# Wear Study: Performance of Reusable Garments Used for Operators Handling Nutrients/Pesticides

## Contents

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Background Information</td>
<td>2</td>
</tr>
<tr>
<td>Rationale</td>
<td>3</td>
</tr>
<tr>
<td>Purpose</td>
<td>3</td>
</tr>
<tr>
<td>Approach and Proposed Benefits</td>
<td>3</td>
</tr>
<tr>
<td>Plan of Work</td>
<td>4</td>
</tr>
<tr>
<td>Presentations and Publications</td>
<td>6</td>
</tr>
<tr>
<td>Appendix A - Checklist for Selection of Study Site/Operators</td>
<td>7</td>
</tr>
<tr>
<td>Appendix B – Farm/Orchard Data</td>
<td>9</td>
</tr>
<tr>
<td>Appendix C</td>
<td>11</td>
</tr>
<tr>
<td>CONSENT FORM</td>
<td>11</td>
</tr>
<tr>
<td>Appendix D - Laundering Practices</td>
<td>12</td>
</tr>
<tr>
<td>Appendix E – Instructions for Person Responsible for Laundering</td>
<td>15</td>
</tr>
<tr>
<td>Appendix F – Dropper Test (Determine Repellency)</td>
<td>16</td>
</tr>
<tr>
<td>Appendix G – Comfort Evaluation</td>
<td>17</td>
</tr>
</tbody>
</table>
Background Information

Performance specification standards based on laboratory and field data are now available to enable development of performance-based requirements for protective clothing for pesticide operators. The following standards have similar requirements:

- ISO 27065:2011, Protective clothing – Performance requirements for protective clothing worn by operators applying liquid pesticides. In Brazil, protective clothing is certified in accordance with ISO 27065, Level 2 and 3 requirements.
- A Japanese Industrial Standard (JIS), based on ISO 27065:2011 has been approved.

Revisions are being proposed to the above standards based on new laboratory data as well as feedback received from different stakeholders. There is ongoing discussion in ISO and CEN to consider a revised ISO/EN standard. The proposed revisions include minimum requirements for three levels of protection. The level of testing increases for protective clothing that provides higher protection.

- Level 1 – Protective clothing in this category is suitable when the potential risk is relatively low. The performance requirement for Level 1 is based on cotton and cotton/polyester garments typically worn for exposure studies.
- Level 2 – Protective clothing in this category is suitable when the potential risk is higher, but not so high as to require the use of impermeable, chemical resistant materials.
- Level 3 – Protective clothing in this category is suitable when the potential risk of contamination requires use of garments made with impermeable, chemical resistant materials.

Level 2 garments include reusable cotton/polyester garments with fluorochemical finishes. These garments were developed to provide a balance between protection and comfort in hot climatic conditions. Operator exposure and comfort studies conducted using new garments show that they have the potential of providing a balance between protection and comfort in hot climatic conditions. The field studies validate that protection provided by these garments is higher than that for Level 1 clothing, and the users find these garments comfortable. However, wear studies and laboratory tests conducted for certification show that performance of fabrics with repellent finish can vary considerably. To achieve the desired performance, selection of appropriate
fabric and finish, as well as quality control in the manufacturing process is crucial. Use and care of these garments is also important as soiling and cleaning can affect the surface properties of the material.

**Rationale**

Developing protective clothing acceptable to pesticide operators in hot climatic conditions is a challenge as it is difficult to balance protection with comfort. Laboratory studies conducted to simulate wear have shown that fluorochemical finishes enhance protection provided by cotton and cotton/polyester garments commonly used by agricultural pesticide operators. Performance specifications require that these garments meet the testing requirements after they have been laundered 30 times according to manufacturer’s instructions. Garments treated with repellent finishes have performed well in exposure and comfort field trials that were conducted in Portugal, Greece, and India. However, additional studies need to be conducted on the impact of use and care on the performance of these garments since wear studies conducted in various countries have shown that performance of fabrics with repellent finish is affected by use and care. Of particular concern are garments that undergo hand washing because the cleaning method varies from person to person, and the process is very different from the methods used for laundering prior to certification testing.

The study would provide valuable information for establishing selection, use, and care recommendations for Level 2 garments.

**Purpose**

The purpose of this project is to evaluate the performance of garments made with “repel and release” finishes after they have been used for one season. The studies will also be used to obtain information on garment design and comfort. Note: Garments that meet Level 2 requirements in accordance with ISO 27065 will be used.

**Approach and Proposed Benefits**

Availability of comfortable PPE for hot climatic conditions is of interest to many groups. Garments with repellent finish show a great potential to fill the void of garments that provide protection as well as comfort. However, as with most situations, understanding the benefits and challenges is crucial for developing a plan to build on the benefits and at the same time adequately address the challenges in order to meet the operators’ needs. A partnership approach is being proposed as there are several groups that can provide the expertise as well as resources that would enable the project to serve as the benchmark study for evaluation of cotton/polyester
garments with repellent finish that meet the Level 2 performance criteria of the ISO standard.

The proposed project would be achieved through collaboration with garment manufacturers, researchers, institutions/government agencies, and the agricultural community. The timeframe for the completion of the project is 2 years. It will be designed such that the scope can be expanded based on interest generated by the findings of the project. The wear studies will include garments, headgear, and if needed, accessories such as an additional layer for knapsack spraying.

**Plan of Work**

Coordination of wear studies will be handled by A. Shaw. A Study Director will be identified by each institution participating in the wear trials. The study Director will be responsible for the overall management of the study for that institution. The Study Directors for the respective institutions will work closely with A. Shaw to conduct pre-trials in Spring/Summer 2015 and actual trials in 2016. It is the responsibility of the Study Directors at the respective institutions to ensure that the study complies with the applicable requirements for research involving human subjects at their institution.

**Pre-trial**

Pre-trials will be conducted in Spring using the garments manufactured in Brazil in 2014. The purpose of the pre-trial is to try out the protocol and questionnaires developed for the study. The pre-trials will be conducted for the same scenario as the actual study. Prior to the method to be used for the location will be identified.

The pre-trials will be conducted with two operators who are willing to work closely with the Study Director for the location to improve the protocol. A visit will be made to observe and record laundering practices. Detailed information on laundering practices will be recorded. Spring 2015 will also be used by the Study Director to obtain input from the users regarding garment design and sizes required for the trial. The garments used for Pre-trial will be used to finalize the methodology to be used for analysis after the completion of wear study.

**Garment Selection**

The fabrics used to construct the garments will be the same for all locations. Garment design and sizes will be provided by the respective Study Directors. A sample of commonly used garment that is well accepted by the applicators could be provided as the garment for size and design. A. Shaw will work closely with the Study Directors in the development of the prototypes. Garment prototypes developed based on the garment design
shall be approved by the respective Study Directors. The garments shall be tested for compliance with Level 2 of ISO 27065:2011. Once tested, the other garments will be made for the study. The box (similar to that used in Brazil to check each time the garment is laundered) and circles marked on the garment to conduct the drop test) will be marked on each garment before the garment is given to the operators.

We are looking at possibilities of getting one garment set from Turkey and possibly another from Brazil as Turkey has agreed to apply only one finish. In addition to garment performance, finish, fiber content, garment design, cost and also the potential for the garment to be made available in other countries are being considered in the development of the two prototypes for the study. The finish is based on C6 technology.

**Selection of Participants and Training**

Eight to ten participants who voluntarily agree to participate in the study will be selected. A questionnaire and logs included as attachments will be used for the study. The information will be translated to the native language of the operators and the translated version reviewed for accuracy prior to the study. A training session will be conducted prior to the start of the trials. The volunteers will be asked to complete the consent form during the training session. The participants will maintain a log recording details about garment use and care. Information about the pesticides applied will also be maintained. The log will be reviewed periodically by designated personnel. The training session will include training to use the drop test to assess garment performance. This test will be conducted prior to each use; garments that fail this test will be collected and further action to be taken coordinated with A. Shaw to determine possible reasons for failure. Participants will receive token remuneration for participating in the project. The amount and type of remuneration will be determined by the Study Direction who will ensure that it is in compliance with the institutions policies.

**Evaluation and Analysis**

Visual observations and spray test will be used evaluate the performance of the garments. Given below is the suggested procedure to be used for the trials. The process needs to be discussed in detail at the meeting in June. A detailed Excel worksheet will have to be developed to assist with the coordination.

- Forms included in the Appendix will be completed and returned to A. Shaw.
- Participants will maintain a log regarding details about wear and laundering.
- Used garments will be collected for visual inspection.
- After visual inspection, the garments will be tested using modified spray test (modification to include
calculation of area of inner dosimeter that has been contaminated).

- The visual observation and spray test results will be used to determine the performance of the garments.
- Manufacturers will be consulted as needed to determine possible factors that could contribute to the performance of garments that may fail the penetration test.
- Further tests may be conducted to determine the amount of pesticide retained in the garments.
- Qualitative and quantitative data will be used to develop a report and possible recommendations for use and care.

**Presentations and Publications**

Findings of the study will be presented at a conference and published in a refereed journal. The Project Directors for the respective institutions will be identified as co-authors. In addition, the Study Directors may choose to present or publish a more detailed article regarding their data. These will be coordinated with A. Shaw and the lab that was responsible for conducting the analysis. The overall purpose of these studies is to determine the performance of the garments with the finish. It is not to be used for marketing or promotion of a product.
Appendix A - Checklist for Selection of Study Site/Operators
To be completed by the Study Directors for the respective locations.

1. Who will be responsible for the coordination of the study?
   Name: _____________________________
   Email: _____________________________
   Phone Number

2. Where are the garments washed?
   - at work/farm
   - at home
   - at an industrial laundering facility

3. Will you be working with the Farm Manager or Supervisor to coordinate the activities?
   - Yes
   - No

4. Are 8-10 operators willing to participate in the study?
   - Yes
   - No

5. How often do operators typically wash the reusable garments?

6. Will they use the study garments the same way?

7. Do the operators typically use the same garment for application and other tasks around the farm?

8. Describe any challenges in getting the garments washed or conducting the study.

9. What type of garment do the operators normally wear when applying pesticide and nutrients? (check all that apply)
   - Regular clothing (pant/shirt or coverall made of woven fabric)
   - Disposable coverall
   - Reusable coverall
   - Rain suit
   - Other, please specify: _____________________________

10. Specify the number of garments need for the study for which you are responsible.
    - M (medium) Specify the number of garments for this size _______________
    - L (large) Specify the number of garments for this size _______________
    - XL (extra-large) Specify the number of garments for this size _______________

11. What will the operators wear under the protective garment? (Check all that apply.)
    - undergarments
    - T-shirt
    - long-sleeved shirt
    - short pants
☐ pants
☐ other (specify): _____________________________

16. Crop(s) treated: (additional crops to be added by Study Directors).
   ☐ apples
   ☐ pears
   ☐ cherries
   ☐ sugarcane
   ☐ grapes
   ☐ other (specify): _____________________________

17. What type of spray equipment will be used by the operators?
   ☐ Airblast sprayer
   ☐ Boom sprayer
   ☐ Cannon sprayer
   ☐ Backpack sprayer
Appendix B – Farm/Orchard Data
To be completed by the Study Director prior to Pre-Trial updated prior to trials.

Name and address of the farm:
___________________________________________________________________________________________
___________________________________________________________________________________________
_________________________________________________________________________

Phone: ________________________________________________________________________________

Farm Manager or Supervisor Name: ____________________________________________________

RESPONSES TO BE PROVIDED BY THE FARM MANAGER OR SUPERVISOR

1. Who orders the garments used by pesticide operators?
   □ Me
   □ My supervisor/boss
   □ Someone in the office
   □ I don’t know.
   □ Other _________________________________________________________________

2. If you are responsible for ordering garments, what are the main reasons for garment selection?
   □ Cost
   □ Level of protection
   □ Easily available
   □ Have used previously
   □ No specific reason
   □ Other ____________________________________________________________________________

3. How many garments do you order per year?
   □ <10
   □ 10-50
   □ 50-200
   □ 200-500
   □ >500
4. For how many operators do you order garments?

5. Approximately how much do you spend on garments in one season (include the currency) ?

6. Protective garments protect operators from pesticide formulations, but garments also serve to protect operators from water, dirt, or other contaminants. How important is it to operators that a protective garment protect them from the following factors?

Rating: 1 = most important; 4 least important

| Prevent operators from getting wet
| Protect operators from chemicals
| Prevent operators’ garments from getting contaminated from other contaminants that may have low or no toxicity, such as some micronutrients, oil, and dirt
| Other, please specify:

7. Provide a sample of the garment/s currently being used. (The person conducting the survey should record garment details in the table below and take photographs of the garment.)

<table>
<thead>
<tr>
<th>Garment 1</th>
<th>Garment 2</th>
<th>Garment 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Name of garment</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cost of garment</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Are these garments disposable?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Are these garments laundered?</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Appendix C - CONSENT FORM

Information for the operator

You will receive free of charge two protective garments for mixing/loading and applying plant nutrients and/or pesticides. By signing below, you agree to wear the garments regularly while loading-mixing and applying nutrient/pesticide. The study will serve to collect information that will provide an understanding of the performance of the garment under practical field conditions.

The garments you receive have been a repellent finish to provide additional protection to regular work clothing. The garments have been tested and they meet the performance requirements for Level 2 protection level according to ISO 27065:2011. These garments are being evaluated to see how they perform after they have been worn and washed. After a day’s work, the garment should be given to the person responsible for washing the garments. In case you feel uncomfortable, unsafe, or wet during treatments, you should stop any further work, take off the garment, and return it to the farm manager.

It is understood that besides the protective garment, additional personal protective equipment (gloves, boots, face shield, mask, goggles, hat) needs to be worn as indicated on and required by the crop protection product label.

I, the operator, volunteer to participate.

Name of operator: ________________________________________

Signature of operator: _____________________________________

Date: _____________________________________
Appendix D - Laundering Practices
To be completed by the Study Director during the visit prior to Pre-Trial on laundering practices (not what they will be instructed to do for the study).

PART 1
INDUSTRIAL LAUNDERING

1. How are the garments sorted before they are washed?

_____________________________________________________________________________________
_____________________________________________________________________________________

2. What are the chemical used for washing (include images of the containers with images)
   Detergent:____________________________________________________________________________
   Bleach:_______________________________________________________________________________
   Softener:_________________________________________________________________________
   Other Specify:__________________________________________________________________________
_____________________________________________________________________________________
_____________________________________________________________________________________

3. Information about the washing machine
_____________________________________________________________________________________
_____________________________________________________________________________________
_____________________________________________________________________________________

4. Details of the program used for washing (number of cycles, temperature etc.).
_____________________________________________________________________________________
_____________________________________________________________________________________
_____________________________________________________________________________________

5. Information about the washing machine
_____________________________________________________________________________________
_____________________________________________________________________________________
_____________________________________________________________________________________

6. Details of the program used for washing (number of cycles, temperature etc.).
_____________________________________________________________________________________
_____________________________________________________________________________________
_____________________________________________________________________________________

7. Are the garments typically ironed?  ☐ Yes  ☐ No
PART 2
MACHINE WASHING
(TO BE COMPLETED FOR EACH OPERATOR IF WASHED AT HOME)

1. Where are the garments washed?

2. Who washes the garments?

3. What type of machine is used?:
   - ☐ Top loaded washing machine
   - ☐ Front loaded washing machine

4. What temperature setting is used?
   - ☐ Hot water setting
   - ☐ Warm water setting
   - ☐ Cold water setting

5. Detergent (product name): ____________________________________________
   - ☐ Powder
   - ☐ Liquid

6. Bleach information (product name, if used): ______________

7. Softener information (product name, if used): ______________

8. Describe how clothes are typically dried:
   - ☐ Machine dried
   - ☐ Air-dried indoors
   - ☐ Outdoors in the shade
   - ☐ Outdoors in the sun

9. Are the garments typically ironed?
   - ☐ Yes
   - ☐ No
PART 3
HAND WASHING
(TO BE COMPLETED FOR EACH OPERATOR IF WASHED AT HOME)

1. Where are the garments washed?
2. Who washes the garments?
3. Describe how they are washed? Provide pictures or short videos if possible.
   - Top loaded washing machine
   - Front loaded washing machine
4. What temperature setting is used?
   - Hot water setting
   - Warm water setting
   - Cold water setting
5. Detergent (product name): ________________________________
   - Powder
   - Liquid
6. Bleach information (product name, if used): ______________
7. Softener information (product name, if used): ______________
8. Describe how clothes are typically dried:
   - Air-dried indoors
   - Outdoors in the shade
   - Outdoors in the sun
9. Are the garments typically ironed?
   - Yes
   - No
Appendix E – Instructions for Person Responsible for Laundering

**PART 1**

**INSTRUCTIONS TO THE FARM MANAGER IF THE GARMENTS ARE CLEANED AT THE FARM OR SENT TO AN INDUSTRIAL LAUNDERING FACILITY**

1. This study requires washing of reusable garments at the end of each day. The same procedure is used each day the garment is worn.
2. Please assign a person who IS WILLING to and who WILL wash the garment and keep a daily record.
3. The person responsible for washing will inform you if the garment fails the dropper test to measure repellency. Please notify ________ of garment failure, and she will make the necessary arrangements to pick up the garment.

**INSTRUCTIONS TO THE PERSON RESPONSIBLE FOR WASHING**

1. This study requires that the washing procedure complies with the care instructions provided with the garments. The same wash procedure is to be used each time the garment is washed.
2. The garment is tested using the dropper test, and a tally mark is made on the garment each time it is washed and tested. The marking and testing with the dropper will be done by you according to the instructions.

**PART 2**

**INSTRUCTIONS TO THE OPERATOR IF THE GARMENTS ARE CLEANED AT HOME**

1. You have been provided two garments. Please wear the garment on every alternate day that you apply pesticide or nutrient. Please check the pesticide label to make sure the garments provided meet the requirement on the pesticide label.
2. After the garment has been used, they must be given to the person responsible for washing.
3. Please ask the person responsible for washing to follow the care instructions provided with the garment.
4. Once the garment has been washed and dried the dropper test needs to be conducted by ___________ to determine the repellency of the garment. The instructions for the dropper test should be given to ___________.
5. If the garment fails the test, it should be returned to _________________.
6. Continue wearing the garment until the garment fails the repellency test.
Appendix F – Dropper Test (Determine Repellency)

The dropper test should be done by the person responsible for washing after each time the garment is washed. The dropper test shows whether the garment is still repellent or not.

Procedure

Test the performance of the garment using the dropper and the bottle of tap water provided to you.

1) Place the garment on a flat surface and apply 1 drop of water next to the spots marked on the pant and shirt.

2) Check whether the drops are repelled or absorbed.

3) If the drops are repelled, the garment is protecting (some partially repelled drops are acceptable). Make a note in the wear study log sheet.
   - If the drop is repelled (R), the garment is OK.
   - If the drop is absorbed (A), record the location(s) in which the drop is absorbed and send the garment and the log to ________________.
Appendix G – Comfort Evaluation

Demographic Data
Age: ____________________ years
Height: ___ ft. _____ in
Weight ______ pounds

TO BE COMPLETED BY THE STUDY DIRECTOR WITH RESPONSES PROVIDED BY THE OPERATOR AT THE END OF THE STUDY. SEPARATE FORM TO BE COMPLETED FOR EACH GARMENT SET

1. Protective Garment Code:___________________________________________

4. Was the garment correct for your body size?
   □ Yes
   □ No       ○ too big       ○ too small

5. In general, do you like the design of the garment?
   □ Yes
   What features do you like?_____________________________________________
   ____________________________________________________________
   □ No
   What features do you not like?_______________________________________
   ____________________________________________________________

6. Do you think the protective garment is suitable for use in hot weather?
   □ Yes
   □ No
   Explain ________________________________________________________

7. Would you be willing to use the garment if it was available?
   □ Yes
   If yes, would you wear it
   □ over your work clothing
   □ as your protective work garment (with only undergarments)
   □ under your protective work garment
   □ No
   If no, explain ____________________________________________________
## Appendix H – Study Information

<table>
<thead>
<tr>
<th>Institute</th>
<th>Study Director</th>
<th>Country</th>
<th>Scenario</th>
<th>Application Equipment</th>
<th>Crop</th>
<th>Season start</th>
<th># of Subjects</th>
<th>Laundering method</th>
<th>Laundry-location</th>
</tr>
</thead>
<tbody>
<tr>
<td>IAC</td>
<td>H. Ramos</td>
<td>Brazil</td>
<td>Orchard-overhead</td>
<td>Airblast</td>
<td>citrus</td>
<td>Year round</td>
<td>10</td>
<td>industrial</td>
<td>company</td>
</tr>
<tr>
<td>CIRCOT</td>
<td>S. Saxena</td>
<td>India</td>
<td>Vineyard</td>
<td></td>
<td>grapes</td>
<td>August - June*</td>
<td>10</td>
<td>hand washing</td>
<td>institute**</td>
</tr>
<tr>
<td>WSU</td>
<td>C. Black</td>
<td>USA</td>
<td>Orchard-overhead</td>
<td>Airblast</td>
<td>tree fruits</td>
<td>April - August</td>
<td>10</td>
<td>washing machine</td>
<td>home</td>
</tr>
</tbody>
</table>

* Pesticide applied between August and October and then in May
** Garments are typically hand washed at home by the wife. For wear study it will be washed by one of the women at the research institute using the method similar to the one used at home.