



Schlussbericht 28.02.2019

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## IEA 4E Electric Motor Systems Annex: Übernahme der Aktivitäten im Task «International Standards»

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Berner  
Fachhochschule

**Datum:** 28. Februar 2019

**Ort:** Bern

**Auftraggeberin:**

Bundesamt für Energie BFE  
Forschungsprogramm Elektrizitätstechnologien  
CH-3003 Bern  
[www.bfe.admin.ch](http://www.bfe.admin.ch)

**Kofinanzierung:**

Berner Fachhochschule, Departement Technik und Informatik, Quellgasse 21, CH-2501 Biel

**Auftragnehmer/in:**

Labor für Elektrische Maschinen und Antriebssysteme  
Berner Fachhochschule  
Departement Technik und Informatik  
Quellgasse 21  
CH-2501 Biel

**Autor/in:**

Prof. Dr. Andrea Vezzini, Berner Fachhochschule

<b>BFE-Bereichsleitung:</b>	Michael Moser, <a href="mailto:michael.moser@bfe.admin.ch">michael.moser@bfe.admin.ch</a>
<b>BFE-Programmleitung:</b>	Roland Brüniger, <a href="mailto:roland.brueeniger@brueniger.swiss">roland.brueeniger@brueniger.swiss</a>
<b>BFE-Vertragsnummer:</b>	SI/501538-01

**Für den Inhalt und die Schlussfolgerungen sind ausschliesslich der Autor dieses Berichts verantwortlich.**

**Bundesamt für Energie BFE**

Mühlestrasse 4, CH-3063 Ittigen; Postadresse: CH-3003 Bern  
Tel. +41 58 462 56 11 · Fax +41 58 463 25 00 · [contact@bfe.admin.ch](mailto:contact@bfe.admin.ch) · [www.bfe.admin.ch](http://www.bfe.admin.ch)



## Zusammenfassung

Die Übergabe Task Leader Internationale Standards zwischen Conrad Brunner (alt) und Andrea Vezzini (neu) wurde im Verlauf der Jahre 2018 - 2019 abgeschlossen. An den Sitzungen aller relevanten IEC TC's und WG's wurde mindestens einmal teilgenommen. Die nationalen (NC) und die Europäischen Meetings (CEN/CENELEC) wurden ebenfalls besucht.

Für die Überarbeitung der IEC 61800-9-2:2017 wurde zudem ein Pilot des Round Robin Test für die Messung von Wechselrichterverlusten organisiert, durchgeführt und am Motor Summit 2018 vorgestellt. Ziel war es die Prüfverfahren für Wechselrichter durch unabhängige Tests zu bestätigen. Im Rahmen der Pilotphase wurde das Vorgehen überprüft und dokumentiert, so dass in einer grösseren Testphase 2019/20 eine umfassende Testreihe (RR'C 2) durchgeführt werden kann.

Bei Abschluss der Aktivitäten im Task «International Standards» wurden anlässlich des IEC SC22G/WG18 Meetings in Melbourne Australia die Organisation des RR'C Phase 2 vorgestellt.

## Résumé

Le transfert de la responsabilité des normes internationales Task Leader entre Conrad Brunner (ancien) et Andrea Vezzini (nouveau) s'est achevé au cours des années 2018-2019. Les réunions de tous les TC et WG concernés de la IEC ont été suivies au moins une fois. Les réunions nationales (NC) et réunions européennes (CEN/CENELEC) ont également été suivies.

Pour la révision de la CEI 61800-9-2:2017, un test pilote du Round Robin Test pour la mesure des pertes des onduleurs a été organisé, réalisé et présenté au Motor Summit 2018. L'objectif était de confirmer les procédures de test des onduleurs par des tests indépendants. Pendant la phase pilote, la procédure a été vérifiée et documentée afin qu'une série d'essais complète (RR'C 2) puisse être réalisée dans une phase d'essai plus large en 2019/20.

A la fin des activités de la tâche "Normes internationales", l'organisation de la phase 2 du RR'C a été présentée lors de la réunion CEI SC22G/WG18 à Melbourne, Australie.

## Summary

The handover of Task Leader International Standards between Conrad Brunner (old) and Andrea Vezzini (new) was completed during the years 2018 - 2019. The meetings of all relevant IEC TC's and WG's were attended at least once. The national (NC) meetings and at the European meetings (CEN/CENELEC) were also attended.

For the revision of IEC 61800-9-2:2017, a pilot of the Round Robin Test for the measurement of inverter losses was organized, carried out and presented at the Motor Summit 2018. The aim was to confirm the test procedures for inverters through independent tests. During the pilot phase, the procedure was checked and documented so that a comprehensive test series (RR'C 2) can be carried out in a larger test phase in 2019/20.

At the end of the activities in the task "International Standards", the organization of the RR'C Phase 2 was presented at the IEC SC22G/WG18 meeting in Melbourne Australia.



# Inhaltsverzeichnis

<b>1</b>	<b>Einleitung .....</b>	<b>6</b>
<b>2</b>	<b>Projektziele.....</b>	<b>6</b>
<b>3</b>	<b>Durchgeführte Arbeiten und erreichte Ergebnisse.....</b>	<b>6</b>
3.1	Aktivitäten .....	6
3.2	Nationale Zusammenarbeit .....	7
3.3	Internationale Zusammenarbeit.....	8
3.4	Normenarbeit.....	8
3.5	Bewertung und Ausblick .....	8
<b>4</b>	<b>Publikationen .....</b>	<b>9</b>
<b>5</b>	<b>Referenzen .....</b>	<b>9</b>
<b>6</b>	<b>Anhänge .....</b>	<b>9</b>



## Abkürzungsverzeichnis

BFE	Bundesamt für Energie
IEC	International Electrotechnical Commission
CENELEC	European Committee for Electrotechnical Standardization
SC	IEC Technical Subcommittees
WG	Working Group
TCP	IEA Technology Collaboration Programmes
RR'C	Round Robin Converte



# 1 Einleitung

Das Ziel des Electric Motor Systems (EMSA) Annex des IEA 4E Technology Collaboration Programms (TCP) ist die weltweite Steigerung der Energieeffizienz durch den Einsatz von effizienten elektrischen Antriebssystemen. Dies soll durch eine Sensibilisierung für das grosse bestehende Einsparpotential und die Förderung des internationalen Austausches erreicht werden. Best Practice soll für die Umsetzung von politischen Massnahmen und technischen Programmen vermittelt werden.

Ein wichtiger Bestandteil der Aktivitäten ist der Einsatz in den internationalen Normengremien (IEC, IEEE, CENELEC) durch den Task Leader International Standards (TL-IS). Dieser wird von den EMSA-Mitgliedern parallel zu den EMSA-Programmperioden ernannt.

## 2 Projektziele

Der Nachfolger Task Leader Internationale Standards (Prof. Dr. Andrea Vezzini) soll an verschiedenen Sitzungen und Konferenzen durch seinen Vorgänger (Conrad F. Brunner) eingeführt werden. Ebenso soll die Anmeldung in die nationalen und internationalen Gremien von TK2 und TK22 abgeschlossen werden.

Im Rahmen der nächsten EMSA-Programmperiode ist ein Round Robin für Wechselrichtertests geplant ("Round Robin for Converter Losses" RR'C). Der Round Robin wird von der EMSA in Zusammenarbeit mit IEC SC22G/WG18 durchgeführt. EMSA wird die Ergebnisse rechtzeitig für die Revision des Standards IEC 61800-9-2 vorbereiten. Die erste Phase (Pilot) des Round Robin wurde bis Ende Februar 2019 abgeschlossen.

## 3 Durchgeführte Arbeiten und erreichte Ergebnisse

### 3.1 Aktivitäten

Im Zusammenhang mit der Überarbeitung der IEC 61800-9-2:2017 (Ausgabe 1)<sup>1</sup> und der Veröffentlichung einer kommenden, überarbeiteten Ausgabe 2 müssen eine Reihe von Fragen rund um das Thema Wechselrichterverluste geklärt werden.

Die Referenzverluste wurden vor etwa fünf Jahren anhand eines Simulationsmodells definiert, die schließlich in einer CENELEC-Norm EN 50598-2:2015 erschien. Diese Werte wurde seither noch nicht durch Tests von mehreren Marktprodukten verschiedener Hersteller bestätigt. Auch die Prüfverfahren für Wechselrichter wurde noch nie hinreichend detailliert beschrieben durch unabhängige Tests bestätigt.

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<sup>1</sup> Adjustable speed electrical power drive systems - Part 9-2: 2017: Ecodesign for power drive

systems, motor starters, power electronics and their driven applications - Energy efficiency indicators

for power drive systems and motor starters



Während der Projektperiode wurde deshalb erfolgreich eine Round Robin Testreihe organisiert und umgesetzt. Folgende Aktivitäten wurden bis dato erledigt:

1. Bis zum 8. November 2018 haben die vier beteiligten Labore 9 Umrichter zwischen 0,75 kW und 5,5 kW mit 29 verschiedenen Motoren in 47 Einzeltests getestet. Die Motoren waren IE1, IE2 oder IE3, 2- oder 4-polig, betrieben mit 50 Hz oder 60 Hz.
2. Die vorläufigen Testergebnisse, die am RR'C-Workshop vom 13. November 2018 in Zürich vorgestellt wurden, zeigen eine kleine Bandbreite von Abweichungen, sowohl in absoluten Zahlen (W) als auch in relativen Zahlen (Standardabweichung). Es bestätigt sich auch, dass die 9 Umrichter mit 19 % bis 28 % deutlich geringere Verluste aufweisen als die Referenzwerte in IEC 61800-9-2 (Ausgabe 1) des IE1.
3. Mit Hilfe der EMSA Mitglieder wurde ein RR'C 2 Projektpapiers (V5), erstellt. Er beschreibt die Phasen, den Umfang und liefert erste Budgetinformationen. Ebenso wurde ein online Projektmanagement Tool eingerichtet (Trello)
4. Die Ergebnisse der Pilotphase RR'C 1 und die Planung für die zweite Runde RR'C 2 wurden anlässlich des IEC SC22G/WG18 Meetings in Melbourne Australia vorgestellt und diskutiert

Eine genauere Beschreibung der Resultate findet sich im Jahresbericht von Impact Energy: «Concept and Verification of Round Robin Test Program for Converters (RR'C)»

Es fanden zwei EMSA-Sitzungen statt, bei denen der Task-Leader "EMSA International Standards" über die Fortschritte berichtete:

1. 28 - 29 May 2018, Schaffhausen, Switzerland (before the 4E ExCo meeting)
2. 12 - 13 November 2018 in Zurich, (before the Motor Summit 2018 International).

Um eine bessere Zusammenarbeit mit den Herstellern im Rahmen des RR'C 2 zu erreichen wurden folgende Einzelgespräche geführt:

1. 28.11.2018: an der SPS Drives, Nürnberg, Norbert Hanigovszki, Danfoss
2. 4.12.2018: am CENELEC TC22X Plenary Meeting, Brüssel, Benno Weiss, Siemens

### 3.2 Nationale Zusammenarbeit

An folgenden nationalen Meetings wurde teilgenommen:

1. Organisation und Teilnahme an der BRE-NET 36. Trendwatching-/Begleitgruppen-Sitzung
2. Teilnahme am MOTOR SUMMIT 2017 Switzerland am 21. November 2017
3. Teilnahme an IEC-Cenelec-CES-Workshop 2017 bei electrosuisse am 3. November 2017
4. Teilnahme an an der 37. und 38. Trendwatching-/Begleitgruppen-Sitzung (26. April / 30. October 2018)
5. Nationales IEC-Meeting bei electrosuisse am 9. November 2018
6. Workshop RR'C Results 2018 Switzerland am 13. November 2018
7. Teilnahme am MOTOR SUMMIT 2018 Switzerland am 14. November 2018



### 3.3 Internationale Zusammenarbeit

An folgenden Internationalen Meetings wurde teilgenommen:

1. IEC SC 22G WG18, 26 - 28 February 2018, Tampa FL, USA (report no 31)
2. IEC TC2 WG28, 21 May 2018, Shanghai, CN (report no 33)
3. IEC TC2 WG 31, 22 May 2018, Shanghai, CN (report no 34)
4. IEC TC2, 23 May 2018, Shanghai, CN (report no 35)
5. IEC TC2 WG12, 24 May 2018, Shanghai, CN (report no 36)
6. IEC TC2 WG 12, 9 November 2018, Prague, CZ (report no 38)
7. CENELEC TC 22X Plenary Meeting, 4. - 5. December 2018, Brussels, Belgium (report no 39)
8. CENELEC TC 2 Plenary Meeting, 14. February 2019, Brussels, Belgium
9. IEC SC 22G WG18, 19 - 20 February 2019, Melbourne, Australia (report no 41)
10. IEC TC2 WG 12, 10 April 2019, Frankfurt, DE (report no 43)
11. IEC TC2 WG 38, 11 April 2019, Frankfurt, DE (report no 44)

### 3.4 Normenarbeit

An folgenden Normentwürfen wurde mitgearbeitet:

1. IEC 60034-1, Rotating electrical machines - Part 1: Rating and performance, next edition: Conrad U. Brunner provides draft chapter 10: rating plates (including QR code to link with technical data on motor manufacturer's company server)
2. IEC 60034-2-3, Rotating electrical machines - Part 2-3: Specific test methods for determining losses and efficiency of converter-fed AC induction motor: preparation of edition 2 with improved testing method, substantial comments by Andrew Baghurst.
3. IEC 60034-31: Rotating electrical machines - Part 31: Selection of energy-efficient motors including variable speed applications - Application guide, next edition: Conrad U. Brunner provides draft chapter 9 on system performance and optimization.

### 3.5 Bewertung und Ausblick

Der Task Leader Internationale Standards (Vezzini) wurde erfolgreich eingeführt. Mit der Pilotphase für einen Round Robin Test zum Thema Wechselrichterverluste (IEC 61800-9-2:2017) konnte zudem auch schon ein erstes grösseres Projekt durchgeführt werden.

Die grosse Herausforderung im kommenden Jahr wird die Organisation und Durchführung des Round Robin Converter Phase 2 mit über 10 internationalen Labors. Wichtig wird es sein auch die Hersteller von der Wichtigkeit des RR'C zu überzeugen und sie ins gemeinsame Boot zu bringen.

Nur wenn die Resultate des RR'C von allen Mitgliedern des IEC SC 22G WG18 mitgetragen werden, lassen sich in der 2<sup>nd</sup> Revision der IEC 61800-9-2 entscheidende Verbesserungen anbringen.





## 4 Publikationen

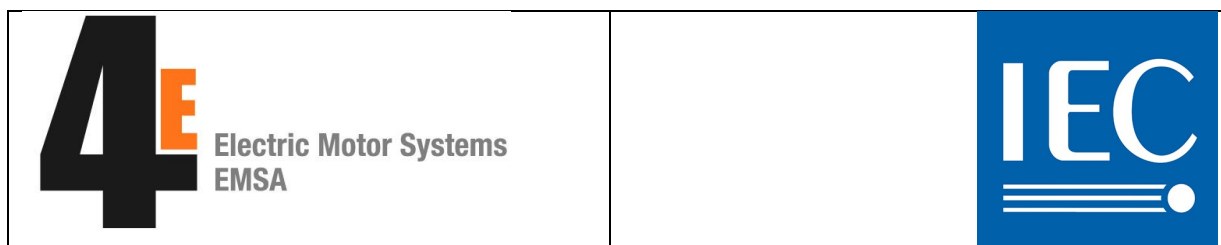
- [1] Emmanuel Agamloh, Andrew Baghurst, Conrad U. Brunner, Sandie B. Nielsen, Andrea Vezzini, EMSA IEC WG 18: Round Robin of Converter Losses, Report of Results of Phase 1, Zurich, Switzerland, March 2019 (available at [www.motorsystems.org](http://www.motorsystems.org))
- [2] Sandie B. Nielsen, Andrea Vezzini, Preliminary results from (RR'C) round robin for converter losses, phase 2, in: EEMODS'19 conference proceedings, Tokyo, Japan, 2019

## 5 Referenzen

- [1] IEC 61800-9-2, Edition 1: Adjustable speed electrical power drive systems - Part 9-2: Ecodesign for power drive systems, motor starters, power electronics and their driven applications - Energy efficiency indicators for power drive systems and motor starters, Geneva, Switzerland, 2017

## 6 Anhänge

- [1] Anhang 1: Beschreibung Round Robin Converter Losses (RR'C): Phase 2
- [2] Anhang 2: Memorandum of Understanding (MoU) (V6)



4E EMSA, Task International Standards

IEC TC22 SC 22G WG 18

## Round Robin Converter Losses (RR'C): Phase 2

Draft proposal, edition 4

20190410 SBN, VIA, CUB

### Contents

Contents.....	1
1. Background.....	2
2. Goal .....	2
3. Organization.....	3
Experience from RR'C Phase 1 .....	3
RR'C leading team.....	3
4. Operating schedule Phase 2 .....	4
Preparation .....	4
Phase 2 .....	4
Timeline .....	4
5. Test laboratories in Phase 2.....	5
6. Product selection.....	5
7. Uniform Testing Protocol (UTP).....	7
Background .....	7
Test program .....	8
8. Management and collaboration tool.....	8
9. Results and evaluation .....	9
10. Cost and financing .....	10
ANNEX 1: Contact Addresses of participating labs.....	11

## 1. Background

In the context of the revision of IEC 61800-9-2:2017<sup>1</sup> and the publication of an upcoming edition 2, several issues around converter losses need to be clarified. The reference losses have been defined about five years ago based on a simulation model that eventually appeared in a CENELEC standard EN 50598-2:2015. These values have never since been verified by tests of market products from different manufactures. The test method has never been verified by independent tests.

On its meeting on 6 September 2017 at EEMODS'127 in Rome, representatives from IEC, EMSA and several independent testing labs ("project group") decided to have 4E EMSA to undertake the project leadership and the organization of the RR'C in cooperation with IEC WG18.

Subsequently the Round Robin testing program for converter losses (RR'C) was established to serve as scientific base for establishing both a secured testing method and the necessary data base for converter losses through the entire range of 0.12 kW to 1000 kW that can be implemented in IEC 61800-9-2 (currently as edition 1, 2017).

In Phase 1 (from November 2017 to February 2019) the main goal was to verify a proposed testing method that would be both accurate and repeatable and that would be practical for industry and research testing labs. The "Uniform Testing Protocol" (UTP) has been made available as edition 2 by November 2018. Currently Phase 1 has been completed and the final report has been discussed during the IEC SC 22G WG18 Meeting in Melbourne, Australia (19 - 21 February 2019). As a consequence, a new UTP (Phase 2) has been established.

In Phase 2 (from May 2019 to December 2020) the main goal is to establish a sufficiently wide data base of testing results over the entire range of converters between 0.12 kW and 1000 kW in order to check the earlier reference data and iE-classes in IEC 61800-9-2, edition 1 that were based on simulation only.

The RR'C was launched by EMSA in cooperation with IEC SC 22G (Working Group 18). The eventual benefit of RR'C will be to validate the IEC 61800-9-2 in its second edition.

## 2. Goal

The main goals of an international Round Robin test (RR'C) for converters are:

- The test method described in IEC 61800-9-2:2017 (edition 1) for converters (and in IEC TS 60034-2-3:2013<sup>2</sup> for motors driven by converters) have not been used for sufficient time to know their accuracy and repeatability. ► Clarify and verify test method.
- The test laboratories around the world using this test method are not yet familiar with it. ► Check laboratory performance
- The performance of the converters and their losses need to be verified vs. the catalogue data. ► Provide scientifically based and documented evidence.

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<sup>1</sup> Adjustable speed electrical power drive systems - Part 9-2: Ecodesign for power drive systems, motor starters, power electronics and their driven applications - Energy efficiency indicators for power drive systems and motor starters

<sup>2</sup> Rotating electrical machines - Part 2-3: Specific test methods for determining losses and efficiency of converter-fed AC induction motors

- Different products from different manufacturers need to be tested as to defining the reference and IE1/IE2 or eventual higher levels. ► Clarify spread of product performance by different manufacturers.

The results of the Round Robin test will build the key evidence for the revision of IEC 61800-9-2 → ed. 2, especially the design of an updated and solid testing procedure which in the current version is often referred to as being vague and ambiguous, and also the provision of sufficient solid and impartial measured background data for a potential correction of the current level of the reference values for losses inside converters.

### 3. Organization

#### Experience from RR'C Phase 1

The organization of RR'C in Phase 2 profits from the near completion of Phase 1 where a vast body of evidence was gathered by 4 international testing laboratories (Advanced Energy/USA, CalTest/Australia, DTI/Denmark and BFH/Switzerland). We thank the four involved laboratories for their work and the governments of USA, Australia, Denmark and Switzerland for providing the necessary funding.

#### RR'C leading team

The RR'C Task Force and its leadership from 4E EMSA, IEC SC 22G WG18 and industry has been selected and mandated at the EEMODS'17 meeting in Rome on 6 September 2017. The cooperation between IEC WG18 and 4E EMSA has been clarified at the IEC WG18 meeting on 26-28 February 2018 in Tampa FL USA.

- **Project manager RR'C Phase 2 (PM):**
  - Sandie B. Nielsen/DK (Task Force leader)
  - Andrea Vezzini/CH (deputy Task Force leader)
- **Advisory group (technical support for the PM):**
  - Emmanuel Agamloh/Advanced Energy, USA
  - Pierre Angers/Hydro Quebec, CA
  - Andrew Baghurst/CalTest, AU
  - Martin Doppelbauer/KIT, Karlsruhe/GE
  - Chai Qing/China National Center for Quality Supervision and Test of Electrical Control and Distribution Equipment/Tianjin, CN
  - Kurt Stockman/University of Gent, BE
- **Steering committee (strategic support and financial resources):**
  - Maarten van Werkhoven/NL (4E EMSA)
  - Roland Brüniger/Swiss government CH
  - Rikke Naeraa/Danish government DK
- **Industry contact group:**
  - ABB (Freddy Gyllensten, Sweden; Henri Kinnunen, Finland)
  - Danfoss (Norbert Hanigovszki, DK)
  - Fuji Electric (Ikuya Sato, Japan)

- Rockwell (Jiangang Hu, USA)
- SEW Eurodrive (Tim Schumann, US)
- Siemens (Bill Finley, USA)

## 4. Operating schedule Phase 2

### Preparation

The RR'C workshop on 13 November 2018 at the Motor Summit in Zurich has served as a first opportunity for an intermediate report on the results of the RR'C Phase 1 and the clarification of the plan for Phase 2. Also, the IEC SC 22G WG18 meeting on 18-22 February 2019 in Australia served both for the final reporting of the results of the RR'C Phase 1 and the launch of RR'C Phase 2. The timeline of Phase 2 has already been synchronized with the preparation of IEC 61800-9-2, edition 2.

The preparation phase for RR'C Phase 2 included the following tasks:

- Product definition and selection to include a representative sample of typical converter types, sizes, frequencies and phases, etc. The goal is to select a sufficient number of products in the entire range of 0.12 kW up to 1000 kW to get the necessary information on reviewing the reference losses and the IE-classes.
- Workshop regarding organizational issues as well as testing procedures (UTP)
- Discussion with IEC WG18 to include the results in IEC 61800-9-2, edition 2 (next WG18 meeting in February 2019 in Australia).

### Phase 2

Phase 2 includes the following tasks:

- Setup phase 2 (collect converter data and planning of testing schedule)
- Full converter testing campaign in about 10 - 12 testing labs with some 60-80 products based on the UTP, edition 2.
- Analysis and report of the results.
- Publication of results.

The bulk of the testing work in Phase 2 will be between spring of 2019 and summer of 2020. After that, the evaluation and reporting in the fall of 2020 will take the rest of the program's time. For budgetary reasons the testing might be continued in 2021.

### Timeline

1 May 2019 - 31 December 2020 (full testing phase)

- |                                      |               |
|--------------------------------------|---------------|
| • Phase 2: start                     | March 2019    |
| • Phase 2: final report to EMSA/WG18 | October 2020  |
| • Phase 2: results dissemination     | December 2020 |

## 5. Test laboratories in Phase 2

A group of independent test laboratories, qualified for converter tests, has been selected to be invited to participate in Phase 2. As a result of a questionnaire, sent to all labs in August 2018, we have positive responses by 18 September 2018 for the participation in the Round Robin Phase 2 from the following 7 laboratories (details see Annex 1):

- Canada                      Hydro Quebec, Laboratoire des Technologies de l'Énergie, Shawinigan, Québec,
- China                        China National Center for Quality Supervision and Test of Electrical Control and Distribution Equipment, Tianjin City,
- Denmark                    Danish Technological Institute (DTI), Aarhus,
- Germany                    Karlsruhe Institute for Technology (KIT), Elektrotechnisches Institut, Karlsruhe,
- Japan                        Fuji Electric Co., Ltd., Suzuka-shi, Mie,
- Switzerland                Bern University of Applied Sciences (BFH), Biel,
- USA                         Advanced Energy, Raleigh NC.
- Australia:                 CalTest, Port Elliot SA 5212

We have also invited four industry laboratories that are capable to test their own large size converters on the factory site (200 - 1000 kW) according to the UTP. So far, we have positive responses to participate in stationary tests with an expert of the Task Force attending from:

- Denmark:                Danfoss Drives, Graasten
- USA                        Rockwell, Mequon, Wisconsin, USA

Currently pending are the responses and the details of the cooperation from ABB and Siemens to participate in the stationary tests for large converters.

- Finland                    ABB
- Germany                  Siemens

## 6. Product selection

The product selection will be decided by the following criteria:

- Converter type: hardware and software
- Grid feeding phases, frequency
- Converter power range, general purpose products
- Number of relevant manufacturers
- Number of products per size.

Phase 2 includes a total of circa 60 – 80 converters in the power range of from 0.12 - 1000 kW from 5 to 8 manufacturers to form a representative sample of converters used in the global market for motor driven units.

RR'C Budget Phase 2 Details by size	Converter tests	Output power range		Number of products under test
	Products size	kW	kW	
1	small	0.12	5	18
2	medium	11	30	21
3	large	37	110	15
4	very large	200	1000	6
	<b>Total (average)</b>			60

**Table 1 Proposed minimum selection of converters for tests, by size (preliminary)**

The total number of products to be tested is dependent on the availability of the products, the capability of the test laboratories, the cost and available resources to cover the cost. The four classes of converter sizes are chosen to reflect the power and the market share of the respective groups.

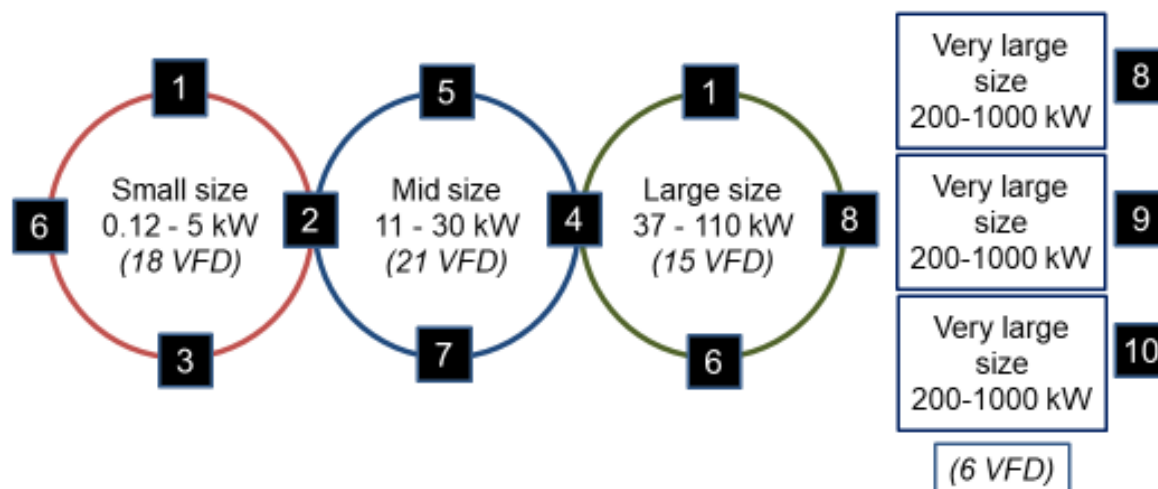
The estimate is for about a minimum of 60 converters between 0.12 and 1000 kW to be tested and evaluated in about 6 to 8 countries and their respective independent laboratories plus some industry laboratories. The converter sizes will be distributed between the labs according to their available capacity and testing equipment (see Figure 1). This table will be updated once the feedback of the participating labs has been consolidated.

Available converter testing capacity											
RR'C Phase 2	Round Robin (small and intermediate machines)							Stationary tests (large machines)			All
Output power (kW)	1	2	3	4	5	6	7	8	9	10	Total (Labs)
	TRIED, CN	DTI, DK	BFH, CH	Advanced Energy, USA	Hydro Québec, CA	Fuji Electric, JP	KIT, GE	Danfoss, DK	ABB, FI	Rockwell, USA	
	CHAI Qing	Sandie B. Nielsen	Andrea Vezzini	Emmanuel Agamloh	Pierre Angers	Ikuya Sato	Alexander Stahl	Norbert Hanigovszki	Henri Kinnunen	Jiangang Hu	
0.12 to <0.18											3
0.18 to <0.25											3
0.25 to <0.37											4
0.37 to <0.56											5
0.56 to <0.75											6
0.75 to <1.1											6
1.1 to <1.5											8
1.5 to <2.2											8
2.2 to <3.7											8
3.7 to <5.5											8
5.5 to <7.5											8
7.5 to <11											8
11 to <15											8
15 to <18.5											8
18.5 to <22											8
22 to <30											7
30 to <37											7
37 to <45											7
45 to <56											5
56 to <75											5
75 to <90											4
90 to <110											4
110 to <150									pending		3
150 to <185											3
185 to <220											1
220 to <250											1
250 to <375											1
375 to 1000											1
Number of products	10	?	20	20	5	17	5	4	?	3	84

**Figure 1 Testing capacity: Converter size (results from questionnaire, September 2018)**

In order to satisfy the rules of a Round Robin (and to save money and time) the current plan is not to have all products go through tests in all the 7 labs. All products between 0.12 kW

and 110 kW (around 50) are to be tested normally by three labs. A total of circa 160 tests are anticipated (circa 15 - 25 tests per lab).



**Figure 2 Four subgroups of laboratories for the Round Robin**

To have the necessary testing capacity which only few manufacturers have (and to also save time and money) the test of these bigger machines is not following the formal Round Robin rules, but they will be tested only stationary at the manufacturer's testing lab.

Currently, for the testing of larger machines between 200 - 1000 kW (maybe a total of 6 to 8), the involvement of Danfoss and Rockwell is confirmed, the discussion is ongoing with ABB. The RR'C project management will send one of the independent laboratory testing engineers as auditor to monitor these tests and to make sure that they are executed according to the Uniform Testing Protocol of the RR'C.

Separately, a batch of promised additional industry test results following the UTP will be used to gain statistical evidence.

## 7. Uniform Testing Protocol (UTP)

### Background

To speed up and to reach early convergence, the advisory group is charged with the design of a complementary Uniform Testing protocol, that includes all current knowledge for improvement. It will include among others:

- Choice of requirements of load motor. Testing with IE2 or IE3 load motor.
- Timing and sequence of tests on x operating points in partial speed and torque.
- Necessary accuracy of measurement instruments for electric input and output of the converter and the mechanical output of the load motor.
- Standby and control losses
- Testing in 50 Hz and 60 Hz grids under the respective nominal voltage
- PWM frequency of converter under test applied.
- etc.



## Test program

The test program according to the UTP must be defined (coordinate with IEC WG18 and IEC WG28):

- Selection of load motor(s)
- Measurement of losses at defined operating points and in standby
- Number of tests per converter at each location

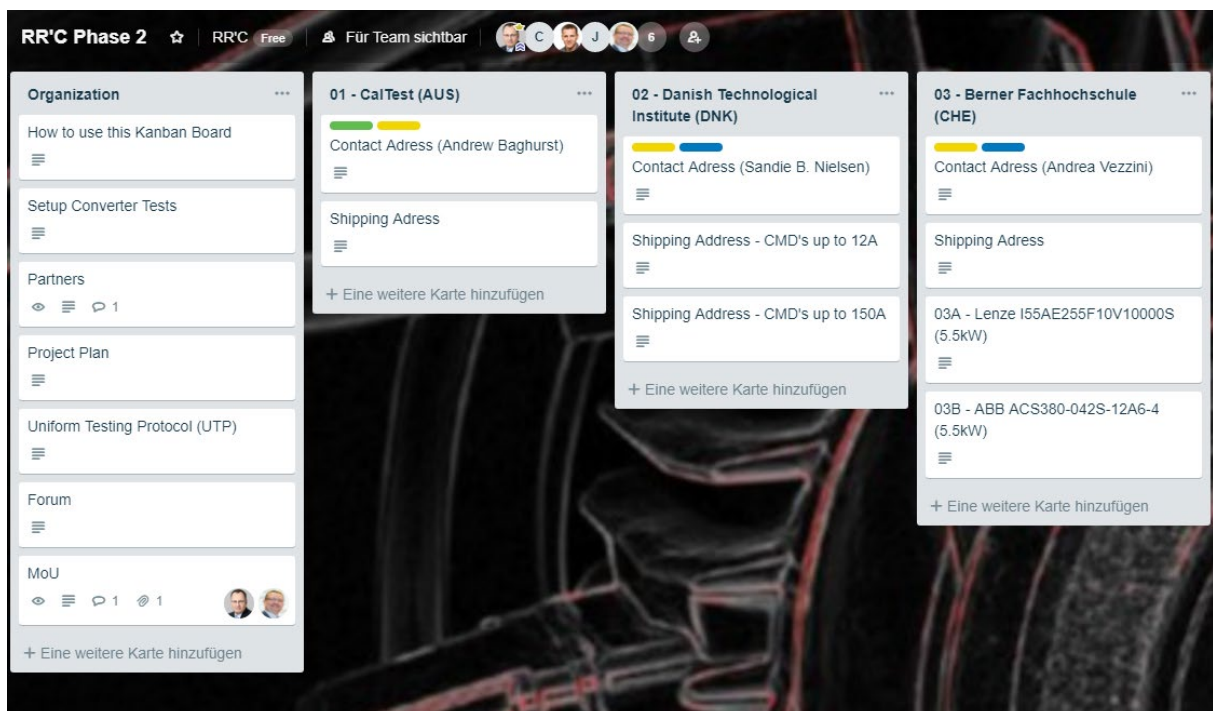
## 8. Management and collaboration tool

Phase 2 will be coordinated with the help of Trello.

Trello is an online collaboration tool that organizes your projects into boards. In one glance, Trello tells you what's being worked on, who's working on what, and where something is in a process.

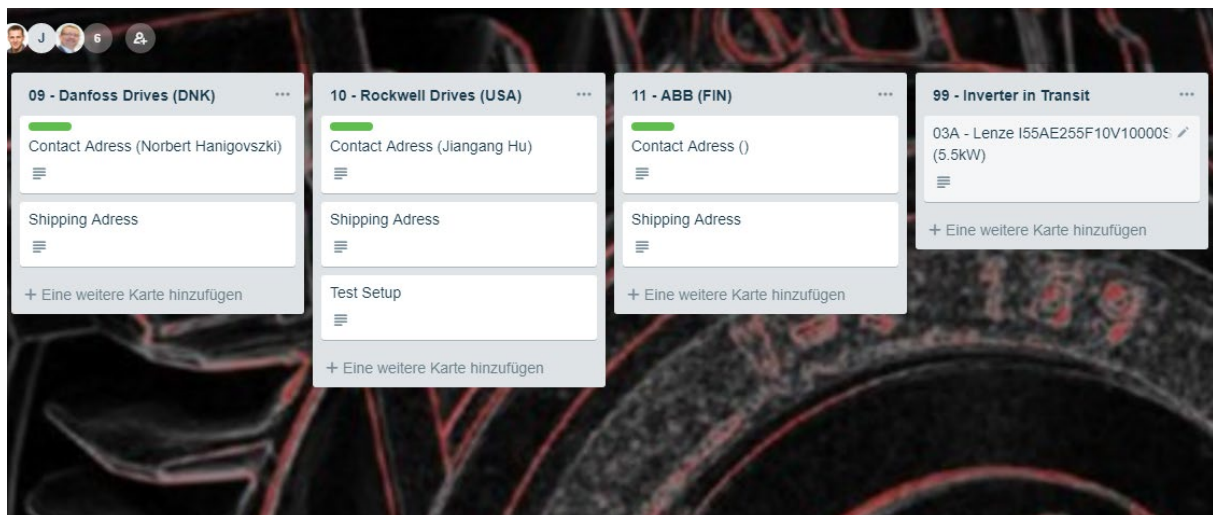
Trello can be compared with a white board, filled with lists of sticky notes, with each note representing one of the devices under test. Each of those sticky notes (DUTs) has photos, attachments from other data sources, documents, and a place to comment and collaborate with other team members.

The lists are representing the current position of the DUTs. This can be either in a laboratory or in transit.



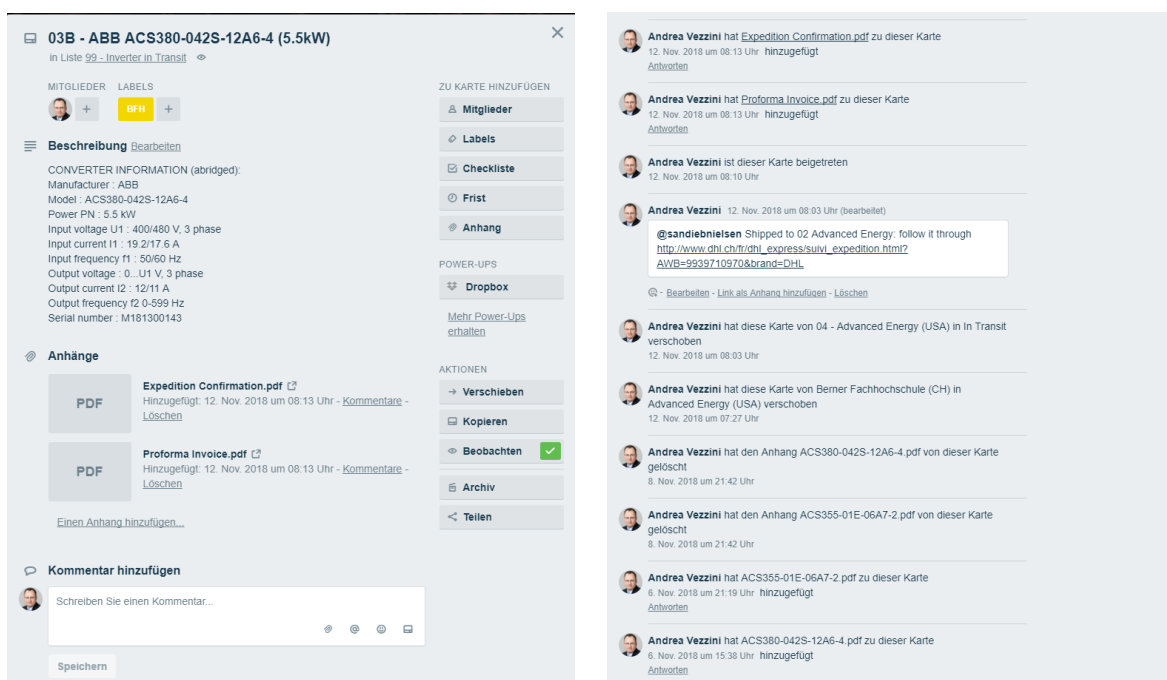
Part of the Trello whiteboard, showing, that the inverters Nr. 03A and 03B are currently at Berner Fachhochschule. Details about the contact Person and the shipping address are also attached to the same list.

Once the tests at Bern University of Applied Sciences have been finished, the inverters are shipped to the next lab and the sticky note is moved to the new list called “99 – Inverter in transit”.



Special list where all the DUTs currently shipping (in transit) are placed). This allow to track the status of the shipping

Additionally, the shipping documents as well as the expedition confirmation are attached to the note as seen on the next picture. This allows the receiving laboratory to check how long the shipment will take and prepare the reception of the DUTs



In this example BFH has directly adresse DTI (by using the identifier @sandiebnielson) to give a link where the shipment can be tracked.

An introduction to Trello has been given during the workshop at the next WG18 meeting in February 2019 in Australia).

## 9. Results and evaluation

The RR'C Task leader decides on the program and timeline in detail. They prescribe an Excel data sheet to be filed for every test of every product. The data are accumulated,

verified (plausibility check), evaluated and described in a report (anonymous manufacturers). A fully transparent documentation will be made and available for the laboratories, manufacturers, the IEC WG18- and EMSA-members involved. A short report with the key results will be made publicly available.

## **10. Cost and financing**

The cost of the RR'C consists of the following components:

- Converters: acquisition of the products for tests
- Shipment of products between the test labs
- Testing work at each lab
- Project management, evaluation, reporting and publication

The financing is based on the following concept of burden sharing:

- The manufacturers of the converters to be tested and the necessary motors for the test are invited to provide their products free of charge (leasing agreement or with a discount) for the RR'C.
- The governments, hosting the testing and research laboratories, are invited to carry the testing costs in their nationally assigned independent laboratories and the shipment costs. The industry labs involved are invited to provide their work as in-kind contribution to the RR'C.
- EMSA and its member countries are invited to share the cost of the project management, the evaluation, the reporting to EMSA and IEC WG18 and the publication.

The final plan for RR'C Phase 2 has been discussed at the EMSA meeting in Zurich on 12/13 November 2018 and at the RR'C workshop on 13 November 2018 in order to be confirmed in February 2019 at the IEC WG18 meeting in Australia.

## ANNEX 1: Contact Addresses of participating labs

1. Chai Qing (Aimee Chai)  
Tianjin Research Institute of Electric Science Co., Ltd.  
China National Center for Quality Supervision and Test of Electrical Control and Distribution Equipment  
NO.6 Xintong Road, Dongli District  
300300 Tianjin  
China  
Mail: [standard6197@163.com](mailto:standard6197@163.com)  
Phone: +86 13602180882  
skype: 798d499961700f5c  
Internet:
2. Sandie B. Nielsen  
Senior Specialist  
Danish Technological Institute  
Kongsvang Allé 29  
8000 Aarhus – Denmark  
Mail: [sbn@dti.dk](mailto:sbn@dti.dk)  
Phone: +45 7220 1257  
skype:  
Internet: <http://www.dti.dk>
3. Prof. Dr. Andrea Vezzini  
Laboratory for Electrical Machines and Adjustable Speed Drives  
Bern University of Applied Sciences  
Quellgasse 21  
CH-2501 Biel/Bienne  
Switzerland  
Mail: [andrea.vezzini@bfh.ch](mailto:andrea.vezzini@bfh.ch)  
Phone: +41 79 351 54 51  
skype: vezzini  
Internet:
4. Emmanuel Agamloh  
North Carolina Advanced Energy Corporation  
909 Capability Drive  
Suite 2100  
Raleigh, NC 27606  
USA  
Mail: [eagamloh@advancedenergy.org](mailto:eagamloh@advancedenergy.org)  
Phone: +1 919-857-9023  
skype: sirrrj  
Internet: <https://www.advancedenergy.org/>

5. Pierre Angers  
Hydro Quebec  
Laboratoire des Technologies de l'Énergie  
600 ave de la Montagne  
G9N 7N5 Shawinigan (Quebec)  
Canada  
Mail: [angers.pierre@ireq.ca](mailto:angers.pierre@ireq.ca)  
Phone: +1 819-539-1400 ext. 1427  
skype:  
Internet:
6. Ikuya Sato  
Fuji Electric Co., Ltd.  
5520 Minami Tamagaki-cho  
513-8633 Suzuka-shi, Mie  
Japan  
Mail: [sato-ikuya@fujielectric.com](mailto:sato-ikuya@fujielectric.com)  
Phone: +81 42 583 6118  
skype:  
Internet:
7. Martin Doppelbauer / Alexander Stahl  
Karlsruher Institute für Technologie  
Elektrotechnisches Institut  
Engebert-Arnold-Straße 5  
76131 Karlsruhe  
Germany  
Mail: [stahl@kit.edu](mailto:stahl@kit.edu)  
Phone: +49 721 608 41837  
skype: [stahl.eti@outlook.de](mailto:stahl.eti@outlook.de)  
Internet:
8. Norbert Hanigovszki  
Danfoss Drives  
Ulsnaes 1  
6300 Graasten  
Denmark  
Mail: [norbert@danfoss.com](mailto:norbert@danfoss.com)  
Phone: +45 2928 4617  
skype:  
Internet:
9. Henri Kinnunen  
ABB  
Finland  
Mail: [henri.kinnunen@fi.abb.com](mailto:henri.kinnunen@fi.abb.com)  
Phone: +  
skype:  
Internet:

10. Jiangang Hu  
Rockwell  
USA  
Mail: jnhu@ra.rockwell.com  
Phone: +1  
skype:  
Internet:
11. Dr. Benno Weis  
Siemens AG  
Digital Factory Division  
Technology and Innovations  
Frauenauracher Str. 80  
91056 Erlangen, Germany  
Mail: benno.weis@siemens.com  
Phone: +49 173 9985927  
skype:  
Internet: [www.siemens.com/ingenuityforlife](http://www.siemens.com/ingenuityforlife)
12. Prof. Kurt Stockman  
Ghent University  
Gr.Karel.de Goedelaan 5  
8500 Kortrijk  
Mail: Kurt.Stockman@UGent.be  
Phone: +32 56 24 12 41  
skype:  
Internet: <http://www.ugent.be>
13. Andrew Baghurst  
CalTest  
36-40 Hill Street  
(PO Box 546)  
5212 Port Elliot  
South Australia  
Mail: abaghurst@caltestlab.com.au  
Phone: +61 417 856 291  
skype: abaghurst

## EMSA Round Robin for Converters (RR'C): Phase 2

### Memorandum of Understanding (MoU) (V6)

#### 1 Terminology

In this document, the following terminology is used:

<b>EMSA, IEA 4E EMSA</b>	Electric Motor Systems Annex of the IEA Technology Collaboration Programme on Energy Efficient End-Use Equipment
<b>IEA 4E TCP</b>	IEA Technology Collaboration Programme on Energy Efficient End-Use Equipment
<b>DUT</b>	Device under test: products selected by the Task Force Leader to be included in the RR'C testing program
<b>IEA</b>	International Energy Agency, Paris France
<b>IEC</b>	International Electrotechnical Commission, Geneva, Switzerland
<b>STR</b>	Standard Reporting Format
<b>RR'C</b>	The Round Robin testing programme for converters undertaken by 4E EMSA in co-operation with the IEC SC 22G WG18
<b>UTP</b>	Uniform Testing Protocol

#### 2 Subject

This Memorandum of Understanding (MoU) is between

##### **PARTY A**

on behalf of the **Electric Motor Systems Annex (EMSA)** of the IEA Technology Collaboration Programme on Energy Efficient End-Use Equipment:

Sandie B. Nielsen (Task Force Leader)  
Danish Technological Institute  
Kongsvang Allé 29  
8000 Aarhus – Denmark

and

Prof. Dr. Andrea Vezzini (Deputy Task Force Leader)  
Laboratory for Electrical Machines and Adjustable Speed Drives  
Bern University of Applied Sciences  
Quellgasse 21  
2501 Biel/Bienne - Switzerland

and

##### **PARTY B**

on behalf of <Institute / Organizational Unit> <Institution / Company>:

Contact person <Title> <First> <Name Name> <(Function)>  
<Institute / Organizational Unit>  
<Institution / Company>  
<Address>  
<ZIP-Code> <City> – <Country>

The period of this MoU is from 1 May 2019 to 31 December 2021.

### 3 Objective

The Round Robin testing programme for Converters (RR'C) was established at the end of 2017 to clarify and verify the testing method and to develop a database for converter losses for the range of 0.12 kW to 1000 kW.

The RR'C was launched by Party A in cooperation with IEC SC 22G (Working Group 18). The results of the RR'C will be used to validate the testing methods proposed the IEC 61800-9-2.

Phase 1 (November 2017 to February 2019) is intended to establish an accurate and repeatable testing method that will also be practical for industry and research testing laboratories. The "Uniform Testing Protocol" (UTP) has been made available as edition 2 by November 2018. Currently Phase 1 is being completed and the final report will be discussed during the IEC SC 22G WG18 Meeting in Melbourne, Australia (19 - 21 February 2019).

In Phase 2 (May 2019 to October 2021) the main goal is to establish a sufficiently wide database of testing results over the entire range of converters between 0.12 kW and 1000 kW in order to check the earlier reference data and IE-classes in IEC 61800-9-2 (edition 1) that were based on simulation.

This Memorandum of Understanding concerns only Phase 2 of the RR'C.

### 4 Project management

Party A is responsible for the coordination and management of the RR'C. The Task Force Leader of Party A for the RR'C is Sandie B. Nielsen, with Andrea Vezzini as Deputy Task Force Leader.

- 1) Party A will update the UTP for Phase 2 and the draft guidelines for the RR'C after the workshop meeting in Melbourne based on the input of the participants.
- 2) Party A will also maintain suitable tools for the control and data collection during Phase 2 RR'C.
- 3) Party A will, upon completion of the tests and the finalization of the report, give Party B a copy of the report with all the results. All fully participating labs will be mentioned in the report.

### 5 Tasks

Party B agrees to undertake his best effort to fulfil the following tasks:

- 1) To acquire the necessary DUTs from regional manufactures
- 2) To receive the nominated DUTs as agreed with Party A;
- 3) To perform laboratory tests on the DUTs according to the UTP and any guidelines provided by Party A at its own costs;
- 4) To record the results, as specified by the Task Force Leader, with the Standard Reporting Format defined by Party A;
- 5) To keep these test results confidential until the final report is issued by the Party A.
- 6) To provide the results only to Party A, using a designated data cloud service or if this is not permitted by their organization through e-mail;
- 7) To forward the DUTs at its own cost to the destination specified by Party A, or assist in this process.

### 6 Expert witness

Where it is deemed necessary by Party A, an independent laboratory testing engineer may be required to monitor tests to ensure that they are executed according to the UTP of the RR'C. Party B agrees to co-operate and facilitate this process.

### 7 Deliverables

The key deliverable will be the provision of the test results for the nominated DUTs, as specified by Party A.



## **8 Timeline**

The tasks in Clause 5 will be undertaken during May 2019 to December 2021.

Party A will establish a timeline for testing and shipping the DUT in agreement with the information given by Party B.

Party B agrees to advise Party A of any delay in meeting this schedule, at the earliest opportunity.

## **9 Endorsement**

Party B may use only the following text to in relation to its role in the RR'C:

"Party B is one of (no.) high quality laboratories selected to participate in the international Round Robin testing programme for Converters conducted by the IEA 4E EMSA in cooperation with IEC SC 22G WG18."

"The results of this programme conducted between March 2019 and October 2021 will be used to validate IEC 61800-9-2."

Any inference that involvement in this project infers any endorsement of the services of Party B by either Party A, the IEA 4E TCP, IEA, or the IEC, or their members, is strictly forbidden.

## **10 Intellectual Property**

Title to all Intellectual Property Rights and associated documentation made solely by Party A resulting from the RR'C Phase 2 shall reside in Party A; title to all Intellectual Property Rights and associated documentation made solely by Party B resulting from the RR'C Phase 2 shall reside in Party B; title to all Intellectual Property Rights and associated documentation made jointly by Party A and Party B resulting from the RR'C Phase 2 shall reside jointly in Party A and Party B.

## **11 Confidential information**

Confidential Information is information that is by its nature confidential and:

- (a) is designated by a party as confidential;
  - (b) is described in this agreement as confidential; or
  - (c) a party knows or ought to know is confidential,
- but does not include:
- (d) information which is or becomes public knowledge otherwise than by breach of this Agreement or any other confidentiality obligation.

In this MoU, Confidential Information includes but is not limited to any data and documents provided by Party A and the test results provided to Party A.

Party B and its subcontractors must not, without the prior written consent of Party A, disclose any Confidential Information to a third party.

## **12 Period of confidentiality**

The obligations under clause 11 shall continue, notwithstanding the expiry or termination of this MoU for a period of 5 years after the termination of RR'C Phase 2.

## **13 Return of information**

At Party A's request, Party B must promptly return all the physical and written records containing Confidential Information, and all documentation relating to that Confidential Information (including copies), to Party A in a form reasonably requested.

If requested by Party A, Party B must destroy such items in the manner specified by Party A and promptly certify to Party A in writing that it has done so.

## **14 Assignment & sub-contracting**

Party B must not assign, subcontract, or transfer its rights or obligations in this MoU without agreement of Party A.

Any consent given by the other parties to any sub-contract, or to any assignment of this MoU, does not relieve Party B from the obligations in, or liabilities arising from, this MoU, and in all respects Party B shall remain obliged and liable for:

- (a) the performance of this MoU; and
- (b) the acts and omissions of any sub-contractor or assignee.

## **15 Variations**

Any variation to this MoU shall be made in writing, and signed by Party A and B.

## **16 Termination**

Any party may terminate this MoU by giving to the others 30 days written notice, and in that event this MoU terminates upon the expiration of that period.

Any party may terminate this MoU by notice in writing served upon the other if:

- (a) one party is in default of any obligation contained in this MoU;
- (b) such default has continued for not less than 10 working days;
- (c) the non-defaulting parties serves upon the defaulting party notice in writing requiring the default to be remedied within 20 working days of the date of such notice, or such greater number of days as the non-defaulting parties may in its discretion allow; and
- (d) the defaulting party shall have failed to comply with the notice referred to in paragraph (c) and in that event this MoU terminates upon the expiration of the period referred to in the notice given pursuant to paragraph (c).

Upon the termination of this MoU, Party B must immediately cease performing the Services and transfer any work in progress to Party A.

## Signature of Parties

This Agreement shall be effective when signed by all parties, and its effective date is the latest of the dates set out below.

### SIGNED on behalf of Party A

Signature: .....  
Signed by: Sandie B. Nielson (DTI)

Place, Date .....

Signature: .....  
Signed by: Prof. Dr. Andrea Vezzini (BFH)

Place, Date .....

### SIGNED on behalf of Party B

Signature: .....  
Signed by: <First Name> <Name> (<Institution>)

Place, Date .....

Signature: .....  
Signed by: <First Name> <Name> (<Institution>)

Place, Date .....

Annex 1	List of necessary DUTs from regional manufactures for Party A
Annex 2	Description of data cloud (Trello, <a href="https://trello.com">https://trello.com</a> ) and data format (Standard Reporting Format)
Annex 3	Plan of destination specified for the Round Robin