SMOKE CONTROL ASSOCIATION

Varying Speed of Powered SHEVs at Elevated Temperatures Using Variable Speed Drives Technical Report

JULY 2025

Federation of Environmental Trade Associations

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HEATING | VENTILATION | AIR CONDITIONING

FOREWORD

The Smoke Control Association (SCA) is part of the Federation of Environmental Trade Associations (FETA) and has over 40 members involved in the design, manufacture, supply and fitting of smoke control equipment and systems.
Set up in 1987 the SCA's aim is to promote and enhance the design, manufacture, installation and maintenance of life safety smoke ventilation systems across all types of building.

In recent years the smoke control industry has improved the performance of life safety systems by embracing advances in the technologies available to it, in particular, those technologies employed in fans and variable speed drives. Mechanical Smoke Ventilation Systems which use varying extract fan speeds for smoke extraction are commonplace and are referenced in BS9991, BS9999 as well as various other guidance including the SCA's own *Guidance on Smoke Control to Common Escape Routes of Residential Buildings*. Whilst these systems are now in widespread use, the principal product testing regime for powered SHEVs, namely BS EN 12101 part 3, is limited in its scope when considering varying the speed of fans in an emergency operation. At the time the SCA began this work, there were no published standards which incorporated tests that included varying speeds of fans at elevated temperatures through inverters.

The SCA recognises that there is a need to widen industry's knowledge of products' performances when used in these applications.

Dame Judith Hackitt, chair of the Transition Board set up to establish the new Building Safety Regulator, said: *"Product testing, marketing, labelling and approval processes are flawed, unreliable and behind the times."*

She made it clear that forthcoming regulation will directly impact the construction product materials supply chain. Manufacturers will have to provide data and performance accreditation, use standardised systems and take a more collaborative approach, including adopting a transparent attitude to data sharing.

This project represents a pooling of specialist industry knowledge with respect to Smoke and Heat Exhaust Ventilators -SHEVs (fans) and their potential application to directly answer questions raised by industry via an initial study.

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1. SCA WORKING GROUP

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2. INTRODUCTION

The SCA has undertaken this research in order understand the performance of powered SHEVs when fan speeds are varied dynamically through inverter drives and whilst being subjected to elevated temperatures. This research is intended to be a step towards establishing whether similar levels of product performance can be expected from powered SHEVs certified to EN12101-3 but when used in this way. This research has focused on the particular application of mechanical smoke ventilation system for residential multi-occupancy dwellings.

The use of fans with variable speeds drives is well established in the HVAC industry but performance data for the use of a variable speed operation at temperatures expected in a mechanical smoke ventilation system (MSVS) is lacking. The purpose of this research was to build up a performance profile of key equipment. Parameters of temperature, time and fan speeds were established to simulate the conditions the equipment would be expected to experience. Importantly the research looked to understand of how the equipment reacted to changes in inputs typically expected during firefighting activities. These input changes were simulated in the test regime to represent expected real-life conditions.

At the time the SCA began this work, there were no published standards which incorporated tests that vary speeds of fans at elevated temperatures through inverters. However, in 2022 BS EN 12101 Part 6 *Specification for pressure differential systems – Kits* was published which included an annex that set out such a test (Annex C). The SCA working group decided that it would continue with the research using the assumptions and test regime set out in this document and not use EN12101-6 2022, as it was important that the research reflected the application which is commonplace for SCA members. Importantly the national foreword of BS EN12101 part 6 2022 specifically states the standard is not intended for corridor/ lobby extract or Mechanical Smoke Ventilation Systems and they are outside of the scope of the standard. See Note on p14 for further information.

The test methodology was based on the performance of an MSVS with variable rates of extract intended for use in residential applications as set out in the SCA's **Guidance on Smoke Control to Common Escape Routes in Apartment Buildings (Flats and Maisonettes)** July 2020 and BS9991 2015. Any output from this study is valid for this specific application only.

This report sets out its conclusions on page 14.

3. METHODOLOGY

The approach taken was to define a scenario which was representative of the application the industry typically encounters.

This representative scenario was then used as a basis for creating a test regime that could subject the equipment to demands that would be experienced in the application. Equipment was then selected according to the assumptions built into the representative scenario and then subjected to the test regime set out below. The results of the tests were recorded and are included below. This data was then used to draw conclusions and recommendations.

4. REPRESENTATIVE SCENARIO

The representative scenario was developed to reflect the performance criteria a powered SHEV would typically be expected to experience in a mechanical smoke ventilation system installed in a multi occupancy dwelling.

The expected development of the fire scenario in a residential apartment application is illustrated in Figure 1 below, taken from the Smoke Control Association's: *Guidance on Smoke Control to Common Escape Routes in Apartment Buildings (Flats and Maisonettes) – Revision 3.1: 13 July 2020.*

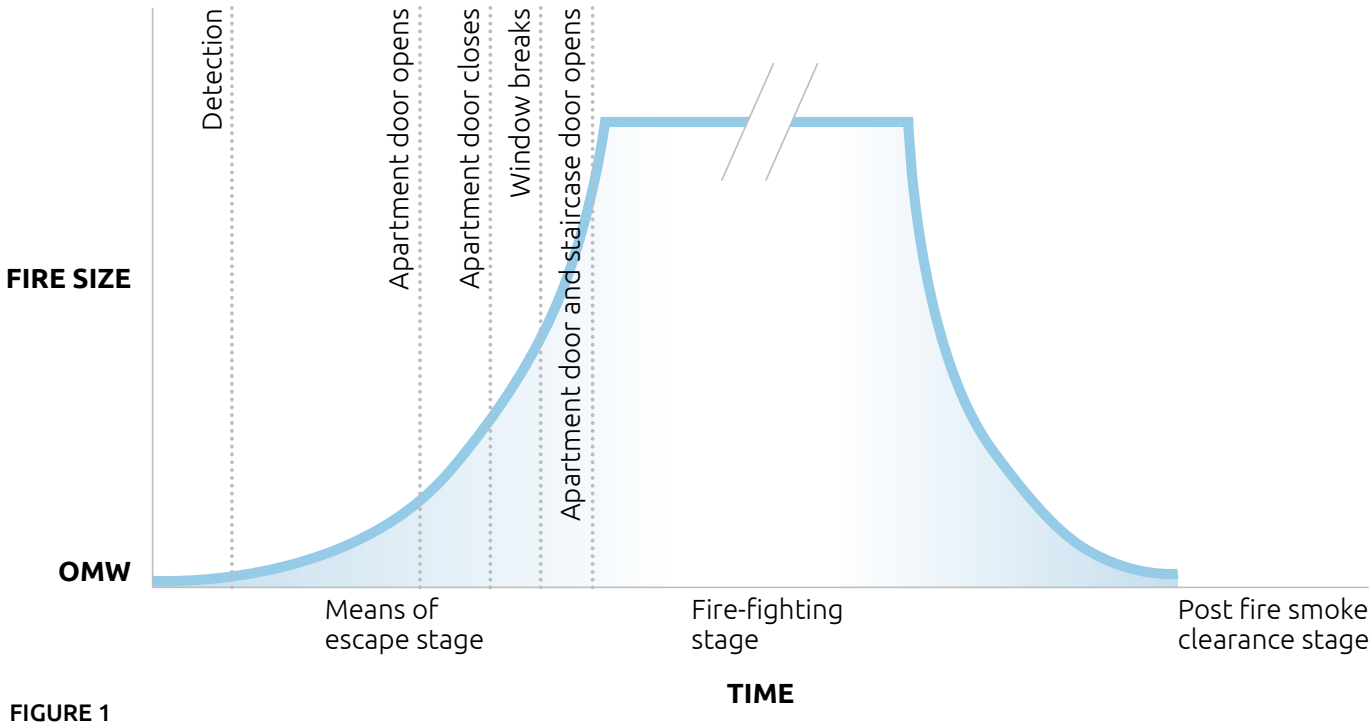

FIGURE 1

The first stage of the scenario is described as "means of escape". During this phase the powered SHEVs would be exposed to temperatures above ambient but below the 300 degrees C commonly tested in EN12101-3. It is also common for fans to be run at less than maximum speed during this initial phase.

A test regime which therefore creates more onerous conditions for the equipment such as running at maximum speed and at elevated temperature for a period would be representative. The existing EN1201-3 standard sets out the procedures for such a test with a duration of 60 minutes.

The equipment is likely to experience the most onerous conditions during the firefighting stage (fig. 1 above). Typically, fans will have been exposed to a period of elevated temperatures before firefighting operations begin. Once firefighting is underway it is reasonable to expect changes to the air pathways between the staircase and the affected fire floor, as fire doors are opened and closed and firefighting equipment (e.g. hoses) is introduced. Each occurrence would require a change in the fan speed to maintain design extract rates and prevent over pressures. Fan speed variance would therefore be expected to take place at high temperatures and every occurrence could, in a worst-case scenario, create a transition in fan speed from maximum to minimum and back to maximum at high temperature. A cautious approach to representing these scenarios in a test environment would be to cycle the equipment at 300 degrees C for one hour. A full cycle would vary the fan speed from maximum rotational speed to a minimum rotational speed of 20%* and back to maximum rotational speed. It was felt that ten full cycles should be undertaken after completion of the means of escape phase test.

In order to ensure that actual system installations are represented in the tests, the physical location of the equipment was considered. Whilst some system installations see fan control panels located immediately adjacent to the fans, other sites require the fan control panels to be installed remotely. It was felt that a cable distance of 20 metres would be representative of these applications.

During the commissioning phase of a system installation, it is common for the ramp up speed of systems to be adjusted to tune the system performance to site specific conditions. A ramp up speed of 5 seconds is seen as cautiously representative for the purposes of this work item.

20% is the typical minimum rotational speed setting for most systems. Whilst slower rotational speeds can be selected, they would not be representative. The 20% figure represents a comfortable margin of safety for the purpose of this project.

5. TEST REGIME

5.1 GENERAL

The current harmonised European standard for powered smoke and heat exhaust ventilators is EN 12101-3 2015. The Smoke Control Association requires members to only install fans which fully comply with this standard where those systems require powered smoke and heat exhaust ventilation. It is therefore representative that fans certified to EN12101-3 be used in this test regime.

In order to understand the performance of the typical range of products that may be used in the scenario, tests on two fans with a temperature rating of F300 and incorporating 5.5 kW, 2-pole and 30 kW 4-pole motors were undertaken.

It was agreed that these sizes represented the smallest and largest examples of products TYPICALLY used in the application described. The F300 rating is considered acceptable for the purposes of this exercise as fans rated at higher temperatures would not normally be used in the scenario (see fig. 1).

5.2 TEST RIG

The test rig was in accordance with EN12101-3. The equipment cycle testing described below was pre-programmed into the inverters.

5.3 EQUIPMENT UNDER TEST

The equipment to be tested comprised:

- 1 x Fan set rated F300 incorporating a WEG 30 kW IEC / 36 kW AOM 4-pole 400V / 3-phase / 50Hzsmoke extraction motor certified to EN12101-3
- 1 x Fan set rated F300 incorporating a WEG 5.5 kW IEC / 6.6 kW AOM 2-pole 400V / 3-phase / 50Hz smoke extraction motor certified to EN12101-3
- 2 x WEG CFW-500 series fire mode inverters with dynamic braking, models CFW500 C 16P0 T4 DB20C2H00G2 - 16A - 400V 3-phase and CFW500 F 77P0 T4 DB20C3H00G2 - 77A - 400V 3-phase
- 20m Fire rated cable between the inverter and the fan set under test.

5.4 TEST ROUTINE

The test used the following sequence.

Step 1 Warm up routine per EN12101-3 then heat fan up to 300 degrees C.

Step 2 Run fan for 15 minutes to establish temperature stability.

Step 3 Cycle fan 10 times for 60 minutes with temperature being maintained at 300 degrees C. (see notes 1 and 2 below).

Step 4 Run fan at full speed at elevated temperature for 60 minutes.

Step 5 End test.

Note 1: One cycle included a transition from maximum rotational speed to minimum rotational speed (20%) and a return back to maximum rotational speed. The ramp down time from maximum rotational speed to minimum rotational speed was 5 seconds. The fan was run at minimum rotational speed for 3 minutes. Thereafter the rotational speed of the equipment under test was increased back to its maximum with a ramp up time of 5 seconds and maintained for 3 minutes. The ramp up speeds in both cases are included in the 3-minute cycle. This process was repeated 10 times.

Note 2: Whilst it is desirous for the temperature to be maintained at 300 degrees C it is recognised that this may not be possible due to the constraints of the testing equipment. Nevertheless, the temperatures that the equipment under test were recorded and include in the Results section below.

6. RESULTS

6.1 TEST 1 (WITH WEG 30 KW / 36 KW, 4-POLE, 400V MOTOR, FRAME SIZE 200L)

TEST 1 INVERTER MEASUREMENT RESULTS

Clause A.1.n of EN 12101-3:2015 requires the fan to operate for a minimum of 10 minutes, at ambient temperature to allow measurements to be taken. Measurements are taken once a minute, and from these measurements, the maximum voltage peak, peak to peak value and the maximum rate of voltage rise (du/dt) are shown in the table below.

TABLE 1. INVERTER TEST RESULTS

Maximum Peak Voltage (Vmax)	**284**
Maximum Peak to Peak Voltage (Vp)	**616**
Maximum Voltage Rise du/dt = (0.8*Vp/dt)	**3.779 V/nS**

TEST 1 HIGH TEMPERATURE TEST RESULTS

The table below shows a summary of the start and finish values for the test sample for the dual- purpose ambient stability test and the high temperature test.

In the dual purpose test the fan is run at ambient temperature for one hour or until the fan motor case shows a temperature increase of less than 2 degrees in ten minutes, whichever is the longer.

Table 2 shows the start and finish values, the full test period being displayed on the following graph.

TABLE 2. SUMMARY OF RESULTS FOR TEMPERATURE/TIME TEST

	START OF WARM UP	END OF WARM UP	START – HIGH TEMP TEST	INTERRUPT	END – HIGH TEMP TEST
Time	10:29	11:36	11:48	N/A	14:27
Volts V	419	418	421		423
Amps A	57.2	53.8	33.0		33.6
Watts kW	33.3	30.9	18.2		18.7
Power Factor	0.802	0.795	0.757		0.758
Average Air Temperature (°C)	20.8	47.1	306		306
Motor Case Temperature (°C)	28.3	52.0	255		310
Fan Case Temperature (°C)	17.0	45.7	188		265
Static Pressure, Fan Outlet (Pa)	467	403	231		244
Corrected Static Pressure (Pa)	475	447	464		489

TABLE 3. TEST OBSERVATIONS

TIME	TEST OBSERVATION
10:29	Elevated temperatures due to pre-test running
11:48	At 300°C
12:03	Start of frequency steps (50Hz to 10Hz) with 5 sec ramp time
13:06	Start of 1hr at full speed test
14:13	3 sec ramp time
14:16	2.5 sec ramp time
14:19	2 sec ramp time *1 sec and 0.5 sec ramp times attempted*
14:27	End of testing, burners switched off

TABLE 4. OBSERVATIONS ON CONDITION OF VENTILATOR AFTER TEST

Impeller rotates easily

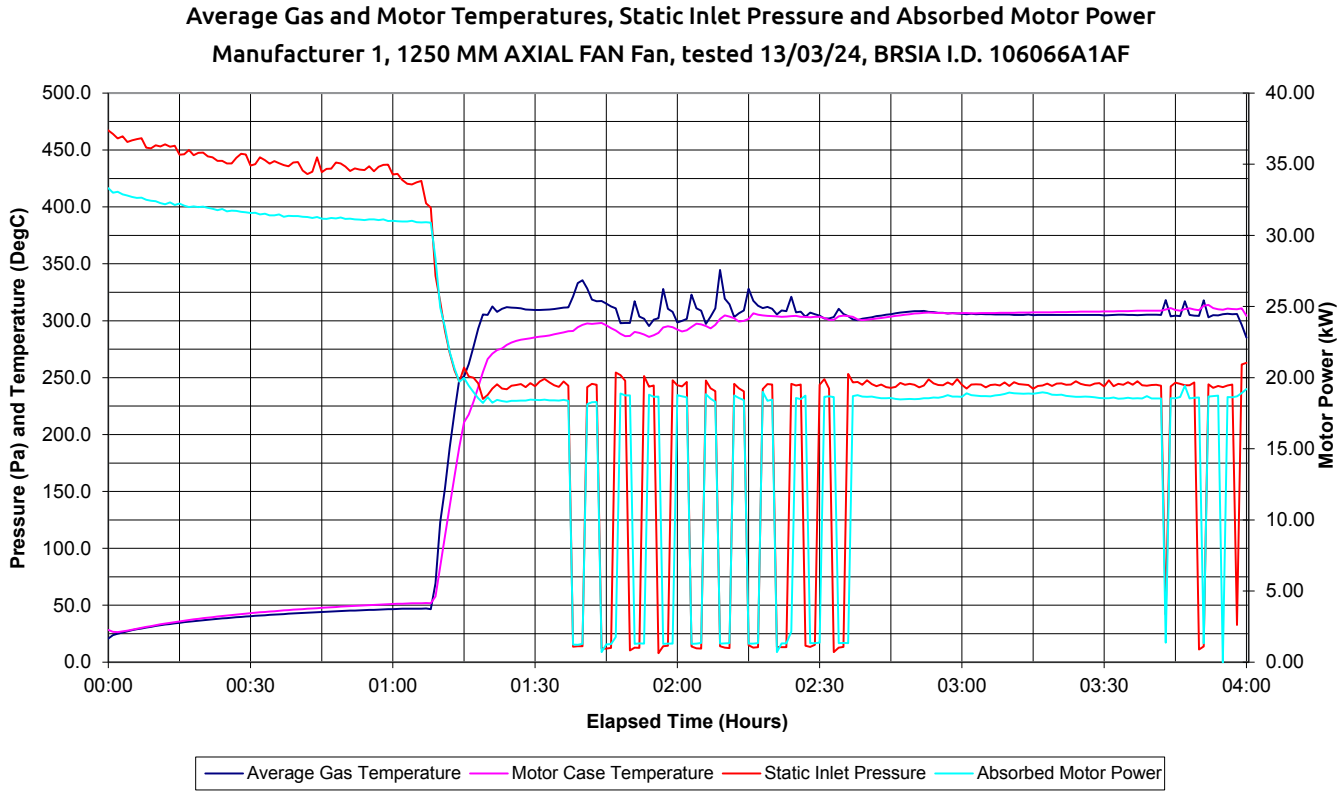

FIGURE 2.

Inverter Output During Cycle Test

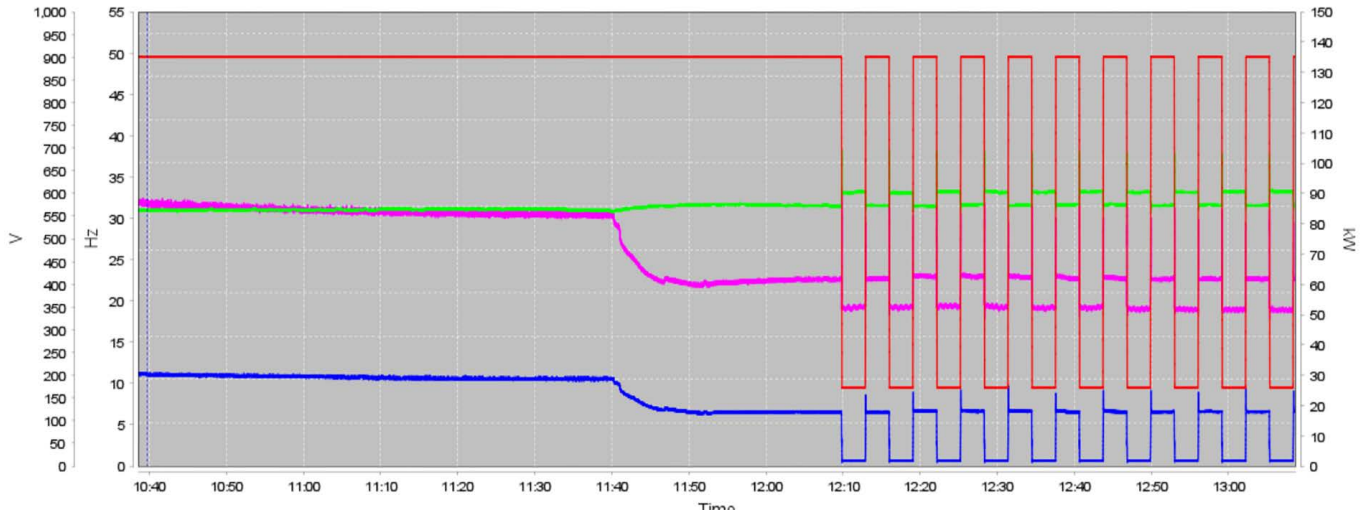

FIGURE 3.

Test 1 concluded using the worst-case scenario of no brake resistors fitted and all drive protections switched on.

6.2 TEST 2 (WITH WEG 5.5 KW / 6.6 KW, 2-POLE, 400V MOTOR, FRAME SIZE 132S)

TEST 2 INVERTER MEASUREMENT RESULTS

Clause A.1.n of EN 12101-3:2015 requires the fan to operate for a minimum of 10 minutes, at ambient temperature to allow measurements to be taken. Measurements are taken once a minute, and from these measurements, the maximum voltage peak, peak to peak value and the maximum rate of voltage rise (du/dt) are shown in the table below.

TABLE 5. INVERTER TEST RESULTS

Maximum Peak Voltage (Vmax)	304
Maximum Peak to Peak Voltage (Vp)	616
Maximum Voltage rise du/dt = (0.8*Vp/dt)	4.989 V/nS

2.2 TEST 2 HIGH TEMPERATURE TEST RESULTS

The table below shows a summary of the start and finish values for the test sample for the dual- purpose ambient stability test and the high temperature test.

In the dual purpose test the fan is run at ambient temperature for one hour or until the fan motor case shows a temperature increase of less than 2 degrees in ten minutes, whichever is the longer.

Table 6 shows the start and finish values, the full test period being displayed on the following graph.

TABLE 6. SUMMARY OF RESULTS FOR TEMPERATURE/TIME TEST

	START OF WARM UP	END OF WARM UP	START – HIGH TEMP TEST	INTERRUPT	END – HIGH TEMP TEST
Time	9:44	10:50	11:03	N/A	13:39
Volts V	423	424	423		422
Amps A	8.73	8.53	5.21		5.48
Watts kW	3.96	3.84	2.27		2.40
Power Factor	0.623	0.618	0.600		0.604
Average Air Temperature (°C)	10.1	16.3	301		305
Motor Case Temperature (°C)	19.0	30.7	153		334
Fan Case Temperature (°C)	9.20	15.5	267		303
Static Pressure, Fan Outlet (Pa)	183	165	82.0		91.0
Corrected Static Pressure (Pa)	180	166	163		182

TABLE 7. TEST OBSERVATIONS

TIME	TEST OBSERVATION
9:44	Elevated temperatures due to pre-test running
11:03	At 300°C
11:17	Start of frequency steps (50Hz to 10Hz) with 5 second ramp time
12:21	Start of 1-hour full speed test
13:39	End of testing, burners switched off

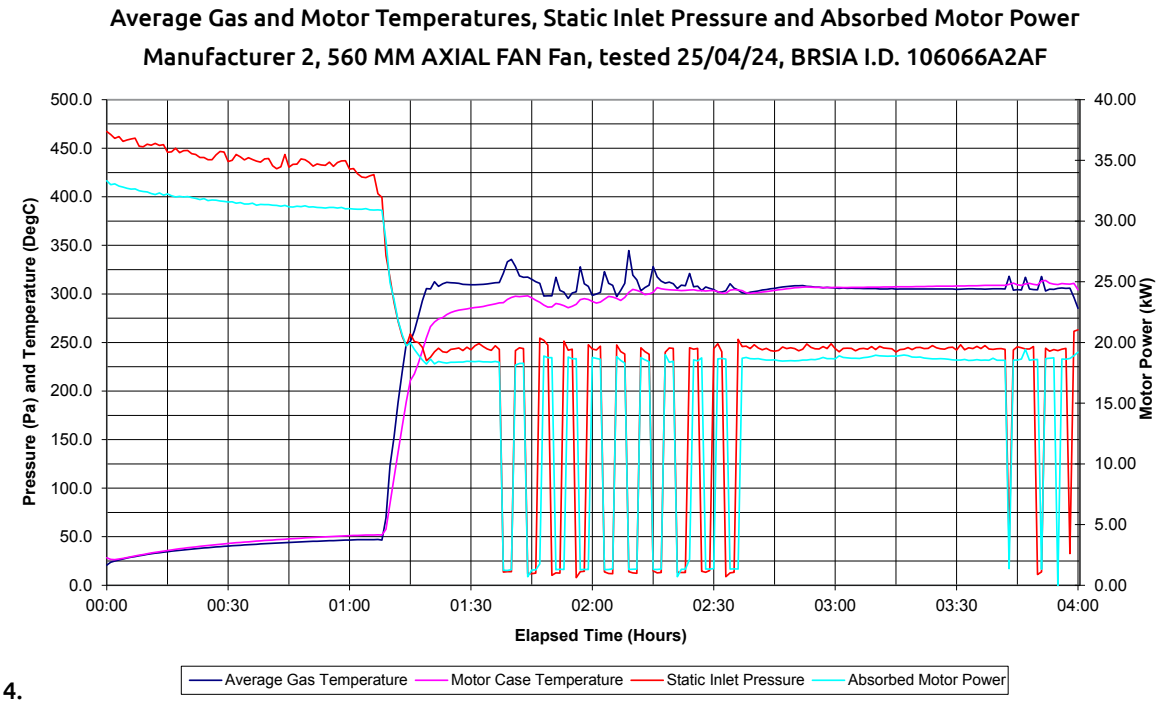

FIGURE 4.

**Inverter Output During Cycle Test **

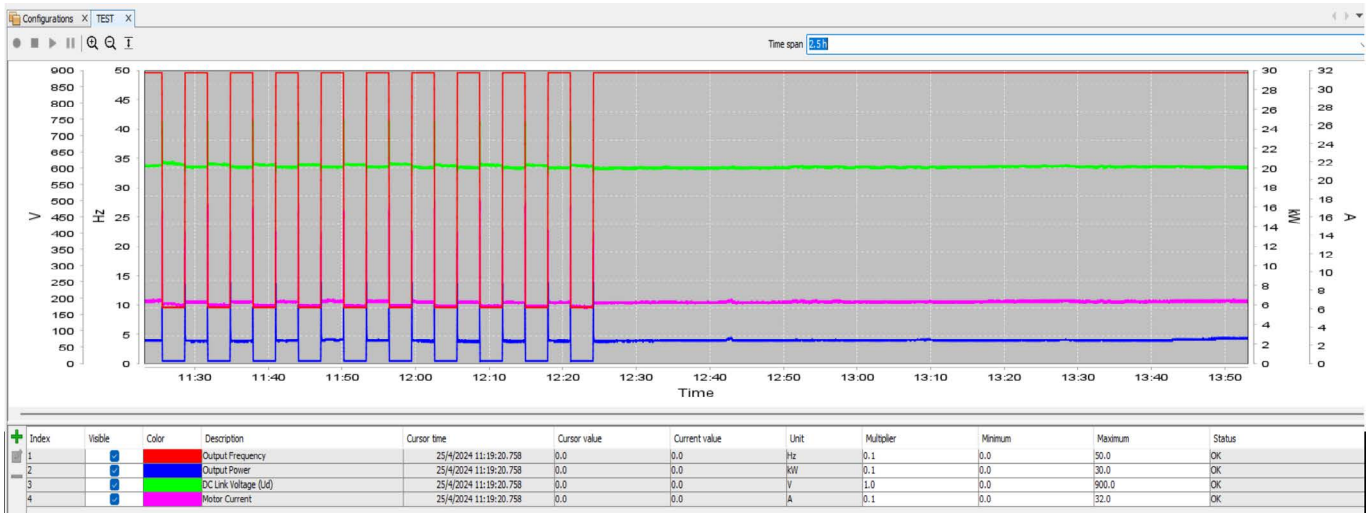

FIGURE 5.

Note 3: Due to the mass and moment of inertia of the fan impeller, it was determined during the pre-HT test that the drive did require 2x 65R braking resistors in parallel (33 ohms) to achieve the 5 sec deceleration as specified. The impeller weight also resulted in an increase in the starting current, although the 5 second starting ramp was still achieved.

7. CONCLUSIONS

At the time the SCA began this work, there were no published product standards which incorporated tests that included varying speeds of fans at elevated temperatures through inverters.

The SCA has undertaken research in order understand the performance of powered SHEVs when fan speeds are varied dynamically through inverter drives and whilst being subjected to elevated temperatures.

The results of the tests undertaken indicate that for the equipment under test, there are no obvious problems associated with varying the speed of powered SHEVs certified to EN12101-3 at 300 degrees via an inverter for the application set out in this document.

8. RECOMMENDATIONS

The SCA recommends that a new product standard is developed or existing product standards are updated to include testing to establish products' performance against criteria of varying fan speed at elevated temperatures.

This work item has been proposed to the European committee responsible for the EN12101 standards series on 30th October 2024 (CEN/TC191/SC1). The proposal is currently being considered by the committee.

Note: EN12101-6: 2022 Smoke and heat control systems - Specification for pressure differential systems. Kits includes a method for testing powered SHEVs at varying speeds and at elevated temperatures for the application of pressure differential systems. However there are limitations with this:

1) It is not a harmonised standard so there are no routes to certification.
2) There are insufficient details within the annex to determine how to test and certify a range of products in an equivalent way to EN12101-3.
3) The standard is for "kits" and not components such as the fan.

While EN12101-6 is a published standard that gives a test method for testing a variable speed fan in Annex C, the test requirements are vague with no fixed frequency steps or test duration.

C.1.4 "See C.1.2 frequency control range" frequency control range depends on the kit and application to determine the frequency steps required

C.1.5 "The duration of the fire test is specified by the sponsor".

The SCA therefore continues to push for the development of new guidance with fixed test parameters to cover the use of fans at variable speed.

Tests on varying speed of powered SHEVs

1250 MM AXIAL FAN

Carried out for

Smoke Control Association

Report 106066/1

Compiled by Andrew Freeth

26 November 2024

www.bsria.com/uk

Tests on varying speed of powered SHEVs

1250 MM AXIAL FAN

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QUALITY ASSURANCE

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SUMMARY

The smoke extract fan described in Table 1 below was submitted for testing. A high temperature test was carried out in accordance with the SCA test regime, based on Annex C of BS EN 12101-3:2015 for the application classes and temperature/time classification listed.

Table 1 Test summary

Date of Test	13/03/24
BSRIA Test Item Number	106066A1AF
Ventilator Details	
Ventilator Manufacturer	Manufacturer 1
Ventilator Model	1250 MM AXIAL FAN
Ventilator Serial Number	XXXXX
Motor Details	
Motor Manufacturer	WEG
Motor Model	3~200L-04
Motor Serial Number	1089141432
Test Conditions	
BS EN 12101-3 Test Class	F300
Test Temperature	300°
Test Time (Hours)	2 hrs
Application Classes	Un-insulated Smoke reservoir Dual purpose No ducted cooling air required
Power Supply	Mains Supply Nominal Voltage: 400V Supply Frequency: 50Hz Inverter: Yes
Test Set-up	Horizontal Insulated (to simulate immersion) Form B (air over impeller-motor)

BS EN 12101-3:2015 Clause 4 states a range of “Requirements”. Indication of compliance to each relevant clause of the standard is shown in Table 2. Any clause marked fail in the compliance column shows that the fan has not met the type test requirements. A clause marked N/A in the compliance column does not apply to the fan tested.

Table 2 Table of compliance to clauses 4 of BS EN 12101-3:2015

Clause	Title	Compliance
4.1.1	Response delay: - Opening under wind load within a given time	N/A
4.1.2	Response delay: - Opening under snow load within a given time.	N/A
4.2.2	Operational reliability: Application categories;	N/A
4.2.3	Operational reliability: Motor rating.	N/A
4.3	Effectiveness of smoke / hot gas extraction: Gas flow and pressure maintenance during smoke and heat extraction test.	N/A
4.4	Resistance to fire	N/A
4.5.1	Ability to open under environmental conditions: - Opening under wind load within a given time	N/A
4.5.2	Ability to open under environmental conditions: - Opening under snow load within a given time.	N/A
4.6	Durability of operational reliability.	N/A

CONTENTS

TABLES

APPENDICES

1 INTRODUCTION

The smoke extract fan described in Table 3 below was submitted for testing. A high temperature test was carried out in the BSRIA High Temperature Fan Test Rig, in accordance with the SCA test regime, based on Annex C of BS EN 12101-3:2015.

Table 3 Ventilator details

Ventilator Manufacturer	Manufacturer 1
Ventilator Model	1250 MM AXIAL FAN
Ventilator Serial Number	XXXXX
Motor Manufacturer	WEG
Motor Model	3~200L-04
Motor Serial Number	1089141432
Date of Test	13/03/24
BSRIA Test Item Number	106066A1AF

2 PRODUCT DESCRIPTION

The ventilator supplied has been classified into the following application classes.

- Un-insulated
- Smoke reservoir
- Dual purpose
- No ducted cooling air required

Full details of the unit are to be found in Appendices A.

The fan has been tested in conjunction with an inverter. Details if the inverter model and configuration may be found in the table below:

Table 4 Details of inverter and configuration

Inverter Manufacturer	WEG
Inverter Model	CFW 500
Inverter Serial Number	1089442073
Inverter Type	PWM
Cable Type, Section and Length	25 m 10mm² 4 core FP600
Switching Frequency	4 kHz
Start Ramp Time	5 Sec
Type of Filter (if applicable)	None
Output Frequency	50 Hz
Braking resistors	None

3 TEST METHODS

The high temperature tests were carried out as specified by the SCA test regime, based on BS EN 12101-3:2015 'Smoke and heat control systems- part 3: Specification for powered smoke and heat exhaust ventilators.' Annex C. The test conditions were as shown below.

Table 5 Test conditions

BS EN 12101-3 Test Class	F300
Test Temperature	300°
Test Time (Hours)	2 hrs
Power Supply	Mains Supply Nominal Voltage:400V Supply Frequency:50Hz Inverter: Yes
Test Set-up	Horizontal Insulated (to simulate immersion) Form B (air over impeller-motor)

There was no requirement for testing wind and snow loading.

The aim of this test was to investigate if 3 minute switching cycles of 50Hz and 10Hz, had any effect on the motor.

The test comprised of:

- EN 12101-3 'warm-up' period, before heating the fan up to 300°C.
- Once at 300°C, fan allowed to run for around 15 min to establish temperature stability
- Frequency steps between 50Hz and 10 Hz, for about 1 hour
- Continuous running for about 1 hour
- Trying different ramp times (about 10 minutes)

4 TEST EQUIPMENT

The test sample was tested on the BSRIA High Temperature Fan Test Rig. The facility conforms to annex C of BS EN12101-3.

All sampling and data acquisition and measuring instrumentation is calibrated against national standards or where no standard is available is calculated from first principles.
Details of the instruments and equipment may be found in Table 6 below.

Table 6 Test equipment

Description	BSRIA Identifier	Calibration expiry date
High temperature test facility	730	Test Aid
Micromanometer	2969	01/05/24
Switchbox	709	Test Aid
Type K Thermocouple Position 1	2102	18/10/24
Type K Thermocouple Position 2	1847	21/11/24
Type K Thermocouple Position 3	1797	21/11/24
Type K Thermocouple Position 4	2062	19/10/24
Type K Thermocouple Position 5	2105	03/07/24
Type K Thermocouple Position 6	1676	21/11/24
Type K Thermocouple Position 7	2137	03/07/24
Type K Thermocouple Position 8	1748	21/11/24
Type K Thermocouple Position 9	N/A	N/A
Type K Thermocouple Position 10	1731	03/07/24
Eurotherm Thermocouple	2110	18/10/24
HP logger	708	As Thermocouples
Eurotherm	700	As Thermocouples
Barometer	881	20/09/24
Power meter	1410	24/09/24
Stopwatch	053806	29/09/24
Oscilloscope	1633	01/01/25
HP VEE logging Program *(Record Version)⇒*	HTFT Rig logger V8 11 Oct 17	
Spread sheet for logged data *(Record Version)⇒*	V7	
Tape Measure	678	19/10/23
Vernier Calipers	2057	05/07/24

5 TEST RESULTS

5.1 INVERTER MEASUREMENT RESULTS

Clause A.1.n of EN 12101-3:2015 requires the fan to operate for a minimum of 10 minutes, at ambient temperature to allow measurements to be taken. Measurements are taken once a minute, and from these measurements, the maximum voltage peak, peak to peak value and the maximum rate of voltage rise (du/dt) are shown in the table below.

Table 7 Inverter test results

Maximum Peak Voltage (Vmax)	284
Maximum Peak to Peak Voltage (Vp)	616
Maximum Voltage rise du/dt = (0.8*Vp/dt)	3.779 V/nS

5.2 HIGH TEMPERATURE TEST RESULTS

The table below shows a summary of the start and finish values for the test sample for the dual-purpose ambient stability test and the high temperature test.

In the dual purpose test, the fan is run at ambient temperature for one hour or until the fan motor case shows a temperature increase of less than 2 degrees in ten minutes, whichever is the longer.

Table 8 shows the start and finish values, the full test period being displayed on the following graph.

Table 8 Summary of results for temperature/time test

		Start of Warm Up	End of Warm Up	Start - High Temp Test	Interrupt	End - High Temp Test
Time		10:29	11:36	11:48	N/A	14:27
Volts	V	419	418	421		423
Amps	A	57.2	53.8	33.0		33.6
Watts	kW	33.3	30.9	18.2		18.7
Power Factor		0.802	0.795	0.757		0.758
Average Air Temperature (°C)		20.8	47.1	306		306
Motor Case Temperature (°C)		28.3	52.0	255		310
Fan Case Temperature (°C)		17.0	45.7	188		265
Static Pressure, Fan Outlet (Pa)		467	403	231		244
Corrected Static Pressure (Pa)		475	447	464		489

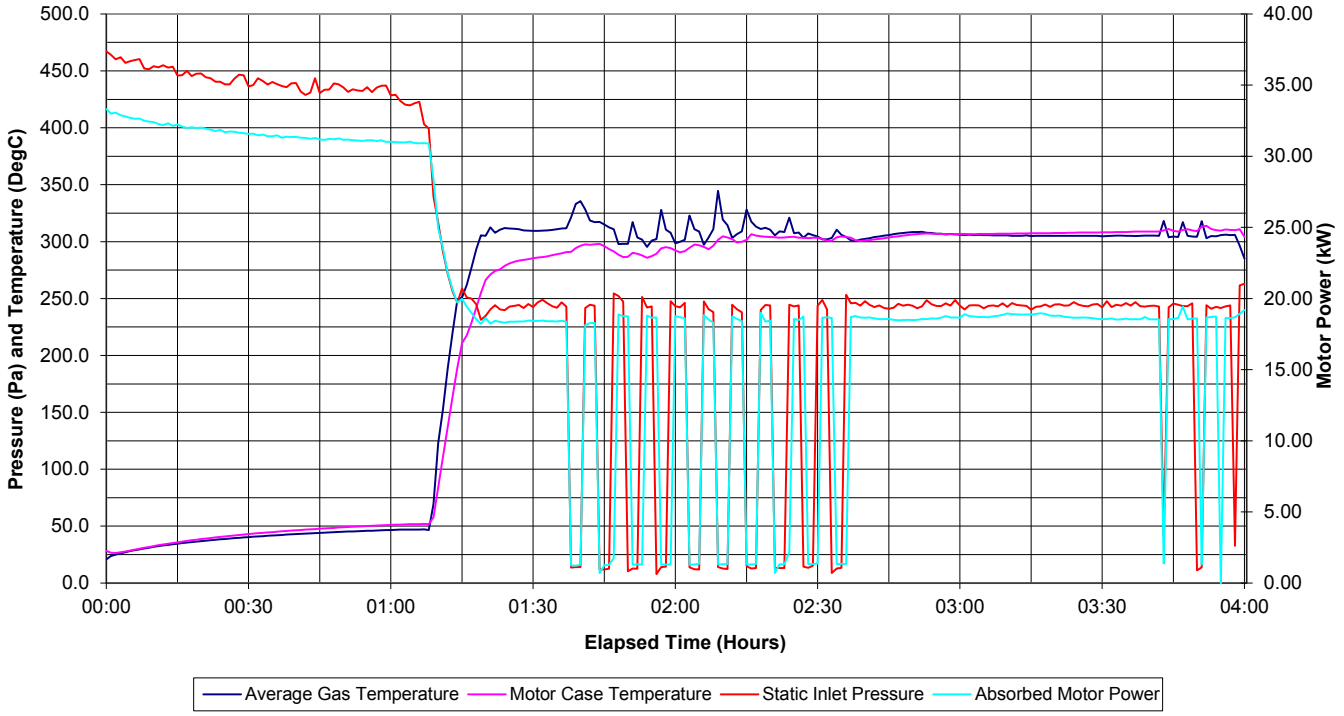
Table 9 Test observations

Time	Test observation
10:29	Elevated temperatures due to pre-test running.
11:48	At 300°C
12:03	Start of frequency steps (50Hz to 10Hz) with 5 sec ramp time
13:06	Start of 1hr at full speed test
14:13	3 sec ramp time
14:16	2.5 sec ramp time
14:19	2 sec ramp time
	1 sec and 0.5 sec ramp times attempted
14:27	End of testing, burners switched off

Table 10 Observations on condition of ventilator after test

Impeller rotates easily.

Average Gas and Motor Temperatures, Static Inlet Pressure and Absorbed Motor Power
Manufacturer 1, 1250 MM AXIAL FAN Fan, tested 13/3/24, BSRIA I.D. 106066A1AF



6 CONCLUSIONS

The fan detailed below was tested in accordance with the SCA test regime, based on BS EN 12101-3:2015.

Table 11 Summary of fan and test classes

Ventilator Manufacturer	Manufacturer 1
Ventilator Model	1250 MM AXIAL FAN
Ventilator Serial Number	XXXXX
BS EN 12101-3 Test Class	F300
Test Temperature	300°
Test Time (Hours)	2 hrs
Application Classes	Un-insulated Smoke reservoir Dual purpose No ducted cooling air required

BS EN 12101-3:2015 Clause 4 states a range of “Requirements”. Indication of compliance to each relevant clause of the standard is shown in Table 9. Any clause marked fail in the compliance column shows that the fan has not met the overall type test requirements. A clause marked N/A in the compliance column does not apply to the fan tested.

Table 12 Table of compliance to clauses 5 to 6.7 for BS EN 12101-3:2015

Clause	Title	Compliance
4.1.1	Response delay: - Opening under wind load within a given time	N/A
4.1.2	Response delay: - Opening under snow load within a given time.	N/A
4.2.2	Operational reliability: Application categories;	N/A
4.2.3	Operational reliability: Motor rating.	N/A
4.3	Effectiveness of smoke / hot gas extraction: Gas flow and pressure maintenance during smoke and heat extraction test.	N/A
4.4	Resistance to fire	N/A
4.5.1	Ability to open under environmental conditions: - Opening under wind load within a given time	N/A
4.5.2	Ability to open under environmental conditions: - Opening under snow load within a given time.	N/A
4.6	Durability of operational reliability.	N/A

APPENDIX A: TEST SAMPLE DETAILS

Introduction

Appendix A contains the technical details for the unit tested both supplied by the manufacturer or his agent, and the measured and recorded information taken by BSRIA. This includes photographs of the test fan and test record sheets from TP26.

Photograph of Test Unit

Test Unit photographs removed

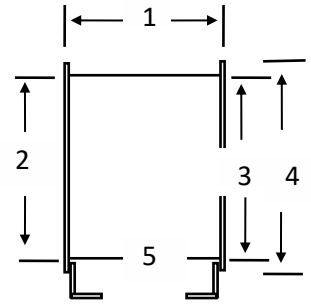
TEST RECORD SHEET TP26/1: TEST ITEMS CONDITION SHEET 1 OF 1

Date of receipt or inspection	08/03/24
BSRIA Reference	106066A1AF
Test Engineer	A Freeth
Full description of test item (including any damage noted on receipt or inspection prior to testing) and checks undertaken to ensure conformity of test item with normal production units.	

TEST RECORD SHEET TP26/2: TEST ITEMS SHEET 1 OF 3

BSRIA Identification 106066A1AF

FAN AND MOTOR DETAILS -INFORMATION IS EITHER SUPPLIED BY THE MANUFACTURER OR OBTAINED BY THE TEST ENGINEER BY INSPECTION OF UNIT UNDER TEST OR AT BUILD INSPECTION



		Site Measurement
FAN MANUFACTURER		Manufacturer 1
FAN TYPE		Axial
MODEL No		1250 MM AXIAL FAN
SERIAL No.		XXXXX
CASING MATERIAL		Galvanised Steel
CASING LENGTH	(1) mm	835
NOMINAL DIAMETER	mm	1250
INLET DIAMETER	(2) mm	1250
OUTLET DIAMETER	(3) mm	1250
FLANGE / OVERALL DIAMETER	(4) mm	1380
DUCT ATTACHMENT SYSTEM		Bolted Flange
FAN ASSEMBLY MOUNTING		Flange

IMPELLER	MATERIAL		Aluminium	
	No OF BLADES		12	
	LENGTH OF BLADE	mm	440	
	TIP CLEARANCE	mm	13 mm	
	WIDTH	mm	Tip: 110	Base:130
	BLADE ANGLE		30°	
	HUB DIAMETER	mm	360	
	BLADE - FIXED / MOVABLE		Moveable	

TEST RECORD SHEET TP26/2: TEST ITEMS SHEET 2 OF 3

BSRIA Identification 106066A1AF

MOTOR	MANUFACTURER	WEG	
	CATALOGUE No	3~200L-04	
	SERIAL NUMBER	1089141432	
	MOUNTING	Pad	
	ELECTRICAL CONNECTION METHOD	Flying Leads	
	FRAME SIZE	200L	
	MECHANICAL POWER	36 kW (AOM)	
	VOLTAGE / FREQUENCY	400 V	50 Hz
	1 OR 3 PHASE - STAR / DELTA	3 Phase Delta	
	RUNNING CURRENT	67.8 (AOM)	
	STARTING CURRENT	N/A	
	POWER FACTOR	0.82 (AOM)	
	No OF POLES	4	
	MOTOR SPEED	1475 RPM (AOM)	
	INSULATION CLASS	H	
	IP RATING	55	
	CAPACITOR TYPE	N/A	
	CAPACITOR SIZE	N/A	
	BEARING FIT	C3	
	BEARING TYPE	DE:6312-C3	NDE:6212-C3
	LUBRICANT	Mobil Polyrex EM	
	END COVER MATERIAL	Cast Iron	
	COOLING IMPELLER MATERIAL	N/A	
	MOTOR CARCASE MATERIAL	Cast Iron	
	DRIVE	Direct	
PULLEY DIAMETERS – MOTOR mm FAN mm		N/A	
BELT SIZE mm		N/A	
No OF BELTS		N/A	

TEST RECORD SHEET TP26/2: TEST ITEMS SHEET 3 OF 3

BSRIA Identification 106066A1AF

Enter any ancillaries supplied here

ANCILLARIES
Inverter
Please use additional sheets where necessary

Tests on varying speed of powered SHEVs

560 MM AXIAL FAN

Carried out for

Smoke Control Association

Report 106066/2

Compiled by Andrew Freeth

26 November 2024

www.bsria.com/uk

Tests on varying speed of powered SHEVs

560 MM AXIAL FAN

Carried out for: Smoke Control Association
2 Waltham Court, Milley Lane
Harehatch
Reading
RG10 9TH

Contract: Report 106066/2

Issued by: BSRIA Limited
Old Bracknell Lane West
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Telephone: +44 (0)1344 465600

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Email: bsria@bsria.co.uk
Website: www.bsria.com/uk/

QUALITY ASSURANCE

Issue	Date	Compiled by:	Approved by:	Signature
FINAL	*26 Nov 2024*	*Andrew Freeth*	*Mark Roper*	
		Senior Test Engineer	*Head of Laboratory*	

SUMMARY

The smoke extract fan described in Table 1 below was submitted for testing. A high temperature test was carried out in accordance with the SCA test regime, based on Annex C of BS EN 12101-3:2015 for the application classes and temperature/time classification listed.

Table 1 Test summary

Date of Test	25/04/24
BSRIA Test Item Number	106066A2AF
Ventilator Details	
Ventilator Manufacturer	Manufacturer 2
Ventilator Model	560 MM AXIAL FAN
Ventilator Serial Number	
Motor Details	
Motor Manufacturer	WEG
Motor Model	3~132S-02
Motor Serial Number	1089178942
Test Conditions	
BS EN 12101-3 Test Class	F300
Test Temperature	300°
Test Time (Hours)	2 hrs
Application Classes	Un-insulated Smoke reservoir Dual purpose No ducted cooling air required
Power Supply	Mains Supply Nominal Voltage: 400V Supply Frequency: 50Hz Inverter: Yes
Test Set-up	Vertical Immersed Form B (air over impeller-motor)

BS EN 12101-3:2015 Clause 4 states a range of “Requirements”. Indication of compliance to each relevant clause of the standard is shown in Table 2. Any clause marked fail in the compliance column shows that the fan has not met the type test requirements. A clause marked N/A in the compliance column does not apply to the fan tested.

Table 2 Table of compliance to clauses 4 of BS EN 12101-3:2015

Clause	Title	Compliance
4.1.1	Response delay: - Opening under wind load within a given time	N/A
4.1.2	Response delay: - Opening under snow load within a given time.	N/A
4.2.2	Operational reliability: Application categories;	N/A
4.2.3	Operational reliability: Motor rating.	N/A
4.3	Effectiveness of smoke / hot gas extraction: Gas flow and pressure maintenance during smoke and heat extraction test.	N/A
4.4	Resistance to fire	N/A
4.5.1	Ability to open under environmental conditions: - Opening under wind load within a given time	N/A
4.5.2	Ability to open under environmental conditions: - Opening under snow load within a given time.	N/A
4.6	Durability of operational reliability.	N/A

CONTENTS

TABLES

APPENDICES

1 INTRODUCTION

The smoke extract fan described in Table 3 below was submitted for testing. A high temperature test was carried out in the BSRIA High Temperature Fan Test Rig, in accordance with the SCA test regime, based on Annex C of BS EN 12101-3:2015.

Table 3 Ventilator details

Ventilator Manufacturer	Manufacturer 2
Ventilator Model	560 MM AXIAL FAN
Ventilator Serial Number	XXXXX
Motor Manufacturer	WEG
Motor Model	3~132S-02
Motor Serial Number	1089178942
Date of Test	25/04/24
BSRIA Test Item Number	106066A2AF

2 PRODUCT DESCRIPTION

The ventilator supplied has been classified into the following application classes.

- Un-insulated
- Smoke reservoir
- Dual purpose
- No ducted cooling air required

Full details of the unit are to be found in Appendix A.

The fan has been tested in conjunction with an inverter. Details if the inverter model and configuration may be found in the table below:

Table 4 Details of inverter and configuration

Inverter Manufacturer	WEG
Inverter Model	CFW500C16P0T4DB20C2H00G2
Inverter Serial Number	1089552463
Inverter Type	PWM
Cable Type, Section and Length	Approx. 24 m of Prysmian FP600 fire resistant armoured cable
Switching Frequency	Unknown
Start Ramp Time	5 seconds
Type of Filter (if applicable)	None
Output Frequency	50 Hz
Braking resistors	2x 65R braking resistors in parallel (33 ohms)

3 TEST METHODS

The high temperature tests were carried out as specified by the SCA test regime, based on BS EN 12101-3:2015 'Smoke and heat control systems- part 3: Specification for powered smoke and heat exhaust ventilators.' Annex C. The test conditions were as shown below.

Table 5 Test conditions

BS EN 12101-3 Test Class	F300
Test Temperature	300°
Test Time (Hours)	2 hrs
Power Supply	Mains Supply Nominal Voltage: 400V Supply Frequency: 50Hz Inverter: Yes
Test Set-up	Vertical Immersed Form B (air over impeller-motor)

There was no requirement for testing wind and snow loading.

The aim of this test was to investigate if 3 minute switching cycles of 50Hz and 10Hz, had any effect on the motor.

The test comprised of:

- EN 12101-3 'warm-up' period, before heating the fan up to 300°C.
- Once at 300°C, fan allowed to run for around 15 min to establish temperature stability
- Frequency steps between 50Hz and 10 Hz, for about 1 hour
- Continuous running for about 1 hour

4 TEST EQUIPMENT

The test sample was tested on the BSRIA High Temperature Fan Test Rig. The facility conforms to annex C of BS EN12101-3.

All sampling and data acquisition and measuring instrumentation is calibrated against national standards or where no standard is available is calculated from first principles.
Details of the instruments and equipment may be found in Table 6 below.

Table 6 Test equipment

Description	BSRIA Identifier	Calibration expiry date
High temperature test facility	730	Test Aid
Micromanometer	2969	01/05/24
Switchbox	709	Test Aid
Type K Thermocouple Position 1	2109	15/12/24
Type K Thermocouple Position 2	1733	15/12/24
Type K Thermocouple Position 3	1831	19/10/24
Type K Thermocouple Position 4	2062	19/10/24
Type K Thermocouple Position 5	2105	03/07/24
Type K Thermocouple Position 6	1848	18/10/24
Type K Thermocouple Position 7	1849	18/10/24
Type K Thermocouple Position 8	1748	21/11/24
Type K Thermocouple Position 9	N/A	N/A
Type K Thermocouple Position 10	N/A	N/A
Eurotherm Thermocouple	2110	18/10/24
HP logger	708	As Thermocouples
Eurotherm	700	As Thermocouples
Barometer	881	20/09/24
Power meter	1410	24/09/24
Stopwatch	053806	29/09/24
Oscilloscope	1633	01/01/25
HP VEE logging Program *(Record Version)⇒*	HTFT Rig logger V8 11 Oct 17	
Spread sheet for logged data *(Record Version)⇒*	V7	
Micrometer	2957	05/07/24
Drill Set	1665	Test Aid

5 TEST RESULTS

5.1 INVERTER MEASUREMENT RESULTS

Clause A.1.n of EN 12101-3:2015 requires the fan to operate for a minimum of 10 minutes, at ambient temperature to allow measurements to be taken. Measurements are taken once a minute, and from these measurements, the maximum voltage peak, peak to peak value and the maximum rate of voltage rise (du/dt) are shown in the table below.

Table 7 Inverter test results

Maximum Peak Voltage (Vmax)	304
Maximum Peak to Peak Voltage (Vp)	616
Maximum Voltage rise du/dt = (0.8*Vp/dt)	4.989 V/nS

5.2 HIGH TEMPERATURE TEST RESULTS

The table below shows a summary of the start and finish values for the test sample for the dual-purpose ambient stability test and the high temperature test.

In the dual purpose test, the fan is run at ambient temperature for one hour or until the fan motor case shows a temperature increase of less than 2 degrees in ten minutes, whichever is the longer.

Table 8 shows the start and finish values, the full test period being displayed on the following graph.

Table 8 Summary of results for temperature/time test

		Start of Warm Up	End of Warm Up	Start - High Temp Test	Interrupt	End - High Temp Test
Time		9:44	10:50	11:03	N/A	13:39
Volts	V	423	424	423		422
Amps	A	8.73	8.53	5.21		5.48
Watts	kW	3.96	3.84	2.27		2.40
Power Factor		0.623	0.618	0.600		0.604
Average Air Temperature (°C)		10.1	16.3	301		305
Motor Case Temperature (°C)		19.0	30.7	153		334
Fan Case Temperature (°C)		9.20	15.5	267		303
Static Pressure, Fan Outlet (Pa)		183	165	82.0		91.0
Corrected Static Pressure (Pa)		180	166	163		182

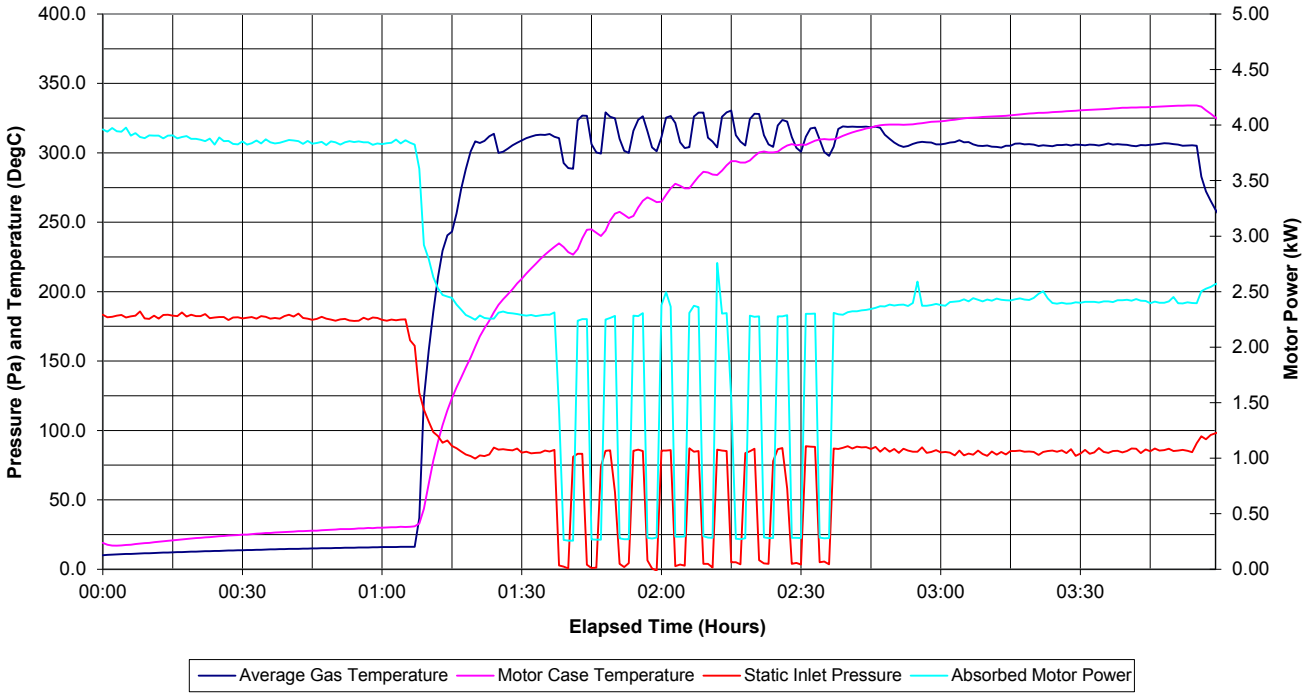
Table 9 Test observations

Time	Test observation
9:44	Elevated temperatures due to pre-test running.
11:03	At 300°
11:17	Start of frequency steps (50Hz to 10Hz) with 5 second ramp time.
12:21	Start of 1-hour full speed test.
13:39	End of testing, burners switched off.

Table 10 Observations on condition of ventilator after test

Impeller rotates freely

Average Gas and Motor Temperatures, Static Inlet Pressure and Absorbed Motor Power
Manufacturer 2, 560 mm Axial Fan, tested 25/04/24, BSRIA I.D 106066A2AF



6 CONCLUSIONS

The fan detailed below was tested in accordance with the SCA test regime, based on BS EN 12101-3:2015.

Table 11 Summary of fan and test classes

Ventilator Manufacturer	Manufacturer 2
Ventilator Model	560 MM AXIAL FAN
Ventilator Serial Number	XXXXX
BS EN 12101-3 Test Class	F300
Test Temperature	300°
Test Time (Hours)	2 hrs
Application Classes	Un-insulated Smoke reservoir Dual purpose No ducted cooling air required

BS EN 12101-3:2015 Clause 4 states a range of "Requirements". Indication of compliance to each relevant clause of the standard is shown in Table 9. Any clause marked fail in the compliance column shows that the fan has not met the overall type test requirements. A clause marked N/A in the compliance column does not apply to the fan tested.

Table 12 Table of compliance to clauses 5 to 6.7 for BS EN 12101-3:2015

Clause	Title	Compliance
4.1.1	Response delay: - Opening under wind load within a given time	N/A
4.1.2	Response delay: - Opening under snow load within a given time.	N/A
4.2.2	Operational reliability: Application categories;	N/A
4.2.3	Operational reliability: Motor rating.	N/A
4.3	Effectiveness of smoke / hot gas extraction: Gas flow and pressure maintenance during smoke and heat extraction test.	N/A
4.4	Resistance to fire	N/A
4.5.1	Ability to open under environmental conditions: - Opening under wind load within a given time	N/A
4.5.2	Ability to open under environmental conditions: - Opening under snow load within a given time.	N/A
4.6	Durability of operational reliability.	N/A

APPENDIX A: TEST SAMPLE DETAILS

Introduction

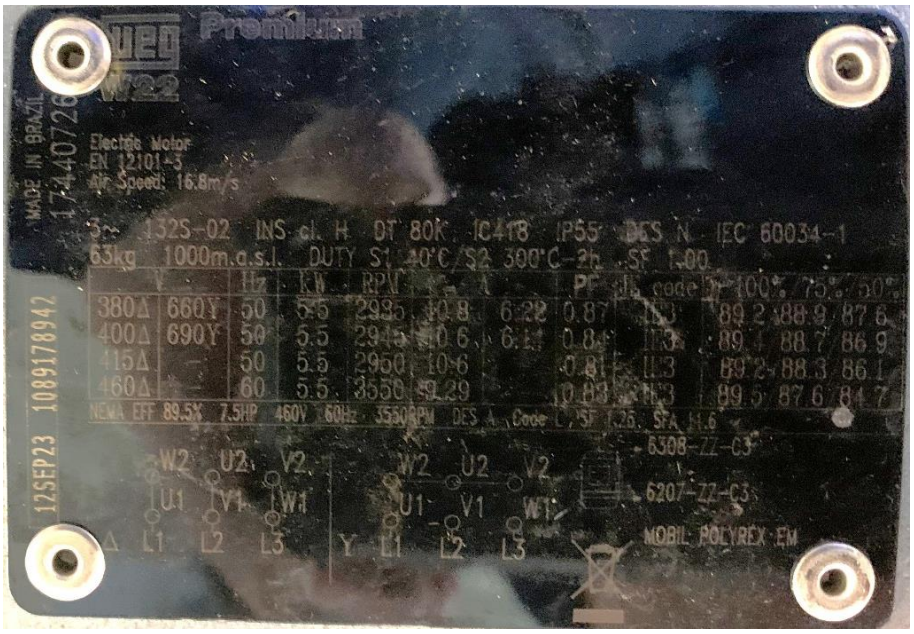
Appendix A contains the technical details for the unit tested both supplied by the manufacturer or his agent, and the measured and recorded information taken by BSRIA. This includes photographs of the test fan and test record sheets from TP26.

Photograph of Test Unit

Test unit photographs removed

TEST RECORD SHEET TP26/1: TEST ITEMS CONDITION SHEET 1 OF 1

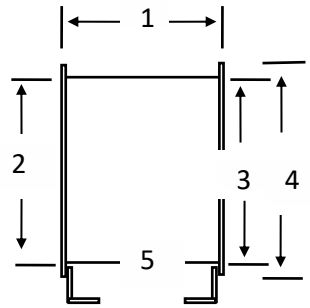
Date of receipt or inspection	23-4-24
BSRIA Reference	106066A2AF
Test Engineer	A Freeth
Full description of test item (including any damage noted on receipt or inspection prior to testing) and checks undertaken to ensure conformity of test item with normal production units.	



TEST RECORD SHEET TP26/2: TEST ITEMS SHEET 1 OF 3

BSRIA Identification 106066A2AF

FAN AND MOTOR DETAILS -INFORMATION IS EITHER SUPPLIED BY THE MANUFACTURER OR OBTAINED BY THE TEST ENGINEER BY INSPECTION OF UNIT UNDER TEST OR AT BUILD INSPECTION



		Site Measurement
FAN MANUFACTURER		Manufacturer 2
FAN TYPE		Axial
MODEL No		560 MM AXIAL FAN
SERIAL No.		XXXXX
CASING MATERIAL		Galvanised Steel
CASING LENGTH	(1) mm	410
NOMINAL DIAMETER	mm	560
INLET DIAMETER	(2) mm	560
OUTLET DIAMETER	(3) mm	560
FLANGE / OVERALL DIAMETER	(4) mm	650
DUCT ATTACHMENT SYSTEM		Bolted Flange
FAN ASSEMBLY MOUNTING		Flange

IMPELLER	MATERIAL		Aluminium
	No OF BLADES		6
	LENGTH OF BLADE	mm	160 Leading Edge 100 Trailing Edge
	TIP CLEARANCE	mm	2.4
	WIDTH	mm	155
	BLADE ANGLE		25°
	HUB DIAMETER	mm	350
	BLADE - FIXED / MOVABLE		Moveable

TEST RECORD SHEET TP26/2: TEST ITEMS SHEET 2 OF 3

BSRIA Identification 106066A2AF

MOTOR	MANUFACTURER	WEG	
	CATALOGUE No	3~132S-02	
	SERIAL NUMBER	1089178942	
	MOUNTING	Flange	
	ELECTRICAL CONNECTION METHOD	Flying Leads	
	FRAME SIZE	132S	
	MECHANICAL POWER	5.5 kW	
	VOLTAGE / FREQUENCY	400 V	50 Hz
	1 OR 3 PHASE - STAR / DELTA	3 Phase Delta	
	RUNNING CURRENT	10.6	
	STARTING CURRENT	N/A	
	POWER FACTOR	0.84	
	No OF POLES	2	
	MOTOR SPEED	2945 RPM	
	INSULATION CLASS	H	
	IP RATING	55	
	CAPACITOR TYPE	N/A	
	CAPACITOR SIZE	N/A	
	BEARING FIT	C3	
	BEARING TYPE	DE:6308-ZZ-C3	NDE:6207-ZZ-C3
	LUBRICANT	Mobil Polyrex EM	
	END COVER MATERIAL	Cast Iron	
	COOLING IMPELLER MATERIAL	N/A	
	MOTOR CARCASE MATERIAL	Cast Iron	
	DRIVE	Direct	
PULLEY DIAMETERS – MOTOR mm FAN mm		N/A	
BELT SIZE mm		N/A	
No OF BELTS		N/A	

TEST RECORD SHEET TP26/2: TEST ITEMS SHEET 3 OF 3

BSRIA Identification 106066A2AF

Enter any ancillaries supplied here

ANCILLARIES
Duct extension (410mm)
Flexible coupling
Braking Resistors x2
Please use additional sheets where necessary