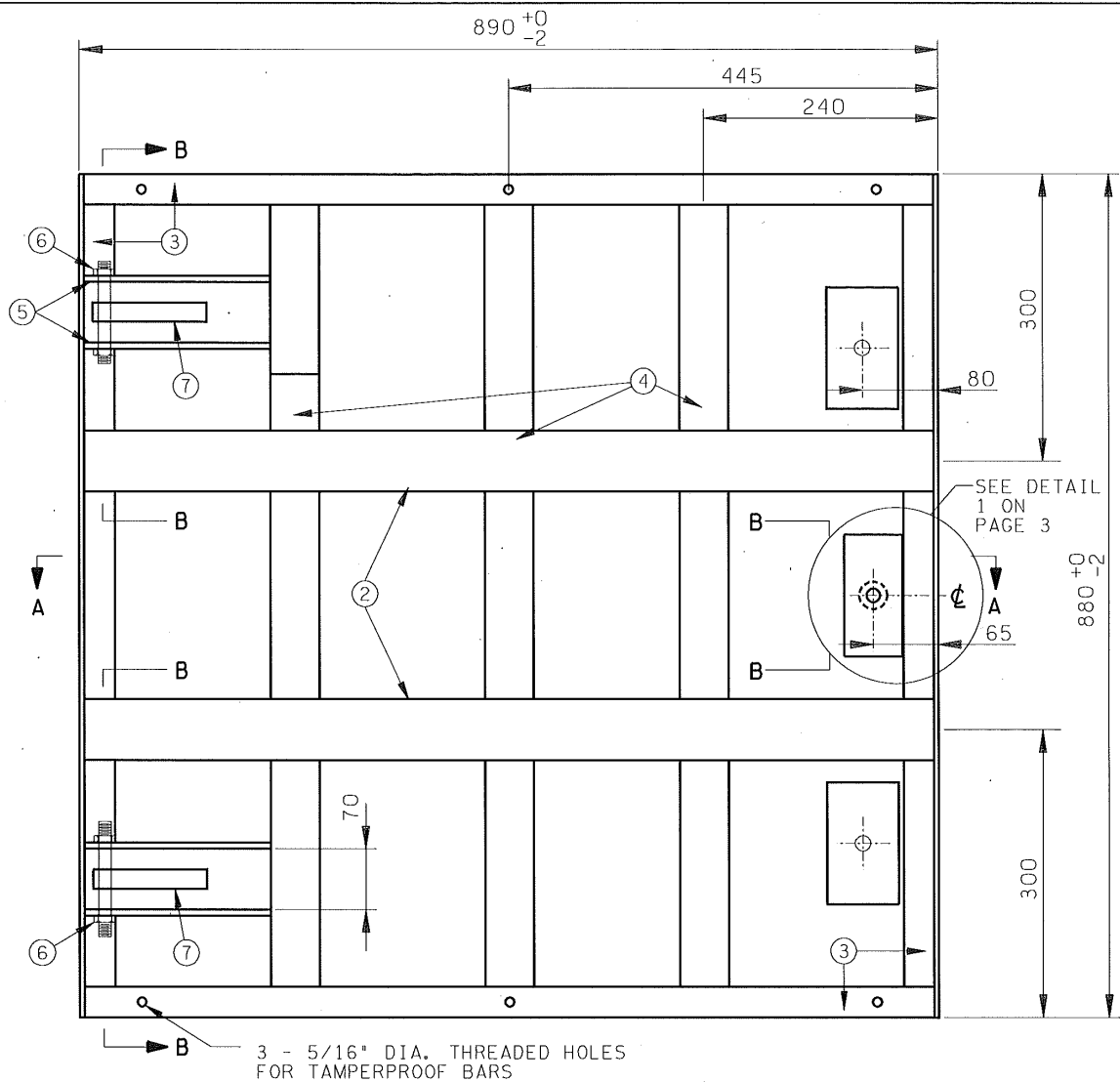
4

4

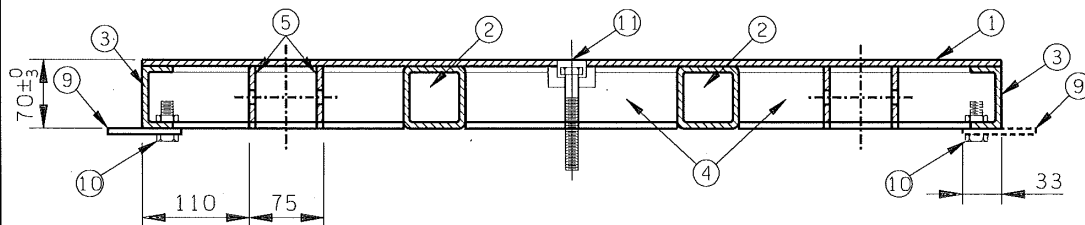
BCH STOCK NO. 9600-7598

R. 1

R	0
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U/S BASE FRAME



SECTION B-B

DRAFTER: DC	DESIGNER M. KELVIN	RECOMMENDED M. KELVIN	APPROVED F. DENNERT	LIGHTWEIGHT ALUMINUM LID FOR SERVICE AND JUNCTION BOXES		
	ORIGINAL ISSUE DATE: JAN 2009					
	BC Hydro  DISTRIBUTION STANDARDS			PAGE 2 OF 3	G-U08-A828.02	R. 1

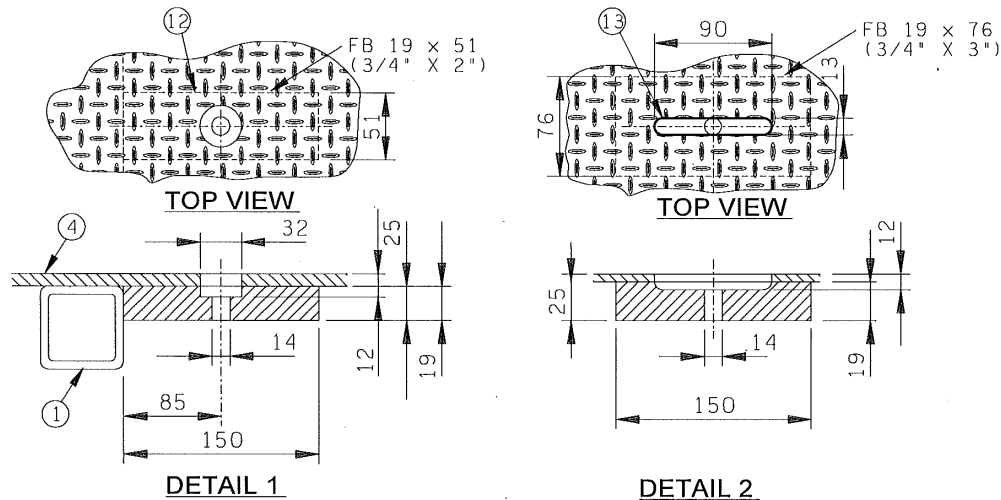
DESIGNED  M. KELVIN	RECOMMENDED  L. STEVANOVIC	ACCEPTED  F. DENNERT	ENGINEER OF RECORD  2017-02-15	VAULT/BOX SAFETY SECURITY BOLTS FOR LIGHTWEIGHT LIDS		
DISTRIBUTION STANDARDS 			ISSUED: MAR 2016 REPLACES: N/A ORIGINALLY ISSUED: MAR 2016	PAGE 4 OF 18	ES54 P1-01.04	R 0

BILL OF MATERIAL

<u>ITEM</u>	<u>DESCRIPTION</u>	<u>QTY. REQ'D</u>
1	1/4" Checker Plate, AL, 3003	1
2	2 1/2" x 2 1/2" x 1/4" Square Tube, Al, 6061	2
3	2 1/2" x 1 5/16" x 3/16" Channel, Al, 6061	4
4	2 1/2" x 1 1/2" I-Beam, Al, 6061	3
5	2 1/2" x 1/4" Flat Bar, Al, 6061	4
6	1/2" Dia. Hinge Pin per G-U08-A717	2
7	Hinge Link per G-U08-A717	2
8	Tee Handle, per G-U08-A717	2
9	Tamperproof Bar, per G-U08-A840	1
10	5/16" x 1" Brass Bolt per G-U08-A717	3
11	BCH Security Bolt per G-U08-A823	1

NOTES:

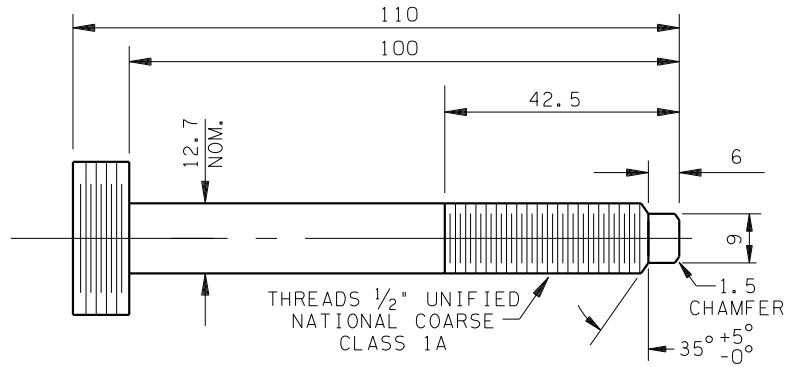
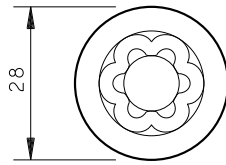
1. Aluminum plates and extruded shapes should be in accordance with CSA S157-05.
2. All structural elements to be AL 6061-T6
3. All joints welded per CSA W59.2 - M1991(R2003)
4. Weld beads max 25 mm long, min 19 mm long @ 100 mm spacing.
5. Net weight of 33 kg approx.



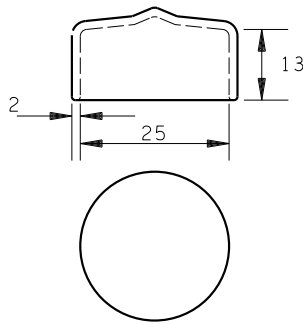
DRAFTER: DC	DESIGNER M. KELVIN	RECOMMENDED M. KELVIN	APPROVED F. DENNERT	LIGHTWEIGHT ALUMINUM LID FOR SERVICE AND JUNCTION BOXES
	ORIGINAL ISSUE DATE: JAN 2009			
	BChydro  DISTRIBUTION STANDARDS			
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	ISSUED: MAR 2016 REPLACES: N/A ORIGINALLY ISSUED: MAR 2016				
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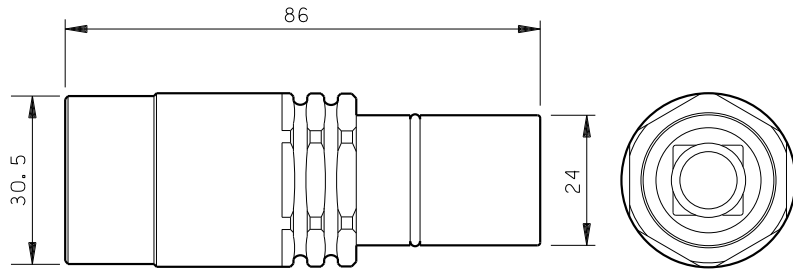
BOLT LENGTH	STOCK NO.
75mm (3")	96005248
58mm (2 1/4")	96005249
45mm (1 3/4")	96005250



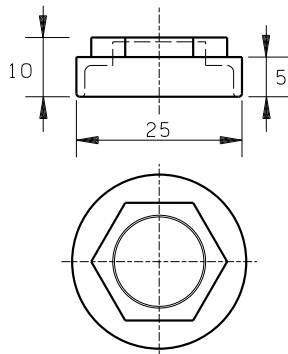
17-4 STAINLESS STEEL PUZZLE BOLT
(STOCK NO. 96005174)



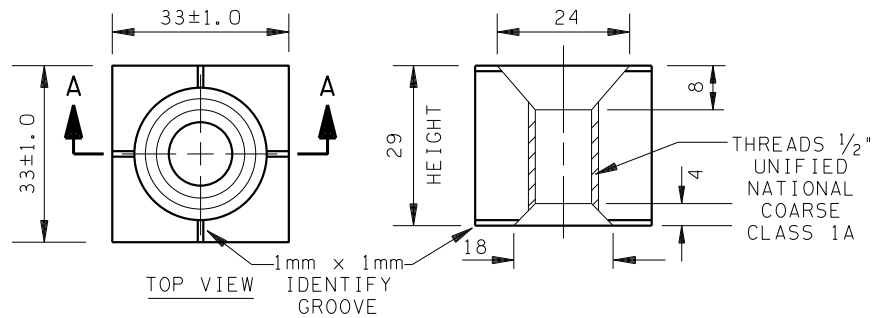
VINYL BOLT CAP
(STOCK NO. 96005355)



PUZZLE BOLT DRIVER, 1/2" SQUARE
(STOCK NO. 96005175)



PLASTIC BOLT CAP



C95400 BRASS BLOCK NUT
(STOCK NO. 96005404)

NOTES

1. ALL DIMENSIONS ARE IN MILLIMETRES UNLESS OTHERWISE STATED.
2. ALL TOLERANCES UNLESS OTHERWISE SHOWN TO BE $\pm 0.5\text{mm}$.

DRAFTER: JW/DC R1-DIMENSION DETAILS REVISED, APR. 2010 MK

DESIGNER	RECOMMENDED	APPROVED
M. KELVIN	M. KELVIN	F. DENNERT
ORIGINAL ISSUE DATE: DECEMBER 2007		

PUZZLE BOLT FOR LIGHTWEIGHT LIDS

BChydro  DISTRIBUTION STANDARDS

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R. 1

DESIGNED	RECOMMENDED	ACCEPTED
		
M. KELVIN	L. STEVANOVIĆ	F. DENNERT

ENGINEER OF RECORD



2017-02-15

VAULT/BOX SAFETY
SECURITY BOLTS FOR
LIGHTWEIGHT LIDS

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REVISIONS:

DISTRIBUTION STANDARDS
BC Hydro
ISSUED: MAR 2016
REPLACES: N/A
ORIGINALLY
ISSUED: MAR 2016

Form V4 – Stores Process

Background: The McGard Bolt has been developed as a replacement for the Penta bolt used to secure many of our pieces of electrical equipment. The Penta bolt was intended to control access through control of the special sockets needed to tighten and loosen specialized bolts. BCH has been aware for some time that the sockets have become more widely available to other than BCH's personnel and contractors and that in some cases other tools can be used to operate the bolts. The McGard Bolt is intended to re-establish security by replacing the Penta bolts and closely controlling access to the sockets.

Objectives:

1. Corporate Security requirements for security include:

- Each socket will be controlled throughout its life.
- Sockets will be issued to only those requiring them for performance of their duties.
- Sockets will be issued using a "master key" procedure which should include:
 - Manager approval for socket issue.
 - Signature for sockets issued.
 - Secured filing of signature forms and related documentation.
 - Timely reporting of lost or stolen sockets
 - Auditability of process, forms and inventory control of sockets.
- Sockets will be kept secure until issued.
- Once issued, sockets will be kept secure.

2. Operations objectives are:

- Sockets are available to employees as and when required.
- Administrative processes around issuance and control balance the security needs, operational requirements and cost.

3. MMBU's objectives are:

- Sockets will be secured while in MMBU's care.
- Sockets will be issued only from Store 1.
- Existing processes will be used where ever possible.

Process:

1. Application

- The processes outlined in this document apply once sockets are delivered to MMBU and end once delivered to the end user.

2. General:

- Sockets will be identified as a traceable item which will require each socket to be controlled and recorded separately.
- Sockets will only be stored at Store 1 in Surrey.
- PassPort will be used to track and document the sockets while in MMBUs care. The sockets will be assigned a uniquely tracked commodity (UTC) number at time of receipt.

3. On receipt:

- As part of the normal receiving process, the serial numbers on each socket will be verified and recorded in PassPort. Each will be assigned a UTC number in the system.
- On receipt, a random sample of sockets will be selected and test fitted to the bolts in stock.
- The sockets will be stored in a secure area with access limited to those authorized to issue the sockets.

4. Filling requests:

- Request for sockets will only be processed when received from authorized requestors.

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DISTRIBUTION STANDARDS 		ISSUED: MAR 2016 REPLACES: N/A ORIGINALLY ISSUED: MAR 2016		PAGE 7 OF 18	ES54 P1-01.07
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REVISIONS:

- b. The list of authorized requestors will be provided to MMBU Operations (currently Stephen Pulford) by the Manger Provincial Planning & Processes (currently Brad Bishop) or the Senior General Manager Distribution Operations (currently Donia Snow).
- c. The authorized requestor will email their request for sockets to a the MMBU email **shipping-mdc** with the following information:
 - 1. Stock number: 96005175
 - 2. Qty requested:
 - 3. Needed by date:
 - 4. Shipping details:
 - 5. Contact information:
- d. The material request (MR) will be created by the email recipient in 4.c. above.
- e. The sockets will be issued and PassPort will be updated with the issuing details including the specific serial numbers of the sockets issued.
- f. The sockets will be shipped by BCH's secure "mail" service "OCS" and include confirmation of delivery.
- g. The packages containing the sockets will not indicate the contents, just the delivery address.

5. Socket verification:

- a. At least annually, the socket inventory will be verified against the records to ensure the specific serial numbered sockets actually in stock match the records. This will be performed according to the standard inventory cycle count procedures.

6. Security of Sockets while in Stores:

- a. Any unassigned sockets will be stored in a secure location.
- b. A record of the serial numbers of the stored sockets will be maintained and updated when the sockets are issued or returned to storage.

7. Lost/stolen sockets:

- a. Any loss or theft of sockets will be reported immediately on discovery to Corporate Security 24/7 reporting desk (1-877-311-8611).
- b. An immediate search for lost sockets will be undertaken and a summary of the measures taken provided to Corporate Security. Corporate Security's advice on the search will be followed.

8. Documentation:

- a. All documentation related to sockets will include the unique serial numbers stamped on each socket
- b. Documents maintained should include:
 - 1. Packing and Receiving slips
 - 2. Inventory verification / count documents
 - 3. Material requests
 - 4. Shipping slips
 - 5. Confirmation of delivery

9. Process audit:

- a. Responsibility for audit of the sockets, socket control processes, systems and records, building and card access overall shall rest with Corporate Security.
- b. Periodic compliance reviews will be the responsibility of the MMBU management team.

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		REPLACES: N/A ORIGINALLY ISSUED: MAR 2016									

Form V5 – PLT Process

Background: The McGard Bolt has been developed as a replacement for the Penta bolt used to secure many of our pieces of electrical equipment. The Penta bolt was intended to control access through control of the special sockets needed to tighten and loosen specialized bolts. BCH has been aware for some time that the sockets have become more widely available to other than BCH's personnel and contractors and that in some cases other tools can be used to operate the bolts. The McGard Bolt is intended to re-establish security by replacing the Penta bolts and closely controlling access to the sockets.

Objectives:

4. Corporate Security requirements for security include:

- a. Each socket will be controlled throughout its life.
- b. Sockets will be issued to only those requiring them for performance of their duties.
- c. Sockets will be issued using a "master key" procedure which should include:
 - i. Manager approval for socket issue.
 - ii. Signature for sockets issued.
 - iii. Secured filing of signature forms and related documentation.
 - iv. Timely reporting of lost or stolen sockets
 - v. Auditability of process, forms and inventory control of sockets.
- d. Sockets will be kept secure until issued.
- e. Once issued, sockets will be kept secure.

5. Operations objectives are:

- a. Sockets are available to employees as and when required.
- b. Administrative processes around issuance and control balance the security needs, operational requirements and cost.

Process:

10. Application

- a. The processes outlined in this document apply once sockets are delivered to a Distribution Operation's area or field office. Control processes from manufacturer to the receiving Distribution Operation's area or field office is beyond the scope of these procedures.

11. Requesting Sockets

- a. Only Senior Field Services Manager of Regional Manager may order sockets.
- b. Sockets are requested from Store 1 by emailing **shipping-mdc** with the following information:
 1. Stock number: 96005175
 2. Qty requested:
 3. Needed by date:
 4. Shipping details:
 5. Contact information
- c. Receipt should be monitored and if not received within 5 working days or advised of a back order, the order should be followed up.

12. For employees with occasional or limited use requirements:

- a. A socket will be issued at the beginning of the requirement and collected once the requirement for the socket is finished.
- b. Only one socket will be issued to an employee at any one time.

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REVISIONS:

- c. The employee will sign¹ for any issued sockets.
- d. Employee will acknowledge care and control requirements. (See Appendix A)
- e. The socket information will be documented (serial number, contractor details, etc.).

13. For employees with continual or urgent use requirements:

- a. Approval for the issue of a socket for continual or ongoing use by a BCH employee will be by the area Senior Field Manager or delegate (in writing).
- b. Criteria for issuing a socket on a continual or ongoing basis will be based on operational requirements that can include either:
 - 1. Constant and frequent use
 - 2. Use in response to urgent or emergent situations (i.e. trouble response)
- c. Only one socket will be issued to an employee at any one time.
- d. The employee will sign for any issued sockets.
- e. The employee will acknowledge care and control requirements. (See Appendix A)
- f. The socket information will be documented (serial number, date issued).
- g. Quarterly as part of safety equipment verification/checks or other convenient time each employee will present the socket to an authorized BCH representative who will record that the assigned socket is still in the possession of the employee.
- h. Periodically as part of normal safety meetings, managers will review the care and control requirements with their employees.
- i. At the termination of employment in the HQ or when the requirement for continual need has ended, the employee shall be required to return the issued socket and the BCH records updated.

14. Socket verification:

- a. Each socket has a unique serial number. Verification will include comparing the number of the presented socket against the issuing records.
- b. Verification will be undertaken by individuals delegated by the Senior Field Manager.
- c. Documentation will commence manually using the form attached. Documentation and tracking will move to an automated system using either with Corporate Security's key/access control system or "bar code" system being evaluated for control of certain other pieces of equipment (hot sticks).

15. Security of Spare Sockets:

- a. Any unassigned sockets will be stored in a secure cabinet and issued under the direction of the Senior Field Manager.
- b. A record of the serial numbers of the stored sockets will be maintained and updated when the sockets are issued or returned to storage.

16. Lost/stolen sockets:

- a. Any loss or theft of sockets will be reported immediately on discovery to the Senior Field Manager and Corporate Security 24/7 reporting desk (1-877-311-8611).
- b. An immediate search for lost sockets will be undertaken and a summary of the measures taken provided to Corporate Security. Corporate Security's advice on the search will be followed.
- c. The circumstances of the loss or theft will be followed up specifically with the employee and in general with the HQ/District at the earliest opportunity.

17. Documentation:

- a. Documentation will commence manually using the form attached or the existing key registers. Documentation and tracking will move to an automated system using either

¹ If the line room / office is equipped with automated (swipe) key control, this will substitute for signing subject to Corporate Security approval.

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with Corporate Security's key/access control system or "bar code" system being evaluated for control off certain other pieces of equipment (hot sticks).

18. Process audit:

- a. Responsibility for audit of the sockets, socket control processes, systems and records, building and card access overall shall rest with Corporate Security.
- b. Periodic compliance reviews will be the responsibility of the Senior Field Services Managers for their respective areas.

Other:

1. Audit & compliance checklists will to be developed.
2. Expanded guidelines for the care and custody of sockets and keys assigned to individual employees will be developed by Corporate Security.

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Appendix A

McGard Bolts Socket Care and Control – BC Hydro Employee

Initial Issue

Socket Number: _____

Initial Issue Date: _____

Expected Return: _____

Issued to: _____

Phone number: _____

Issued by: _____
Name

Signed

Date

Care & Control Requirements

1. Purpose – The McGard bolt and socket is intended to help prevent unauthorized access to BCH plant and equipment.
2. Unauthorized access can result in death or injury as well as increase costs to BCH.
3. Sockets shall not be loaned out or used to grant access to non-authorized individuals
4. Employees shall immediately report any lost, missing, stolen or damaged sockets to their manager/supervisor
5. Employees will secure the socket at all times and will not release custody or leave the socket unattended
6. Any unsecured sockets found by employees in the course of their duties should be turned into their manager/supervisor as soon as possible.
7. At least once every 3 months, each employee issued with a socket will verify that they are still in possession of the socket in the manner prescribed by Area management.

Acknowledgement

I acknowledge that I have read and understand the Care and Control requirements above.

Signed (Employee)

Date

See over for **Possession Verification** and **Return**

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Possession Verification

[illegible]

Date returned: _____

Signed (BC Hydro)

Date _____

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Form V6 – Contractor Process

Background: The McGard Bolt has been developed as a replacement for the Penta bolt used to secure many of our pieces of electrical equipment. The Penta bolt was intended to control access through control of the special sockets needed to tighten and loosen specialized bolts. BCH has been aware for some time that the sockets have become more widely available to other than BCH's personnel and contractors and that in some cases other tools can be used to operate the bolts. The McGard Bolt is intended to re-establish security by replacing the Penta bolts and closely controlling access to the sockets.

Objectives:

6. Corporate Security requirements for security include:

- a. Each socket will be controlled throughout its life.
- b. Sockets will be issued to only those requiring them for performance of their duties.
- c. Sockets will be issued using a "master key" procedure which should include:
 - i. Manager approval for socket issue.
 - ii. Signature for sockets issued.
 - iii. Secured filing of signature forms and related documentation.
 - iv. Timely reporting of lost or stolen sockets
 - v. Auditability of process, forms and inventory control of sockets.
- d. Sockets will be kept secure until issued.
- e. Once issued, sockets will be kept secure.

7. Operations objectives are:

- a. Sockets are available to contractors as and when required.
- b. Administrative processes around issuance and control balance the security needs, operational requirements and cost.

Process:

19. Application

- a. The processes outlined in this document apply once sockets are delivered to a Distribution Operation's area or field office. Control processes from manufacturer to the receiving Distribution Operation's area or field office is beyond the scope of these procedures.

20. Requesting Sockets

- a. Only Senior Field Services Manager of Regional Manager may order sockets.
- b. Sockets are requested from Store 1 by emailing **shipping-mdc** with the following information:
 1. Stock number: 96005175
 2. Qty requested:
 3. Needed by date:
 4. Shipping details:
 5. Contact information
- c. Receipt should be monitored and if not received within 5 working days or advised of a back order, the order should be followed up.

21. For limited job/contract specific use:

- a. Socket(s) will be issued at the beginning of the job and collected once the requirement for the socket is finished.
- b. The Contractor's representative will sign for any issued sockets.
- c. Contact information requirements for sockets in their possession.

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DISTRIBUTION STANDARDS 			ISSUED: MAR 2016 REPLACES: N/A ORIGINALLY ISSUED: MAR 2016	PAGE 14 OF 18	ES54 P1-01.14
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- d. Pre-job briefings will include instruction on socket security requirements and expectations.
- e. The socket information will be documented (serial number, contractor details, etc.).
- f. For jobs that extend beyond 90 days, the contract manager will verify the sockets are still in the Contractor's possession, the Contractor will re-sign for them and security requirements reviewed.

22. For Contractors with continual need for sockets:

- j. Contractors will be provided written direction on the socket security requirements. (See Appendix B.)
- k. Contractors will be issued their requested number of sockets.
- l. The Contractor's representative will sign for each socket provided.
- m. The socket information will be documented (serial number, contractor details, etc.).
- n. At least quarterly the Contractor will present the socket to an authorized BCH representative who will record that the assigned socket is still in the possession of the contractor. (See 3. below)
- o. Annual audits will be undertaken of Contractor's socket security compliance.
- p. At the termination of the contract the Contractor shall be required to return issued sockets and the BCH records updated.

23. Socket verification:

- a. Verification can be completed by either BCH personnel or authorized BCH security contractor.
- b. Documentation will commence manually using the form attached or the existing key registers. Documentation and tracking will eventually move to an automated system using either with Corporate Security's key/access control system or "bar code" system being evaluated for control off certain other pieces of equipment (i.e. hot sticks).
- c. Documentation will form part of the contract file maintained by FO Contracts and Client Relations (TBC²).

24. Security of Spare Sockets:

- a. Any unassigned sockets will be stored in a secure cabinet and issued under the direction of the Senior Field Manager.
- b. A record of the serial numbers of the stored sockets will be maintained and updated when the sockets are issued or returned to storage.

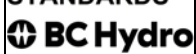
25. Lost/stolen sockets:

- a. Any loss or theft of sockets will be reported immediately on discovery to the Senior Field Manager and Corporate Security 24/7 reporting desk (1-877-311-8611).
- b. An immediate search for lost sockets will be undertaken and a summary of the measures taken provided to Corporate Security. Corporate Security's advice on the search will be followed.
- c. The circumstances of the loss or theft will be followed up specifically with the employee and in general with the HQ/District at the earliest opportunity.

26. Documentation:

- a. Documentation will commence manually using the form attached. Documentation and tracking will move to an automated system using either with Corporate Security's key/access control system or "bar code" system being evaluated for control off certain other pieces of equipment (hot sticks).

² TBC – To be confirmed.

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- b. When the socket is returned, a copy of the form will be forwarded to FO Contracts and Client Services for filing in the contract (TBC).

27. Process audit:

- a. Responsibility for the audit of compliance by contractors of the sockets security process will rest with FO Contracts and Client Relations (TBC).
- b. Responsibility for audit of the sockets, socket control processes, systems and records, building and card access overall shall rest with Corporate Security.
- c. Periodic compliance reviews will be the responsibility of the Senior Field Services Managers for their respective areas.

Other:

3. Security guidelines will be developed to be provided to contractors as part of contract start up and/or pre-job briefings.
4. Audit & compliance checklists will be developed.

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Appendix A

McGaad Bolts Socket Security Form – BC Hydro Contractor

Initial Issue

Socket Number: _____

Initial Issue Date: _____

Issued to:

Contractor Name: _____

Corporate Office Address: _____

Corporate Office Phone: _____

Corporate Contact Name: _____

Local Office Address: _____

Local Office Phone: _____

Local Contact Name: _____

Signed (Contractor)

Date

Possession Verification

Date	Contractor Representative Name	Initial	BCH Representative Name	Initial

Return

Date returned: _____

Signed (BC Hydro)

Date

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Appendix B. – Socket Care & Custody Guidelines

Purpose: Close care and custody of McGard sockets is important for the safety of BC Hydro's customers, employees and contractors. The security afforded by the special sockets and bolts will also protect BC Hydro assets. Loss of sockets by any means, reduces their effectiveness overall.

Expectations:

The Contractor:

1. Is responsible for the care and custody of all sockets in their possession at all times.
2. Shall ensure their employees are personally accountable for any sockets assigned to their care
3. Shall have clear processes to ensure the security of sockets issued to them.
4. Will fully instruct their employees on the care and custody of sockets.
5. Will permit BC Hydro to audit their procedures and socket security.
6. Return to BC Hydro any sockets not required.
7. Return any sockets they find in the course of their business to BC Hydro.

Acknowledgement:

On behalf of:

Contractor Name

Signed (Contractor)

Date _____

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Blast Proofing System

Electrical faults and arcing in underground cables can release several MJ of energy, and can produce temperatures of 10,000K along the arc path (see Reference Document 1, page 6). When a fault like this occurs, the associated air pressure could launch a cover tens of metres into the air with forces of 109 kN (24 kip) (see Reference Documents 2 and 3, page 6). To prevent such events, BC Hydro has developed a cover restraint system that can relieve internal vault pressures. This is shown in Figures 1 and 2 below.



Figure 1: Manhole Cover and Frame with Anchor Rods for Blast Proofing

The BC Hydro design illustrated above uses six anchor rods to restrain the frame. The cover is attached to the frame by two high tensile strength bolts – see the “When to Blast Proof” section below. This is adequate to mitigate the risk of a 225 kg cast iron cover turning into a projectile during a blast. The anchored frame and bolted cast iron cover/frame assembly moves up to open a cavity and to relieve the explosive gas pressure, as seen in Figure 2. Hot explosive gasses are released below the asphalt, which mitigates the risk of causing a burn injury to pedestrians. The asphalt lifts slightly during an explosion, but returns to its original position with little damage to the infrastructure - as shown below in Figure 3. Complete details of the design and testing are found in Reference Document 4 (see page 5).

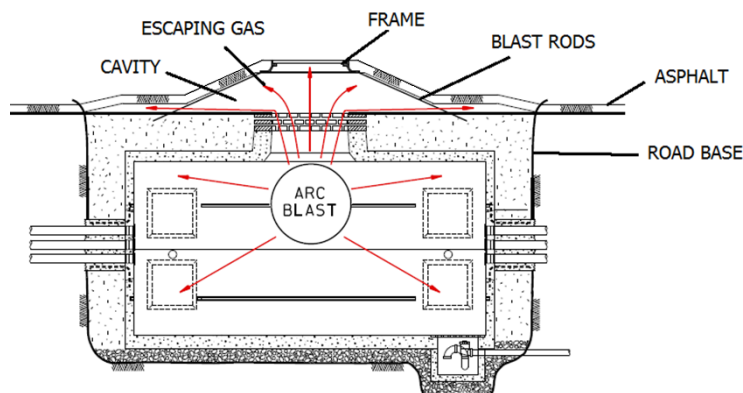


Figure 2: Blast Proofing System on C1 Manhole

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Design Calculations

Reaction forces of the six rods are shown in Figure 3: Force Diagram. Where F is 109 kN (24 kip), the tensile reaction force along each rod would be 107 kN (24 kip) for a 10° angle.

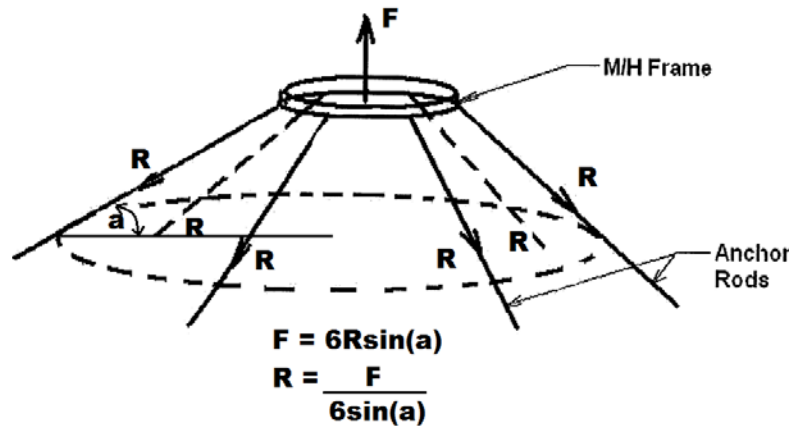


Figure 3: Force Diagram

To prove that the asphalt would not tear, see Figure 4: Shear Surface in Asphalt. If the six rods are completely pulled out of the ground, the tear surface shown in Figure 4: Shear Surface in Asphalt would follow a circular shape with a 1.5 metre radius. Asphalt thickness is generally 0.1 metres. The shear surface, S1, and applied shear stress, τ , are:

$$S1 = 2 * 1.5 * \pi * 0.1 = 0.942\text{m}^2$$

$$\tau = F/S1 = 109\,000/0.942 = 116\text{ KPa (16.8 psi)}$$

New asphalt tear resistance is 2.0 - 3.4 MPa (300-500psi). Old asphalt can withstand 345 KPa (50 psi). This provides a minimum three-fold safety factor. The design was successfully tested during a controlled field test administered by Pacific Blasting Ltd., using standard TNT explosive sticks to create an upward force on the cover as high as 157 kN (35 kip).

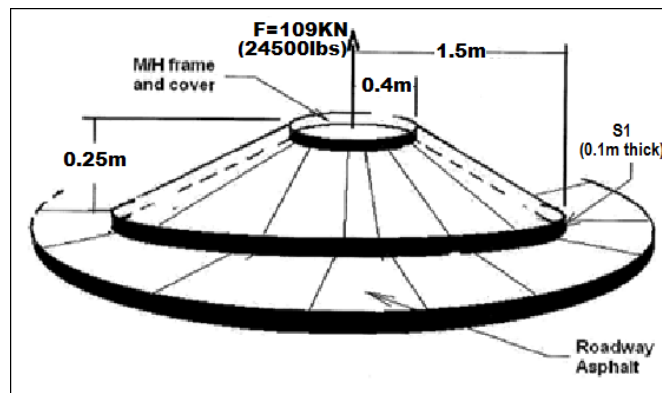


Figure 4: Shear Surface in Asphalt

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When to Blast Proof

Worst-case scenario primary faults could create forces of 109 kN [2], assuming manhole volumes of 15 m³ approximately. Tables 1, 2 and 3 below show the pressure and force exerted on the cover for various fault conditions on the secondary side. All cases are based on single line-to-ground faults, and assume no pressure relief or blast proofing has been installed.

In all but three cases, the cover could launch if it is not restrained. The gravity force on a cover that is bolted to a frame is 2.2 kN (0.49 kip), or 1 kN (0.22 Kip) if the cover is not bolted. The mortar bond between the frame and access chimney breaks at 13 to 22 kN (3 to 5 kip). With no restraint system, the risk of the cover being launched is certain, when the upward force reaches the 12 to 15 kN range, if the cover is bolted to the frame. Field testing with TNT charges was performed with a resulting upward force up to 157 kN (35 kip), as outlined in Reference Document 4 (see page 5).

Table 1: Three-Phase 347/600 V Secondary

Vault	10 KA	20 KA	30 KA
332	Pressure: 200 KPa Force: 136 KN Cover launched	Pressure: 400 KPa Force: 273 KN Cover launched Bolt heads launched	Pressure: 600 KPa Force: 409 KN Cover launched Bolt heads launched
632	Pressure: 87 KPa Force: 59 KN Cover launched	Pressure: 173 KPa Force: 118 KN Cover launched	Pressure: 260 KPa Force: 177 KN Cover launched
555	Pressure: 77 KPa Force: 52 KN Cover launched	Pressure: 152 KPa Force: 104 KN Cover launched	Pressure: 228 KPa Force: 156 KN Cover launched

Table 2: Three-Phase 120/208 V Secondary

Vault	10 KA	20 KA	30 KA
332	Pressure: 69 KPa Force: 47 KN Cover launched	Pressure: 138 KPa Force: 94 KN Cover launched	Pressure: 207 KPa Force: 141 KN Cover launched
632	Pressure: 30 KPa Force: 20 KN Cover launched	Pressure: 60 KPa Force: 41 KN Cover launched	Pressure: 90 KPa Force: 61 KN Cover launched
555	Pressure: 26 KPa Force: 18 KN Risk of launch	Pressure: 53 KPa Force: 36 KN Cover launched	Pressure: 80 KPa Force: 54 KN Cover launched

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Table 3: Single-Phase 120/240 V Secondary

Vault	10 KA	20 KA	30 KA
332	Pressure: 23 KPa Force: 16 KN Risk of launch	Pressure: 46 KPa Force: 31 KN Cover launched	Pressure: 69 KPa Force: 47 KN Cover launched
632	Pressure: 10 KPa Force: 7 KN <i>(no launch expected)</i>	Pressure: 20 KPa Force: 14 KN Risk of launch	Pressure: 30 KPa Force: 20 KN Cover launched
555	Pressure: 9 KPa Force: 6 KN <i>(no launch expected)</i>	Pressure: 18 KPa Force: 12 KN <i>(no launch expected)</i>	Pressure: 26 KPa Force: 18 KN Risk of launch

When dealing with three-phase voltages above 120/208, it is highly recommended to select larger vaults, in addition to the blast proofing system. Doubling the volume will cut the explosive pressure by half. This decision is left to the discretion of the project engineer. Also note that the ½", 1170 MPa (170 ksi) bolts break explosively when forces on the cover reach 260 kN (58 kip). This is 130 kN (29 kip) per bolt.

Note that the lightweight vault lids were tested in the 1990s for 14.4 kV single line-to-ground faults on the 832 box. The cement collars lifted and pressures were released satisfactorily.

Construction

The blast proofing system is added after normal construction is complete. To install the blast proofing system, first construct the manhole or vault assembly as specified in ES54 sections B and C, using standard construction procedures for the cast iron frame. Blast proofing anchor rods and security nuts could later be installed by a different crew at any time using a hammer drill and standard wrenches, as shown in Figure 5 below.



Figure 5: Anchor Rod Installation Using Hammer Drill

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	BC Hydro			REPLACES: N/A ORIGINALLY ISSUED: MAR 2016			

Use a Hilti hammer drill to drive the blast proofing rods through the flutes in the frame and into the packed road base. The flutes have a 10° angle to allow the rods to be inserted without contacting the top of the frame. Use double jam nuts on the end of the rods where the drill is applied. Existing man-hole assemblies can be made blast-proof by replacing the old frame with the current one, which has flutes to accommodate the blast-proofing rods. For all installations, bolt the cover to the frame with high strength BC Hydro security bolts. The bill of materials for the blast proofing system is shown in Table 4: Bill of Materials for Blast Proofing.

Refer to Application Guide 028 (Reference Document 5 below) for detailed construction instructions with illustrations.

Table 4: Bill of Materials for Blast Proofing

Item	Part #	Quantity
Dayton steel rods	N/A	6
½" hex nuts	N/A	12
Hilti hammer drill	TE70	1
0.75" SD drill bit shaft	TE-Y	1
1.25" hex socket for ¾" driver	N/A	1
1.5" crescent wrench	N/A	2
BC Hydro security bolt*	96005174	2
Belleville washer ½" dia.*	102-4131	2

* Indicates the parts are stocked by BC Hydro.

Reference Documents

1. R. Lee, "Pressures Developed by Arcs," *IEEE Transactions on Industry*, Vols. IA-23, no. 04, pp. 760-764, 1987.
2. P. Mukerjee and D. Tarampi, "Arc Pressure Estimates for Underground Cable Vaults," BC Hydro E738, 2009.
3. W. Black and J. Cotes, "Mitigating Manhole Events," IEEE PES Insulated Conductors Committee - C34D, 2014.
4. M. Kelvin, "Manhole Blastproofing and Restricted Access ETR 041," BC Hydro, Vancouver.
5. S. Crockett and M. Kelvin, "Manhole Security, Restricted Access and Blast Proofing," BC Hydro DSAG 028, 2014.

REVISIONS:	DESIGNED  M. KELVIN	RECOMMENDED  L. STEVANOVIC	ACCEPTED  F. DENNERT	ENGINEER OF RECORD  2017-02-15	VAULT/BOX SAFETY BLAST PROOFING		
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Application

This standard provides information on the slip resistance of BC Hydro underground access hatches (enclosure lids) installed in pedestrian walkways.

BC Hydro enclosure lids are tested to ASTM E303. This is the most widely used pedestrian slip resistance test method in the world, used to evaluate the frictional properties of walking surfaces through a standardized test that replicates heel slippage in wet conditions. BC Hydro's requirement for manufacturers is a minimum surface friction pendulum test value (PTV) or British pendulum number (BPN) of 55. This value is based on Australian and New Zealand classification criteria for external ramps with slopes steeper than 4.1°.

Revision Notes

New standard. This revision released concurrently with Standards and Equipment Advisory Information Bulletin 2023-043 *New Standard ES54 P1-03 Vault / Box Safety Aluminum Lids Slip Resistance*.

References

External Documents

ASTM E303 *Standard Test Method for Measuring Surface Frictional Properties Using the British Pendulum Tester*

ASTM C1028-06 *Standard Test Method for Determining the Static Coefficient of Friction of Ceramic Tile and Other Like Surfaces by the Horizontal Dynamometer Pull-Meter Method* (withdrawn in 2014)

AASHTO T 278 *Standard Method of Test for Surface Frictional Properties Using the British Pendulum Tester*

ANSI A137.1 *Standard Specifications for Ceramic Tile*

SA HB 198 *Guide to the specification and testing of slip resistance of pedestrian surfaces*

BS EN 16165 *Determination of slip resistance of pedestrian surfaces. Methods of evaluation*

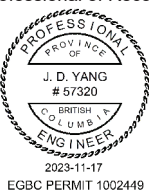
Safety Direct America *Slip Resistance Testing Standards in 2023*

Coefficient of Friction

The coefficient of friction (COF) is the ratio of the vertical to horizontal force. There are two types of COF:

- Static COF is the ratio of the maximum static friction force between the surfaces in contact before movement commences; and
- Dynamic COF is the ratio of the kinetic friction force between the surfaces in contact during movement.

COF can be measured or estimated using different instruments and methods but the procedure is always the same. A specified weight is attached to a slider and pulled across a tested surface at a constant speed. The force to get the slider started (static) and to maintain motion (kinetic) is divided by the slider weight to get the COF.

Designed: J. Yang, P. Eng			Vault / Box Safety Aluminum Lids Slip Resistance	
Checked: L. Stevanovic, P. Eng				
Reviewed: L. Stevanovic, P. Eng			DISTRIBUTION STANDARDS BC Hydro	ES54 P1-03 R0
Approved: H. Giesbrecht, P. Eng		Issued: 2023-11-17 Effective: 2023-11-17		

COF can vary on the same surface depending on the slider material used for testing. Sliders are usually made of hard or soft rubber. Hard rubber simulates dress shoes, while soft rubber is more representative of bare feet, athletic shoes, and car tires. The same surface could have a COF of 0.4, 0.5, 0.6, or 0.7 depending solely on the pedestrian footwear.

Slip Resistance Standards

The BC Building Code does not provide a specification for COF. The BC Building Access Handbook provides a list of some floor materials with descriptive slip resistance assessment (i.e. good, fair, poor). Concrete, linoleum, terrazzo, and vinyl are assessed as good when dry and fair to poor when wet.

The International Building Code (used in the United States) refers to ANSI A137.1 which specifies a slip resistance test procedure. The code applies a hard rubber slider and limits the minimum wet dynamic COF for tiles in level interior spaces to 0.42. The test uses a digital instrument (tribometer) intended for indoor surfaces. It is not suitable for testing outdoor floors and surfaces. BC Hydro does not use this test as it is inappropriate for access hatches intended for outdoor applications in public rights-of-way.

The British pendulum tester is the most widely used pedestrian slip resistance test method. This method is specified in ASTM E303. The test uses a hard or soft rubber slider (specifying the rubber properties) to measure PTV or BPN. There is no direct correlation between BPN and COFs determined by other test types.

British Pendulum Tester

The British pendulum tester measures the frictional resistance between a rubber slider mounted on the end of a pendulum arm and the test surface. The pendulum arm has a spring-loaded rubber slider on the pendulum foot.



Figure 1 – British pendulum tester

The tester is placed and levelled on the portion of the floor surface being tested. The height of the pendulum suspension centre is adjusted to a fixed value which is read on a special gauge. The pendulum is released from its horizontal position to swing down freely until the rubber slider contacts the test surface. The pendulum slows as the slider travels across the surface for a fixed distance. The frictionally constrained pointer affixed to the pendulum arm measures the highest point in the pendulum arc. The pointer position is read on the measuring arc, graduated from 0 to 150. Pointer readings indicate the test surface resistance to skidding.

Table 1 – Pendulum test value safety criteria for various floors from Australian standard SA HB 198

Building or walkway type	Line no.	Location or function of area	Minimum wet PTV (or BPN)	
			Hard rubber slider	Soft rubber slider
External pavements and ramps	1	External ramps with slopes steeper than 1 in 14 (4.1 degrees)	55	45
	2	External ramps, slopes less than 1 in 14	45	40
	3	Level surfaces: external sales areas (e.g. markets), external car parks, external colonnades, walkways, pedestrian crossings, balconies, verandas, carports, driveways, courtyards, roof decks	45	40
	4	Car parks, undercover	35	35
Hospitals and aged care facilities	5	Bathrooms and ensuites in hospitals and aged care facilities	35	35
	6	Wards and corridors in hospital and aged care facilities	25	20
Hotels, offices, public buildings, schools, kindergartens; entries and access areas including common areas, internal elevator lobbies	7	Dry area	12	NS
	8	Hotel bathrooms, ensuites and toilets	25	20
	9	Hotel kitchens and laundries	25	20
	10	Restroom facilities in offices, bars and shopping centers	35	35
	11	Transitional areas, intended to be kept dry	25	20
	12	Wet area	35	35
Kitchens (commercial), serving areas, cold stores	13	Commercial kitchens	55	45
	14	Serving areas behind bars in bars and clubs	45	40
	15	Cold stores and freezers	45	40
Loading docks	16	Loading docks under cover	55	45
Sports stadiums	17	Undercover concourse areas	35	35
Supermarkets and shopping centers	18	Dry areas in separate shops in shopping centers	12	NS
	19	Fast food outlets, buffet food servery areas, food courts and fast food dining areas in shopping centers	35	35
	20	Fresh fruit and vegetable areas in shops and supermarkets	35	35
	21	Shop entry areas with external entrances	35	35
	22	Supermarket aisles (except fresh food areas)	12	NS
	23	Wet areas in separate shops in shopping centers	35	35
Swimming pools and sporting facilities	24	Communal changing rooms	35	35
	25	Communal shower rooms	45	40
	26	Swimming pool decks	45	40
	27	Swimming pool ramps and stairs leading to water	55	45
Stairs	28	Dry treads or landings	35	35
	29	Wet treads or landings	45	40

Enclosure Lids

BC Hydro distribution enclosure lids are tested to 55 BPN. Gratings on transformer vaults are installed perpendicular to the sidewalk alignment to provide adequate slip resistance.

Slip test measurements are assessed based on statistical methods to ensure uniform quality of installed lids, assuming a normal or Gaussian distribution curve. This method sets the percentage of installed lids below the specified limit to 5%.

The test method involves calculating statistical parameters from a minimum of three test results for each subplot (50 units) and lot (annual supply). The average (mean) value and standard deviation are calculated, and the difference from the sample mean to the specified test limit is divided by the standard deviation. This yields the quality index. The percent below the specified limit of the tested population is determined based on the quality index and the number of samples.

Application

This standard describes the installation of snow markers on pad-mounted equipment. Snow markers should be installed in areas of high snow depth to avoid damage from snowplows.

Revision Notes

R0 – New standard. October 2022, ST

Items Required

Item	Description	Material Number
1	Marker, 4 ft length, red, snow marker, polycarb, comes with 2" length bolt and curved washer	9700-9262
	Marker, 6 ft length, red, snow marker, polycarb, comes with 2" length bolt and curved washer	9700-9888
2	$\frac{5}{8}$ " round flat washer	102-3043
3	Washer, flat, $\frac{5}{8}$ " nominal, hot dip galvanized, 11/16" inner diameter, 2 $\frac{1}{4}$ " square outer diameter, 3/16" thick	420-1521
4	Mechanical spacer, $\frac{3}{4}$ " inner diameter, 1" length	9700-9946

Notes

1. Install snow markers directly to the lifting bosses on the side of the pad-mounted equipment closest to the roadway using a $\frac{5}{8}$ " machine bolt.
2. Install six-foot snow markers in areas with high snow levels or topography where the four-foot markers would not be seen by snow removal vehicles from the roadway.
3. Four-foot and six-foot snow marker assemblies come with $\frac{5}{8}$ " diameter by 2" length machine bolts, flat washer, and curved washer.
4. Use a flat washer with spacer to extend the snow marker past the lid overhang where required, depending on pad-mounted equipment configuration and vintage.

DESIGNED  S. TASKOV	RECOMMENDED  H. GIESBRECHT	ACCEPTED  F. DENNERT	ENGINEER OF RECORD  S. TASKOV #45419 BRITISH COLUMBIA ENGINEER 2022-10-31 EGBC PERMIT 1002449	SNOW MARKERS INSTALLATION ON PAD-MOUNTED EQUIPMENT	
DISTRIBUTION STANDARDS  BC Hydro	ISSUED: OCT 2022 REPLACES: N/A ORIGINALLY ISSUED: OCT 2022	PAGE 1 OF 3		ES54 P2-01.01	R 0

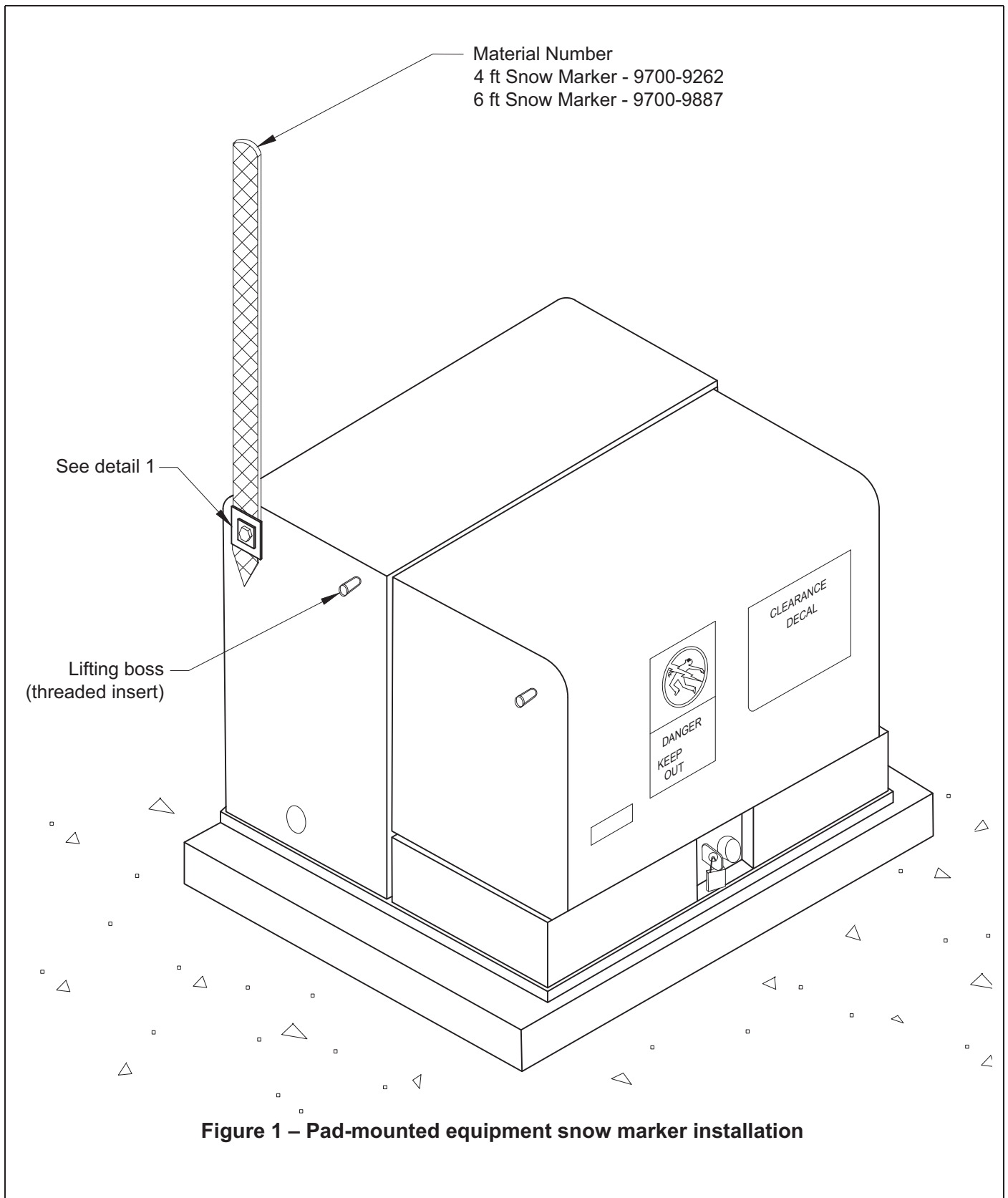
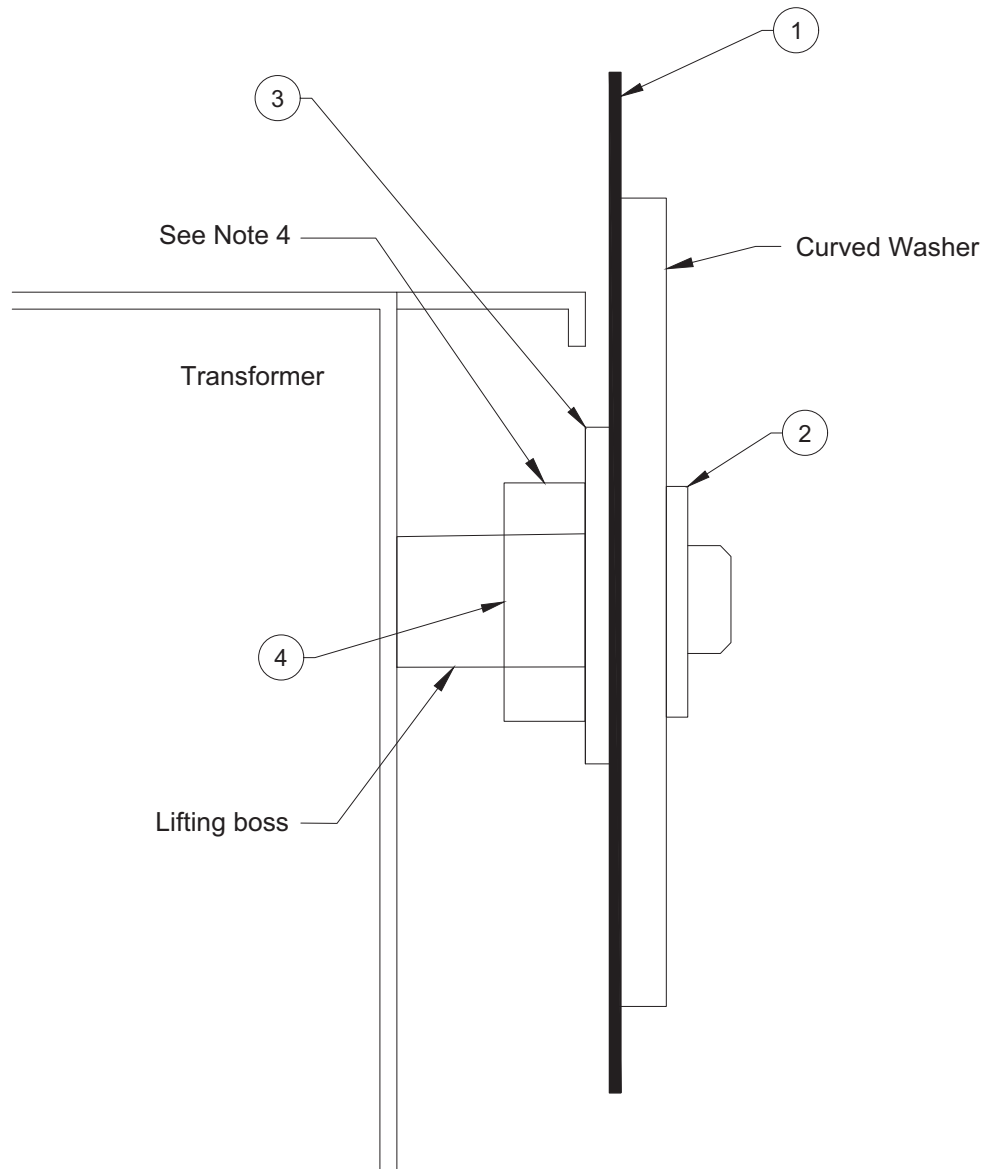


Figure 1 – Pad-mounted equipment snow marker installation

DESIGNED  S. TASKOV	RECOMMENDED  H. GIESBRECHT	ACCEPTED  F. DENNERT	ENGINEER OF RECORD  S. TASKOV # 45419 BRITISH COLUMBIA ENGINEER 2022-10-31 EGBC PERMIT 1002449	SNOW MARKERS INSTALLATION ON PAD-MOUNTED EQUIPMENT	
DISTRIBUTION STANDARDS 		ISSUED: OCT 2022 REPLACES: N/A ORIGINALLY ISSUED: OCT 2022		PAGE 2 OF 3	ES54 P2-01.02
					R 0



Detail 1 – Side view

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					R 0