Methodology

ILO SID Biometric Interoperability Test

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Bion BIOMETRICS

WORLD LEADER IN STANDARDS & TESTING

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Terms and Definitions

For the purposes of this document, the following terms and definitions apply:

administrator
person performing the testing or enrolment, recording test data and/or monitoring the crew

attempt
submission of one (or a sequence of) biometric samples to the system
NOTE An attempt results in an enrolment template, a matching score (or scores), or possibly a failure–to-acquire.

Biometric Identification Record (BIR)
refers to a ILO SID-0002 conformant data record containing up to two fingerprint minutiae templates

crew
set of test subjects gathered for an evaluation

detection error trade-off (DET) curve
modified ROC curve which plots error rates on both axes (false positives on the x-axis and false negatives on the y-axis)

enrolment
application in which the user is processed by a system in order to generate and store an enrolment template for that individual

enrolment attempt
the submission of three enrolment presentations of one finger on the part of a user for the purpose of enrolment in a biometric system

enrolment presentation
the submission of a single biometric characteristic (fingerprint) on the part of a user for the purpose of enrolment

enrolment transaction
sequence of up to 10 enrolment attempts (one per finger) on the part of a user resulting in an enrolment or a failure-to-enrol

experimenter
person responsible for defining, designing, and analyzing the test

failure-to-acquire rate (FTA)
proportion of verification transactions for which the system fails to capture or locate an image or signal of sufficient quality

failure-to-enrol rate (FTE)
proportion of the population for whom the system fails to complete the enrolment process

NOTE The observed failure-to-enrol rate is measured on test crew enrolments. The predicted/expected failure-to-enrol rate will apply to the entire target population.

false accept rate (FAR)
proportion of verification transactions with wrongful claims of identity that are incorrectly confirmed

false match rate (FMR)
proportion of zero-effort impostor attempt samples falsely declared to match the compared non-self template
NOTE The measured/observed false match rate is distinct from the predicted/expected false match rate (the former may be used to estimate the latter).

false non-match rate (FNMR)
proportion of genuine attempt samples falsely declared not to match the template of the same characteristic from the same user supplying the sample
NOTE The measured/observed false non-match rate is distinct from the predicted/expected false non-match rate (the former may be used to estimate the latter).

false reject rate (FRR)
proportion of verification transactions with truthful claims of identity that are incorrectly denied

features
digital representation of the information extracted from a sample (by the signal processing subsystem) that will be used to construct or compare against enrolment templates
EXAMPLE Minutiae coordinates and principal component coefficients are features.

genuine attempt
single good-faith attempt by a user to match their own stored template

guidance
direction provided by an administrator to a test subject in the course of data capture for enrolment or verification
NOTE Guidance is separate from feedback provided by a biometric system or device in the course of data capture, such as audible or visual presentation queues.

habituation
the degree of familiarity a test subject has with a device
NOTE A test subject with substantial familiarity using a biometric device, such as that gained in the course of employment, is referred to as a habituated test subject.

impostor attempt
see *zero-effort impostor attempt*

intermediate template
biometric sample generated or processed to conform to a vendor's own closed unknown format

interoperability
measure expressing the verification performance associated with the use by vendor A of biometric data conforming to a standard interchange format generated by vendor B or vice versa

match attempt
the submission of three match presentations on the part of a user for matching in a biometric system

match presentation
the submission of a single biometric characteristic (fingerprint) on the part of a user for matching

match transaction
sequence of two match attempts (corresponding with two templates in a BIR) on the part of a user simulated during offline testing resulting in a verification decision
NOTE If a BIR only contains a single enrolled template, a match transaction will consist of a single match attempt.

offline testing
execution of enrolment and matching separately from data capture
NOTE 1 Collecting a database of samples for offline enrolment and calculation of matching scores allows greater control over which samples and attempts are to be used in any transaction.
NOTE 2 Technology evaluation will always involve data storage for later, offline processing. However, with scenario evaluations, online transactions might be simpler for the tester – the system is operating in its usual manner and storage of samples, although recommended, is not necessary.

online testing
execution of enrolment and matching at the time of image or signal submission
NOTE 1 In online evaluations, the experimenter may decide not to retain biometric samples, reducing storage requirements and in certain cases ensuring fidelity to real-world system operations. However, retention of samples in online tests is recommended for auditing and for subsequent offline analysis.
NOTE 2 Testing a biometric system will involve the collection of input images or signals, which are used for template generation at enrolment and for calculation of matching scores at later attempts. The images/signals collected can be used immediately either for an online enrolment, verification, or identification attempt, or may be stored and used later for offline enrolment, verification, or identification.

presentation
submission of a single biometric sample on the part of a user

receiver operating characteristic (ROC) curve
plot of the rate of false positives (i.e. impostor attempts accepted) on the x-axis against the corresponding rate of true positives (i.e. genuine attempts accepted) on the y-axis plotted parametrically as a function of the decision threshold

sample
user's biometric measures as output by the data capture subsystem
EXAMPLE Fingerprint image, face image and iris image are samples.

scenario script
a script utilized by an administrator in the direction of a user during enrolment and recognition transactions

similarity score
measure of the similarity between features derived from a sample and a stored template
NOTE 1 A match or non-match decision may be made according to whether this score exceeds a decision threshold.
NOTE 2 As features derived from a presented sample become closer to the stored template, similarity scores will increase.

target population
set of users of the application for which performance is being evaluated

template
model of the user's stored reference measure based on features extracted from enrolment samples
NOTE The reference measure is often a template comprising the biometric features for an ideal sample presented by the user. More generally, the stored reference will be a model representing the potential range of biometric features for that user.

test organization
functional entity under whose auspices the test is conducted

test subject
user whose biometric data is intended to be enrolled or compared as part of the evaluation

transaction
sequence of attempts on the part of a user for the purposes of an enrolment or verification
NOTE There are two types of transactions: enrolment sequence, resulting in an enrolment or a failure-to-enrol; or a verification sequence resulting in a verification decision.

user
person presenting biometric sample to the system

verification
application in which the user makes a positive claim to an identity, features derived from the submitted sample are compared to the enrolled template for the claimed identity, and an accept or reject decision (and possibly a match similarity score) regarding the identity claim is returned

verification decision
determination of the validity of a user's claim to identity in the system

zero-effort impostor attempt
attempt in which an individual submits his/her own biometric characteristics as if he/she were attempting successful verification against his/her own template, but the comparison is made against the template of another user

References

a. Seafarers' Identity Documents Convention (Revised), 2003 (Convention No. 185)

b. ILO SID-0002 Finger Minutiae-Based Biometric Profile for the Seafarers' Identity Documents

c. ILO Seafarers' Identity Documents Biometric Testing Campaign Report - Part 1

d. ILO Seafarers' Identity Documents Biometric Testing Campaign Report – Part 2

e. ISO/IEC CD 19794-2 – Biometric Data Interchange Formats – Part 2: Finger Minutiae Data (ISO/IEC JTC 1 SC37 N 340, dated 2003-10-07)

f. ISO/IEC 19795-1 Biometric Performance Testing and Reporting – Part 1: Principles and Framework

g. ISO/IEC 19795-2 Biometric Performance Testing and Reporting – Part 2: Test Methodologies

h. ISO/IEC 19795-4 Biometric Performance Testing and Reporting – Part 4: Interoperability Performance Testing

Background

The International Labour Organization (ILO), established in 1919, is a Specialized Agency of the United Nations (UN). It is a tripartite organization, in which representatives of Governments, Employers, and Workers take part with equal status. In June 2003, the ILO adopted the Seafarers' Identity Documents Convention (Revised), 2003 (Convention No. 185). The revision of the earlier Convention of 1958 was prompted by discussions held in the International Maritime Organization (IMO) reviewing measures and procedures to prevent acts of terrorism that threaten the security of passengers and crews and the safety of ships. ILO Convention No. 185, which came into force on February 9, 2005, is a binding international treaty for all Members that ratify it.

For successful implementation of ILO Convention No. 185, Seafarers' Identity Documents (SIDs) issued in each ratifying State must be able to be used for verifying a seafarer's identity in every other State to which that seafarer travels in the course of his or her duties. Since this represents the world's first internationally interoperable biometric verification system, in March 2004, the ILO Governing Body adopted the technical standard, ILO SID-0002 Finger Minutiae-Based Biometric Profile for Seafarers' Identity Documents, which is used to enable global biometric interoperability of Members' implemented systems (as specified in ILO Convention No. 185). The biometric storage format described in ILO SID-0002 was based on draft ISO standards dated October 2003, but minor modifications were made to satisfy the requirements of storing two fingerprint templates on a two-dimensional PDF417 barcode. Since the ISO standards were still in a relatively early draft form, no manufacturers were known to have products that supported these standards. Consequently, modifications to commercial products were necessary. In order to ensure that products supporting these standards, particularly the draft version of ISO 19794-2 specified in ILO SID-0002, could provide adequate interoperable performance on real seafarers, the ILO commissioned the ILO SID Biometric Testing Campaign to develop a list of compliant biometric products for Members to use when implementing ILO Convention No. 185.

The first ILO Seafarers' Identity Document Biometric Interoperability Test (ISBIT-1) consisted of two phases. In the first phase, several biometric algorithm and sensor pairs (referred to as biometric products) underwent preliminary evaluation to determine those systems with sufficient conformance to the standards and basic matching performance to be included in the second phase of testing. Seven products were included in the second phase, which was conducted onboard a seafaring vessel. The experimental procedures, results, and analysis were included in the document, ILO Seafarers' Identity Documents Biometric Testing Campaign Report - Part 1, wherein the tested systems are referred to as Products A through G.

Only two of the seven products, A and F, achieved the ILO targets for both native and interoperable performance, and so it became apparent that interoperability using the standard might not be as simple as had been anticipated. A follow-on study, ISBIT-2, was commissioned to investigate what had caused the problems in interoperability. During this study, supplementary guidance to the information contained in ILO SID-0002 was developed in order to provide clarity on certain areas in the standard that were suspected to be the source of problems. After the vendors modified their software in the light of the new guidance information, the images collected in the previous test were used in an offline test with the new software. In this case, all of the major interoperability problems were resolved and three products (A, C, and F) were determined to be interoperable at the ILO required performance threshold of 1% FRR at 1% FAR.

ISBIT-2 was completed in early 2005 and by 2006 there were several new products ready to be tested for use with the ILO SID. In early 2006, the three previously approved products were tested along with six new products in the ISBIT-3 test. The methodology for that test was almost identical to the one described in this document, and it resulted in all nine products being placed on an approved product list published by the ILO. This list is available from the ILO web site at http://www.ilo.org/public/english/dialogue/sector/sectors/mariti/products.pdf

The ILO plans to encourage further interoperability tests whenever there are sufficient requests from the vendor community to have products added to the ILO's list of products mentioned above. The present test, ISBIT-4 is designed to allow any additional desktop products, such as the nine already qualified, to be tested.

Introduction

This test methodology is designed to determine whether products submitted for testing satisfy the biometric-related requirements of ILO Convention No. 185 and ILO SID-0002. To determine whether products meet the ILO's requirements, two primary biometric functions are performed: enrolment and verification.

During enrolment, a test subject will attempt to enrol a primary and a secondary finger. If necessary, the test subject can try up to all ten fingers to get two fingers enrolled. The test subject is considered enrolled if at least one finger is enrolled.

During verification, the test subject will attempt to match their primary or secondary finger with a BIR previously enrolled. The test subject is considered verified if either finger is matched. A limited number of genuine comparisons are performed by each test subject during online testing, while exhaustive genuine and impostor comparisons are performed during a subsequent offline test.

The products submitted to the lab will be tested for conformance to ensure that they can produce and read fingerprint templates in the form of the Biometric Interchange Records (BIRs) defined in Annex B of SID-0002. If they are conformant, then they will be integrated with distributed test software and some preliminary interoperability tests will be run in the lab. During this period, any problems will be reported to the vendors and they will have an opportunity to provide updated software and/or hardware if they can do so within the time constraints of this phase of the test. In some cases, this may involve multiple iterations of the vendor providing software, the lab testing it for conformance and preliminary interoperability, and the vendor making modifications based on the feedback from the lab. In order to simplify integration with the test control software and to allow for both online and offline testing to be conducted, a simple API specification that must be satisfied by the software component of each product will be provided to those companies that indicate potential interest in participating in the test.

Those products that can demonstrate conformance and preliminary interoperability will be used in the second phase. During this phase, approximately 180 people will enrol on each system and attempt to verify multiple times on each system against BIRs generated by the same system and by other systems. These test subjects will each visit the test lab twice, separated by approximately three weeks. After the online portion of the test, the images collected will be used in an extensive offline set of cross-comparisons to allow all possible combinations of enrol on one system and verify on another to be explored for both genuine and impostor distributions. A set of ROC curves will be generated and the generalized false reject rate (GFRR) at a generalized false accept rate (GFAR) of 1% (G^1) will be computed for each product when verifying against enrolled templates from every enrol product.

The mean of the G^1 values for all nine of the previously approved products will be called $G^{MEAN.}$ The maximum of all the G^1 values of the nine previously approved products will be called G^{MAX}. Since all the previous products are approved for both enrolment and verification functions, G^{MEAN} and G^{MAX} will be computed from 81 separate G^1 values. If a new product or set of products is to be added to the approved list then a new calculation of G_2^{MEAN} and G_2^{MAX} will take place using the G^1 values of these new products along with the G^1 values for the previously approved products. The following conditions must then be satisfied for the new product or products to be approved:

1. G_2^{MEAN} is less than or equal to G^{MEAN} OR G_2^{MEAN} is less than 1%

2. G_2^{MAX} is less than or equal to G^{MAX}

Performing third-party, independent testing of biometric products from several vendors for both enrolment and verification will provide a high level of assurance that systems using successfully tested biometric technology will be able to verify seafarers' identities accurately, provided their SIDs were created with another successfully tested biometric technology.

General Test Conditions

Environment

This test scenario will be executed in a "normal office environment," under indirect fluorescent lighting. The biometric products will be deployed in accordance with recommendations of the product suppliers.

Order Effects

The order in which the biometric products are used could potentially affect performance due to the reasons listed below. Therefore, the order in which products are used will be randomized for each test subject visit.

- Feedback from one biometric product may affect user behaviour (e.g. finger pressure) on another.
- As each product is used, the user may become habituated to presenting their fingerprint and thus may achieve better results with later products.
- On arriving at the test lab, test subjects could be out of breath (if they have hurried to make their appointment) or have cold hands/fingers (when cold outside), recovering to a more normal state after a few minutes.

Test Team

The test team consists of two members: an Experimenter and Administrator. The Experimenter is responsible for the overall management of the test, ensuring consistency in the guidance provided to the test subjects, and reviewing test results on an ongoing basis to ensure integrity. The Administrator guides each test subject through the enrolment and verification visits, ensures that the test system functions properly, and records test subject and visit information.

Test Control Software

The primary functions of the test control software are as follows:

- Integration with biometric products using the API Specification
- Tracking of test subject information including; test subject ID, year of birth, nationality group, job group, and gender
- Online enrolment and verification
- Offline genuine comparisons
- Offline impostor comparisons
- Fingerprint image and template storage, access, and security
- Data analysis and reporting

Test Crew

In addition to the biometric products, test subjects are needed during the performance and interoperability test phase.

Solicitation

Test crew must be volunteers who are aware of the purpose of the test and are willing to give up their fingerprints and some limited demographic information as part of being tested. Requests for volunteers are distributed through various community groups with notification of the nature of the test, the period over which it will occur, and the means by which the test crew will be rewarded for their participation. Since ISBIT-3 established a test crew, these individuals shall also be contacted explicitly to encourage their participation in ISBIT-4. If a large percentage of the test crew is the same between both tests, then results are more likely to be reproducible.

People that volunteer will have their initial visit scheduled, and will be shown the privacy and data protection statement during that visit. They will be allowed to keep a copy until they return for their second visit, at which point they will sign it for the second time, indicating they have had time to consider it, seek legal counsel if desired, and are completely satisfied with it. If they decline to sign during the second visit, then they will be deleted from the database immediately.

Visits

Each test subject will make two visits to the test lab for the online component of the performance and interoperability test phase. The first visit will require each test subject to enrol on each enrolment-capable biometric product, and verify multiple times on all biometric products (which passed integration and conformance), while the second visit will be a repeat of the first, approximately three weeks later.

At the time of each test subject's first visit, the administrator will enter the following data into the test control software's database: test subject ID, birth year, gender, nationality group, and job group.

The administrator will demonstrate one correct finger placement on each biometric product, and the test subject will be instructed which sensor to use and which finger to present. To represent supervised operating conditions, the administrator will also, whenever a test subject has problems using a biometric product, provide finger placement and quality guidance based on their experience with the products and any available direct feedback from the biometric product (e.g. moistening the finger if it is too dry).

Privacy

It is expected to retain the fingerprint images and templates for approximately 10 years to allow future testing to make use of existing databases. All of this will be outlined in the privacy and data protection statement that each test subject will review and sign.

Product Solicitation and Integration

Participation in the ILO SID Biometric Interoperability Test is open to all vendors with biometric products compliant with ILO Convention No. 185 and ILO SID-0002. Since ILO Convention No. 185 will be implemented in up to 148 countries, it is important to include as many biometric products in the tests as possible to ensure global access to solution providers.

All vendors interested in participating in the test are provided with this document and a detailed API specification along with any additional requirements for their products in advance of the test. Since the hardware and software provided are evaluated as a single combined biometric product, each biometric vendor is encouraged to select the biometric product that they believe would be most advantageous to them (for a seafaring population) for the purposes of the test.

Desktop biometric product submissions must include an API that complies with the API Specification, and conforms to the relevant parts of ILO Convention No. 185 and SID-0002.

Once successfully integrated into the test control software, each biometric product will be evaluated for stability and its effects on the stability of other biometric products in the test harness. The cooperation of the product vendor with the test lab will be required to resolve any issues related to integration and conformance. Once these issues are resolved successfully, the product may proceed to the final test phase.

Conformance

Those biometric products, which can be successfully integrated with the test control software, are required to demonstrate conformance to the relevant parts of ILO SID-0002 before they may proceed to the final test phase. A biometric product must therefore meet certain functional and procedural requirements divided into three categories, Enrolment, Verification, and Nominal Interoperability.

Enrolment

Several enrolment trials will be performed to ensure that each biometric product:

- prompts for placement of all ten possible finger positions by name or other visual indicator
- provides visual feedback of the fingerprint image presented to the sensor
- indicates a failure-to-acquire or failure-to-enrol for fingerprints of insufficient quality
- successfully enrols two fingers if two fingers of sufficient quality are available
- successfully enrols one finger (in the event no other finger is available)
- produces BIRs that conform to the data format specified in ILO SID-0002 Annex B

Verification

Several verification trials will be performed to ensure that each biometric product:

- prompts for placement of all ten possible finger positions by name or other visual feedback (e.g. if the primary enrolled finger in the BIR is a right index finger, the product must ask the user to present their right index finger)
- provides visual feedback of the fingerprint image presented to the sensor
- indicates a failure-to-acquire for fingerprints of insufficient quality
- correctly interprets both enrolled and "unenrolled" templates from conformant BIRs
- indicates a match for most genuine comparisons
- indicates a non-match for most impostor comparisons
- indicates a similarity score as defined in the API Specification

Nominal Interoperability

Each biometric product will be tested for basic interoperability by attempting to verify at least one of the primary or secondary fingers against conformant BIRs enrolled on each of the other biometric products. The product is considered to have passed a single interoperability test for a particular BIR from another product if either the primary or the secondary finger is verified within three match presentations.

For a given product to pass this interoperability test overall, it has to pass single interoperability tests with at least 50% of the BIRs from products other than itself, and 50% of those other products have to successfully pass interoperability tests with the given product's BIR.

For example, with 11 total products, the BIR from Product 1 containing the right and left index fingers from a single test subject will be used to attempt a successful verification on each of Products 2 through 11. Similarly, the test subject will attempt a successful verification on Product 1

against the BIRs from each of Products 2 through 11. For Product 1 to be considered interoperable, at least 50% of ten, or five of these ten single interoperability tests must match when verification is being attempted using Product 1 and at least five must match when verification is being attempted on Products 2 through 11 against the BIR from Product 1. The process would be repeated for a small group of well-habituated test crew and the average number of passed tests should be at least 50% in both cases.

Any product that fails at this stage will not proceed to the performance and interoperability test phase.

Performance and Interoperability

The objective of the Performance and Interoperability phase of the ILO SID Biometric Interoperability Test is to determine both native (enrol and verify on the same product) and non-native (enrol and verify on different products) false reject and false accept rates for biometric verification of the test crew over a reasonable period.

The performance component seeks to demonstrate that the biometric technologies being offered in the marketplace are able to provide sufficient accuracy to be reliable for the seafaring population.

The interoperability component seeks the largest combined set of products which can achieve an average false accept rate less than or equal to 1% with an average false reject rate also less than or equal to 1%, as required by ILO SID-0002.

Test subjects will be instructed when to place a finger, and (for most types of sensors) when to remove it. The administrator will consider a presentation as being completed as soon as it is determined that either a) the biometric product indicates a successful capture, or b) the biometric product indicates that it failed to acquire an image of acceptable quality or c) the timeout was reached before the biometric product returned any result. If the test subject removes his/her finger before being instructed to do so, the administrator will cancel and repeat the presentation process from the beginning.

Enrolment

Test subjects are enrolled on each biometric product during both visits in accordance with the requirements stated in ILO SID-0002. During enrolment, a test subject will make two enrolment attempts to enrol a primary and a secondary finger, starting with the right and left index fingers respectively. If an index finger is missing or damaged to the extent that a fingerprint can neither be captured nor enrolled by a biometric product, the test subject will make another enrolment attempt using another finger or thumb according to the presentation order defined in ILO SID-0002, Section 5.1.1.

If none of the subject's ten fingers can be enrolled, then that test subject will be recorded as being unable to enrol on that biometric product. That test subject will not be able to participate in native genuine comparisons on that product during subsequent verifications, although the test subject will still participate in impostor comparisons and non-native genuine comparisons on that product.

All of the output images and BIRs will be stored in a secure database for subsequent online and offline verifications.

Online Verification

After the enrolment session is complete, each test subject will make a limited number of genuine comparisons against a previously enrolled template on each biometric product. To maintain active participation by test subjects, the match/non-match decision for each attempt will be prominently displayed. In this way, online verification also functions as a controlled data collection of images for all offline genuine and impostor comparisons. Note that the manufacturers of the biometric products will have established initial threshold settings to be used for online verification, and these

will determine the match/non-match indications provided here as feedback to the users. Subsequent offline tests will probably determine that other threshold settings are optimal for maximizing interoperability, and these will be the ones used in producing the final G[1] results.

The distributed test software determines the unique finger positions enrolled during that visit for all biometric products (usually two for the right and left index), randomizes the order of products used for match attempts, and randomizes the match attempts for each product.

Offline Verification

Offline testing will allow exhaustive native and non-native genuine comparisons to be performed. That is, every match presentation of a test subject's finger will be matched against every BIR with the same finger enrolled by the same test subject on all biometric products. Normally this would involve three presentations of each finger and the maximum similarity score of all three will be used as the similarity score for that attempt.

Similarly, exhaustive native and non-native impostor comparisons will be performed offline by attempting to match every match attempt with templates of the same finger for all other enrolled test subjects on all biometric products.

Two-finger match transactions, as defined in ILO SID-0002, will be simulated during offline testing by taking the maximum similarity score of each pair of match attempts using the two fingers from each individual enrolment BIR. If a BIR contains only a single enrolled finger, then only a single match attempt will be used to compute the transactional similarity score.

Data Analysis and Reporting

The final report will include a selection of relevant metrics, but the most important for the decision of the ILO as to which products are considered interoperable will be a single interoperability matrix of G^1 values calculated using the two-finger (six-presentation) offline matching transactions described above. For each possible combination of enrolment biometric product and verification biometric product, an ROC curve will be generated and a threshold score value selected to obtain a GFAR of 1%. The value of GFRR (i.e. G^1) will then be computed at that threshold score and will be entered into the two dimensional interoperability matrix for that enrol/verify combination, as shown in this sample matrix.

FAR = 1.0%	Verify on A	Verify on B	Verify on C	Verify on D
Enrol with A	x.x%	x.x%	x.x%	x.x%
Enrol with B	x.x%	x.x%	x.x%	x.x%
Enrol with C	x.x%	x.x%	x.x%	x.x%
Enrol with D	x.x%	x.x%	x.x%	x.x%

All possible combinations of the existing approved products and one or more of the newly tested products will be considered to determine if the interoperability matrix can satisfy the approval requirements described in the Introduction to this document. The largest group of products that can satisfy those requirements will become the new group of approved products. This list of products will be submitted to the ILO for final approval at their next Governing Body meeting after the test report is completed. Once the list is approved, it will be published on the ILO website for all member states to use in making purchasing decisions.