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Operational Field Assessment Report
Improved Structural Firefighting Glove

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National Urban Security Technology Laboratory (NUSTL)

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Executive Summary

An operational field assessment (OFA) of the Improved Structural Firefighting Glove was conducted on April 23, 2014, at the Northern Illinois Public Safety Training Academy in Glenview, Illinois. Six firefighters from Illinois, California, and Maryland participated. The OFA focused on glove dexterity; separate testing will address compliance with requirements for thermal protection.

The gloves were developed under the Department of Homeland Security Science and Technology Directorate's First Responders Group, First Responders Technology Program. The requirements for the structural firefighting glove include improved dexterity and don and doff ability to reduce the risk of injury firefighters face when removing gloves to perform manual tasks. Prototype gloves were developed by NanoSonic Inc. and Shelby Specialty Gloves using a nanocomposite insulative array of fire-restrictive material combined with other materials in a 3-D design.

The participating firefighters compared the new gloves to the gloves they currently use while performing different manual tasks that are typically required in structural firefighting operations. The firefighters found the new gloves to be better than their current gloves for performing intricate manual tasks requiring tactility, such as tying knots in ropes, manipulating hose couplings, operating radio control buttons, and donning and doffing when wet.

The firefighters, who represented areas of expertise such as master firefighter,[1] paramedic, fire investigator, helicopter rescue medic, and captain, also offered specific recommendations that could refine the prototype. Recommendations included small changes to the glove construction, such as seam location and stitching alignment, and adjustments to the depth of the fabric between the thumb and trigger finger, which would allow for improved fit.

[1] Firefighter certification level requirements vary by state and involve a combination of training hours and years in service to progress to the next level. For example, some states have four progressive certification levels—basic, intermediate, advanced, and master firefighter—where the master firefighter level is the highest and requires 60 college credit hours and a cumulative 24 years of service.

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1 Introduction

Firefighters require thermal hand protection while fighting structural fires, but they also need to be able to perform manual tasks such as connecting hose couplings, using hand and power tools, operating radios, and using a self-contained breathing apparatus (SCBA), which require dexterity and grip. The goal of the Department of Homeland Security (DHS) Science and Technology Directorate (S&T) First Responders Technology Program (R-Tech) Improved Structural Firefighting Glove project was to develop an improved glove that meets firefighters' needs. Shelby Specialty Gloves and NanoSonic Inc. partnered to integrate NanoSonic's nanocomposite fire-restrictive material with Shelby's glove designs into a new prototype. The glove design was optimized with feedback from firefighter focus groups during product development.

An operational field assessment (OFA) was conducted for firefighters to evaluate the new glove's performance for manual tasks; its thermal protective performance will be evaluated separately in additional certification testing for compliance with National Fire Protection Association (NFPA) standards (1). On April 23, 2014, representatives from the San Diego Fire-Rescue Department, Montgomery County (Md.) Fire and Rescue Service, Calumet City (Ill.) Fire Department, Morton Grove (Ill.) Fire Department, DHS S&T, Oakton Community College, Shelby Specialty Gloves, NanoSonic Inc., and Northern Illinois Public Safety Training Academy (NIPSTA) convened at the NIPSTA campus located at 2300 Patriot Blvd., Glenview, Illinois, to participate in the OFA.

1.1 Purpose

The purpose of the OFA was to assess the prototype gloves for use in typical manual tasks that are required for structural firefighter operations.

1.2 Objective

The OFA conducted realistic operational scenarios for six firefighters to assess and evaluate the new gloves' suitability compared to the firefighters' current gloves.

1.3 Requirements

The guiding requirements for this project are described in the Statement of Work (2). Many of the requirements have been assessed during the development process, and others will be verified in the NFPA standard certification process. The requirements addressed in this OFA are summarized in Table 1.

Table 1 – Improved Structural Firefighting Glove Capability Requirements Matrix

Feature	Description
Simple operation	Gloves shall operate similarly to current generation of gloves.
Compatibility with Personal Protective Equipment (PPE)	Gloves shall be compatible and able to be worn with existing PPE.
Dexterity	Gloves should provide improved dexterity over current generation models. Firefighters should be able to comfortably and adequately accomplish common operational tasks without removing the glove.
Water resistance	Gloves shall be resistant to water and shall not increase in weight or otherwise impede movement when in contact with water.

1.4 Prototype Description

The prototype gloves used in this OFA are shown in Figure 1. They consist of the HybridShield® material combined with leather, cotton, and Kevlar® and Nomex® synthetic fiber materials in a 3-D design. The yellow material on the back of the glove and fingers consists of Kevlar combined with the HybridShield high-profile insulative array. The black material on the fingers is Kevlar with the HybridShield low-profile insulative array. Reflective material made by 3M is used on the top of the fingertips and Nomex is used on the wristlet. The palm of the hand consists of cow split leather layered with Crosstech® film technology and a cotton simplex knit.[2]

The prototypes included four gloves sized extra-large and two sized large. The gloves were matched to the size that the six evaluators wear and were sent to each evaluator two to four weeks in advance to give them an opportunity to verify the fit and begin to break them in.

Figure 1 – Prototype 3-D structural firefighter gloves

2 Operational Field Assessment Design

Six experienced firefighters participated in the operational field test of the prototype gloves. They included three who had participated in prior focus groups for this project who were from San Diego, California, and Montgomery County, Maryland, as well as three new evaluators from the local Chicago, Illinois, area. They represented areas of expertise such as master firefighter,[3] paramedic, fire investigator, helicopter rescue medic, and captain. The details of the OFA are found in the *Operational Field Assessment Plan for the Improved Firefighting Structure Glove* (3).

2.1 Event Design

Twelve activity stations incorporated test scenarios recommended by firefighter focus groups, firefighters, and trainers. Specialized indoor and outdoor training props included ladders, fire hoses and couplings, ropes, communication radios, a flashlight, a fire extinguisher, SCBA accessories and ensembles, power tools (i.e., chain saw and extrication device), hand tools (i.e., sledgehammer, pike

[2] Kevlar and Nomex are trademarked synthetic fiber materials developed by DuPont. Crosstech is trademarked material developed by Gore Inc.

[3] Firefighter certification level requirements vary by state and involve a combination of training hours and years in service to progress to the next level. For example, some states have four progressive certification levels—basic, intermediate, advanced, and master firefighter—where the master firefighter level is the highest and requires 60 college credit hours and a cumulative 24 years of service.

pole, and hydrant wrench), and a mannequin. Activities at the various test stations required finger and palm grip, finger flexibility, and fingertip tactility. Table 2 summarizes the tasks involved. All of the evaluators brought their current structural firefighting gloves to the OFA, which included the five different brands shown in Table 3. All of the evaluators also brought their SCBA face mask, and the three local firefighters brought their complete turnout gear.

Data collectors observed the evaluators performing the activities and captured their feedback about the glove performance. After each task was completed, the data collectors interviewed the evaluators individually using a survey questionnaire to rate both gloves. Subsequent group discussions captured additional feedback.

Table 2 – Summary of activities performed during the OFA

Activity	Key Tasks
1. Ceiling Breach	Use pike pole to push up on a 60-pound hinged ceiling door and pull down on an 80-pound ceiling door in a mechanized testing device.
2. Power Tools	- Operate a chain saw. - Set up a portable generator. - Attach hydraulic hoses and cables to set up and operate extrication device.
3. Rope	Use 0.5 inch diameter nylon rope to tie various knots, including bowline and butterfly, with and without looking at the rope.
4. SCBA	Don and secure apparatus, perform an operational check, activate a Personal Alert Safety device, and operate buddy breathing.
5. Fire Hose Couplings	- Connect hose to standpipe. - Find Higby notch[4] and connect hoses, with and without looking at the hoses
6. Rescue	Drag weighted mannequin 20 feet using harness shoulder handles.
7. Forcible Entry	Use a 10-pound sledgehammer to strike a target on a mechanized device to simulate forcible entry.
8. Manual Tasks	- Operate power, emergency, channel, and volume buttons on a radio and a pillow microphone. - Carry and operate a flashlight and fire extinguisher. - Access Drag Rescue Device on back of turnout jacket; - Open room, fire vehicle entry, and equipment compartment doors.
9. Ladder Extension and Raise	Use rope lanyard to extend a ladder and perform a two-man ladder raise.
10. Donning/Doffing Wet and Dry	Test donning and doffing using: - dry gloves, with dry hands and wet hands - wet gloves, with dry hands and wet hands
11. Wet Gloves: **- Pike Pole** **- Hydrant**	- Repeat ceiling breach activity with wet gloves and a wet pike pole. - Attach a hose to a hydrant, use a wrench to open a valve, and operate a hose.
12. Wet Gloves: **- Ropes** **- Manual Tasks**	Repeat Activity 3 and Activity 8 with wet gloves.

[4] The Higby notch is a tactile reference point on a hose coupling used by firefighters to identify male and female coupling components. It can also be used to identify the exit direction (female end of the hose) in a blind escape scenario.

Table 3 – Structural firefighting gloves currently used by evaluators

American Firewear Super Glove (2)
Honeywell Super Glove
Pro-Tech 8 Titan
Lion Defender
Dragon Fire Alpha

2.1.1 Limitations of OFA Design

There are a few limitations inherent in the OFA design. Market research conducted May-June 2014 identified 10 U.S. manufacturers of structural firefighting gloves with more than 40 different glove models commercially available.[5] It was not possible for this OFA to compare the prototype to every commercially available structural firefighting glove. In addition, since the evaluators' current gloves have been worn during routine use for a longer time, they are likely to be more broken-in, which could have varying effects on how the gloves compare. For example, a more comfortable fit in the current gloves could mean a lower rating for the new gloves, or conversely, older gloves that are more worn out may not perform as well. Finally, individual variability in hand shape is expected to affect fit and glove performance.

2.2 Summary of the OFA

The meeting started in a NIPSTA classroom; test activities were performed in the adjacent field training facility. DHS S&T led introductions, which provided participants with background information on the R-Tech program, the long term goals of the program, and the goals and purpose of the OFA. The NIPSTA executive director provided a welcome and introduction to the test facility. A brief presentation on the gloves by the development team from Shelby Specialty Gloves and NanoSonic Inc. followed. The National Urban Security Technology Laboratory provided an overview of the test activities and schedule. Firefighters were divided into three teams of two,[6] and a data collector was assigned to each team. Before any test activities began, the teams toured the test stations, led by the NIPSTA activity coordinator who demonstrated the use of props and equipment and answered questions.

The teams then followed an activity rotation schedule so that all were working simultaneously at different stations. Photographs of some of the activities are shown in Figures 2 through 5. Data collectors interviewed the evaluators after each station, asking them to rate their current glove and the new glove as poor, good, very good, or excellent, and to provide comments describing the glove performance. After working through three stations, all reconvened in the classroom to provide

[5] Compiled in a *System Assessment and Validation for Emergency Responders (SAVER) Market Survey Report on Structural Firefighting Gloves* (October 2014). See http://www.firstresponder.gov/saver

[6] Firefighters were paired with a teammate from another part of the country.

additional feedback, and a group discussion followed that also provided an opportunity to suggest improvements to test stations. All of the activities went very well with no major changes required, though the following enhancements were added at the suggestion of the evaluators: a more complicated butterfly knot was added to the rope tying activity, and both an ax and sledgehammer were used in the ceiling breach activity.

After completion of all activities, DHS S&T led the participants in a discussion to provide feedback about the gloves in specific tasks and in overall performance. In addition, the Shelby Specialty Gloves representative used a schematic drawing of the glove to record specific design improvement suggestions from each evaluator.

Figure 2 – Tying knots to test dexterity and tactility

Figure 3 – Evaluator setting up the hydraulic extrication device

Figure 4 – Ax used for forcible entry

Figure 5 – Hose coupling activity

Figure 6 – Operating buddy breathing in the SCBA activity

3 Results

This section contains feedback from the evaluators' questionnaires and group discussions. Ratings of the new and old gloves were processed to determine how the gloves compared, and the associated comments were sorted as positive or negative and analyzed for the key features that influenced the rankings (Section 3.1). Group discussions expanded on the questionnaires and evaluators offered suggested improvements to the new gloves (Section 3.2). A succinct summary is provided in the Conclusions (Section 3.3).

3.1 Operational Scenario Survey

The individual evaluator ratings from the questionnaire are shown in Table 4, which includes a row for each of the 12 activities and a column for each of the six evaluators. A color-coded format is used: green squares mark activities in which the evaluator rated the prototype glove higher than their current glove, yellow indicates that both gloves received the same rating, and red shows activities in which the evaluator's old glove received a higher rating. In this table, the activities have been sorted into three sections. The activities with mostly green squares are displayed in the top section, those with mostly yellow squares are grouped in the middle section, and those with mixed results (no clear majority) are in the lower section. Within each section, the activities are listed in sequential numerical order. Associated comments from all of the evaluators for each activity are discussed below and shown in Table 5, located within the Appendix.

Table 4 – Results of test activity questionnaire for six evaluators (1-6)

Activity	1	2	3	4	5	6
3. Rope						
5. Fire Hose Couplings						
8. Manual Tasks						
10. Donning and Doffing Wet and Dry						
2. Power Tools						
6. Rescue						
7. Forcible Entry						
1. Ceiling Breach						
4. SCBA						
9. Ladder Extension and Raise						
11. Wet Gloves: Pike Pole, Hydrant						
12. Wet Gloves: Ropes, Manual Tasks						

The predominance of green squares in Table 4 for the rope, fire house coupling, and manual activities shows that the new gloves were found to be better for activities involving more intricate tasks that require greater dexterity and tactility. Comments associated with these activities, as noted in Table 5, amplify this. The evaluators noted that they could feel the rope and Higby notch much better through the new gloves and could distinguish the width of the tag on the fire extinguisher and the depression of buttons. They also reported that the fingers on the new gloves were less bulky, were significantly more flexible, could pinch and fit into handles better, and that the finger pads offered better grip.

Table 4 also shows a majority of green squares for the donning and doffing activity; five out of six evaluators found the new gloves to be better in the wet and dry combinations. Evaluators noted that the inside of the new gloves stayed dry when the outside was exposed to water; in contrast, one evaluator noted that the old gloves absorbed much more water, causing them to become heavy and drip when performing tasks. Another evaluator demonstrated that his current glove doffed too easily when wet; it was so large and heavy that it flew off by simply shaking his hand. Evaluators also reported

that in some of the current gloves, wet material tended to bunch up or get stuck to the thumb, causing the liner to pull out. Evaluators reported no bunching or liner separation in the new gloves and described the new gloves as “far superior” and “significantly easier” for wet donning and doffing.

A predominance of yellow squares for the power tools, rescue, and forcible entry activities indicates that evaluators found that the gloves performed about the same as current gloves for tasks that involve larger tools, grip without fine motor skills, and do not require tactility. Notably, the comments still report several positive features of the gloves for these tasks. Better dexterity and less bulk in the pinky finger were noted, allowing it to serve as an anchor point while swinging the sledgehammer and grasping the rescue harness. Evaluators noted that the new glove’s improved profile and structure allowed it to fit better into the handle of the chain saw and the loops on the rescue harness. During the power tool activities, the evaluators noted that the new gloves mitigated vibrations better; bunched less; and offered better finger dexterity, good trigger finger function, and durability. Evaluators noted during this task, however, that the webbing between the thumb and index finger was not as deep as in their old gloves, which made gripping and twisting the round connections on the extrication tool more difficult. One evaluator also noted some difficulty in pinching a lever switch with the thumb.

The ceiling breach, SCBA, ladders, and wet glove activities reflect mixed opinions on the improvement of the new gloves: some evaluators thought the new gloves were better than the old, and others rated them the same or, in a few cases, worse. Comments on these activities reflect mixed opinions and desired areas for improvement. For the ceiling breach task, all the comments in Table 5 were positive, describing better grip on the pike pole with no slipping. In the SCBA activities, positive comments described the new gloves as better for grabbing and tightening straps, while negative comments indicate that it was primarily extra thumb length that was a problem for some evaluators. In the ladder activities, positive comments noted better comfort and grip; two negative comments reported more slippage in hand-over-hand movements on the extension rope, requiring a torqueing action to prevent slippage. The wet glove comments indicate that some evaluators thought the new gloves functioned equally both wet and dry; some reported improved grip while wet and others report reduced grip or tactility when wet. A negative comment referred to the hydrant wrench when the evaluator found that extra fabric at the tip of the thumb caused difficulty in aligning to the fingertip.

3.2 Operational Scenario Debrief

During the debrief session, the evaluators discussed their experiences during the test activities, expanded on their questionnaire feedback, and discussed overall performance. Discussions revealed that although they shared similar opinions about some features, in other cases individual variations in hand shape and ways of performing tasks resulted in different experiences. Two evaluators stated the gloves were slightly large and that they would have liked to try the glove in one size smaller; one noted that his hands are typically between standard glove sizes and that could have resulted in his ability to better perform certain tasks with his current gloves.[7]

[7] The firefighters were matched with the size gloves they wear and were provided the gloves in advance to verify fit and break them in. No additional prototypes were available to change to a different size during the OFA.

The discussion moderators asked for feedback that could be used to refine the prototype and received very specific, constructive suggestions. The feedback covered dexterity, tactility, grip, and durability. The line drawing in Figure 7 illustrates the parts of the glove focused on during the discussion, and are explained below. After the discussion, the representative from Shelby Specialty Gloves used a similar diagram to discuss specific comments with each evaluator.

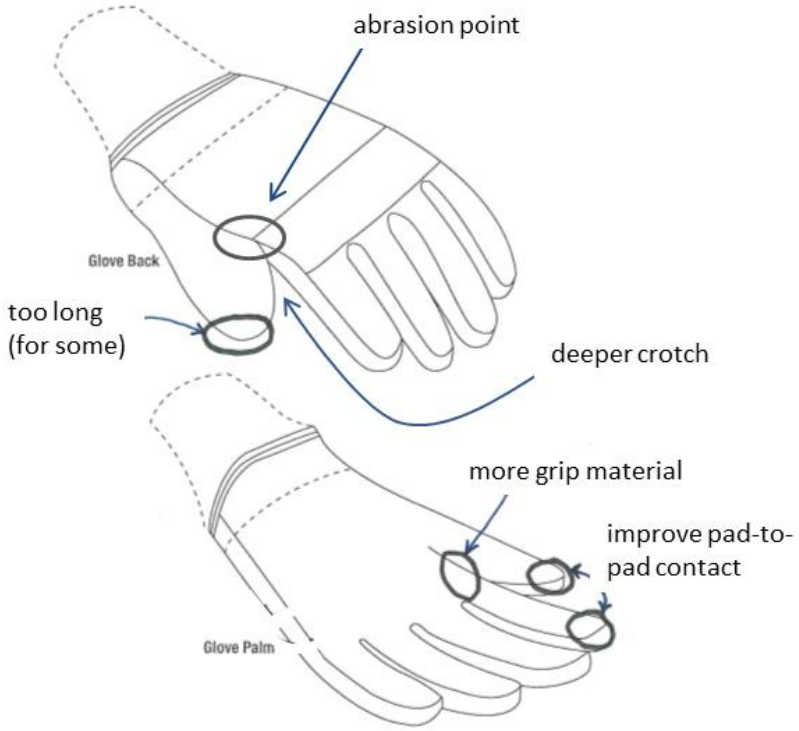

Figure 7 – Line drawing of glove prototype showing areas discussed

Drawing courtesy of Shelby Specialty Gloves

A resonating theme during the group discussion was that the prototype gloves offer much better finger tactility and flexibility, which is important for manual tasks that require fine motor skills. All agreed on two specific modifications that could improve this advantage further:

- The crotch between the thumb and index finger should be deeper with less webbing material.
- The thumb pad and index fingertip should be better aligned for pinching. A possible remedy would be to modify the stitching on the index finger to eliminate a twisting effect and allow the fingertip pad and thumb pad to touch for more precision pinching.

Another suggestion related to tactility and dexterity appeared to reflect variability in individual hands:

- Four of the evaluators thought that the thumb was about one inch too long, with extra material at the tip, while the other two thought the thumb length was just right.

Regarding grip, most of the evaluators found the new gloves to be the same or better than their current gloves. A suggestion for grip improvement was offered:

- The extra grip/friction component material on the prototype could be extended to the palm and thumb.

The group also made the following suggestion related to durability:

- When grasping rope or the mannequin harness, two evaluators noticed an abrasion point on the back of the glove at the thumb/index finger webbing seam between fabric and non-fabric material. It was suggested that leather in this component could prevent abrasion.[8]

3.3 Conclusions

The general consensus among the evaluators was that the prototype gloves are an improvement over their current gloves for intricate tasks requiring dexterity and tactility and for donning and doffing when wet or dry. The group agreed the prototype gloves are about the same for gripping and using larger tools. Based on these observations, the evaluators found that the gloves would address a critical need for firefighter safety.

[8] The glove manufacturer later reported that this was due to a broken stitch due to a factory flaw, rather than a possible corrective action. Deepening the thumb crotch would also shift the seam from the abrasion point.

4 Citations and Bibliography

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5 Acronym List

DHS - Department of Homeland Security

NFPA - National Fire Protection Association

NIPSTA - Northeastern Illinois Public Safety Training Academy

OFA - Operational Field Assessment

PPE - Personal Protective Equipment

R-Tech - First Responders Technology Program

S&T - Science and Technology Directorate

SCBA - Self-Contained Breathing Apparatus

Appendix

Table 5 – Evaluators' individual comments recorded on questionnaires for each activity[9]

Activity	Positive comments on new glove	Negative comments on new glove
1 Ceiling Breach (Pike pole)	• No slippage (minor slippage with old gloves on work hand) • Better grip • Significant grip improvement, no slippage • Noticeably better grip on the new gloves (slight slippage on old glove) • New gloves were tighter and more comfortable	• Little slippage with work hand
2 Power Tools (Chain saw, extrication device)	• New gloves fit better into handle of chain saw (could not get full hand inside handle with old gloves) • Less blousing on new glove with extrication device • New gloves mitigate vibration of chain saw better • Dexterity with new gloves is better (old gloves feel like paddles) • New gloves provided greater dexterity and it was easier to use fingers • Trigger finger had good durability and dexterity	• Need to exaggerate lateral thumb movement to grab paddle for stop button on the saw; hard to pinch lever switch with thumb, need to perform movement sideways • (Deeper material between thumb/index finger webbing in old gloves allowed for better grip when twisting the round connections on extrication tool) • Concern that wristlet/cuff could create a potential hot spot on wrist during a fire because it presses tightly against skin
3 Rope	• (Could not feel rope as well with old gloves because they had wider fingers) • Dexterity with new gloves is better (width of fingers for old gloves got in the way) • Significant difference: better feel while tying knots, the difference was drastic while attempting blind tying of knots, especially the bowline knot • Particularly better with tying butterfly knot • Can feel more, not an easy task • Could feel rope better, had good flexibility	• Extra length at the tip of the thumb (approximately 1 inch) presented a challenge for tactility • Size might be too big for evaluator and were a little clumsier • Might want leather between thumb and finger to prevent abrasion
4 Self-contained breathing apparatus (SCBA)	• Better grabbing fingers (not as pointy in old gloves and old gloves do not offer quite the dexterity) • Allowed for better grabbing of webbing on SCBA mask while donning • Easier to adjust the mask, they feel great, there is no guessing what you are feeling • Better for tightening strap • Better tactility	• Cotton layer inside new gloves does not allow wearer to grip inside of gloves • Slightly large on thumb and middle finger • Thumb size is big, lost dexterity and feeling in that area; it flapped, was too long, did not pinch right, but gloves might be a size too big

[9] Remarks about old gloves are included in parentheses when they expand on comments about the new glove. Repetitious remarks indicating that gloves performed the same are omitted.

Activity	Positive comments on new glove	Negative comments on new glove
5 Fire Hose Couplings	• Notches felt more pronounced • Better feel of parts of standpipe while performing hose connections and overall • Much easier to find Higby notch. Liked the fingers of the new glove better as they were easier to get into tight spaces such as working with hose connections • A lot more tactile feeling and dexterity • Better feel and flexibility for this task	None
6 Rescue (Mannequin)	• More structure, better profile allowed fingers to slip easier into loop handles of mannequins • More comfortable, less compression (old gloves cause more stress on hands when pulling the mannequin because material in between fingers bunched up) • Pinky finger was able to be used for wrapping around the pull strap (on the old gloves, the pinky finger was not useful due to its bulk) • New gloves fit better in handle straps • Better grip on new gloves	• Indicated wear between index finger and thumb after carrying around mannequin
7 Forcible Entry (Sledgehammer)	• New gloves offered better dexterity in the pinky finger to allow better anchor point while swinging the hammer and there was no glove creep (with old gloves, experienced glove creep while swinging the hammer and fingers were bulky) • (Pinky finger came off hammer in old gloves because of width of the finger) • Provided better grip • Less slipping	None
8 Manual Tasks	• Tactility is better: easier to feel the width of the tag on fire extinguisher and can feel depression of radio buttons better • Easier to pinch from the side • Pads have better slip resistance • Tactility between index finger and thumb provided better performance with radio controls and there were no bulk issues with fingers (due to old glove bulk, could not get all four fingers into flashlight handle and could not change radio channel or volume) • Tactility was very good • Easier for changing channel button on radio and removing fire extinguisher pin due to better dexterity in index finger • New glove fits smoothly in flashlight handle • Good on radio knobs; better, significant dexterity • Pulling pin on fire extinguisher is easier • Fine motor skills are better, pinch is better • Trigger finger has good durability • Finger design is better for tightening components on the truck • Significant difference with radio; much better for emergency button • Could feel radio buttons much better	• Harder to pinch from the top • Too much bulk at fingertips • Added length of the thumb got in the way • Pinching is difficult due to seams contacting and not pads of the index finger and thumb • Paddle design and orientation to the index finger presented some challenges when trying to grasp radio control buttons

Activity	Positive comments on new glove	Negative comments on new glove
9 Ladder Extension and Raise	• More comfortable and provided better grip with no slippage on rope (experienced some slippage with old gloves on rope extension) • Better for this task (slippage on old gloves with rope pull task) • Better grip	• More slippage on rope when doing hand-over-hand movements. Recommend improving grip on new glove, but it may also be dependent on synthetic vs. manila rope material • Cannot do hand-over-hand extension; requires torqueing action to prevent slippage, causes stress to user • Some slippage (old gloves offered better grip with rope on extension ladder) • Suggest extending the friction component to palm
10 Donning and Doffing – Wet and Dry	• No bunching of material (old gloves bunched a lot in all fingers for wet glove and wet hand) • Liked security that collar provided in keeping gloves in place • (Old gloves absorbed much more water, causing them to become heavy and drip when performing tasks) • Easier to doff when glove and hand are both dry • Significantly easier to put on and take off when both hand and glove were wet. (Old gloves were more work to put on when both hands and glove were wet: glove binds to thumb, pulling the liner out) • Liked collar for keeping gloves secure • Dry donning/doffing was very good • (Doffing is too easy with old gloves – so loose they can fly off) • No moisture inside while exposing outside to water • Wet donning and doffing was far superior (was poor on old gloves) • Inside did not get wet while exposing outside to water (old gloves got wet inside) • New gloves were easy and similar to being dry, inside did not get wet when exposing outside to water • (Old gloves got wet inside; inner lining separates and folds over, making donning/doffing difficult) • Dry donning and doffing was easy • No moisture felt inside • Dry hands dry gloves – new gloves don well (old gloves don poorly) • Wet hands dry gloves – new gloves are easier in comparison (old gloves are very, very poor)	• (Old gloves a little easier to put on because they had a wide collar but had other problems) • Pinky puckered up • Lengthier interface intended to go under the cuff of the turnout jacket; however, it is difficult to get the jacket cuff over the glove collar with the gloves on • Pinky gets caught in donning • More force is needed to put wet hands into dry gloves • Wristlet material bunches up and needs adjusting
11 Wet Gloves: Pike Pole, Hydrant	• No slippage; performed as should on hydrant • No slippage on pike pole • Good grip with no slippage • Easily gripped wetness improved the grip (old gloves slip)	• Hydrant wrench – could not get pad of thumb to tip of finger with extra material • Appeared to slip a little • Binding while donning, took a while to get a good grip

Activity	Positive comments on new glove	Negative comments on new glove
12 Wet Gloves: Ropes, Manual Tasks	• Dexterity was not lost when wet, radio and flashlight the same as dry • More tactile than old gloves • Similar to dry performance • Slightly better feel when wet for manual tasks when tactility is required • Increased tactile feel of new gloves when wet using rope (old gloves now feel like wet rags) • Same in use/feel for manual tasks when wet and dry (old gloves are difficult to use when wet) • Easier to hit emergency button on radio, better dexterity for this task • Easier to use wet than old gloves	• (Old gloves more pliable when wet) • More sensitive when dry than wet – hard to maneuver radio buttons • For ropes, gloves felt sloppier and fingers moved around more in glove for this task • Wet gloves had issue with binding when donning for pike pull tasks; it took a while to get a good grip, but (old gloves had some pulling)
Additional Comments	• Performance overall was superior with emphasis on dexterity and tactility • Overall, the new gloves offered slightly better performance in specific tasks, particularly when added tactility and dexterity is required	• Concern on the paddle thumb design and its orientation to the index finger • Abrasion point: Potential rope wear spot at the thumb/index finger webbing; while grasping the rope it can be seen that the rope rubs against the fabric on the back of the glove versus the non-fabric material • Prevailing issue was the added length on thumb that would get in the way when thumb is needed for functionality