CARBOLITE® GERO 30-3000°C

CAF G5

ASH FUSIBILITY FURNACE

The Carbolite Gero CAF G5 encompasses and enhances the original features whilst new features such as semi-automated image analysis and increased camera resolution along with zoom facility greatly improve the quality of test results and increased efficiency in laboratories.

part of VERDER

CAF G5

NEW GENERATION ASH FUSIBILITY FURNACE

Today, our latest CAF solution is of particular interest for those who have a requirement to test biomass to the DD CEN/TS 15370-1:2006 standard. The 5th Generation model encompasses and enhances original features while adding new features such as semi-automated image analysis with a vastly improved camera. The camera's high image resolution and zoom facility significantly improves the quality of test results in comparison to previous CAF models. In addition, speed efficiencies assist laboratories by reducing testing cycle times allowing for more frequent testing of differing material batches.

Coal ash is the non-combustible waste material left after coal is burned. The heat from the burning of the coal melts the coal ash which, when cool forms 'clinker', a stony residue from burnt coal.

TEST STANDARDS

Ash melting is a complex process where shrinkage, sintering and swelling can occur. The test method covers the observation of the temperatures at which the ash melting behaviour of coal and coke ash conforms to the below Standards:

Standard	Description
DIN 51730:2007-09	Testing of solid fuels - Determination of fusibility of fuel ash
BS ISO 540:2008	Hard coal and coke - Determination of ash fusibility
ASTM D1857 / D1857M - 18	Standard Test Method for Fusibility of Coal and Coke Ash
DD CEN/TS 15370-1:2006	Solid biofuels. Method for the determination of ash melting behaviour. Characteristic temperatures method
PD CEN/TR 15404 : 2010	Solid recovered fuels (SRF). Methods for the determination of ash melting behaviour by using characteristic temperatures

Large coal furnaces suffer from clinker build-up which can result in the closure of the furnace to allow removal. If the fusibility characteristics of the coal ash are known, control of the temperature can avoid clinker formation.

A test piece made from ash is heated under standard conditions and continuously observed. The temperatures at which characteristic changes of shape occur are recorded. The characteristic coal ash temperatures are defined as deformation, sphere, hemisphere and flow. Although the deformation is usually performed in a reducing atmosphere, additional information can sometimes be obtained by performing a further determination in an oxidising atmosphere.

With a maximum operating temperature of 1600°C the Carbolite Gero CAF G5 is designed to test coal ash fusibility and, optionally, the increasingly popular determination of biomass ash or solid recovered fuels (SRF) ash conforming to the listed Standards.

A large diameter work tube ensures that only one furnace is required to analyse more than six test pieces simultaneously. The furnace's efficient heating and cooling rates allow up to three tests per day to be completed.

STANDARD FEATURES

- Maximum operating temperature 1600 °C enabling biomass, SRF & coal ash testing
- Automatic and continuous recording of digital images
- Manual image analysis software with automatic features
- Software zoom function to enable accurate post-test analysis of individual samples with improved resolution
- One configurable grid assigned to each test piece
- Temperature controller program set up within the software
- Space saving embedded computer with Windows IoT Enterprise software runs future-proof firmware
- Default software settings and individual analysis form for coal ash, biomass and SRF
- Low thermal mass insulation allows quick cooling permitting multiple tests to be completed during the day
- Automated digital image capture of samples. The frequency of images recorded is set by customer preference, from every 1°C increment to every 20 °C

STANDARD ACCESSORIES

- Sample carrier x 1
- Sample tiles x 100
- Sample loading tool x 1
- Test piece mould x 1 (coal ash)
- Test piece mould and hand press x 1 (biomass & SRF)
- External mounting proprietary CO alarm x 1

Biomass and SRF ash test piece mould & press

Coal ash test piece pyramidal mould

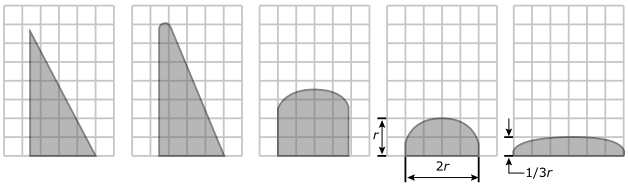
CAF G5

MULTIPLE SAMPLE TESTING AT ANY ONE TIME

A large diameter work tube ensures that only one unit is required to test more than six test pieces at any one time. Heating and cooling rates allow up to three tests per day to be completed. A grid overlay feature ensures accurate comparisons of the height and width of each sample for manual or automatic analysis

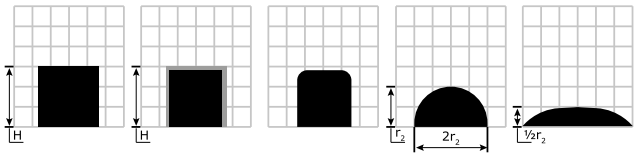
AUTO ANALYSIS SOFTWARE

The CAF G5 includes a software package. The sample profiles are identified by individual grids for each test piece. When using the automatic analysis option the software identifies the four melt point profiles as defined in the coal ash, standard and creates graphical data of the various form factors including height, width, area, circumference, shape factor ratio and height/width ratio.



Stages of Melt Points – Coal ash

The melt points of biomass and SRF samples have to be manually analyzed due to the small sample size. The user can select which data from these factors they want to show on the graph. The software automatically populates the results table and stores the deformation point images (IDT, ST, HT, FT – coal ash) and offers a printed report function.

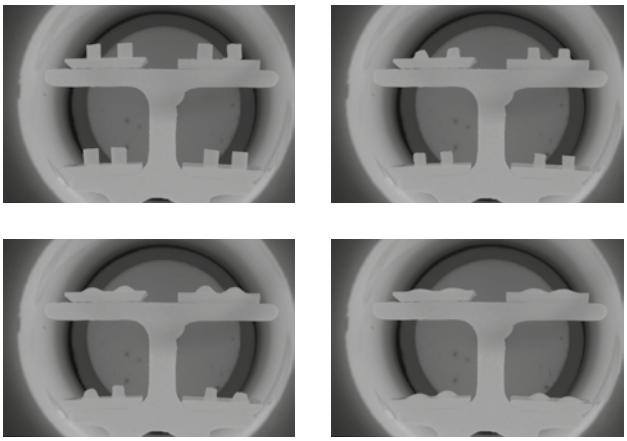


Stages of Melt Points – Biomass ash

ACCURATE DIGITAL IMAGE RECORDING

The digital camera, mounted externally on the door, is simple to use, easy to access and can be quickly adjusted to different positions. Its automated and continuous high resolution images of the samples' four melt points are captured at temperature intervals set by customer preference with the computer software. The image capture rate can be set in increments from every 1 °C to every 20 °C. The maximum interval for auto analysis is 5 °C.

Multiple images are stored on an embedded computer in sequence including date, time, a batch identifier and the temperature at the point of capture. The automatic and continuous recording of digital images allows laboratory technicians to carry out other tasks while the test is in progress, reviewing results later.



Example images taken from a typical test run

IMAGE GRID ASSISTANCE

A grid overlay feature is provided within the software for each sample (more than 6 samples can be simultaneously tested). The grids are positioned to identify the samples for automatic analysis or are used to assist manual analysis. They ensure accurate comparison of the height and width of the sample melt points. The position and scale of each grid is easily adjustable.

Figure (a) shows a zoomed image of two samples with analysis grids in position..

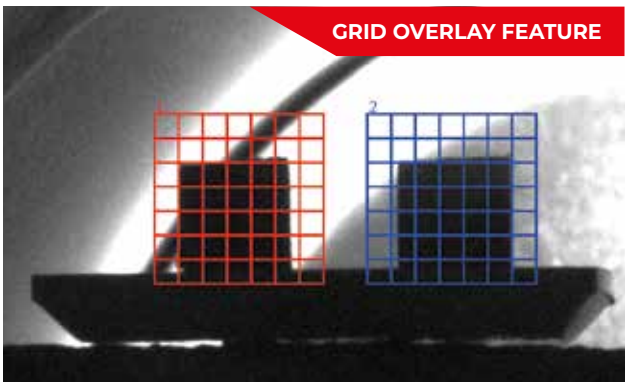


Fig. a

GAS OPTIONS

All CAF G5 furnaces can be run in reducing or oxidizing gas mode but due to the two different sets of gases the furnace is constructed specifically for the gases that are to be used to the Standard. Maximum gas pressure 276 mbar (4 psi).

Ash Material	Test standard	Reducing Gas	Oxidizing Gas	Purge Gas
Coal & Coke	ASTM D 1857-18	$CO + CO_2$	Air	N_2
Coal & Coke	BS ISO 540:2008 & DIN 51730:2007-09	$CO + CO_2$ or $H_2 + CO_2$	Air or CO_2	N_2 or CO_2
Solid Recovered Fuels	PD CEN/TR 15404:2010	$CO + CO_2$	Air	N_2
Biomass	DD CEN/TS 15370-1:2006	$CO + CO_2$	Air	N_2

SPECIFICATION SUMMARY

Temperature Range	Up to 1600 °C (1600 °C required for some biomass samples)
Temperature Precision	± 3 °C above 800 °C
Temperature Ramp Rate	7 °C per minute
Temperature Control	Digital multiple PID terms with gain scheduling and multi offset parameters
Temperature Display	°C
Work Tube dimensions	79 mm internal diameter
Tube material	Mullite
Heating Elements	Silicon carbide x 6
Maximum Sample Load	
Manual Analysis	8
Automatic Analysis	6
Conforms to Standards	BS ISO 540:2008; ASTM D 1857 / D1857M – 18; DD CEN/TS 15370-1:2006; PD CEN/TR 15404:2010
Ash Fusibility Determination	Automatic or Manual (Coal & coke: DT, ST, H, FT) Manual only (Biomass / SRF: IST, DT, HT, FT)
Analysis Time	3 runs per working day (including cool down times)

Image Collection	Digital – up to 1 frame per 1 °C rise in temperature
Image Resolution	1280 x 1024 pixels
Gas Requirements	(Specific gas choice must be made at time of ordering,see item numbers below)
Purge	N_2 or CO_2
Oxidising	CO_2 or Air
Reducing	$CO + CO_2$ or $H_2 + CO_2$
Ventilation	Forced air ventilation
Exhaust	Pipe to be vented into a separate fume hood
Safety	Fail safe gas system and CO alarm supplied
Dimensions	700 x 505 x 765 x 970 mm (H x W x Case depth x Overall depth)
Weight	84 kg (furnace)
Power supply	380 – 415 V, 50/60 Hz two phase 25 A/phase or 220 – 240 V, 50/60 Hz single phase 50 A
Power switching	Solid state relays
Maximum power consumption	7000 W
Environment Conditions	
Operating Conditions	5 °C – 40 °C
Relative Humidity	maximum 80 % up to 31 °C decreasing linearly to 50 % at 40 °C
Overtemperature protection	Digital with single high alarm relay

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