Certificate G59/3.

Engineering Recommendation

Manufacturer	N.V. Nederlandsche Apparatenfabriek "Nedap"
Address	Parallelweg 2, 7141 DC Groenlo, The Netherlands
Test house details	Bureau Veritas Consumer Products Services Germany GmbH
Test house address	Businesspark A96, 86842 Türkheim, Germany

Product type reference	PR50S / PR50SB / PR50SBi	PR37S / PR37SB / PR37SBi	PR30S / PR30SB
Max. AC power	5000W	3680W	3000W
Nominal AC power	5000W	3680W	3000W
Grid connection	Single phase	Single phase	Single phase

The results of the G59/3 test are summarized in this certificate.

N.V. Nederlandsche Apparatenfabriek "Nedap" declares that all products as stated above comply with the requirements defined in engineering recommendation G59/3. These settings cannot be changed by the installer, user or any other person without the use of a tool (password protected). The complete documentation can be viewed at N.V. Nederlandsche Apparatenfabriek "Nedap" after prior announcement.

Test Summary (for details see attached test report)

Power Quality

- Harmonic
- Voltage fluctuations and flicker
- DC injection
- Power factor

Protection

- Frequency test
- Voltage test
- Loss of mains test
- Frequency change test
- Reconnection timer
- Fault level contribution

Drawn up in	Groenlo, The Netherlands
Date	January 28th, 2015
Name and position	W. Klunder, Managing Director Nedap Energy Systems

G59/3 - Appendix A13.1
Generation Unit Type Test Report

Type Tested Generating Unit (>16A per phase but ≤ 50 kW 3-phase or 17 kW 1-phase)

All tests were performed on model PR30S provided with software version 6.0.0 unless stated otherwise. Tests on models PR30S and PR50S were considered representative for all PowerRouter models as listed under "Product type reference".

Power Quality. 13.8.4.1 Harmonics Current Emissions					**P**	
Model PR30S						
SSEG rating per phase (rpp)					NV=MV*3.68/rpp	
	At 45-55% of rated output 1.49 kW		100% of rated output 2.99 kW			
Harmonic	Measured Value (MV) in Amps	Normalised Value (NV) in Amps	Measured Value (MV) in Amps	Normalised Value (NV) in Amps	Limit in BS EN 61000-3-2 in Amps	Higher limit for odd harmonics 21 and above
2nd	0.049	0.060	0.050	0.061	1.080	
3rd	0.059	0.072	0.063	0.078	2.300	
4th	0.016	0.019	0.009	0.011	0.430	
5th	0.076	0.093	0.100	0.123	1.140	
6th	0.007	0.008	0.006	0.008	0.300	
7th	0.041	0.050	0.078	0.096	0.770	
8th	0.004	0.005	0.005	0.006	0.230	
9th	0.026	0.032	0.051	0.062	0.400	
10th	0.004	0.005	0.005	0.006	0.184	
11th	0.022	0.027	0.035	0.043	0.330	
12th	0.004	0.005	0.005	0.006	0.153	
13th	0.018	0.023	0.030	0.037	0.210	
14th	0.004	0.005	0.004	0.005	0.131	
15th	0.013	0.015	0.021	0.026	0.150	
16th	0.003	0.004	0.003	0.004	0.115	
17th	0.009	0.011	0.018	0.022	0.132	
18th	0.003	0.004	0.003	0.004	0.102	
19th	0.006	0.007	0.013	0.016	0.118	
20th	0.002	0.003	0.003	0.003	0.092	
21th	0.005	0.006	0.012	0.015	0.107	0.160
22th	0.002	0.003	0.003	0.003	0.084	
23th	0.004	0.005	0.010	0.012	0.098	0.147
24th	0.002	0.003	0.003	0.003	0.077	
25th	0.003	0.003	0.009	0.011	0.090	0.135
26th	0.002	0.003	0.002	0.003	0.071	
27th	0.002	0.002	0.007	0.009	0.083	0.124
28th	0.002	0.002	0.002	0.002	0.066	
29th	0.002	0.003	0.008	0.009	0.078	0.117
30th	0.002	0.002	0.002	0.002	0.061	
31th	0.002	0.003	0.006	0.008	0.073	0.109
32th	0.002	0.002	0.002	0.002	0.058	
33th	0.003	0.003	0.006	0.007	0.068	0.102
34th	0.002	0.002	0.002	0.002	0.054	
35th	0.003	0.003	0.006	0.007	0.064	0.096
36th	0.002	0.002	0.002	0.002	0.051	
37th	0.003	0.003	0.004	0.005	0.061	0.091
38th	0.002	0.002	0.002	0.002	0.048	
39th	0.003	0.004	0.005	0.006	0.058	0.087

40th	0.001	0.002	0.001	0.002	0.046	

Note:
The higher limits for odd harmonics 21 and above are only allowable under certain conditions, if these higher limits are utilised please state the exemption used as detailed in part 6.2.3.4 of BS EN 61000-3-2 in the box below.

N/A

Power Quality. **13.8.4.1 Harmonic Current Emissions** - Generating Unit tested to BS EN 61000-3-12						**P**
Model PR50S						
Generating Unit rating per phase (rpp)						
	At 45-55% of rated output 2.51 kW		100% of rated output 4.97 kW			
Harmonic	Measured Value (MV) in Amps	Measured Value (MV) in in %	Measured Value (MV) in Amps	Measured Value (MV) in %	Limit in BS EN 61000-3-12 in %	
					1-phase	3-phase
2nd	0.055	N/A	0.454	N/A	8%	8%
3rd	0.419	N/A	0.769	N/A	21.6%	N/A
4th	0.012	N/A	0.214	N/A	4%	4%
5th	0.355	N/A	0.319	N/A	10.7%	10.7%
6th	0.013	N/A	0.059	N/A	2.67%	2.67%
7th	0.243	N/A	0.334	N/A	7.2%	7.2%
8th	0.011	N/A	0.039	N/A	2%	2%
9th	0.170	N/A	0.272	N/A	3.8%	N/A
10th	0.013	N/A	0.030	N/A	1.6%	1.6%
11th	0.118	N/A	0.131	N/A	3.1%	3.1%
12th	0.011	N/A	0.024	N/A	1.33%	1.33%
13th	0.089	N/A	0.159	N/A	2%	2%
14th	0.011	N/A	0.022	N/A	N/A	N/A
15th	0.068	N/A	0.129	N/A	N/A	N/A
16th	0.010	N/A	0.019	N/A	N/A	N/A
17th	0.064	N/A	0.113	N/A	N/A	N/A
18th	0.011	N/A	0.021	N/A	N/A	N/A
19th	0.053	N/A	0.098	N/A	N/A	N/A
20th	0.010	N/A	0.020	N/A	N/A	N/A
21th	0.051	N/A	0.084	N/A	N/A	N/A
22th	0.010	N/A	0.021	N/A	N/A	N/A
23th	0.043	N/A	0.074	N/A	N/A	N/A
24th	0.010	N/A	0.023	N/A	N/A	N/A
25th	0.037	N/A	0.071	N/A	N/A	N/A
26th	0.009	N/A	0.024	N/A	N/A	N/A
27th	0.030	N/A	0.061	N/A	N/A	N/A
28th	0.010	N/A	0.025	N/A	N/A	N/A
29th	0.033	N/A	0.059	N/A	N/A	N/A
30th	0.009	N/A	0.025	N/A	N/A	N/A
31th	0.023	N/A	0.049	N/A	N/A	N/A
32th	0.008	N/A	0.024	N/A	N/A	N/A
33th	0.021	N/A	0.042	N/A	N/A	N/A
34th	0.008	N/A	0.022	N/A	N/A	N/A
35th	0.017	N/A	0.040	N/A	N/A	N/A
36th	0.009	N/A	0.020	N/A	N/A	N/A
37th	0.015	N/A	0.033	N/A	N/A	N/A
38th	0.011	N/A	0.019	N/A	N/A	N/A

39th	0.015	N/A	0.030	N/A	N/A	N/A
40th	0.008	N/A	0.017	N/A	N/A	N/A
THD	1.29%	N/A	1.12%	N/A	23%	13%
PWHD	0.13%	N/A	0.11%	N/A	23%	22%

Power Quality. 13.8.4.3 Voltage Flicker.							**P**	
Model PR30S								
	Starting			**Stopping**			**Running**	
	d_{max}	d_c	$d_{(t)}$	d_{max}	d_{c-}	$d_{(t)}$	P_{st}	P_{lt} 2 hours
Measured Values at test impedance	0.27%	2.68%	0.00%	0.27%	2.68%	0.00%	0.07	0.07
Normalised to standard impedance	0.27%	2.68%	0.00%	0.27%	2.68%	0.00%	0.07	0.07
Limits set under BS EN 61000-3-11	4%	3.3%	3.3% 500ms	4%	3.3%	3.3% 500ms	1.0	0.65
Test impedance	R		0.24* 0.4**	Ω		Xl	0.15* 0.25**	Ω
Standard impedance	R		0.24* 0.4**	Ω		Xl	0.15* 0.25**	Ω
Model PR50S								
	Starting			**Stopping**			**Running**	
	d_{max}	d_c	$d_{(t)}$	d_{max}	d_{c-}	$d_{(t)}$	P_{st}	P_{lt} 2 hours
Measured Values at test impedance	0.33%	3.30%	0.00%	0.33%	3.30%	0.00%	0.09	0.09
Limits set under BS EN 61000-3-11	4%	3.3%	3.3% 500ms	4%	3.3%	3.3% 500ms	1.0	0.65
Test impedance	R		0.24* 0.25**	Ω		Xl	0.15* 0.25**	Ω

Note:
* Applies to three phase and split single phase Generating Units
** Applies to single phase Generating Units and Generating Units using two phases on a three phase system
For voltage change and flicker measurements the following formula is to be used to convert the measured values to the normalised values where the power factor of the generation output is 0,98 or above.
Normalised value = Measured value*reference source resistance/measured source resistance at test point.
Single phase unit reference source resistance is 0.4Ω
Two phase units in a three phase system reference source resistance 0.4Ω
Two phase units in a split phase system reference source resistance is 0.24Ω
Three phase units reference source resistance is 0.24Ω
Where the power factor of the output is under 0.98 then the Xl to R ratio of the test impedance should be close to that of the Standard impedance.
The stopping test should be a trip from full load operation.
The duration of these tests need to comply with the particular requirements set out in the testing notes for the technology under test. Dates and location of the test need to be noted below.

Power Quality. 13.8.4.4 DC injection.			P
Model PR30S			
Test power level	10%	55%	100%
Recorded value	28.82mA	28.60mA	27.29mA
as % of rated AC current	0.22%	0.22%	0.21%
Limit	0.25%	0.25%	0.25%
Model PR50S			
Test power level	10%	55%	100%
Recorded value	1.24mA	13.96mA	8.71mA
as % of rated AC current	0.01%	0.06%	0.04%
Limit	0.25%	0.25%	0.25%

Note:
The tests should be carried out on a single Generating Unit. Test are to be carried out three power defined levels ± 5%. At 230V a 2kW single phase inverter has a current output of 8.7A so DC limit is 21.75mA, a 10 kW three phase inverter has a current output of 45.3A at 230V so DC limit is 108.75mA.

Power Quality. 13.8.4.2 Power factor.				P
Model PR30S				
	216.2V	230V	253V	Measured at three voltage levels and at full output. Voltage to be maintained within ±1.5% of the stated level during the test.
Measured value	0.999	0.999	0.999	
Limit	>0.95	>0.95	>0.95	
Model PR50S				
	216.2V	230V	253V	Measured at three voltage levels and at full output. Voltage to be maintained within ±1.5% of the stated level during the test.
Measured value	0.999	0.999	0.999	
Limit	>0.95	>0.95	>0.95	

Protection. 13.8.3.2 Over / Under Frequency						
Function	Setting		Trip test		"No trip test"	
	Frequency	Time delay	Frequency	Time delay	Frequency /time	Confirm no trip
U/F stage 1	47.5Hz	20s	47.51Hz	20.01s	47.7Hz / 25s	No trip.
U/F stage 2	47Hz	0.5s	47.01Hz	0.515s	47.2Hz / 19.98s	No trip.
					46.8Hz / 0.48s	No trip.
O/F stage 1	51.5Hz	90s	51.49Hz	90.05s	51.3Hz / 95s	No trip.
O/F stage 2	52Hz	0.5s	51.99Hz	0.508s	51.8Hz / 89.98s	No trip.
					52.2Hz / 0.48s	No trip.

Note:
The total disconnection time for voltage and frequency protection including the operating time of the disconnection device shall be the trip delay setting with a tolerance of, -0s + 0,5s.

For frequency trip tests the frequency required to trip is the setting ±0.1Hz. In order to measure the time delay, a larger deviation than the minimum required to operate the projection can be used. The "No-trip tests" need to be carried out at the setting ±0.2Hz and for the relevant times as shown in the table above to ensure that the protection will not trip in error.

For voltage tests the voltage required to trip is the setting plus or minus 3.45V. The time delay can be measured at a larger deviation than the minimum required to operate the projection. The "No-trip tests" need to be carried out at the setting ±4V and for the relevant times shown in the table above to ensure that the protection will not trip in error.

Protection. 13.8.3.4 Loss of mains protection, inverter connected machines BS EN 62116						P
Model PR30S						
Disconnection limit		0.5 s*				
Test Power and imbalance	33% -5% Q Test 22	66% -5% Q Test 12	100% -5% P Test 5	33% +5% Q Test 31	66% +5% Q Test 21	100% +5% P Test 10
	464 mS	321 mS	657 mS	379 mS	303 mS	492 mS
Model PR50S						
Disconnection limit		0.5 s*				
Test Power and imbalance	33% -5% Q Test 22	66% -5% Q Test 12	100% -5% P Test 5	33% +5% Q Test 31	66% +5% Q Test 21	100% +5% P Test 10
	336 mS	320 mS	737 mS	379 mS	320 mS	446 mS
* Note for technologies which have a substantial shut down time this can be added to the 0.5 seconds in establishing that the trip occurred in less than 0.5s. Maximum shut down time could therefore be up to 1.0 seconds for these technologies.						

Protection. 13.8.3.6 Frequency Drift and Step change, Stability test				P
	Start Frequency	Change	End Frequency	Confirm no trip
Positive Vector Shift	49.5Hz	+9 degrees		No trip.
Negative Vector Shift	50.5Hz	- 9 degrees		No trip.
Positive Frequency drift	49.5Hz	+0.19Hz/sec	51.5Hz	No trip.
Negative Frequency drift	50.5Hz	-0.19Hz/sec	47.5Hz	No trip.

Note:
For the step change test the Generating Unit should be operated with a measureable output at the start frequency and then a vector shift should be applied by extending or reducing the time of a single cycle with subsequent cycles returning to the start frequency. The start frequency should then be maintained for a period of at least 10 seconds to complete the test. The Generating Unit should not trip during this test.

For frequency drift tests the Generating Unit should be operated with a measureable output at the start frequency and then the frequency changed in a ramp function at 0.19Hz per second to the end frequency. On reaching the end frequency it should be maintained for a period of at least 10 seconds. The Generating Unit should not trip during this test.

Protection. 13.8.3.5 Re-connection				P
Test should prove that the reconnection sequence starts after a minimum delay of 20 seconds for restoration of voltage and frequency to within the stage 1 settings of table 1.				
Voltage	Time delay setting		20s	
	Measured delay		23.0s	
Frequency	Time delay setting		20s	
	Measured delay		23.1s	
	Checks on no reconnection when voltage or frequency is brought to just outside stage 1 limits of table 1.			
	At 266.2V	At 196.1V	At 47.4Hz	At 51.6Hz
Confirmation that the Generation Unit does not re-connect.	No reconnection	No reconnection	No reconnection	No reconnection

Note:
Reference in accordance with BS EN 50438 (2007)

Fault level contribution. 13.8.4.6 Short Circuit Current Contribution					P
Model PR30S					
For a directly coupled SSEG			For a Inverter SSEG		
Parameter	Symbol	Value	Time after fault	Volts	Amps
Peak Short Circuit current	i_p	N/A	20ms	77.32	37.51
Initial Value of aperiodic current	A	N/A	100ms	72.55	16.79
Initial symmetrical short-circuit current*	I_k	N/A	250ms	71.73	10.63
Decaying (aperiodic) component of short circuit current*	i_{DC}	N/A	500ms	71.47	7.53
Reactance/Resistance Ratio of source*	$^X/_R$	N/A	Time to trip	0.018	In seconds
Model PR50S					
For a directly coupled SSEG			For a Inverter SSEG		
Parameter	Symbol	Value	Time after fault	Volts	Amps
Peak Short Circuit current	i_p	N/A	20ms	83.19	37.61
Initial Value of aperiodic current	A	N/A	100ms	73.31	16.83
Initial symmetrical short-circuit current*	I_k	N/A	250ms	71.66	10.65
Decaying (aperiodic) component of short circuit current*	i_{DC}	N/A	500ms	71.07	7.54
Reactance/Resistance Ratio of source*	$^X/_R$	N/A	Time to trip	0.018	In seconds
Note: The values of voltage and current should be recorded for a period of up to 1 second when the changeover switch should be returned to the normal position. The voltage and current at relevant times shall be recorded in the type test report including the time taken for the Inverter to trip.					

13.8.4.7 Self-Monitoring solid – solid state disconnection The requirement is specified in section 5.3.1, No specified test requirements.	**N/A**
It has been verified that in the event of the solid state switching device failing to disconnect the SSEG, the voltage on the output side of the switching device is reduced to a value below 50 volts within 0.5 seconds.	
Note: Unit do not provide solid state switching relays. In case the semiconductor bridge is switched off, then the voltage on the output drops to 0. In this case the relays on the output will also open	

Additional comments
None