Test Report issued under the responsibility of:

TEST REPORT
IEC 61727
Photovoltaic (PV) systems – Characteristics of the utility interface

Report Number. ..... :	2219 / 0019 - 3
Date of issue ..... :	23/05/2019
Total number of pages ..... :	19
Name of Testing Laboratory preparing the Report ..... :	SGS Tecnos, S.A. (Electrical Testing Laboratory)
Applicant's name ..... :	Shenzhen SOFAR SOLAR Co., Ltd.
Address ..... :	401, Building 4, AnTongDa Industrial Park, District 68, XingDong Community, XinAn Street, BaoAn District, Shenzhen City, Guangdong Province, P.R. China
Test specification:	
Standard ..... :	IEC 61727:2004 (Second Edition)
Test procedure ..... :	Characteristic Examination
Non-standard test method ..... :	N/A
Test Report Form No. ..... :	IEC61727A
Test Report Form(s) Originator .... :	TÜV SÜD Product Service GmbH
Master TRF ..... :	Dated 2014-11

If this Test Report Form is used by non-IECEE members, the IECEE/IEC logo and the reference to the CB Scheme procedure shall be removed.

This report is not valid as a CB Test Report unless signed by an approved CB Testing Laboratory and appended to a CB Test Certificate issued by an NCB in accordance with IECEE 02.

General disclaimer:

The test results presented in this report relate only to the object tested.
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Test item description .....:	Hybrid Inverter
Trade Mark .....:	SOFAR SOLAR
Manufacturer.....:	Shenzhen SOFAR SOLAR Co., Ltd.
Model/Type reference .....:	HYD 6000-ES
Ratings .....:	**DC input:** 90-580V; Imax.2x15A **AC output**: 230Vac, 50Hz, Imax 27.3A, 6000VA **Serial Number:** SM1ES060JCS423 **Firmware version:** V1.60

Responsible Testing Laboratory (as applicable), testing procedure and testing location(s):		
☐ ~~CB Testing Laboratory:~~		
~~Testing location/ address.....:~~		
☐ ~~Associated CB Testing Laboratory:~~		
~~Testing location/ address.....:~~		
~~Tested by (name, function, signature).....:~~		
~~Approved by (name, function, signature)...:~~		
☒ **Testing procedure: TMP/CTF Stage 1:**	Shenzhen BALUN Technology Co.,Ltd.	
Testing location/ address.....:	Block B, 1st FL, Baisha Science and Technology Park, Shahe Xi Road, Nanshan District, Shenzhen, Guangdong Province. P.R. China	
Tested by (name, function, signature).....:	Hugo Zhang (Project Engineer)	Hugo Zhang
	Roger Hu (Project Engineer)	Roger Hu
Approved by (name, function, signature....:	Jacobo Tevar (Technical Reviewer)	
☐ ~~Testing procedure: WMT/CTF Stage 2:~~		
~~Testing location/ address.....:~~		
~~Tested by (name, function, signature).....:~~		
~~Witnessed by (name, function, signature) .:~~		
~~Approved by (name, function, signature)...:~~		
☐ ~~Testing procedure: SMT/CTF Stage 3 or 4:~~		
~~Testing location/ address.....:~~		
~~Tested by (name, function, signature).....:~~		
~~Witnessed by (name, function, signature) .:~~		
~~Approved by (name, function, signature)...:~~		
~~Supervised by (name, function, signature) :~~		

List of Attachments (including a total number of pages in each attachment):

50 Hz		
Attachment #	Description	Pages
Attachment I	Pictures of the EUT and Electrical Schemes	16pages
Attachment II	Testing Information	4 pages
Attachment III	Graphs and Screenshots of Test Results	21 pages

Summary of testing:

Tests performed (name of test and test clause):

The equipment has been tested according to the standard:
IEC 61727:2004. Testing has been carried out at 50 Hz

All applicable tests according to the above specified standard have been carried out.

From the result of inspection and tests on the submitted sample, we conclude that it complies with the requirements of the standard.

Testing location:

Shenzhen BALUN Technology Co.,Ltd.

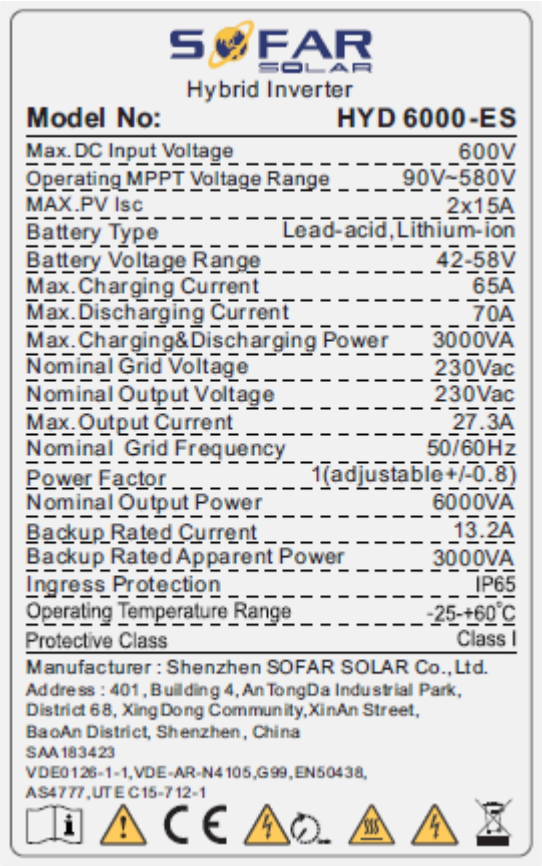
Block B, 1st FL, Baisha Science and Technology Park, Shahe Xi Road, Nanshan District, Shenzhen, Guangdong Province. P.R. China

(All clauses)

Summary of compliance with National Differences:

No National Differences are addressed to this test report

Copy of marking plate(representative):



Note:

1. The above markings are the minimum requirements required by the safety standard. For the final production samples, the additional markings which do not give rise to misunderstanding may be added.
2. Label is attached on the side surface of enclosure and visible after installation
3. Labels of other models are as the same with HYD 6000-ES's except the parameters of rating.

Test item particulars.....:	Hybrid Inverter
Classification of installation and use.....:	Fixed(permanent connection)
Supply Connection.....:	DC; PV
.....:	AC; Grid connection
Possible test case verdicts:	
- test case does not apply to the test object.....:	N/A
- test object does meet the requirement.....:	P (Pass)
- test object does not meet the requirement.....:	F (Fail)
Testing.....:	CTF Stage 1 procedure
Date of receipt of test item .....:	N/A
Date (s) of performance of tests.....:	From 23/04/2019 to 29/04/2019

General remarks:

"(See Enclosure #)" refers to additional information appended to the report.
"(See appended table)" refers to a table appended to the report.

Throughout this report a ☐ comma / ☒ point is used as the decimal separator.

Manufacturer's Declaration per sub-clause 4.2.5 of IECEE 02:

The application for obtaining a CB Test Certificate includes more than one factory location and a declaration from the Manufacturer stating that the sample(s) submitted for evaluation is (are) representative of the products from each factory has been provided ..... :	☐ **Yes** ☒ **Not applicable**

When differences exist; they shall be identified in the General product information section.

Name and address of factory (ies) .....:	Dongguan SOFAR SOLAR Co.,Ltd. 1F - 6F, Building E, No. 1 JinQi Road, Bihu Industrial Park, Wulian Village, Fenggang Town, Dongguan City，Guangdong Province,P.R. China.

General product information:

Product covered by this report is hybrid inverter for indoor or outdoor installation. The connection to the DC input and AC output are through connectors.

The input and output are protected by varistors to Earth. The unit is providing EMC filtering at the output toward mains. The unit does not provide galvanic separation from PV input to output (transformerless). The output is switched off redundant by the high power switching bridge and a two relays. This assures that the opening of the output circuit can operate in case of one error.

Equipment Under Testing:

– HYD 6000-ES

Variant models:

– HYD 5000-ES
– HYD 4000-ES
– HYD 3600-ES
– HYD 3000-ES

Model Number	HYD 6000-ES	HYD 5000-ES	HYD4000-ES	HYD 3600-ES	HYD 3000-ES
Max. input voltage	600Vd.c.				
Max. input current	2 x 15.0 A_{dc}	2 x 15.0A_{dc}	2 x 15.0 A_{dc}	2 x 15.0 A_{dc}	2 x 15.0 A_{dc}
MPPT voltage range	90-580Vd.c.				
Rated grid voltage	230Va.c.				
Rated grid frequency	50Hz				
Rated output power	6kW	5kW	4kW	3.68kW	3kW
Max output current	27.3Aa.c.	22.8Aa.c.	18.2Aa.c.	16Aa.c.	13.7Aa.c.
Power factor	0.8 leading to 0.8 lagging				
Ambient temperature	-25℃~60℃				
Ingress protection	IP65				
Protective class	Class I				

The variants models have been included in this test report without tests because the following features don´t change regarding to the tested model:

– Same connection system and hardware topology
– Same control algorithm.
– Output power within 2,5 and 2/3 of the EUT or Modular inverters.
– Same Firmware Version

IEC 61727			
Clause	Requirement + Test	Result - Remark	Verdict
4	**UTILITY COMPATIBILITY**		**P**
	The quality of power provided by the PV system for the on-site AC loads and for power delivered to the utility is governed by practices and standards on voltage, flicker, frequency, harmonics and power factor.		P
	Deviation from these standards represents out-of-bounds conditions and may require the PV system to sense the deviation and properly disconnect from the utility system.		P
4.1	**Voltage, current and frequency**		**P**
	The PV system AC voltage, current and frequency are compatible with the utility system.		P
4.2	**Normal voltage operating range**		**P**
	Utility-interconnected PV systems do not normally regulate voltage, they inject current into the utility. Therefore, the voltage operating range for PV inverters is selected as a protection function that responds to abnormal utility conditions, not as a voltage regulation function.		P
4.3	**Flicker**		**P**
	The operation of the PV system is not cause voltage flicker in excess of limits stated in the relevant sections of IEC 61000-3-3 for systems less than 16 A or IEC 61000-3-5 for systems with current of 16 A and above.	**(see appended table)**	P
4.4	**DC injection**		**P**
	The PV system is not inject DC current greater than 1 % of the rated inverter output current, into the utility AC interface under any operating condition.	**(see appended table)**	P
4.5	**Normal frequency operating range**		**P**
	The PV system operates in synchronism with the utility system, and within the frequency trip limits defined in 5.2.2.		P
4.6	**Harmonics and waveform distortion**		**P**
	Total harmonic current distortion is less than 5 % at rated inverter output. Each individual harmonic is limited to the percentages listed in Table 1.	**(see appended table)**	P
	Even harmonics in these ranges is less than 25 % of the lower odd harmonic limits listed.		P

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Clause	Requirement + Test	Result - Remark	Verdict
	Table 1 – Current distortion limits **Odd harmonics** / **Distortion limit** 3rd through 9th — Less than 4,0 % 11th through 15th — Less than 2,0 % 17th through 21st — Less than 1,5 % 23rd through 33rd — Less than 0,6 % **Even harmonics** / **Distortion limit** 2nd through 8th — Less than 1,0 % 10th through 32nd — Less than 0,5 %		P
4.7	The PV system has a lagging power factor greater than 0,9 when the output is greater than 50 % of the rated inverter output power.	**(see appended table)**	P
5	**PERSONNEL SAFETY AND EQUIPMENT PROTECTION**		**P**
	This Clause provides information and considerations for the safe and proper operation of the utility-connected PV systems.		P
5.1	**Loss of utility voltage**		**P**
	To prevent islanding, a utility connected PV system ceases to energize the utility system from a de-energized distribution line irrespective of connected loads or other generators within specified time limits.		P
	A utility distribution line can become de-energized for several reasons. For example, a substation breaker opening due to fault conditions or the distribution line switched out during maintenance.		P
5.2	**Over/under voltage and frequency**		**P**
	The abnormal utility conditions of concern are voltage and frequency excursions above or below the values stated in this Clause, and the complete disconnection of the utility, presenting the potential for a distributed resource island.	**(see appended table)**	P
5.2.1	**Over/under voltage**		**P**
	When the interface voltage deviates outside the conditions specified in Table 2, the photovoltaic system ceases to energize the utility distribution system. This applies to any phase of a multiphase system.	**(see appended table)**	P
	Table 2 – Response to abnormal voltages **Voltage (at point of utility connection)** / **Maximum trip time*** V < 0,5 × Vnominal — 0,1 s 50 % ≤ V < 85 % — 2,0 s 85 % ≤ V ≤ 110 % — Continuous operation 110 % < V < 135 % — 2,0 s 135 % ≤ V — 0,05 s * Trip time refers to the time between the abnormal condition occurring and the inverter ceasing to energize the utility line. The PV system control circuits shall actually remain connected to the utility to allow sensing of utility electrical conditions for use by the "reconnect" feature.		P
5.2.2	**Over/under frequency**		**P**

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Clause	Requirement + Test	Result - Remark	Verdict
	When the utility frequency deviates outside the specified conditions the photovoltaic system ceases to energize the utility line. The unit does not have to cease to energize if the frequency returns to the normal utility continuous operation condition within the specified trip time.	**(see appended table)**	P
	When the utility frequency is outside the range of ±1 Hz, the system ceases to energize the utility line within 0,2 s. The purpose of the allowed range and time delay is to allow continued operation for short-term disturbances and to avoid excessive nuisance tripping in weak-utility system conditions.		P
5.3	**Islanding protection**		**P**
	The PV system must cease to energize the utility line within 2 s of loss of utility.	Test according IEC 62116: 2014 Refer to Test Report No: 2219 / 0019 - 4	P
5.4	**Response to utility recovery**		**P**
	Following an out-of-range utility condition that has caused the photovoltaic system to cease energizing, the photovoltaic system is not energize the utility line for 20 s to 5 min after the utility service voltage and frequency have recovered to within the specified ranges.	**(see appended table)**	P
5.5	**Earthing**		**P**
	The utility interface equipment is earthed/grounded in accordance with IEC 60364-7-712.		P
5.6	**Short circuit protection**		**P**
	The photovoltaic system has short-circuit protection in accordance with IEC 60364-7-712.		P
5.7	**Isolation and switching**		**P**
	A method of isolation and switching is provided in accordance with IEC 60364-7-712.		P

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Clause	Requirement + Test	Result - Remark	Verdict

4.3	TABLE: Flicker			P
	Starting	Stopping	Running	
Limit	4%	4%	Pst = 1.0	Plt = 0.65
33%Pn				
Test value	0.199	0.325	0.275	0.233
66%Pn				
Test value	0.254	0.456	0.304	0.252
100%Pn				
Test value	0.282	0.699	0.414	0.338
Supplementary information: N/A				

4.4	TABLE: Direct current injection								P
Rated output current (A)	Ratio of rated output power (VA)	Measured DC output current between terminals (A)						Isolated transformer ? (Yes/No)	Limit (A)
		L1-L2	L1-L3	L2-L3	L1-N	L2-N	L3-N		
26.1	33%	--	--	--	0.024	--	--	No	0.261
26.1	66%	--	--	--	0.034	--	--	No	0.261
26.1	100%	--	--	--	0.049	--	--	No	0.261
Supplementary information: N/A									

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Clause	Requirement + Test	Result - Remark	Verdict

4.6(a)	Table: harmonics and waveform distortion (at 33%Pn)				P
Harmonic	**% of fundamental**	**Limits (% of fundamental)**	**Harmonic**	**% of fundamental**	**Limits (% of fundamental)**
02	0.209	1	03	1.459	4
04	0.106	1	05	1.142	4
06	0.087	1	07	1.090	4
08	0.083	1	09	1.049	4
10	0.082	0.5	11	0.902	2
12	0.080	0.5	13	0.705	2
14	0.085	0.5	15	0.489	2
16	0.087	0.5	17	0.299	1.5
18	0.058	0.5	19	0.159	1.5
20	0.056	0.5	21	0.071	1.5
22	0.043	0.5	23	0.050	0.6
24	0.034	0.5	25	0.067	0.6
26	0.034	0.5	27	0.074	0.6
28	0.037	0.5	29	0.079	0.6
30	0.042	0.5	31	0.064	0.6
32	0.033	0.5	33	0.048	0.6
THD	2.743	5	--	--	--
Supplementary information:					

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Clause	Requirement + Test	Result - Remark	Verdict

4.6(b)	Table: harmonics and waveform distortion (at 66%Pn)				P
Harmonic	**% of fundamental**	**Limits (% of fundamental)**	**Harmonic**	**% of fundamental**	**Limits (% of fundamental)**
02	0.204	1	03	1.085	4
04	0.085	1	05	0.690	4
06	0.067	1	07	0.599	4
08	0.060	1	09	0.625	4
10	0.056	0.5	11	0.579	2
12	0.042	0.5	13	0.452	2
14	0.046	0.5	15	0.319	2
16	0.041	0.5	17	0.214	1.5
18	0.025	0.5	19	0.137	1.5
20	0.023	0.5	21	0.076	1.5
22	0.022	0.5	23	0.056	0.6
24	0.019	0.5	25	0.058	0.6
26	0.019	0.5	27	0.058	0.6
28	0.024	0.5	29	0.051	0.6
30	0.029	0.5	31	0.045	0.6
32	0.018	0.5	33	0.039	0.6
THD	1.789	5	--	--	--
Supplementary information:					

IEC 61727			
Clause	Requirement + Test	Result - Remark	Verdict

4.6(c)	Table: harmonics and waveform distortion (at 100%Pn)				P
Harmonic	**% of fundamental**	**Limits (% of fundamental)**	**Harmonic**	**% of fundamental**	**Limits (% of fundamental)**
02	0.282	1	03	1.059	4
04	0.095	1	05	0.535	4
06	0.188	1	07	0.302	4
08	0.149	1	09	0.441	4
10	0.080	0.5	11	0.350	2
12	0.097	0.5	13	0.157	2
14	0.092	0.5	15	0.245	2
16	0.056	0.5	17	0.139	1.5
18	0.036	0.5	19	0.111	1.5
20	0.056	0.5	21	0.097	1.5
22	0.040	0.5	23	0.065	0.6
24	0.026	0.5	25	0.051	0.6
26	0.030	0.5	27	0.043	0.6
28	0.031	0.5	29	0.033	0.6
30	0.025	0.5	31	0.031	0.6
32	0.020	0.5	33	0.030	0.6
THD	1.461	5	--	--	--
Supplementary information:					

IEC 61727			
Clause	Requirement + Test	Result - Remark	Verdict

4.7	TABLE: Power factor							P
	Input			Output				
No	Voltage (V d.c.)	Current (A d.c.)	Power (W)	Voltage (V a.c.)	Current (A a.c.)	Power (W)	Power factor (*)	Rated output (V.A)
1	408.0	3.1	1260	229.3	5.4	1221	0.991	(20±5)%
2	413.6	4.5	1867	229.4	7.9	1813	0.995	(30±5)%
3	410.5	6.0	2471	229.5	10.5	2401	0.997	(40±5)%
4	407.4	7.6	3106	229.6	13.2	3017	0.998	(50±5)%
5	409.7	9.1	3709	229.5	15.7	3600	0.998	(60±5)%
6	409.2	10.6	4337	229.6	18.3	4207	0.998	(70±5)%
7	409.3	12.1	4940	229.8	20.9	4786	0.999	(80±5)%
8	411.3	13.5	5552	229.9	23.4	5374	0.999	(90±5)%
9	413.4	14.9	6150	229.9	25.9	5947	0.999	(100±5)%

Supplementary information:

(*) 30s average values fill in the table.

IEC 61727			
Clause	Requirement + Test	Result - Remark	Verdict

5.2.1 & 5.4	TABLE: Under-and over-voltage trip settings and reconnection test						P
(1) Under voltage disconnection procedure							
Rated output voltage (V)	**Output power (VA)**	**Required min. voltage (V)**	**Value of PCE trip settings (V)**	**Ratio of decreased (V / s)**	**Interval time (ms)**	**Measured tripped voltage (V)**	**Measured disconnection time (ms)**
50 % Vn≤ V < 85 % Vn							
230	6000	195.5	195	--	2000	194.3	1630
230	6000	155	155	--	2000	153.6	1618
230	6000	117	117	--	2000	117.0	1606
V < 0,5 x Vn							
230	6000	114	114	--	100	113.6	66
(2) Under voltage reconnection procedure							
Ratio of voltage rapidly decreased (V / s)			**Reconnection voltage (V)**			**Reconnection time (s)**	
172.5			231.8			67.5	
(3) **Over voltage disconnection procedure**							
Rated output voltage (V)	**Output power (VA)**	**Required max. voltage (V)**	**Value of PCE trip settings (V)**	**Ratio of increased (V / s)**	**Interval time (ms)**	**Measured tripped voltage (V)**	**Measured disconnection time (ms)**
110 % Vn < V < 135 % Vn							
230	6000	253	255	--	2000	254.9	1916
230	6000	282	282	--	2000	281.2	373
230	6000	309	309	--	2000	117.0	66
135 % Vn≤ V							
230	6000	312	312	--	50	313.2	32
(4) Over voltage reconnection procedure							
Ratio of voltage rapidly decreased (V / s)			**Reconnection voltage (V)**			**Reconnection time (s)**	
115			230			67.9	
Supplementary information: N/A							

IEC 61727			
Clause	Requirement + Test	Result - Remark	Verdict

5.2.2 & 5.4	TABLE: Over/under frequency trip settings and reconnection test	Pass

(1) Under frequency disconnection procedure

Rated output frequency (Hz)	Output power (VA)	Required min. frequency (Hz)	Value of PCE trip settings (Hz)	Ratio of decreased (Hz / s)	Interval time (ms)	Measured tripped frequency (Hz)	Measured disconnection time (ms)
50	6000	49	49	--	200	49.1	166

(2) Under frequency reconnection procedure

Ratio of voltage rapidly decreased (Hz / s)	Reconnection frequency (Hz)	Reconnection time (s)
5.5	50	68.1

(3) Over frequency disconnection procedure

Rated output frequency (Hz)	Output power (VA)	Required max. frequency (Hz)	Value of PCE trip settings (Hz)	Ratio of increased (Hz / s)	Interval time (ms)	Measured tripped frequency (Hz)	Measured disconnection time (ms)
50	6000	51	51	--	200	51.1	164

(4) Over frequency reconnection procedure

Ratio of voltage rapidly decreased (Hz / s)	Reconnection frequency (Hz)	Reconnection time (s)
5.5	50	69.8

Supplementary information:

N/A

IEC 61727			
Clause	Requirement + Test	Result - Remark	Verdict

5.3	Table: tested condition and run-on time								P
No.	P_{EUT} (% of EUT rating)	Reactive load (% of normial)	P_{AC}	Q_{AC}	Run-on time(ms)	P_{EUT} (W)	Actual Q_f	V_{DC} (d.c.V)	Which load is selected to be adjusted (R or L)
Test condtion A									
1	100	100	0	0	496	5948	0.99	500.2	--
2	100	100	-5	-5	189	5952	1.02	501.8	R/L
3	100	100	-5	0	456	5949	1.04	505.2	R
4	100	100	-5	+5	350	5949	1.07	503.6	R/L
5	100	100	0	-5	219	5948	0.97	503.2	L
6	100	100	0	+5	401	5948	1.02	501.4	L
7	100	100	+5	-5	274	5951	0.93	507.6	R/L
8	100	100	+5	0	367	5954	0.95	510.2	R
9	100	100	+5	+5	256	5946	0.95	509.4	R/L
10	100	100	-10	+10	--	--	--	--	R/L
11	100	100	-5	+10	--	--	--	--	R/L
12	100	100	0	+10	--	--	--	--	L
13	100	100	+10	+10	--	--	--	--	R/L
14	100	100	+10	+5	--	--	--	--	R/L
15	100	100	+10	0	--	--	--	--	R
16	100	100	+10	-5	--	--	--	--	R/L
17	100	100	+10	-10	--	--	--	--	R/L
18	100	100	+5	-10	--	--	--	--	R/L
19	100	100	+5	10	--	--	--	--	R/L
20	100	100	0	-10	--	--	--	--	L
21	100	100	-5	-10	--	--	--	--	R/L
22	100	100	-10	-10	--	--	--	--	R/L
23	100	100	-10	-5	--	--	--	--	R/L
24	100	100	-10	0	--	--	--	--	R/L
25	100	100	-10	+5	--	--	--	--	R/L
Test condtion B									

IEC 61727			
Clause	Requirement + Test	Result - Remark	Verdict

10	66	66	0	0	429	3944	1.02	346.4	--
11	66	66	0	-5	343	3953	0.99	343.8	L
12	66	66	0	-4	490	3956	1.00	344.6	L
13	66	66	0	-3	440	3956	1.00	345.8	L
14	66	66	0	-2	304	3953	1.01	346.1	L
15	66	66	0	-1	304	3958	1.02	345.1	L
16	66	66	0	1	372	3964	1.02	344.7	L
17	66	66	0	2	369	3965	1.03	345.6	L
18	66	66	0	3	352	3963	1.04	346.2	L
19	66	66	0	4	216	3958	1.04	343.8	L
20	66	66	0	5	156	3963	1.04	345.4	L
21	66	66	0	6	--	--	--	--	L
Test condition C									
22	33	33	0	0	352	1984	0.96	158.8	--
23	33	33	0	-6	208	1985	0.94	160.7	L
24	33	33	0	-5	244	1985	0.95	162.6	L
25	33	33	0	-4	232	1986	0.95	162.8	L
26	33	33	0	-3	555	1983	0.95	162.8	L
27	33	33	0	-2	410	1978	0.96	162.8	L
28	33	33	0	-1	419	1976	0.96	163.1	L
29	33	33	0	1	401	1970	0.98	163.3	L
30	33	33	0	2	462	1978	0.99	163.3	L
31	33	33	0	3	349	1975	1.00	163.3	L
32	33	33	0	4	368	1971	1.00	163.3	L
33	33	33	0	5	348	1972	1.00	163.8	L

Remark:
For test condition A:
If any of the recorded run-on times are longer than the one recorded for the rated balance condition, then the non-shaded parameter combinations also require testing.
For test condition B and C:
If run-on times are still increasing at the 95 % or 105 % points, additional 1 % increments is taken until run-on times begin decreasing.
The compliances with these requirements are stated in the following test report:
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--- End of test report---