Approval of chemical, biological, radiological and nuclear (CBRN) personal protective equipment (PPE) Closeout Workshop, Ottawa, 4–5 March 2015

Project CBRN Research and Technology Initiative (CRTI) 09-438TA

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IMPORTANT INFORMATIVE STATEMENTS

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All procedures using human subjects were approved by the Royal Military College of Canada Research Ethics Board, following the edition of the Tri-Council Policy Statement: Ethical Conduct for Research Involving Humans that was current at the time the work was conducted.

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Abstract

The workshop communicated the outcomes of the CRTI09-438TA project that exercised the provisions of the standard CAN/CGSB/CSA Z1610-11 *Protection of first responders from chemical, biological, radiological and nuclear (CBRN) events*, and it provided community input to the proposed future activities on the standard's revision and launch of a conformity assessment program.

Significance to defence and security

The workshop successfully engaged the community of interest in the Z1610 standard, with participants attending from across the community. It disseminated the results of a comprehensive evaluation of candidate protective systems provided by leading manufacturers against the standard's provisions in order that the response community be better informed on current protective system capabilities and potential for standardization. The workshop concluded by obtaining community feedback on the priorities for action in order to finalize the development of an approval process for CBRN personal protective equipment for first responders in Canada. This activity furthers the provision of appropriate levels of protection and functionality against the national standard, for CBRN first responders, including fire, hazardous materials, police, emergency medical, paramedic and military responders.

Résumé

L'atelier a permis de transmettre les résultats du projet CRTI09-438TA pour la mise en application des dispositions de la norme CAN/CGSB/CSA Z1610-11, *Protection des premiers intervenants en cas d'incidents chimiques, biologiques, radiologiques et nucléaires* (CBRN). Il a aussi permis d'obtenir les commentaires des membres de la communauté à l'endroit des activités futures proposées concernant la modification de la norme et le lancement d'un programme d'évaluation de la conformité.

Importance pour la défense et la sécurité

L'atelier a mobilisé la communauté d'intérêts envers la norme Z1610 et des membres de l'ensemble de la communauté y ont pris part. Cette activité a permis de communiquer les résultats d'une évaluation exhaustive des éventuels systèmes de protection des principaux fabricants en fonction des dispositions de la norme. Elle visait à mieux informer les membres de la communauté sur les capacités des systèmes actuels de protection et une éventuelle normalisation. À la fin de l'atelier, les membres de la communauté ont fait part de leurs suggestions sur les priorités relatives aux mesures à prendre afin de finaliser l'élaboration d'un processus d'approbation pour l'équipement de protection individuelle en cas d'incident CBRN des premiers intervenants canadiens. Cette activité favorise l'offre de niveaux de protection et de fonctionnalité appropriés, conformément à la norme nationale, pour les premiers intervenants (policiers, personnel médical d'urgence, militaires, ambulanciers paramédicaux, pompiers et intervenants en matières dangereuses, etc.) en cas d'incident CBRN.

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Acknowledgements

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1 Purpose of the workshop

1.1 Background

This workshop was held as the closing technical activity under Project CRTI 09-438TA "Approval of CBRN Personal Protective Equipment" (funded by the CBRN Research and Technology Initiative (CRTI) and through in-kind contributions of the project partners), a project established to develop an approval process against the National Standard of Canada CAN/CGSB/CSA Z1610-11 Protection of First Responders from chemical, biological, radiological and nuclear (CBRN) events [1]. The project was implemented in order to fast track the selection, development and potential approval of CBRN personal protective equipment (PPE) configurations against the standard.

The early project CRTI 01-0029RD "Protecting the first responder from CBRN threats" laid the groundwork for the approach to standardizing Canadian first responder CBRN protection. It identified significant gaps in selection processes and available PPE and the need for a Canadian standard that would result in interoperability of all responder groups across Canada, through integrated guidance for PPE performance and selection that takes into account varied response roles, manufacturer and employer responsibilities [2].

The follow-on project CRTI 05-0016RTD "Development of a Canadian Standard for Protection of First Responders from CBRN Events", led by the Canadian General Standards Board (CGSB) and Canadian Standards Association (CSA), developed and published the voluntary national standard Z1610-11 [1] which has been published by the Standards Council of Canada. This standard will be referenced in Canadian federal regulation in future updates to the Canada Labour Code.

At the time of publication of the standard, it was recognized that in order for it to be taken up by the community, a number of activities would need to be performed. These included: a thorough evaluation of the standard's contents by application, including assessing whether current state-of-the-art PPE could meet the standard's requirements; developing potential approval processes; and working with the responder community to ensure that they were familiar with the standard's contents. Hence this project CRTI 09-438TA "Approval of CBRN Personal Protective Equipment" was launched in order to further mature and transition the standard into the hands of manufacturers and responders.

A number of activities were conducted over the course of the project, including several surveys and workshops run by this project or in conjunction with others, in order to obtain input from users of the standard where consensus-based decisions were important. Examples of input and feedback that were obtained included:

- the types of approval process acceptable to the various sectors of the standard's interest community (first responders, regulators, manufacturers, technical specialists / testers) [3], [4];
- priorities for exercising the standard's technical requirements, that is, which recognized configurations to evaluate (a recognized configuration is a full personal protective

equipment ensemble including respirator and dermal protection that meets all of the technical requirements given in the standard for that configuration, which includes laboratory testing and full system human testing) [4]; and

- appropriateness and ease of use of the standard's pre-event PPE selection processes [1], and of various tools [5], [6] developed elsewhere for performing individual system qualification according to standard.

A final workshop was held as the culminating activity in order to communicate the outcomes of the work and to make further decisions to advance both the approval process and updating of the standard.

1.2 Workshop objectives

The objectives of the closing workshop were to:

- communicate the most important test results of the configurations tested and how the results conformed with the standard's requirements;
- discuss the status of and provide further direction to the development of a certification program under the Z1610 standard, as well as other pertinent activities related to uptake of the standard by the community;
- educate and recruit participants for the standard's committees that will be constituted in order to update and revise the standard and implement the new approval process; and
- review recommended changes to test methods and requirements in the standard, which were developed as a result of the project, and obtain feedback on preferences and priorities for such changes that could be used as a basis for subsequent committee action.

2 Workshop content

2.1 Logistics

The workshop was hosted by the Royal Canadian Mounted Police in Ottawa, and was conducted 4–5 March 2015. It was organized by the main 09-438TA project team members.

2.2 Agenda

The workshop covered the following topics:

1. background information (Day 1):
    a. development of the National Standard CAN/CGSB/CSA Z1610-11; and
    b. project CRTI 09-43TA approval of CBRN PPE;
2. options for changes to the Z1610 PPE CBRN Standard (Day 1);
3. review of requirements and configuration results (Day 1 and 2);
4. updating the Z1610 PPE CBRN Standard (Day 2):
    a. discussion of support and required actions to develop a new edition of Z1610; and
    b. re-establishment of the Technical Committee;
5. certification/conformity assessment options (Day 2):
    a. discuss options;
    b. addressing the opportunity for a certification program; and
    c. role of the Technical Advisory Committee (terms of reference);
6. stakeholder feedback (Day 2):
    a. recap of major results and areas for action as identified over the course of the workshop; and
    b. voting session to prioritize changes to standard and follow-on activities.

2.3 Attendees

A total of 33 persons attended the workshop representing the interest groups pertinent to the standard. These included 12 manufacturer representatives, representing companies that

manufacture CBRN respirators, CBRN protective clothing, and CBRN bomb disposal systems (10 voting), 13 first responder representatives, representing the police, fire and medical communities (9 voting), two regulators (2 voting), and various project representatives representing the technical and standards development organizations (SDOs) (none voting). An additional 17 representatives of the first responder community that had directly participated in the project user trials attended a previous workshop at the Ottawa Paramedic Services at which these results were communicated.

2.4 Presentations

The formal presentations have been distributed on digital media in conjunction with this report. A brief summary is given here.

2.4.1 Background information

The objectives and outcomes of previous projects that developed the standard were reviewed. An outline of the most pertinent recognized configurations under the standard was presented so that the attendees would be familiar with the configuration concepts prior to presenting the results of the evaluations. These configurations [1] are outlined in Table 1.

The activities under the current project were summarized and reviewed, including those of previous workshops that prioritized project activities. The selection process for configurations to be evaluated against the standard's requirements was outlined. An overview of the evaluations performed, and the project's current status were given.

Table 1: PPE configurations assessed.

Configuration	General description of system	Comments	Number of candidate systems
C1S	Totally encapsulating, highly protective.	Complete assessment performed against mandatory Z1610 requirements.	1
C2S	CBRN self-contained breathing apparatus (SCBA) meeting National Institute of Occupational Safety and Health (NIOSH) CBRN standard [7] with a highly protective coverall meeting National Fire Protection Association (NFPA) 1994 Class 2 requirements [8].	Complete assessment performed against mandatory Z1610 requirements.	1

Configuration	General description of system	Comments	Number of candidate systems
Limited protection C2S-like	CBRN SCBA meeting most of NIOSH CBRN standard [7] with a highly protective coverall meeting NFPA 1994 Class 2 requirements [8] (but not in combination with this respirator).	CBRN SCBA does not meet ancillary requirements of NIOSH CBRN standard. Complete assessment performed against mandatory Z1610 requirements for C2S. This facilitated consideration of whether/how this type of configuration should be permitted under Z1610.	1
C2vP	CBRN air purifying respirator (APR) meeting NIOSH APR standard [9] with a highly protective coverall meeting NFPA 1994 Class 2 requirements [8] (but not necessarily in combination with this respirator).	Complete assessment against mandatory Z1610 requirements including canister performance against limited number of toxic industrial chemicals.†‡	1
C2PAPR-vP C4PAPR-P	CBRN powered air purifying respirator (PAPR) meeting NIOSH PAPR standard [10] with a highly protective coverall meeting NFPA 1994 Class 2 requirements [8] (but not necessarily in combination with this respirator).	Partial assessment was performed against mandatory Z1610 requirements for C2PAPR-vP as well as C4PAPR-P.††	1
C4P	Appropriate particulate protective CBRN APR with disposable coverall.	Complete assessment was performed against mandatory Z1610 requirements.‡	2

† With the exception of Clause B.5.5 to perform a specific chemical agent protection test of the respirator facepiece with canister attached. It was originally believed that the system was exempted as it met Clause B.5.4.1 according to the manufacturer but this was later found not to be the case.

‡ With the exception of some respirator requirements that will be recommended for deletion in the next edition of the standard (Clauses B.5.8 and B.5.18.3), and those that had no test method or criteria (Clauses B.5.11 and B.5.13).

†† Assessed against Clauses B.5.10.2, B.5.12, B.5.16 to B.5.18.2, B.5.19, B.5.22.4&.5, B.7.2, B.7.10 and Annex C.

2.4.2 Options for changes to the Z1610 CBRN PPE standard

A brief review of the various types of changes to the standard that could be performed in conjunction with developing an approval process was given.

The standard is very large, full of detail, and technically complex both to evaluate and administer.

Many changes were identified over the course of the project that would be required simply for editorial and technical consistency in order to achieve the standard's original intended content.

Additionally, as part of the project, a number of new test methods and criteria were developed to evaluate against requirements that were quite general. The standard contains many possible recognized configurations, not all of which were subsequently identified as priorities by the user community. The standard is also divided between manufacturer responsibilities (largely design and laboratory testing) and various employer responsibilities that include both evaluations in order to achieve an approved configuration for their group, and various requirements for maintaining a personal protective equipment program including appropriate selection, training, equipment sizing and issue to individuals. Some of the evaluations in particular may be difficult for employer PPE user organizations to perform. Finally, over the course of the project, assessment of how well current state-of-the-art equipment could perform against the standard's requirements was performed, and a number of potential issues with regards to meeting desired protection levels were identified.

In summary, then, for the next edition of the standard, examples then of the types of changes that could be considered are:

- perform required editorial and technical corrections for consistency / technical correctness;
- add new test methods / criteria;
- add/delete recognized configuration types;
- reduce the focus to user evaluations only;
- simplify user evaluation requirements; and
- change protection requirements.

2.4.3 Review of requirements and configuration results and relevant changes to the standard

The results of project assessments on numerous recognized configuration candidate systems were presented. The systems had been selected based on a combination of user priorities and available state-of-the-art PPE systems that were felt by the team might meet the standard's requirements (either provided by manufacturers or purchased by the project). The candidate systems were assessed against the recognized configurations' requirements as summarized in Table 1.

None of the configurations assessed unambiguously met all of the standard's requirements as written. Some of the more important observations with respect to proposed changes to the standard are summarized below.

Firstly, there were a number of areas where the requirements were unclear or perhaps unnecessary which contributed to this observation. In general, the system level test is supposed to be performed with all ancillary equipment worn, but such equipment (e.g., helmets, vests) will differ amongst user groups. Therefore, approval of a system in any generic sense would be difficult. A recommended change is to remove the requirement to assess with ancillary equipment (Clauses C.1 and C.2) but require some subsequent assessment such as the qualitative or quantitative integration assessment (Clauses H.2.4 and H.2.5) with all wearers.

2.4.3.1 Wear, durability and functionality

A systematic wear trial and user functionality trial evaluation procedure was developed, as the standard was very general in this area, with the user organization able to design and assess this performance themselves (Clauses C.3 and C.4). All of the systems assessed appeared to perform adequately in the functionality portion of the trial; the standard requires that the user organization develop means to deal with any functionality issues that were observed, and all observed issues seemed manageable. For the purposes of an approval process, the fact that the tests were performed in a standardized and interpretable manner appears the most important part of the process, with the user organization able to achieve an approved system if desired by accepting the results and explicitly addressing any issues.

The C1S system is primarily assessed for functionality and wear, and met every requirement that had clear criteria. It did not achieve a 100% pass for the integrity test after the wear trial, but that requirement, along with the wear trial, had no explicit criteria. Therefore some clarification of the standard's requirements would be required in this case. It is not practical to be worn for one hour as described in the standard for all configurations due to limitations in the air supply and therefore the standard's duration of use requirements for this configuration should be altered.

Neither of the two respirators that were assessed as C2vP, C2PAPR-vP and C4P systems passed all of the respirator durability tests that would be required by the manufacturer (Clause B.5.10.2) in spite of the fact that one of the two respirators was NIOSH CBRN approved. A point of discussion is whether some of these durability criteria are too harsh.

Neither of the candidate single use coveralls assessed in the C4P configuration survived the wear trial well. Again, the criteria for this requirement (Clause C.4.1) are unclear in the standard, in that the user organization can make the decision whether the outcomes are adequate. Therefore, despite relatively poor performance, a user organization might decide these results were adequate and consider the system "approved" against this particular set of criteria provided they had a mechanism for dealing with the failures.

2.4.3.2 System integration

Neither of the candidate single use coveralls assessed in the C4P configuration integrated well with the additional gloves and respirator, leaving significant gaps in many cases. One recommendation with regards to glove performance would be to use the longer gloves that are now available, and probably to double-glove as well.

One of the over-boot systems assessed with several of the systems had limited sizes available (nothing in smaller sizes) and this again would require the user group to identify how individuals with smaller-sized feet would be accommodated (Clause C.2). This might not be an issue for some user groups depending on their demographics.

Only the C4PAPR-P system passed the respiratory simulated workplace protection factor (SWPF) performance requirements as written, with the following caveats: the respirator was not assessed by itself to determine whether it passed the respiratory SWPF requirements (Clause B.7.2.3.2), nor was the system assessed in negative pressure (PAPR failure) mode (Clause C.5.4.2) due to time constraints. The absence of respirator-alone testing clearly did not preclude the system from passing in positive pressure mode, and therefore the requirement to test the respirator by itself should not be mandatory. While the results in negative pressure mode would be of benefit to the user, it seems that they also should not be mandatory. See also the statement below re sizing distribution of the wearers.

None of the other systems passed the respiratory SWPF requirements at 100% pass rate as required by the standard (Clause C.5.4.2). Nor was it possible to obtain the sizing distribution of persons required to perform the test, even recruiting outside the relatively large pool of demographically typical users that were available to the project (86 participants were evaluated, all appropriately trained for use of the equipment; see Table 2). Both of these issues need to be addressed in the standard for future reference. Less restriction on the user sizing distribution would probably be required, with some caveats on the sizes that were not assessed. The group considered various options for a tiered approval system with regards to the pass rate.

Table 2: Participants involved in user testing.

User Group	**Number of participants**
Police	50
Fire/hazmat	6
Paramedic	14
Military	5
Other (non-first responder)	7

The C2vP and limited protection C2S systems did not pass the C2 system level vapour protection requirements as written (Clause C.5.3). A number of explanations for this were presented but no particular solution was offered; the criteria seem appropriate and are similar to those in existing standards (NFPA 1994 Class 2 [8]), although slightly more difficult to meet because a greater distribution of sizes tested is specified in Z1610. This may simply have been a limitation of the systems tested.

2.4.3.3 Other laboratory testing (material and component tests)

A number of additional requirements under the manufacturer responsibility portion of the standard were assessed (Clauses B.5.20 to B.5.23, B.9.4.2 and B.9.5.2), with the majority testing the APR, C1 and C2 components. These covered drinking, breathing resistance, canister particulate penetration and gas and vapour filtration (both including rough handling), C1 and C2 agent and toxic industrial chemical material permeation, water repellency, cold effects, and other durability tests not already mentioned above. Many required the development or sourcing of new test methods. Most results were a pass under the standard with a few exceptions; a few had unclear test methods and criteria and hence results may have been ambiguous.

2.4.4 Updating the Z1610 PPE CBRN Standard

The standards development organizations presented a summary of the community support and actions required to develop a new edition of Z1610, including:

- demonstrate stakeholder support:
  - government, first responders, manufacturers;
- secure funding/resources:
  - consider complexity of project; and
  - (e.g., how much change? volume of work?);
- project proposal/approval process (CSA & CGSB):
  - project schedule; and
  - deliverables/milestones;
- re-establish the Z1610 Technical Committee.

There was also discussion around the supporting documents required to improve uptake of the standard once revised, such as a guide for employers to help them understand its relevance and application. The standard should be made more user-friendly, and a survey of stakeholders already performed under the project, along with workshop outcomes, will be used to help understand priorities.

2.4.5 Certification/conformity assessment options

The contents of a certification program were reviewed. A program is generally based on standards or regulatory schemes. In the case of Z1610-11, which would be considered a performance standard, it would include assessment against the standard, as well as potentially against the ISO 9001 quality management systems standard [11], periodic product testing and/or performance monitoring and periodic quality auditing or registration.

The proposed certification process/program development, with the participation of the CBRN interest community, provides the following advantages:

- assurance that PPE meet performance-based criteria of standard Z1610-11 on a consistent basis;
- easy identification of PPE compliant with the program requirements;
- facilitation of a competitive bidding process for market existent PPE;
- certification process transparency ensured by third-party monitoring; and
- complaint and redress mechanisms that promote self-policing of the industry participants.

The required review of the approval process ensures process integrity.

In order to develop the certification program, a technical advisory committee (TAC) must be established (the next step and it is expected that a number of the workshop attendees will participate). The TAC will review the documentation already prepared by the SDO's and the project, and address the following requirements of the program:

- standard requirements analysis to document requirements for PPE testing and evaluation:
  - this has been in large part completed under the project, along with revisions to the standard proposed to follow;
- certification and/or qualification program structure and operational procedures, including selection of level of quality system (ISO 9000 series):
  - a draft program manual has been completed under the project;
- assessment criteria:
  - methods and scheduling of testing;
  - product verification and assessments;
  - existing manufacturing processes, process controls;
  - product recall; and
  - advertising guidelines;
- the application and assessment/certification process, including:
  - makeup of the review panel; and
  - recertification interval/maintenance of certification.

3 Outcomes/stakeholder feedback (Day 2)

The outcomes are presented here of the voting session that assessed the workshop attendees' priorities for changes to the standard and future activities, based on the previous presentations and discussion. A few areas of concern were not included, primarily where the issue was too complicated to address by a simple survey. The intent is that these results are guidance for the community, and the various organizations and committees that will handle the future work will be able to use this information along with other inputs available to them in order to decide on the way forward.

Participants were asked to respond to the proposed change or action with one of the following responses, which were each weighted as follows (Table 3).

Table 3: Polling responses and weights.

Response	Weight
Very important	2
Somewhat important	1
Don't care	-1
Disagree	-2

By adding up and weighting the number of responses of each type to a given question or issue, it was possible to decide which items discussed were assigned the greatest priority or viewed the most positively by the group as a whole; the weighting values are arbitrary and simply assist in easily visualizing the outcomes. The group was relatively evenly balanced between manufacturers and users, with fewer regulators.

3.1 Recognized configurations

In this section, the preferences of the group on the number and type of recognized configurations were obtained (Figure 1). In general, the group was neutral or negative about removing any of the existing configurations (the large number is a contributor to the complexity of the document), including removing the North Atlantic Treaty Organization-capable APR as a choice. The group felt more recognized configurations were appropriate, including potentially explicitly recognizing hybrid or combined respirators (both powered-air purifying and self-contained breathing in one device), and those that do not meet all NIOSH CBRN standard requirements [7], [10], as well as CBRN-protective bomb suits.

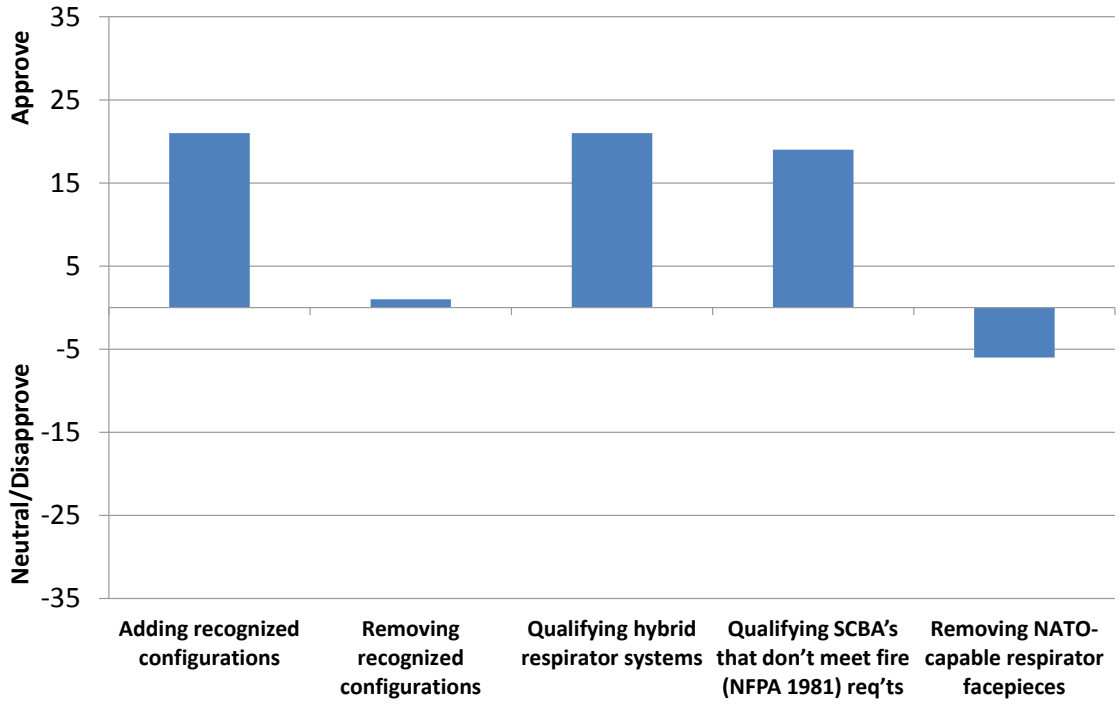

Figure 1: Changing recognized configurations.

3.2 Respirator requirement – manufacturer responsibility

Several respirator requirements that fall within the manufacturer responsibility portion of the standard were considered (Figure 2).

The group felt the drinking device requirement should be maintained on the vP APR, and there should be an explicit requirement to assess the chemical agent protection performance of the entire facility.

The standard currently requires the P and vP APR's to deliver a level of particulate protection (both by the filter and when worn) higher than that required in the NIOSH CBRN APR standard [9]; while the group was neutral about maintaining this requirement, it was in favour of maintaining the requirement for individual canister testing on the production line against the particulate protection performance requirement.

A discussion of the severity of both the canister rough handling and harness pull tests did not lead to a clear preference to reduce the severity of the facepiece connector test in order to achieve a passing system; however it was felt that the rough handling test should be re-assessed.

Cold temperature performance, which is inadequately assessed under the current version of the standard, was felt to be a priority.

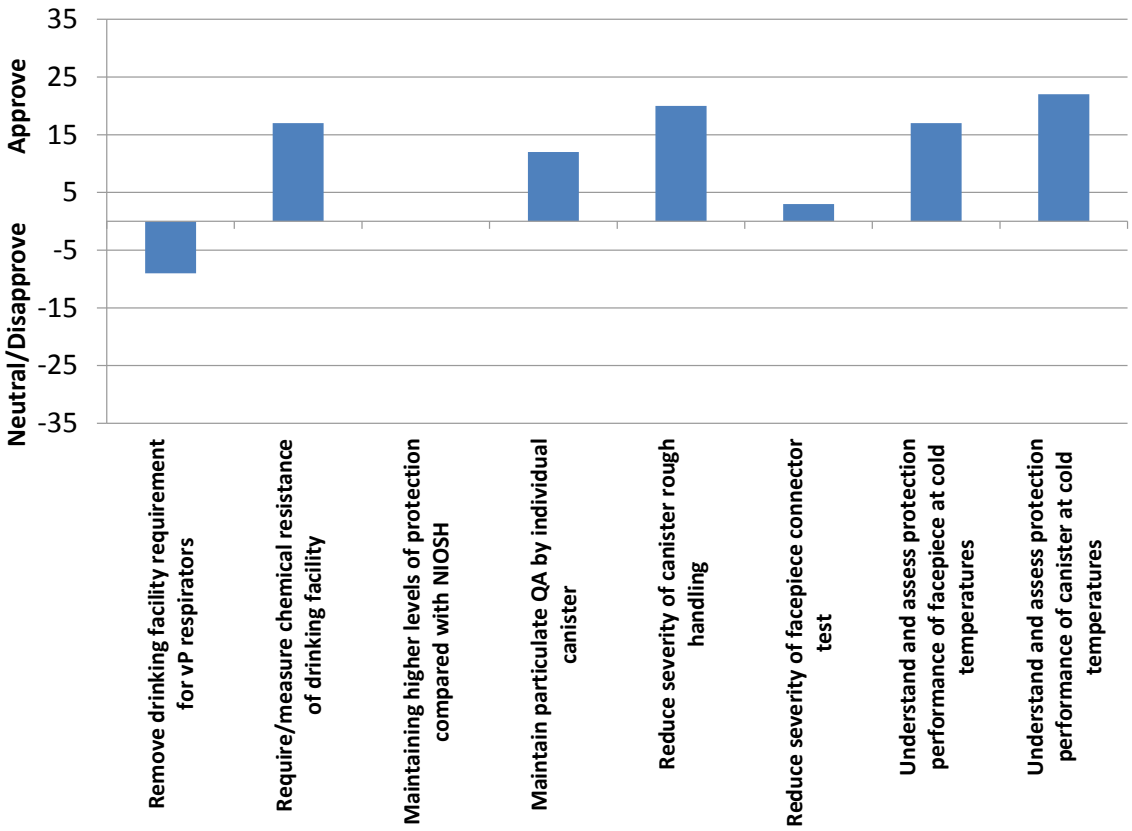

Figure 2: Respirator requirements – manufacturer responsibility.

3.3 System level respiratory protection requirements – employer responsibility

There were a number of challenges with respect to achieving the desired levels of respiratory protection over the entire range of possible wearer anthropometrics and various solutions were proposed to address the problem (Figure 3). The group had no particular consensus on how to address the user anthropometrics problem, and was generally favourable to either suggested approach regarding assessment of respiratory protection performance, using tiers that assigned a tier based on either 100% protection at lower levels than currently required, or the percentage that achieved the protection at the level currently required.

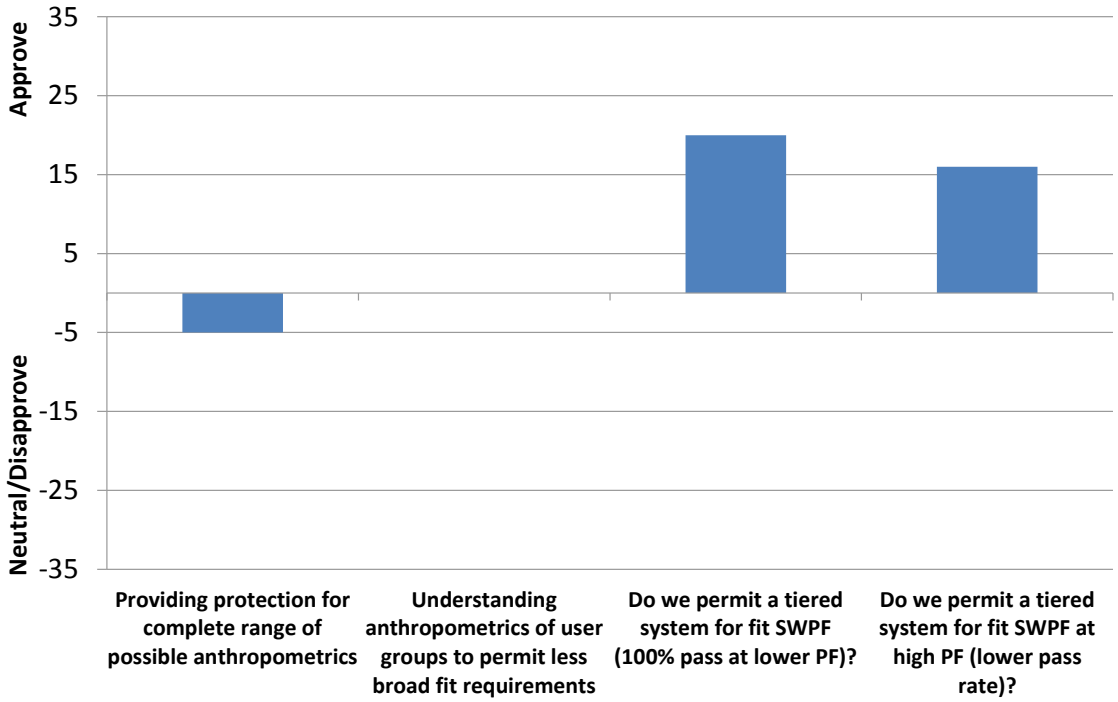

Figure 3: System level respiratory protection requirements – employer responsibility.

3.4 General use requirements – employer responsibility

Issues regarding wear, functionality, doffing, and user burden were discussed (Figure 4).

Inclusion of a standardized wear and functionality methodology such as that developed under the project in the next edition of the standard was viewed as important, as well as providing better assessment of and guidance on the impact of physiological stress on the wearer. Another issue that could be considered for inclusion in the standard is a more explicit set of requirements for suitability for doffing and decontamination.

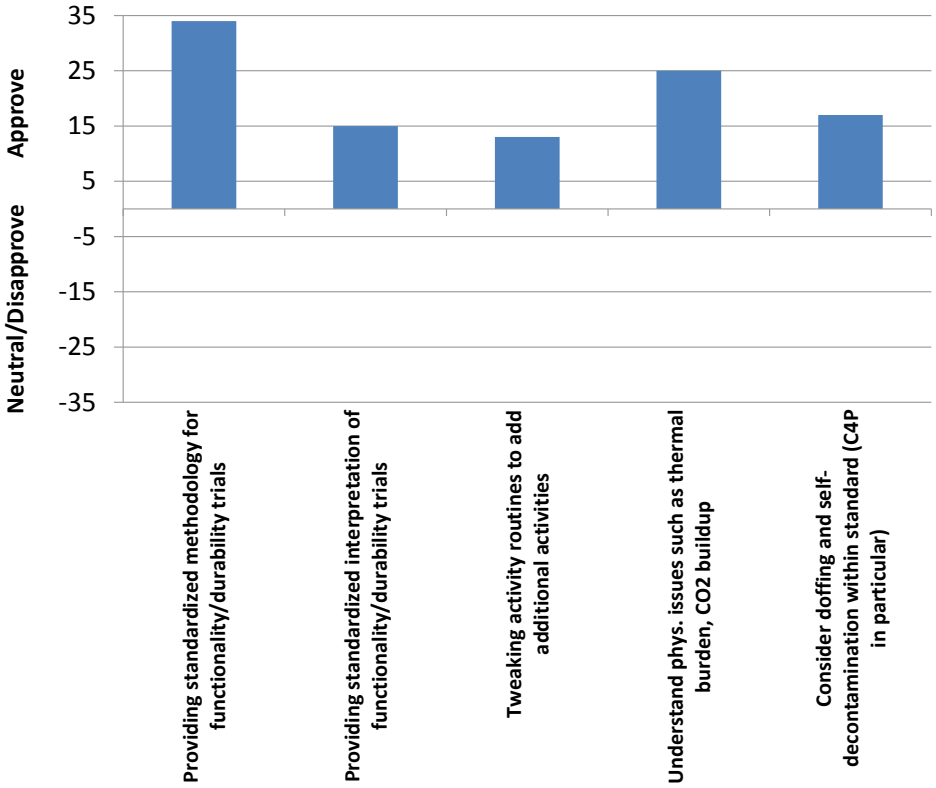

Figure 4: General use – employer responsibility.

3.5 Ease of use of standard

The group felt strongly that guides to the standard for both the employer and the wearer should be developed (score 31 and 30).

3.6 Conformity assessment

3.6.1 Process and accreditation

A number of issues with respect to the practicalities of an approval process were considered and the results are presented here.

For the conformity assessment of the manufacturer's responsibilities, slightly more than half the group would accept/prefer the idea of manufacturers providing the assessments but with an accreditation program, while about half the group would support third party assessments and half a manufacturer declaration of conformity. Note that multiple responses were possible here, since any or all options could potentially be acceptable, and there was no particular trend by the category of the individual responding. Hence all possible options can continue to be considered as there was no strong preference.

For the system level evaluations that are the employer's responsibility, about three quarters of respondents supported the idea that a third party could/should perform the assessments, while about half supported the manufacturer and half supported the employer performing the assessments. Many attendees felt all options were acceptable.

As a general trend, manufacturers would want the manufacturer's portion of the certification to be addressed first, while the users and regulators preferred both portions of the certification program to be addressed immediately.

There was a strong preference (by about 2 to 1) for some form of accreditation program for employers to assure conformity with the employer's portion of the standard versus self-declaration.

3.6.2 Configurations to prioritize

The participants were asked to prioritize the systems for which they would like to see conformity assessment against Z1610, based on which they would like to see pursued first, and which second. Generally, the C2S configuration placed as either first or second for most participants and was the clear preference. Of the remaining configurations, the C4PAPR-P was least desired, and the others all had some support.

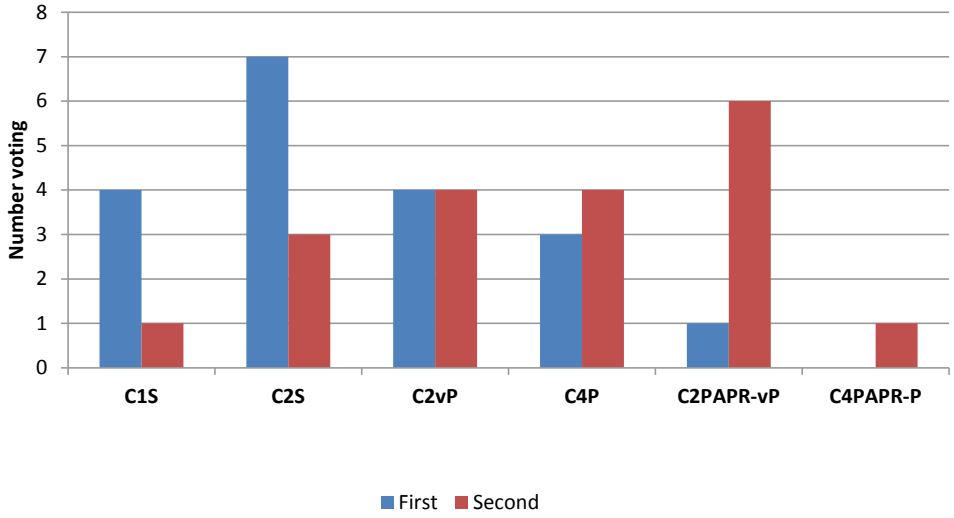

Figure 5: Recognized configuration to be pursued first or second for a conformity assessment program.

3.7 Future participation

The participants were polled for their willingness to participate on the technical committee for the revision of the standard, on the technical advisory committee for the conformity assessment program development, and to assist in development of various guides to the standard. Response was strong, with all but one of the participants confirming future participation on at least one of the activities, and each activity having at least half of the attendees confirming future participation. The interest in supporting each of the activities was spread across all the groups.

4 Conclusions

The workshop successfully engaged the community of interest in the Z1610 standard, with participants attending from across the community. The workshop communicated the outcomes of the CRTI09-438TA project as well as the proposed future activities on the standard's revision and development of a conformity assessment program. The workshop concluded by obtaining community feedback on the priorities for action in order to finalize the development of an approval process for CBRN personal protective equipment in Canada.

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List of symbols/abbreviations/acronyms/initialisms

APR	Air purifying respirator
C1S	Fully encapsulating CBRN protective ensemble with SCBA
C2PAPR-vP	CBRN protective ensemble with PAPR
C2S	CBRN protective ensemble with SCBA
C2vP	CBRN protective ensemble with APR
C4PAPR-vP	Particulate protective ensemble with PAPR
C4P	Particulate protective ensemble with APR
CAN	Canada
CBRN	Chemical, biological, radiological and nuclear
CGSB	Canadian General Standards Board
CRTI	CBRN Research and Technology Initiative
CSA	Canadian Standards Association
ISO	International Organization for Standardization
NFPA	National Fire Protection Association (US)
NIOSH	National Institute of Occupational Safety and Health (US)
PAPR	Powered air purifying respirator
PPE	Personal protective equipment
SCBA	Self-contained breathing apparatus
SDO	Standards development organization
SWPF	Simulated workplace protection factor
TAC	Technical advisory committee
vP	Limited vapour full particulate protection
Z1610	National Standard of Canada covering personal protective equipment for first responders to CBRN events

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The workshop communicated the outcomes of the CRTI09-438TA project that exercised the provisions of the standard CAN/CGSB/CSA Z1610-11 *Protection of first responders from chemical, biological, radiological and nuclear (CBRN) events*, and it provided community input to the proposed future activities on the standard's revision and launch of a conformity assessment program.

L'atelier a permis de transmettre les résultats du projet CRTI09-438TA pour la mise en application des dispositions de la norme CAN/CGSB/CSA Z1610-11, *Protection des premiers intervenants en cas d'incidents chimiques, biologiques, radiologiques et nucléaires* (CBRN). Il a aussi permis d'obtenir les commentaires des membres de la communauté à l'endroit des activités futures proposées concernant la modification de la norme et le lancement d'un programme d'évaluation de la conformité.

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Selection of personal protective equipment; certification; standardization; protective performance; human factors.