Enertek International Limited

Project Number:	E3363
Project Title:	Endotherm Solution Assessment
Client:	Endo Enterprises Ltd
Date:	17 January 2014

Prepared By:

Simon J Axon
Project Manager

Approved By:

Stephen Taylor
Director

BRIEF

To establish if adding a prescribed amount of EndoThermTM solution to the water of a typical central heating system can result in a reduction in the gas consumed by the heating boiler.

Enertek International
International Consultants in Product Research, Design, Development & Certification

1 Malmo Road, Sutton Fields
Kingston upon Hull, HU7 0YF
T: +44 (0)1482 877500
F: +44 (0)1482 877501
www.enertekinternational.com

1 BRIEF

To establish if adding a prescribed amount of Endo-Therm Solution to the water of a typical central heating system can result in a reduction in the gas consumed by the heating boiler.

2 TEST RIG & PROCEDURE

2.1 Test Rig Installation

A Worcester 24i natural gas combination boiler was selected for test purposes. This appliance incorporates a low water content stainless steel heat exchanger with an integral circulation pump and has a total water content of 3.9l. Note: - the appliance gas burner input adjusts automatically between 7 – 24.5kW in order to achieve and maintain the boiler outlet temperature set by the user. For test purposes the boiler temperature control was set to maximum (nominally 82°C).

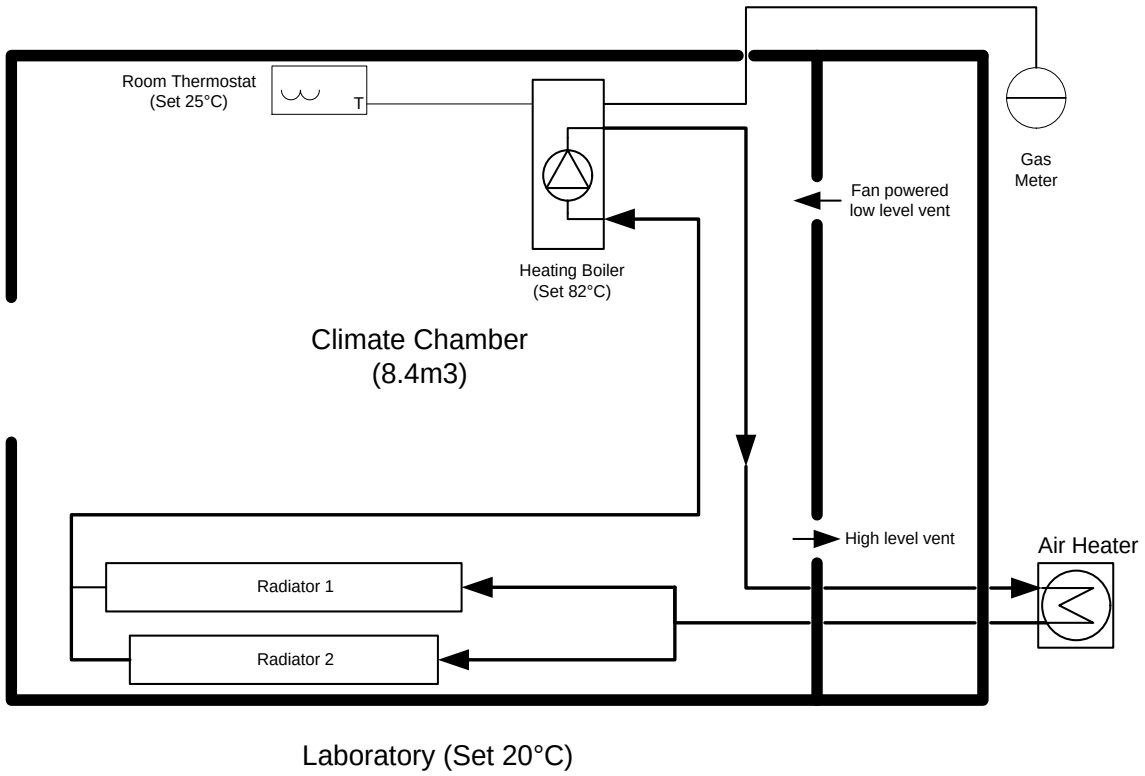
Two double panel radiators and a hydronic air heater were used to provide a heating load.

The boiler and heating load was coupled together using a combination of copper and plastic pipe work and was charged to a pressure of 1.5bar for the duration of each test.

The total system volume was calculated to be 13 litres.

The boiler and radiators were located inside a thermal chamber (a) to control the heat losses from the system and (b) so that a room thermostat (set 25°C) could be used to maintain the room temperature by controlling the boiler heat demand. The air heater was located outside of the thermal chamber to ensure both an adequate heat loss could be achieved from the thermal chamber and satisfactory boiler cycle times using the room thermostat within the test chamber.

<u>Installation Schematic.</u>



2.2 Test Measurements

A number of thermocouples were positioned around the installation to monitor the temperatures listed below:-

Room (centre)
Room Vent (high level)
Room Vent (low level)
Boiler Flow (outlet)
Boiler Return (inlet)
Boiler flue gas
Laboratory
Radiator 1 surface
Radiator 2 surface

Pico logging was used to record the temperatures every 30 seconds throughout the 24hr test period. Following test completion the Pico log data was transferred in to an Excel file to provide easy analysis of the results. Due to the size of these Excel files they have been supplied separately, but a basic overview of the results is provided in Section 3 later in this report.

A calibrated volumetric flow gas meter was used to record the gas consumption of the heating boiler over the 24hr test period.

2.3 Test Procedure

As any fluctuation in heat loss from the chamber could affect the boiler gas consumption, the following procedures were adopted to minimise any potential fluctuation:-

- Each test was preceded by a 12hr period of temperature stabilisation to ensure that the climate chamber walls and all of the system components were at thermal equilibrium.
- During the stabilisation & test period the laboratory in which the thermal chamber is located was maintained at an average temperature 20°C (+/-0.3°C).
- When the stabilisation period was complete, the test was started by turning 'on' power to the heating boiler and the total gas consumption over a period of 24hr was recorded using a gas meter.

The following tests were conducted in turn using the procedure outlined above:-

Test 1 – The system was filled with water only
Test 2 – The system water was dosed to achieve a ratio of 75:1 (Water/Endo-Therm)

The results from tests 1 & 2 were reported and the test rig was allowed to stand idle for a period of 7days (dosed with the Endo-Therm solution) before the tests were repeated in reverse order to verify the previous results.

Test 3 – As previously dosed (Test 2) to achieve a ratio of 75:1 (Water/Endo-Therm)
Test 4 – The system was filled with water only. Note: - the whole system was subjected to multiple flushes using fresh mains water before final filling and testing.

3 TEST RESULTS

Excel files containing all of the test data have been supplied separately for further analysis if required, but a basic summary of the results is provided below.

3.1 Test 1. The system was filled with water only.

System charged to a pressure of 1.5bar, stabilised at room temperature and gas consumption monitored for a period of 24hrs.

Total Gas Consumption in 24hrs	**5.41m^3**
Number of boiler/burner cycles	50
Approximate average cycle time	29mins
Room temp at test start	22.6°C
Lab temp at test start	19.0°C
1st burner firing period	690secs (11.5mins)
Average radiator temp during test	52.4°C
Average room temp during test	27.5°C
Average lab temp during test	19.7°C
Average boiler temperature	44.3°C

3.2 Test 2. The system water was dosed to achieve a ratio of 75:1 (Water/Endo-Therm).

System charged to a pressure of 1.5bar, stabilised at room temperature and gas consumption monitored for a period of 24hrs.

Total Gas Consumption in 24hrs	**4.59m^3**
Number of boiler/burner cycles	42
Approximate average cycle time	34mins
Room temp at test start	22.6°C
Lab temp at test start	19.5°C
1st burner firing period	660secs (11mins)
Average radiator temp during test	49.9°C
Average room temp during test	27.5°C
Average lab temp during test	20.0°C
Average boiler temperature	43.2°C

3.3 Test 3. As previously dosed (Test 2) to achieve a ratio of 75:1 (Water/Endo-Therm).

System charged to a pressure of 1.5bar, stabilised at room temperature and gas consumption monitored for a period of 24hrs.

Total Gas Consumption in 24hrs	**3.26m^3**
Number of boiler/burner cycles	32
Approximate average cycle time	45min
Room temp at test start	22.7°C
Lab temp at test start	19.5°C
1st burner firing period	600secs (10mins)
Average radiator temp during test	44.7°C
Average room temp during test	26.7°C
Average lab temp during test	20.2°C
Average boiler temp during test	40.8°C

3.4 Test 4. The system was filled with water only.

System charged to a pressure of 1.5bar, stabilised at room temperature and gas consumption monitored for a period of 24hrs.

Total Gas Consumption in 24hrs	**3.59m^3**
Number of boiler/burner cycles	34
Approximate average cycle time	42mins
Room temp at test start	23.8°C
Lab temp at test start	20.5°C
1st burner firing period	510secs (8.5mins)
Average radiator temp during test	46.4°C
Average room temp during test	26.9°C
Average lab temp during test	20.0°C
Average boiler temp during test	43.7°C

4 CONCLUSIONS AND RECOMMENDATIONS

When operated under the test conditions described within this report, the addition of Endo-Therm solution to the heating system water resulted in a reduction in the gas consumed by the heating boiler of up to 15% within the 24hr test period.

Tests also show that the introduction of Endo-Therm solution into the system water resulted in a reduction in the number of boiler burner cycles (24hr), without affecting the average room temperature (24hr) by more than 0.2°C.

Results also appear to indicate that leaving the Endo-Therm solution in the heating system for an extended period (>7days) resulted in a further reduction in gas consumption.

APPENDIX A.

Instrument Calibration

Gas Meter	639
Pico Temperature Logger	AV108/135
Pico Temperature Logger	AV108/162
Pico Temperature Logger	AV108/332

CERTIFICATE OF CALIBRATION

ISSUED BY ANTECH

DATE OF ISSUE 06 December 2012 CERTIFICATE NUMBER: U57619-12

UKAS CALIBRATION
0489

Antech Calibration Services
Hewett Road
Gapton Hall Industrial Estate
Great Yarmouth
Norfolk NR31 0NN
Telephone: +44 (0) 1493 440600 Facsimile: +44 (0) 1493 440606
E-mail: sales@antech.org.uk

APPROVED SIGNATORY

CUSTOMER DETAILS **ANTECH REF: 12627.6-12-A**

Company	:	Enertek International Ltd
Address	:	1 Malmo Road Sutton Fields Kingston-Upon-Hull East Yorkshire HU7 0YF
Order Number	:	EIL5258

UNIT CALIBRATED

Manufacturer	:	Elster
Model	:	15RC Positive Displacement Flow Meter
Serial number	:	8588
Plant No.	:	00639
Date received	:	27 November 2012
Date calibrated	:	04 December 2012

CALIBRATION MEDIUM : Dry air @ atmospheric pressure

ENVIRONMENTAL CONDITIONS : 20.0 ± 1.0 °C, 999.3 mbar abs

CALIBRATION PROCEDURE : 60310

Approved Signatory : D. Highton (✓)

\\antyardb09\dfs\CWMS\Jobs\2012\12601-12700\12627.12.A\Certificates\U57619-12.doc

CERTIFICATE OF CALIBRATION

ANTECH

UKAS ACCREDITED CALIBRATION LABORATORY No. 0489

CERTIFICATE NUMBER
U57619-12

CALIBRATION DETAILS

The instrument submitted for calibration is a dry gas flow meter, providing a visible indication of volume passed.

The flow meter was calibrated in the Antech Calibration Services Flow Laboratory against a calibrated bell prover. Measurements were taken at atmospheric pressure.

The uncertainty of measurement of the volume passed was found to be ± 0.16 % plus the instrument resolution.

All equipment used during the calibration was traceable to UK national standards.

CALIBRATION RESULTS

Reference Flow Rate l/sec	UUT Indicated Volume l	Reference Volume l	UUT Error Volume %
0.10	100.01	99.83	0.18
0.47	109.98	109.23	0.68
0.91	100.00	99.06	0.95
1.33	100.25	99.23	1.03
1.77	100.07	99.22	0.86
2.04	119.87	118.78	0.92

The errors have been calculated using unrounded data.

The repeatability was found to be 0.093 at 0.48 l/sec.

The reported expanded uncertainty is based on a standard uncertainty multiplied by a coverage factor $k = 2$, providing a level of confidence of approximately 95 %. The uncertainty evaluation has been carried out in accordance with UKAS requirements.

The instrument was not adjusted.

END OF CERTIFICATE

\\antyardb09\dfs\CWMS\Jobs\2012\12601-12700\12627.12.A\Certificates\U57619-12.doc

Enertek International Limited

Calibration Certificate

Certificate no: 415005

Enertek Inventory Number: PIC095

Pico Logger - Model: TC08

Serial Number: AT 063-135

Date of Calibration: 14 August 2013

Manufacturer's recommended calibration interval: 12 months

Recalibrate before end of: Aug-2014

Traceability Information - equipment used -	
Time electronics millivolt source:	E00051
Calibration certificate number:	ANT U60060-13
Calibration Date:	07/05/2013
Calibration Due Date:	31/05/2014
Thermometer:	00056
Calibration certificate number:	ANT U58734-12
Calibration Date:	28/02/2013
Calibration Due Date:	28/02/2014

Uncertainty Information

Time Electronics source uncertainty < 1.5uV, equivalent to < 0.05K for type K t/couples. Corrections on calibration certificate applied.

Resolution of Pico instrument 0.01 K.

Total uncertainty 0.2 K when corrections herewith applied.

Calibration Point (ºC)	Digital Thermometer Reading (ºC)	Correction (ºC)
0	-0.05	0.1
20	19.95	0.1
40	39.93	0.1
60	59.92	0.1
80	79.93	0.1
100	99.91	0.1
120	119.91	0.1
140	139.92	0.1
160	159.90	0.1
180	179.90	0.1
200	199.90	0.1
220	219.90	0.1
240	239.90	0.1

Remarks -

Calibrated by: CPF

Signed.....

Checked by:

Signed.....

This certificate provides traceability of measurement to recognised National Standards and to the units of measurement realised at the National Physical Laboratory or other recognised National Standards laboratories.

1 Malmo Road, Sutton Fields, Kingston Upon Hull, East Yorkshire, HU7 0YF

Enertek International Limited

Calibration Certificate

Certificate no: 414991

Enertek Inventory Number: PIC092

Pico Logger - Model: TC08

Serial Number: AV 108-332

Enertek International Limited

Date of Calibration: 13 August 2013

Manufacturer's recommended calibration interval: 12 months

Recalibrate before end of: Aug-2014

Traceability Information - equipment used -
Time electronics millivolt source: E00051
Calibration certificate number: ANT U60060-13
Calibration Date: 07/05/2013
Calibration Due Date: 31/05/2014

Thermometer: 00056
Calibration certificate number: ANT U58734-12
Calibration Date: 28/02/2013
Calibration Due Date: 28/02/2014

Uncertainty Information

Time Electronics source uncertainty < 1.5uV, equivalent to < 0.05K for type K t/couples. Corrections on calibration certificate applied.

Resolution of Pico instrument 0.01 K.

Total uncertainty 0.2 K when corrections herewith applied.

Calibration Point (ºC)	Digital Thermometer Reading (ºC)	Correction (ºC)
0	0.05	-0.1
20	20.06	-0.1
40	40.06	-0.1
60	60.05	0.0
80	80.07	-0.1
100	100.08	-0.1
120	120.10	-0.1
140	140.15	-0.2
160	160.14	-0.1
180	180.16	-0.2
200	200.12	-0.1
220	220.06	-0.1
240	240.07	-0.1

Remarks -

Calibrated by: CPF

Signed.....

Checked by:

Signed.....

This certificate provides traceability of measurement to recognised National Standards and to the units of measurement realised at the National Physical Laboratory or other recognised National Standards laboratories.

1 Malmo Road, Sutton Fields, Kingston Upon Hull, East Yorkshire, HU7 0YF

Enertek International Limited

Calibration Certificate

Certificate no: 415008

Enertek Inventory Number: PIC 098

Digital Thermometer - Model: USB TC08

Serial Number: AV108-162

Enertek International Limited

Date of Calibration: 14 August 2013

Manufacturer's recommended calibration interval: 12 months

Recalibrate before end of: Aug-2014

Traceability Information - equipment used -	
Time electronics millivolt source:	E00051
Calibration certificate number:	ANT U60060-13
Calibration Date:	07/05/2013
Calibration Due Date:	30/05/2014
Thermometer:	00056
Calibration certificate number:	58734-12
Calibration Date:	23/02/2013
Calibration Due Date:	28/02/2014

Uncertainty Information

Time Electronics source uncertainty < 1.5uV, equivalent to < 0.05K for type K t/couples. Corrections on calibration certificate applied.

Resolution of Pico instrument 0.01 K.

Total uncertainty 0.2 K when corrections herewith applied.

Calibration Point (ºC)	Digital Thermometer Reading (ºC)	Correction (ºC)
0	0.29	-0.3
20	20.26	-0.3
40	40.22	-0.2
60	60.20	-0.2
80	80.20	-0.2
100	100.15	-0.2
120	120.16	-0.2
140	140.16	-0.2
160	160.14	-0.1
180	180.14	-0.1
200	200.13	-0.1
220	220.14	-0.1
240	240.14	-0.1

Remarks -

Calibrated by: CPF

Signed.....

Checked by:

Signed.....

This certificate provides traceability of measurement to recognised National Standards and to the units of measurement realised at the National Physical Laboratory or other recognised National Standards laboratories.

1 Malmo Road, Sutton Fields, Kingston Upon Hull, East Yorkshire, HU7 0YF

APPENDIX B.

Component Specifications.

Gas Boiler	Worcester Greenstar 24i Junior
Air Heater	Modine HS24S02
Steel Radiator 1	Kudox Premium Type 22 (600x1200mm)
Steel Radiator 2	Kudox Premium Type 21 (500x1000mm)
Room Thermostat	Honeywell T6360B1036

INSTALLATION, COMMISSIONING AND SERVICING INSTRUCTIONS

WALL HUNG RSF GAS FIRED CONDENSING COMBINATION BOILER

GREENSTAR 24i Junior/28i Junior

FOR SEALED CENTRAL HEATING SYSTEMS AND MAINS FED DOMESTIC HOT WATER

The appliance is for use with Natural Gas or L.P.G. (Cat II 2H3P type C13, C33 & C53)		
	Model	GC Number
Natural Gas	24i Junior	47-406-54
	28i Junior	47-406-56
Liquid Petroleum Gas	24i Junior	47-406-55
	28i Junior	47-406-57

UK/IE

benchmark
COLLECTIVE MARK
THE MARK OF QUALITY FOR THE INSTALLATION, COMMISSIONING AND SERVICING OF DOMESTIC HEATING AND HOT WATER SYSTEMS

WORCESTER
Bosch Group

6 720802047 (2013/05)

2.2 TECHNICAL DATA

DESCRIPTION	UNIT	NATURAL GAS 24i junior	NATURAL GAS Low NOx[1)] 24i & 28i junior	NATURAL GAS 28i junior	LPG 24i junior	LPG 28i junior
Domestic Hot Water						
Minimum heat input	kW	7.00		7.00	9.64	9.64
Maximum rated heat output	kW	24		28	24	28
Maximum rated heat input (net)	kW	24.49		28.57	24.49	28.57
Minimum DHW flow rate to activate the boiler	l/min	3	Low NOx only applies to Central Heating	3	3	3
Gas flow rate - Max. 10 minutes from lighting						
Natural Gas G20	m^3/h	2.59		3.02	-	-
Propane Gas (LPG)	kg/h	-		-	1.9	2.22
Maximum mains inlet pressure	bar	10		10	10	10
Minimum mains inlet pressure (working) for max. flow	bar	1.3		1.3	1.3	1.3
Minimum mains inlet pressure (working) for operation	bar	0.2		0.2	0.2	0.2
Domestic Hot Water temperature range	°C	40 - 60		40 - 60	40 - 60	40 - 60
[2)]Max. Domestic Hot Water flow rate - 40 °C rise ± 15%	l/min.	8.6		10	8.6	10
Central Heating						
Maximum rated heat input (net)	kW	24.62	13.4	24.62	24.62	24.62
Maximum rated heat output 40/30 °C	kW	25.67	13.97	25.67	25.67	25.67
Maximum rated heat output 50/30 °C	kW	25.45	13.85	25.45	25.45	25.45
Maximum rated heat output 80/60 °C	kW	24	13	24	24	24
Maximum flow temperature	°C	82	82	82	82	82
Maximum permissible operating pressure	bar	2.5	2.5	2.5	2.5	2.5
Available pump head at 21 °C system temperature rise	m	2.0	2.0	2.0	2.0	2.0
Flue						
Flue gas temperature 80/60 °C, rated/min. load	°C	78/63	66/57	78/64	79/64	79/65
Flue gas temperature 40/30 °C, rated/min. load	°C	54/35	43/35	54/36	55/38	55/39
CO_2 level at max. rated heat output (after 30 minutes)	%	9.8	9.8	9.8	11.0	11.0
CO_2 level at min. rated heat output (after 30 minutes)	%	8.8	8.8	8.8	10.5	10.5
NOx class		5	5	5	5	5
NOx rating	mg/kWh	66	38	66	69	69
Condensate						
Maximum condensate rate	l/h	2.0	1.02	2.0	2.0	2.0
pH value, approx.		4.8	4.8	4.8	4.8	4.8
Electrical						
Electrical power supply voltage	a.c. V	230		230	230	230
Frequency	Hz	50		50	50	50
Maximum power consumption	W	140		140	140	140
Power consumption in standby mode.	W	3.5		3.5	3.5	3.5
General data						
Appliance protection rating	IP	X4D		X4D	X4D	X4D
Appliance protection rating with mechanical or RF mechanical timer or FW100 module fitted	IP	20		20	20	20
Permissible ambient temperatures	°C	0 - 50		0 - 50	0 - 50	0 - 50
Nominal capacity of appliance	litre	3.9		3.9	3.9	3.9
Noise output level (Max central heating)	dBA	42		42	42	42
Total boiler weight	kg	37.5		37.5	37.5	37.5
Lift weight	kg	26.2		26.2	26.2	26.2
SEDBUK 2005	band	A		A	A	A
SEDBUK 2005	%	90.1		90.1	91.8	91.8
SEDBUK 2009	%	89.1		89.1	90.1	90.1

1) The low NOx code plugs for the 24i and 28i Junior are available as an optional accessory.
24i Junior code plug kit number -7 716 192 356- 28i Junior code plug kit number - 7 716 192 357

2) Greenstar i Junior combi boilers are fitted with a flow regulator set to achieve a 40°C temperature rise. This ensures comfortable bathing during the colder winter months.

2.3 LAYOUT

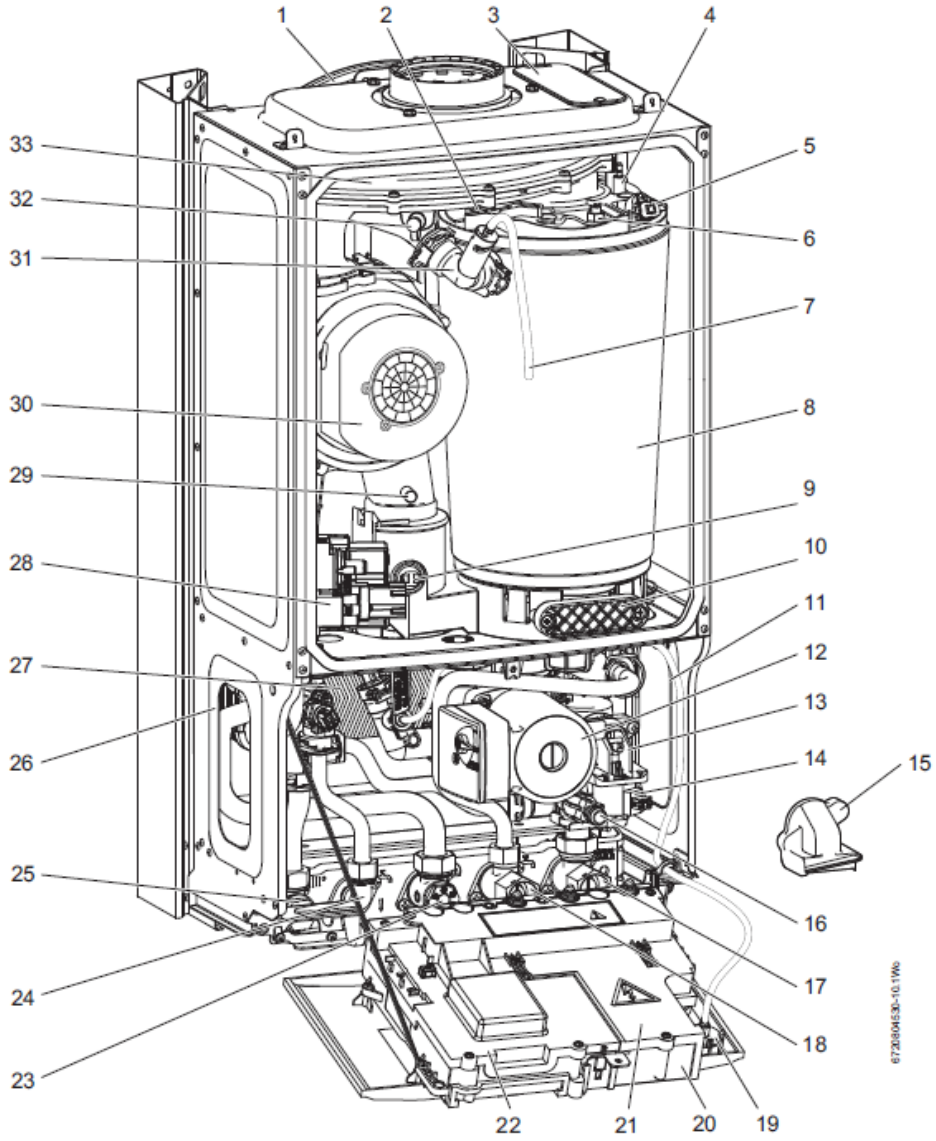


Fig. 1 Main boiler components

1	Expansion Vessel	26	Left side hand-hold for lifting boiler
2	Flow temperature sensor (NTC)	27	Plate to Plate heat exchanger
3	Removable panel - for servicing	28	Gas valve
4	Electrode assembly	29	Flue air pressure switch connection (not used)
5	Overheat thermostat	30	Fan
6	Securing nut - Air/Gas manifold clamp	31	Manual vent point
7	Silicon tube - heat exchanger air vent	32	Fan pressure test point
8	Heat exchanger	33	Air/Gas manifold
9	Flue over heat thermostat	34	Compact hydraulic - left mounting point
10	Access panel - Heat exchanger/sump cleaning	35	Flow connector from heat exchanger
11	Right side hand-hold for lifting boiler	36	Expansion vessel hose connection point
12	Pump	37	Auto air vent
13	Diverter valve assembly (body)	38	Return connection to heat exchanger
14	Diverter valve actuator (stepper motor)	39	Flow turbine
15	Diverter valve protective cover	40	Unused port
16	Drain point	41	Compact hydraulic - right mounting point
17	Central Heating (CH) return isolator	42	Pressure relief valve
18	Domestic Cold Water mains (DCW) isolator	43	CH return connection to service valve
19	System pressure gauge	44	DCW in connection to service valve
20	Control panel (in service position)	45	Internal by-pass
21	Cover - external wiring connections	46	DHW out connection
22	Cover - PCB	47	CH flow connection to service valve
23	Gas inlet connection 22mm	48	Pressure gauge connection point
24	Domestic Hot Water (DHW) connection	49	DHW temperature sensor (NTC)
25	Central Heating (CH) flow isolator		

Table 4 Boiler components

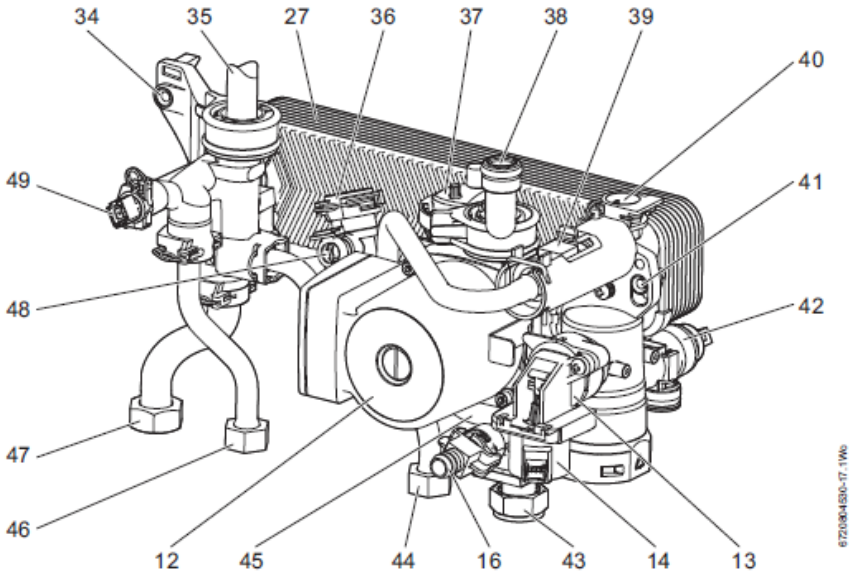


Fig. 2 Hydraulic block components

Kudox Premium Type 21 Double Panel Plus Convector Radiator White 500x1000mm

Tested to EN 442-1.

- Factory Fitted Top Grilles & Side Panels
- Finished to RAL 9010
- Brackets
- Wall Fixings
- Plug & Vent Included
- 15 Year Manufacturer's Guarantee
- High Thermal Capacity
- CE Certification
- 4073 BTU
- 1193W
- 23.24kg
- High Quality Packaging & Corner Protection

Specifications:
Depth (min. to max.): 100-115mm (depending on use of brackets). Wall to centre (min. to max.): 65-80mm (depending on use of brackets). Pressure tested to 13bar. Max. working pressure 10bar. Heat outputs calculated at Delta_T50k. Max. working temperature of 120°C.

Kudox Premium Type 22 Double Panel Double Convector Radiator White 600x1200

Tested to EN 442-1.

- Factory Fitted Top Grilles & Side Panels
- Finished to RAL 9010
- Brackets
- Wall Fixings
- Plug & Vent Included
- 15 Year Manufacturer's Guarantee
- High Thermal Capacity
- CE Certification
- 7324 BTU
- 2146W
- 38.26kg
- High Quality Packaging & Corner Protection

Specifications:
Depth (min. to max.): 134-149mm (depending on use of brackets). Wall to centre (min. to max.): 82-97mm (depending on use of brackets). Pressure tested to 13bar. Max. working pressure 10bar. Heat outputs calculated at Delta_T50k. Max. working temperature of 120°C.

1 Malmo Road
Sutton Fields
Kingston upon Hull
HU7 0YF
Tel: +44 (0)1482 877500
Fax: +44 (0)1482 877501
E-mail: eil@enertek.co.uk
enertekinternational.com
Registered in England No 2262638