Confidential Report

Our Ref: 60/00826/1
Client: NANO TECHNOLOGI CZ s.r.o.
Václavské náměstí 808/66
110 00 Praha 1
Czech Republic

Job Title: RALPH manikin testing of an evacuation suit

Client’s Order No: Email 17 March 2017
March 2017

Date of Receipt: 20 March 2017
Date of Test Start: 6 April 2017

Description of Sample(s): One ankle length coat in the wet condition, referenced:
Evacuation Suit

Work Requested: We were asked to make the following test:
ISO 13506: 2008 on the BTTG™ male manikin (RALPH)
In the “wet” condition
1. **Samples**

One ankle length coat in the wet condition, reference Evacuation Suit was submitted for test.

The waterproof envelope containing the coat was opened and excess water with flame retardant chemical was drained from the envelope. The soaking wet 100% cotton coat was removed from the envelope and immediately dressed on the manikin, once dressed, the test procedure was immediately initiated.

The suit was tested in conjunction with a long sleeved vest and long johns made from 100% cotton with a mass per unit area of 220g/m² and thickness 1.6mm.

The coat and underwear were considered to be a “good” fit on the manikin.

2. **Method of Test**

Testing was undertaken on the 2006 version of the “male” heat sensing manikin known as RALPH (Research Aim Longer Protection against Heat) developed at BTTG™. This version of RALPH together with the associated test facility has been built to comply with ISO 13506: 2008.

RALPH has a total of 135 sensors distributed over the head, torso, legs, arms and hands which monitor the temperature on the surface of the manikin during a test. (The feet of the manikin are not sensored.) For this test the sensors in the hands and interface areas were not used leaving 123 sensors being monitored.

From the temperatures recorded predictive percentage burn injury at Pain, 1st, 2nd and 3rd degree levels are calculated using the Takata and Stoll skin model as specified in Annex C of ISO 13506: 2008.

During a test the manikin is challenged by a flame engulfment apparatus consisting of 12 burners (in two tiers of six) surrounding the manikin in a hexagonal pattern. The manikin is placed at the centre of the hexagonal pattern. The lower set of six burners are pointed at the legs and lower body of the manikin whilst the upper set of six burners are pointed at the upper body and head.

The tests were performed under the following conditions:
- Mean heat flux: 84kW/m² ± 2.5% (i.e. 81.9kW/m² – 86.1kW/m²)
- Flame exposure time: 8 seconds
- Data acquisition time: 120 seconds
3. Cleansing Pretreatment

None (tested in the wet condition)

4. Summary of Results

See pages 4 – 10.

Notes Relating to Interpretation of Results

The RALPH manikin test has been developed to provide information on the flammability and heat transfer performance of clothing systems when subjected to flame envelopment such as might only reasonably be expected to occur under "emergency" conditions. It is essentially intended to compare one clothing system with another, it does not purport to provide information in terms of the "survivability" of a given event. The following points should also be borne in mind when assessing the results obtained.

(a) These results were obtained using the specified test conditions and do not necessarily represent the behaviour of the clothing system under other conditions of test or use.

(b) The fit of the garments has an important bearing on the heat transfer results obtained during the test. For this test the coat was considered to be a “good” fit.

(c) It must be stressed that whilst the test conditions used can be considered very severe there may be occasions where the clothing system is subjected to even greater challenge which could result in serious injury to the wearer.

(d) The RALPH manikin together with the associated test facility has been built to comply with ISO 13506: 2008. Not all manikin test systems fully comply with ISO 13506 and, therefore, currently results from the various manikins will not necessarily be the same. It is very important when comparing manikin test results to take into account which “skin model” has been used to calculate the percentage burn injury results. The results in this report have been calculated using the Takata and Stoll skin model as specified in Annex C of ISO 13506: 2008.

(e) The burn injury results are expressed according to clause 9.5.3 of ISO 13506 which calculates the percentage burn injury based on the total area of manikin covered by the garments under test being 100%. For this test, therefore, the head is not included in the calculations.

(f) These results must not be used in advertising or promotional literature without the written permission of BTTG™.
4. Summary of Results

The observations made during the tests and the examinations after the tests were similar for all three tests.

Observations during the test

The reflective strip on the garment charred. There was no ignition of the suit immediately following the burners being switched off but there was a rise of steam from the coat. There was no “break-open” of the fabric of the garment during the test.

After test examination

Coat: The exposed areas of the coat were undamaged and were still soaking wet after the test

Underwear: The exposed areas of the vest and long johns were undamaged and were soaking wet from being in contact with the wet evacuation suit.

Burn Injury Prediction

See pages 5, 7, 9 for the burn injury prediction diagram.

See pages 6, 8, 10 for the burn injury development with time.

See page 11 for summary of the burn injury results.

Note

The burn injury prediction result is calculated using the Takata and Stoll skin model as specified in Annex C of ISO 13506: 2008. This model is a prediction of burn injury in the “dry” state only. Therefore, caution should be taken with these results as it unproven that the sensors and burn injury model used in these tests predict burn injury in the wet state or in the presence of steam.
RALPH MANIKIN TEST 1 – BURN INJURY PREDICTION AT 120s

Sample: One ankle length coat in the wet condition, referenced: Evacuation Suit
Tested in conjunction with 100% cotton long sleeved vest and long johns.

Flame Exposure Time: 8 seconds (data acquisition time 120 seconds)

Burn Injury Prediction (according to ISO 13506: 2008 clause 9.5.3)

<table>
<thead>
<tr>
<th>Pain</th>
<th>1st° Burn</th>
<th>2nd° Burn</th>
<th>3rd° Burn</th>
<th>2nd° + 3rd° Burn</th>
</tr>
</thead>
<tbody>
<tr>
<td>22.8%</td>
<td>2.6%</td>
<td>14.9%</td>
<td>7.9%</td>
<td>22.8%</td>
</tr>
</tbody>
</table>
RALPH MANIKIN TEST 1 – BURN INJURY DEVELOPMENT WITH TIME

Sample:

One ankle length coat in the wet condition, referenced:
Evacuation Suit
Tested in conjunction with 100% cotton long sleeved vest and long johns.

At 30 seconds

At 60 seconds

At 90 seconds

At 120 seconds

<table>
<thead>
<tr>
<th>Time, s</th>
<th>% Burn</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>30</td>
<td>40</td>
</tr>
<tr>
<td>60</td>
<td>50</td>
</tr>
<tr>
<td>90</td>
<td>60</td>
</tr>
<tr>
<td>120</td>
<td>70</td>
</tr>
</tbody>
</table>

Pain: 1.deg, 2.deg, 3.deg
**RALPH MANIKIN TEST 2 – BURN INJURY PREDICTION AT 120s**

**Sample:**
One ankle length coat in the wet condition, referenced:
Evacuation Suit
Tested in conjunction with 100% cotton long sleeved vest and long johns.

**Flame Exposure Time:**
8 seconds (data acquisition time 120 seconds)

---

**Burn Injury Prediction (according to ISO 13506: 2008 clause 9.5.3)**

<table>
<thead>
<tr>
<th></th>
<th>Pain</th>
<th>1st° Burn</th>
<th>2nd° Burn</th>
<th>3rd° Burn</th>
<th>2nd° + 3rd° Burn</th>
</tr>
</thead>
<tbody>
<tr>
<td>Front</td>
<td>23.7%</td>
<td>1.8%</td>
<td>11.4%</td>
<td>11.4%</td>
<td>22.8%</td>
</tr>
<tr>
<td>Back</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
NANO TECHNOLOGI CZ s.r.o.

RALPH MANIKIN TEST 2 – BURN INJURY DEVELOPMENT WITH TIME

Sample: One ankle length coat in the wet condition, referenced: Evacuation Suit
Tested in conjunction with 100% cotton long sleeved vest and long johns.

Flame Exposure Time: 8 seconds (data acquisition time 120 seconds)

At 30 seconds

At 60 seconds

At 90 seconds

At 120 seconds

% Burn

Time, s

Pain
1.deg
2.deg
3.deg

0 10 20 30 40 50 60

0 30 60 90 120

Copyright © 2016 Shirley Technologies Limited. All rights reserved.

Shirley® Technologies Limited. Registered Office: Wira House, West Park Ring Road, Leeds, LS16 6QL. A company registered in England & Wales with company number 04664651, VAT Number GB 816764800. The supply of all goods and services is subject to our standard terms of business, copies of which are available on request. Our laboratories are accredited to EN ISO/IEC 17025.
RALPH MANIKIN TEST 3 – BURN INJURY PREDICTION AT 120s

Sample: One ankle length coat in the wet condition, referenced: Evacuation Suit

Tested in conjunction with 100% cotton long sleeved vest and long johns.

Flame Exposure Time: 8 seconds (data acquisition time 120 seconds)

<table>
<thead>
<tr>
<th></th>
<th>Front</th>
<th>Back</th>
</tr>
</thead>
</table>

Burn Injury Prediction (according to ISO 13506: 2008 clause 9.5.3)

<table>
<thead>
<tr>
<th></th>
<th>Pain</th>
<th>1st° Burn</th>
<th>2nd° Burn</th>
<th>3rd° Burn</th>
<th>2nd° + 3rd° Burn</th>
</tr>
</thead>
<tbody>
<tr>
<td>Value</td>
<td>21.1%</td>
<td>5.3%</td>
<td>15.8%</td>
<td>7.9%</td>
<td>23.7%</td>
</tr>
</tbody>
</table>
RALPH MANIKIN TEST 3 – BURN INJURY DEVELOPMENT WITH TIME

Sample:
One ankle length coat in the wet condition, referenced:
Evacuation Suit
Tested in conjunction with 100% cotton long sleeved vest and long johns.

At 30 seconds

At 60 seconds

At 90 seconds

At 120 seconds

% Burn

0 30 60 90 120

Time, s

Pain

1.deg

2.deg

3.deg

Copyright © 2016 Shirley Technologies Limited. All rights reserved.
5. **Assessment**

The results below are expressed according to clause 9.5.3 of ISO 13506: 2008 which calculates the percentage burn injury based on the total area of manikin covered by the garments under test being 100%. For these tests, therefore, the head is not included in the calculations.

<table>
<thead>
<tr>
<th>% Burn Injury</th>
<th>Pain</th>
<th>1st° Burn</th>
<th>2nd° Burn</th>
<th>3rd° Burn</th>
<th>2nd° + 3rd° Burn</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test 1</td>
<td>22.8</td>
<td>2.6</td>
<td>14.9</td>
<td>7.9</td>
<td>22.8</td>
</tr>
<tr>
<td>Test 2</td>
<td>23.7</td>
<td>1.8</td>
<td>11.4</td>
<td>11.4</td>
<td>22.8</td>
</tr>
<tr>
<td>Test 3</td>
<td>21.1</td>
<td>5.3</td>
<td>15.8</td>
<td>7.9</td>
<td>23.7</td>
</tr>
<tr>
<td>Average</td>
<td>22.5</td>
<td>3.2</td>
<td>14.0</td>
<td>9.1</td>
<td>23.1</td>
</tr>
<tr>
<td>S.D.</td>
<td>1.3</td>
<td>1.8</td>
<td>2.3</td>
<td>2.0</td>
<td>0.5</td>
</tr>
</tbody>
</table>

Reported by: .............................................................. M T Healey, Principal Technician

Countersigned by: ......................................................... C Dean, Laboratory Manager