REACTOR ENGINEERING AB

CRS Quotation 10081 – Appendix 1

CRS Pilot digester

Delivery type:	Incoterms 2010FCAStenkullen Sweden, plusstart-up and training onsite
Delivery time:	10 months FCA
Commercial terms:	Orgalime S 2012, but the Quotation and its Appendices have precedence over Orgalime S 2012

Short summary

The Pilot Digester is a digester system designed to simulate various existing cooking processes as well as offering possibilities to develop new processes. Although charged in batch it can run in ways that to some extent also simulate continuous processes – by continuous changes of liquor and cooking conditions. The pilot digester also has special features for RDH cooking and bio-pulping.

It is a stand-alone unit, best operated in a laboratory environment, with access to mill supplies and/or special purpose supplies for the laboratory. Necessary supply requirements shall be confirmed by customer before order.

Scope

This offer includes the following below.

1. Complete pilot digester system in a rack
2. Platforms and stairs as needed
3. Special tools if needed for operation
4. Full industrial documentation
5. Start-up on site, provided customer has connected supplies as required
6. All travel expenses for CRS personnel
7. Training of operators on site for 5 days
8. Remote assistance during warranty period

Technical specification

Listed below are the technical specifications.

1. Chip charge approximately 30 L (precise figure available after design)
2. Charging from top, discharge through bottom hole
3. Operating pressure: 0 – 18 bar(g), design 22 bar(g)
4. Operating temperature: ambient – 180 C , design 200 C
5. Temperature ramp rate at least 4 C/min on loop, slightly lower when near steam supply temperature
6. Hot injection/displacement up to 170 C
7. Injection and displacement up to 3 Lpm, extraction up to 2 Lpm
8. Injection from one of the atmospheric tanks of the tank farm
9. Parallel injection and extraction
10. Tank farm made up of 4 atmospheric tanks of at least 80L, one of them also acting as receiver, plus two extra, smaller, receiver tanks
11. All tanks are put on scales for precise dosing
12. Circulation flow rate is controlled, up to 15 Lpm on wood chips – other charges might yield a lower flow
13. Flow direction is top to bottom
14. Injection and displacement are made from the bottom to top – displaced liquor exits through top to receiver
15. Atmospheric and high-pressure steaming, with optional condensate collection in tank
16. Rapid cool-down possible at end of cook, at least 10 C/min from cooking temperature
17. Manual liquor sampling any time during cook
18. Steel materials 316L on process parts and piping, 304 on rack
19. Sealing materials Aflas or PTFE where chemical stress is high, Viton on less stressed positions
20. After process draining of cooking liquor possible
21. Water flushing of content inside digester after cook.
22. Drain outlet lines from hoses (4 pcs) – dirty drains are separated from water drains
23. Vent line connected to one of the drain outlet lines
24. Available free ports on the loop for later added options such as auto-sampling
25. Control panel, mounted cabinet on rack, PLC control and PC for operator interface
26. PC HMI with overview and setups
27. Recipe controlled cooking
28. Data sampling to database

Payment terms and milestones

The delivery is divided into milestones, for which individual payments are due. Each milestone is invoiced on 30 days net, except for the down payment which is on 15 days net. Delays in payments will be added to the delivery time.

Delivery of machinery and equipment will be made Incoterms FCA Stenkullen. Transportation shall be by ocean freight, in container specified by CRS, likely Open Top.

Customer is encouraged to visit CRS and take part in Factory Acceptance Tests before delivery, although this is not strictly required.

CRS does not issue any guarantees on payments, including the down payment.

List of milestones below.

1. **MILESTONE 1: Down payment**
    - Payment due: 20%
    - Completed: Day 0 – at order
2. **MILESTONE 2: Engineering completed**
    - Payment due: 20%
    - Completed: Day 90
3. **MILESTONE 3: Delivery FCA**
    - Payment due: 50%
    - Completed: Day 300
4. **MILESTONE 4: Acceptance**
    - Payment due: 10%
    - Completed: Within 30 days of started installation

Final documentation is handed over at Acceptance.

Certification and third-party approval

CRS manufactures according to CE directives and follows the requirements set up by said directives. Adherence to any other directive or standard is not included in the scope of this offer. CRS does not cover any third-party approval and inspection other than those required during manufacturing for CE reasons.

CE labels are provided where required as well as a declaration of conformity and other technical documentation needed to run and maintain the system.

Warranties

CRS makes the following warranty statement: *All equipment and services supplied by CRS shall conform to specifications. If they do not conform, and the reason for malperformance is not due to mismanagement by customer, nonadherence to regulations, requirements by CRS, or due to force majeure events, CRS shall either remedy the problem or make a settlement with customer*. Please note that this only applies to actual issued specifications of performance. CRS can refrain from making guarantees on process performance.

The warranty is valid until 1 year from acceptance ofstart-upor 1.5 years from completed delivery of machinery from CRS' site, whichever date comes first.

Warranty claims shall be handled according to below procedure.

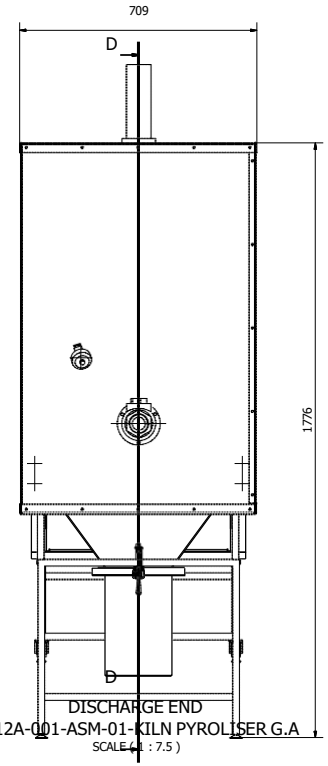
1. Warranty complaint from customer by written notice to CRS (e-mail).
2. Investigation of complaint by CRS.
3. Acceptance or reject of complaint by CRS.
4. If complaint is accepted by CRS, CRS shall propose a plan of remedy to customer.
5. If plan of remedy is accepted by customer, CRS shall replace the part, hardware or software as soon as possible according to below.
    a. CRS shall pay for transportation of returned non-conforming items to Sweden
    b. CRS shall pay for transportation of returned or replaced items to customer, but excluding any taxes and tariffs levied by the state where customer site is located.
    c. CRS shall pay for the repair of non-conforming part or for the replacement of a new one.
    d. Customer shall pay for dismounting and remounting of parts. CRS shall free of charge provide any remote guidance if needed for this.

Non-conforming software shall be updated remotely, free of charge, by CRS.

Supply and facility requirements

This pilot digester requires a supply battery prepared according to below list. Furthermore, it requires space as well as handling of ventilation and drain, also listed below.

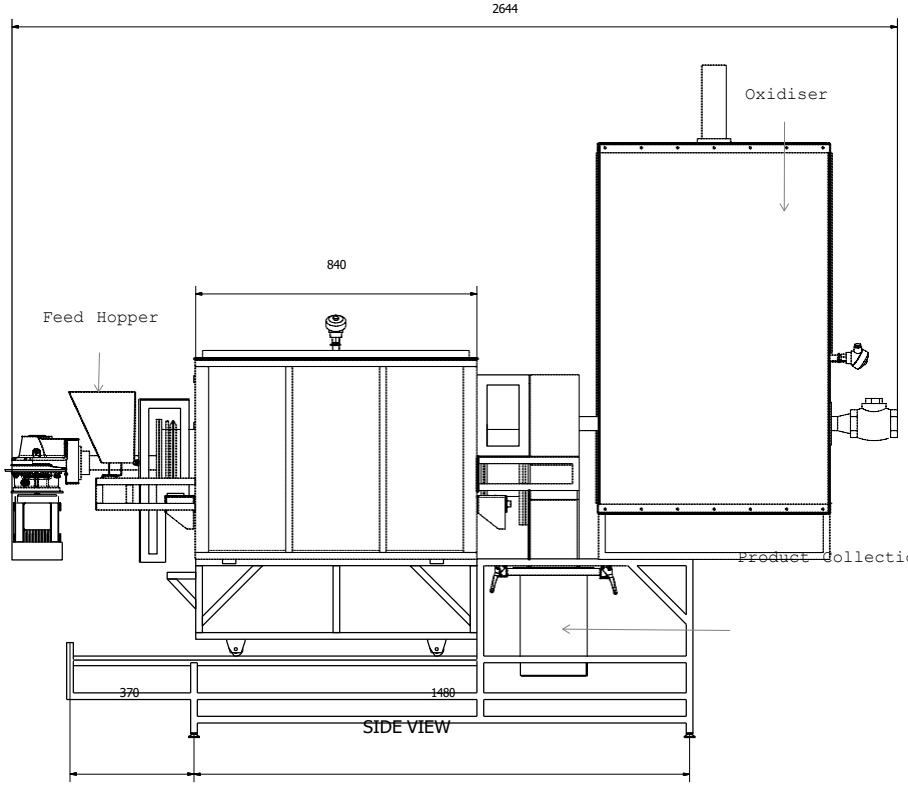
A. **Electrical power**: 3-phase connection at minimum 32A. 380-480 VAC 50/60 Hz. Actual supply must be notified to CRS at order.
B. **Steam**: Minimum 10 bar(g), recommended 12 bar(g), *at peak consumption rate* of 30 g/s. Average consumption is considerably lower.
C. **Compressed air**: Dry air at minimum 6 bar(g), maximum 8 bar(g). Mill supplies are often of inferior quality in terms of moisture present and pressure kept – a separate compressor for laboratory is recommended. Peak consumption 200 NL/min, average considerably lower.
D. **Nitrogen**: Preferably supplied by bottle. Multi-bottle system preferred as to avoid pressure drops when supply running low or bottle switched. Minimum 18 bar(g), maximum 22 bar(g). Actual consumption is very low.
E. **Cooling water**: Minimum 3 bar(g), maximum 6 bar(g), *at peak consumption rate* of 30 Lpm. Maximum temperature 40C.
F. **Demin water**: Minimum 4 bar(g), maximum 8 bar(g), *at peak consumption rate* of 15 Lpm.
G. **Space & entrance**: Pilot outer dimension, including platforms, will be approximately 4 x 2.2 m, but space around is recommended on three sides so that floor space needed will be minimum 6 x 3.2 m, *excluding areas for charge and discharge handling, tools, bottles etc*. Machine height during transportation approximately 3 m and fully mounted on sight approximately 3.5 m. Platform height at approximately 1.6 m above floor. Minimum door dimension for entrance to pilot hall is width 1.4 m and height 3.1 m. Precise dimensions given after engineering has been completed.
H. **Drain**: Pilot will release cooling water and dirty liquors – these drains can be separated. By hose from pilot to collection points. Drain canals recommended.
I. **Ventilation**: Pilot hall will need good ventilation. Consider extra suction points near drain outlets and digester vessel, but this is not strictly required.
J. **Control room / area**: A designated control room is not required, but strongly recommended. The control room can be used not only for the control PC, but as a small near pilot office, storage for special tools and spares etc. Must be overlooking the machine in any case. Please note that a control room could be used for other equipment too. Should be air conditioned, both for the convenience of operators as well as for computers and storage of spares.
K. **Support area**: In our experience, having 10-15 m2 extra floor space for handling, washing, cleaning, near machine storage, service etcetera is often very valuable.



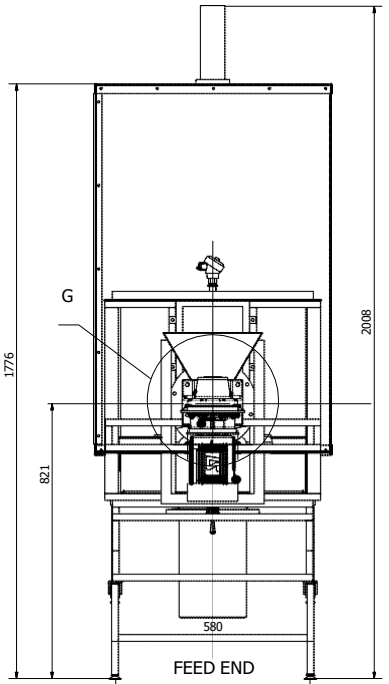
DISCHARGE END

1012A-001-ASM-01-KILN PYROLISER G.A

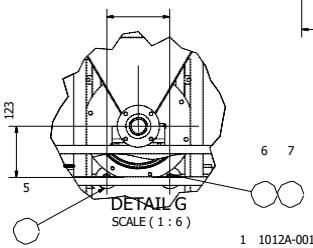
SCALE (1 : 7.5)



SIDE VIEW

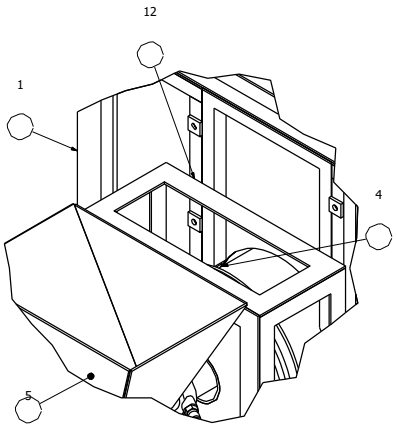


FEED END



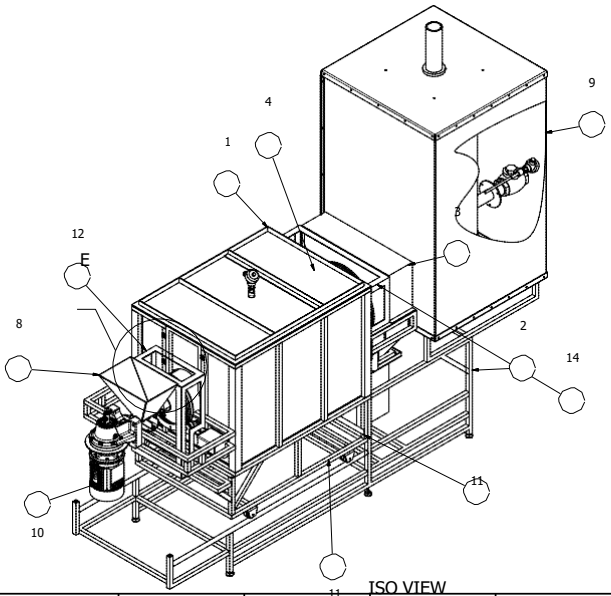
DETAIL G

SCALE (1 : 6)



DETAIL E

SCALE (1 : 3)



ISO VIEW

ITEM	QTY	PART NUMBER
14	1	1012A-001-ASM-08 TUBE GUARD
13	1	1012A-001-ASM-08 COWLING GUARD
12	1	1012A-001-ASM-08 FEED GUARD
11	1	1012A-001-ASM-04 SLIDING FRAME
10	1	CYCLO GEARBOX MOTOR
9	1	1012A-001-ASM-07 01 OXIDISER BOX
8	1	1012A-001-ASM-06-SCREW FEED
7	4	ISO 8674 - M12 x 1.5
6	4	ISO 4762 - M12 x 100
5	4	1012A DIA 52 O.D. B.M.S. LAB ROLLER
4	1	1012A-001-ASM-03-TUBE
3	1	1012A-001-ASM-05-DISCH COWLING
2	1	1012A-001-ASM-04-SUPPORT FRAME
1	1	1012A-001-ASM-02-SHELL

PARTS LIST

Parent Assembly:				Mass: 3053.735 kg	
Drawn by	Checked by	Approved by - date	Job Number	Date	Scale
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Note: This document has been edited for the RFQ

2 BIOCHAR/PYROLYSER KILNS

Note: Page numbers may not be correct

Contents

2 SPECIFICATIONS – PILOT SCALE

Application: - Pyrolysis of various types of biomass.

Production Rate:

Description	Biomass
Feed Rate (kg/hour)	50kg dry basis
Bulk Density (kg/m^3)	Variable assumed 350kg/m³
Moisture Content	≈ 60%
Dry Fixed Carbon	≈ 20%
Volatiles on DB	≈ 80%

Feed Particle Size: - 0x3mm

Max Temp: - 1000ºC

Dimensions: - Tube Diameter 500mm, Hot Zone 4000mm, Overall Length = 5500mm.

Control: - 2 Zone, Electrically Heated (Wire Elements) via 3 Phase Thyristors with PID Microprocessor Temperature Controllers from a standalone control panel. VSDs on tube drive, feed screw and extraction cooling screw.

Utilities: - Electricity – 60 kW Thermal, 5 kW for Motors @ 380V 3phase & N

Battery Limits:
- Surge hopper on feed screw
- Bottom flange on cooling discharge for carburized solids
- Top flange on gas exhaust port
- Electrical supply to the control cabinet in the MCC
- Controlled gas supply to tie in points

3 CONSTRUCTION DETAILS - PILOT

3.1 The Rotary Kiln

The Rotary Kiln will be indirectly fired, and electrically heated. Based on its research function, a facility will be included to allow for counter or co-current gas flows, based on the operator's preference for that run or campaign.

Figure 1 - A Two Zone Midi Rotary Kiln

3.1.1 Structure

The Rotary Lab Kiln will be rectangular in shape, with a removable roof for access to the tube for maintenance. The kiln will be fixed onto a standing structure manufactured from S355JR Structural Steel.

3.1.2 Coatings

The kilns will be surface prepped and coated according to standard SP2. High Temperature Aluminium Paint will be used on the external surfaces of the kilns for anti-corrosion and aesthetics.

3.1.3 Insulation

The kilns will be lined with composite layering of lightweight insulating materials which allows for rapid heat up and cool down.

Type text here

3.1.4 Heating System

The Rotary Lab Kiln will be a 2-zone unit, with each zone controlled by a dedicated temperature controller for regulating power to the zone's elements via a 3 Phase Thyristors or contactors. Each Zone will have 30kW of installed heating power.

3.1.5 Rotary Tube

The working tube will be manufactured from a high-grade stainless steel. The tube diameter will be 470mm with an overall length of 5500mm.

3.1.6 Drive Arrangement

The Rotary Lab Kiln will be driven by a Chain and Sprocket arrangement. The drive sprocket will be fixed to the feed end of the tube and this will be driven by the motor and gearbox via a chain. The motor will be VSD controlled. The feed end of the kilns will accommodate a sealing arrangement that interfaces with the Feed Screw, which will include a gas injection facility for purging, and a discharge facility for gas extraction and tie-in to your gas handing and processing equipment.

Figure 2 - Drive Motor, Chain and Sprocket on a Rotary Kiln.

3.1.7 Feed Screw

The Pilot Kiln will use a feed screw and small surge hopper to feed the kiln. A packed gland rotary seal between the working tube and feed screw will prevent air ingress into the tube. The operator will be responsible for ensuring the surge hopper and feed screw are always charged to prevent air entering the tube. The Feed screw will have VSD control.

Figure 3 - Feed Screw and Surge Hopper on a Specialized Feeding System on a small rotary kiln.

3.1.8 Discharge Arrangement

The discharge end of the tube will interface with an insulated Discharge Cowling. The discharge cowling will incorporate a special rotary sealing system to prevent the ingress of air into the system. This sealing arrangement will include a facility to provide gas supply attachments to allow for controlled atmospheric conditions. The top of the discharge cowling will include for a gas exhaust port which will interface with CSIR's gas handling and condensing system. The bottom flange of the discharge cowling will interface with an indirectly water-cooled extraction auger, which in turn terminates in a simple clamp on the collection box. The cooling auger will come complete with a small evaporative cooling tower and its associated pump and control system.

A Thermocouple will be fitted through the Discharge Cowling to monitor the process gas temperature. This thermocouple will sound an alarm when a Process High Value is measured indicating combustion of the gases and the presence of air in the system.

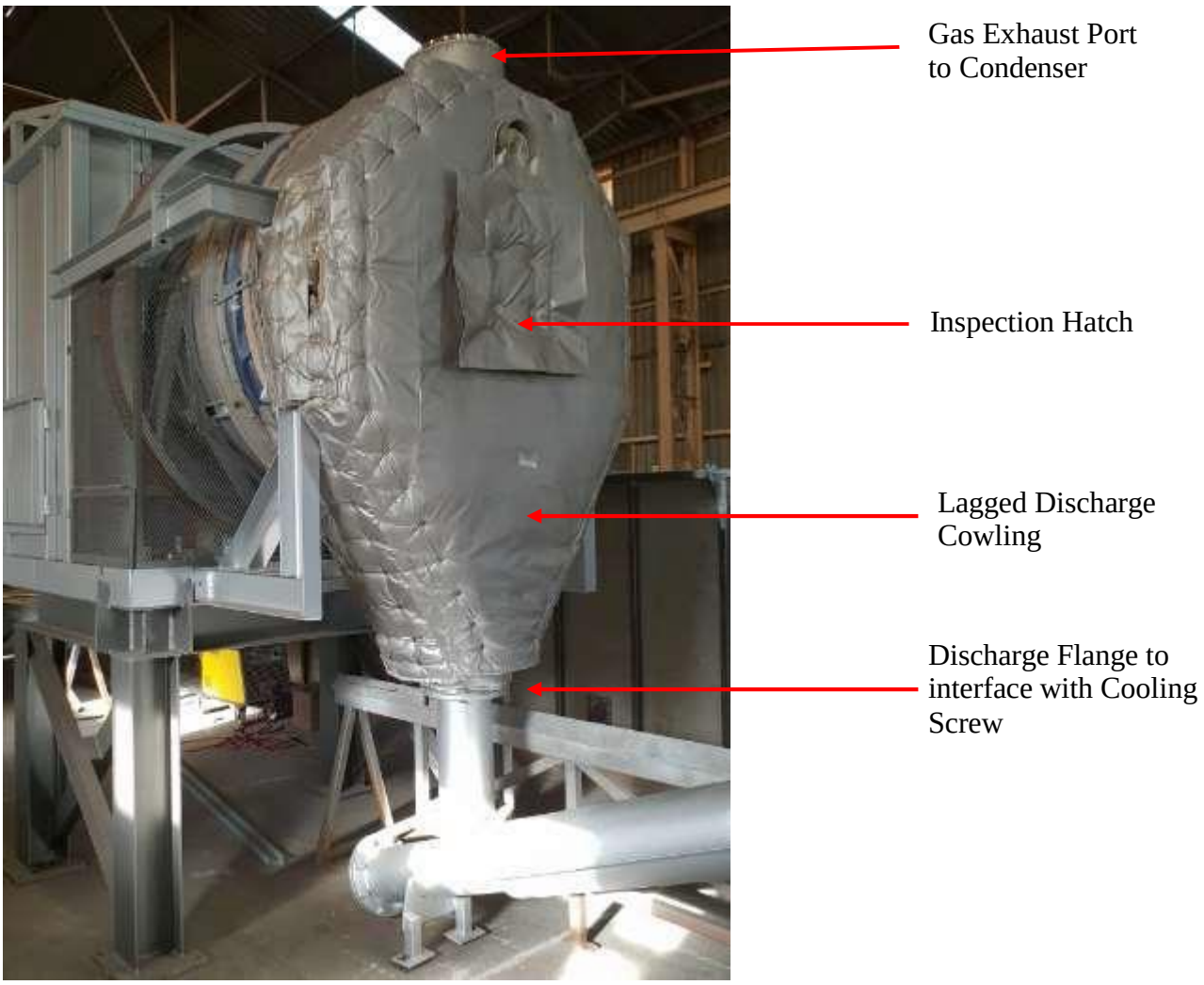


Figure 4 – A Lagged Discharge Cowling illustrating the exhaust port on a co-current process.

3.2 Control and Instrumentation

3.2.1 Control Panel

The Rotary Pilot Kiln will have a standalone control panel that will be fixed onto the sidewall of the kiln, unless the client specifies otherwise. The control panel will house the necessary switchgear for the complete operation of the kiln including 2 PID temperature controllers and the HMIs for the VSDs.

3.2.2 Main Temperature Control

Primary temperature control will be executed by a dedicated RKC RB100 temperature controllers signal outputs to the thyristors or contactors. Type-K thermocouples will provide temperature data to the individual zone controllers. The thermocouples will measure the external air temperature around the rotary tube. A dedicated temperature controller and thermocouple will also be used to monitor the gas temperatures in the discharge cowling.

3.2.3 Variable Speed Drives (VSDs)

The Drive Motors requiring variable speed, namely the feed auger, tube rotation, and extraction cooling screw, will all be supplied with variable frequency drives.

4 SPECIFICATIONS – BENCH SCALE

Application: - Pyrolysis of various types of biomass.

Description	Biomass
Feed Rate (kg/hour)	2-3kg dry basis
Bulk Density (kg/m^3)	Variable assumed 350kg/m³
Moisture Content	≈ 60%
Dry Fixed Carbon	≈ 20%
Volatiles on DB	≈ 80%

Feed Particle Size: - 0x3mm

Max Temp: - 1000°C

Dimensions: - Approximately 1200mm Long x 600mm W x 600mm H

Power Rating: - 5kW @ 220V 50Hz Single phase & N

Control: - Single zone, thyristor/SSR control via microprocessor-based controller

Battery Limits:
- Surge hopper on feed screw
- Sealed discharge bin c/w purge facility for carburized solids
- Top flange on gas exhaust port
- Electrical supply to the control cabinet in the MCC
- Controlled gas supply to tie in points

5 CONSTRUCTION DETAILS – BENCH SCALE

5.1. The Kiln

The kiln will be an electrically fired, indirectly heated, rotary kiln. The kiln will include an auger type feeder to facilitate continuous firing.

Figure 5: A rotary laboratory kiln.

5.1.1. Shell

Structural components of the shell, such as the support frame would be fabricated from mild steel while the sheeting would be manufactured from anodized aluminium.

5.1.2. Insulation

The kiln will be insulated with a composition of lightweight materials such as ceramic wool, calcium silicate and high temperature fiber boards, to ensure minimal heating losses while keeping the weight of the unit to a minimum.

5.1.3. Heating System

The Rotary lab kiln will be a single zone unit controlled with a dedicated temperature controller for regulating power to the zone's elements via a solid-state relay.

5.1.4. Tube

The working tube will be manufactured from a high-grade Stainless Steel. The tube diameter will be 200 mm with a working hot zone of 1000mm in length.

5.1.5. Discharge Cowling

The discharge cowling will separate the process off-gasses from the pyrolised product. This cowling will couple onto the rotary tube by means of a rotary labyrinth seal. The product will discharge out a chute at the bottom of the cowling into a collection bin. This clamp-on bin will seal hermetically and have a purge facility to allow for controlling the atmospheric conditions and prevent the continuous combustion of the hot discharge during cooling. The process gas will discharge out a chimney at the top of the cowling, into your condensing and gas handling facility.

5.2. Feeder

5.2.1. Surge Hopper

The feeder will include a small surge hopper. The operator will manually charge the surge hopper during continuous operation.

5.2.2. Auger

The material will be augered into the kiln via a high-grade stainless-steel auger, driven by a small motor and gearbox arrangement.

5.3. Control and Instrumentation:

5.3.1. Panel

A small control panel will be supplied with the equipment. This panel will be powder coated mild steel with an IP65 ingress protection rating.

5.3.2. Temperature Control

The temperature control system will comprise of a solid-state relay power regulation of the elements via a microprocessor based temperature controller – the RKC RB100.

Figure 6: The RKC RB100 is a robust temperature indicating controller

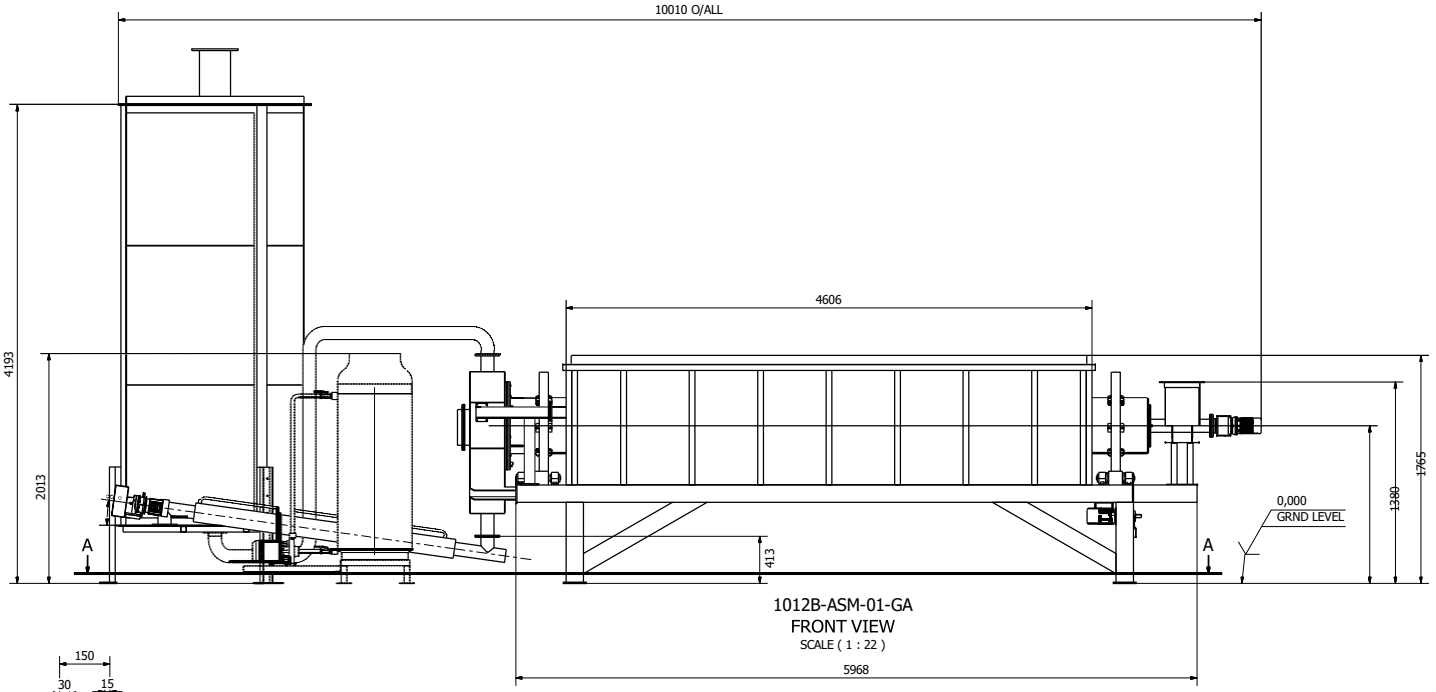
5.3.3. Thermocouples

A single thermocouple will monitor and execute control of the temperature along the heated length of the tube. The temperature will be taken outside the tube, in the insulated heating cavity. The thermocouples will also be placed through the discharge cowling to monitor the internal gas temperature. Again, this will be alarmed to indicate combustion and run-away temperatures.

If the client wants the kiln to have 3 independent heating zones, this must be specified, and the proposal will be adjusted accordingly.

5.3.4. Motor Control

The motors for the auger feeder and the tube rotation will be controlled by VFDs, allowing the operator to adjust feed rates and residence time. The VFD's will be fitted with HMI's mounted on the front of the control panel.



1012B-ASM-01-GA
FRONT VIEW
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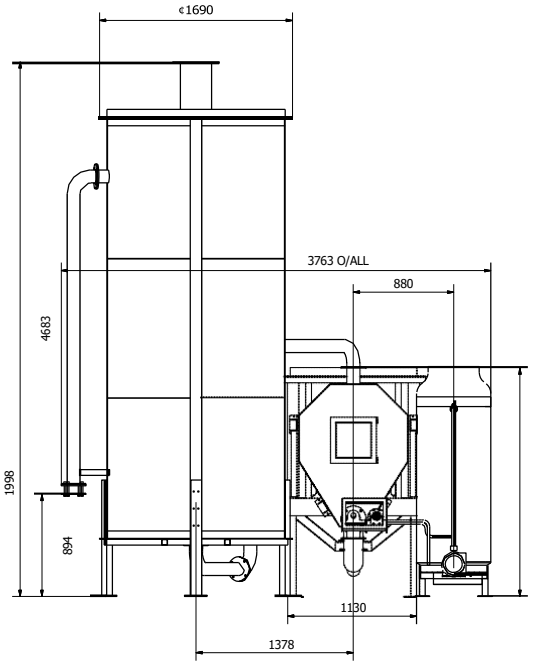
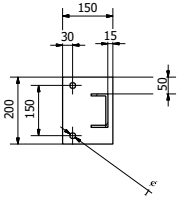
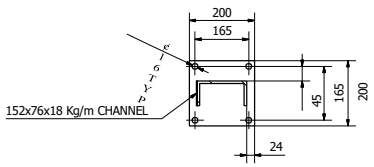


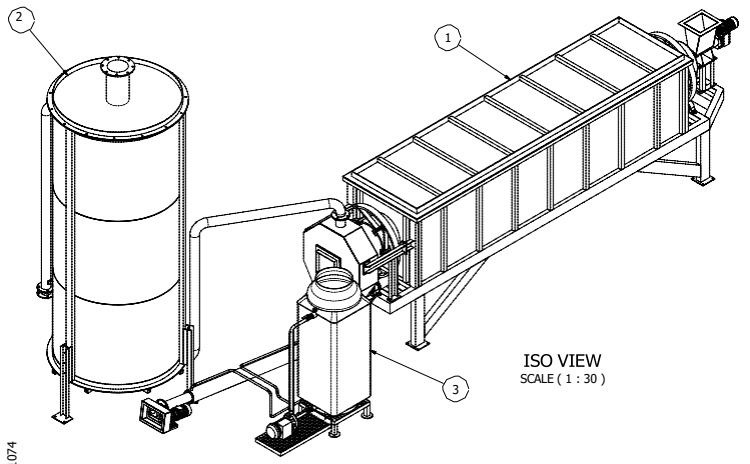
SIDE VIEW FROM DISCHARGE SIDE
SCALE (1 : 22)



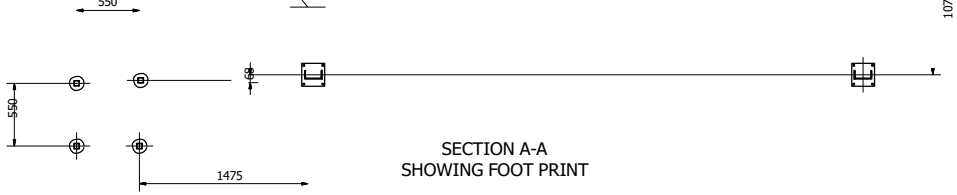
DETAIL B
TYP 3 PLACES
SCALE (1 : 7.5)



DETAIL A
TYP 4 PLACES
SCALE (1 : 7.7)



ISO VIEW
SCALE (1 : 30)

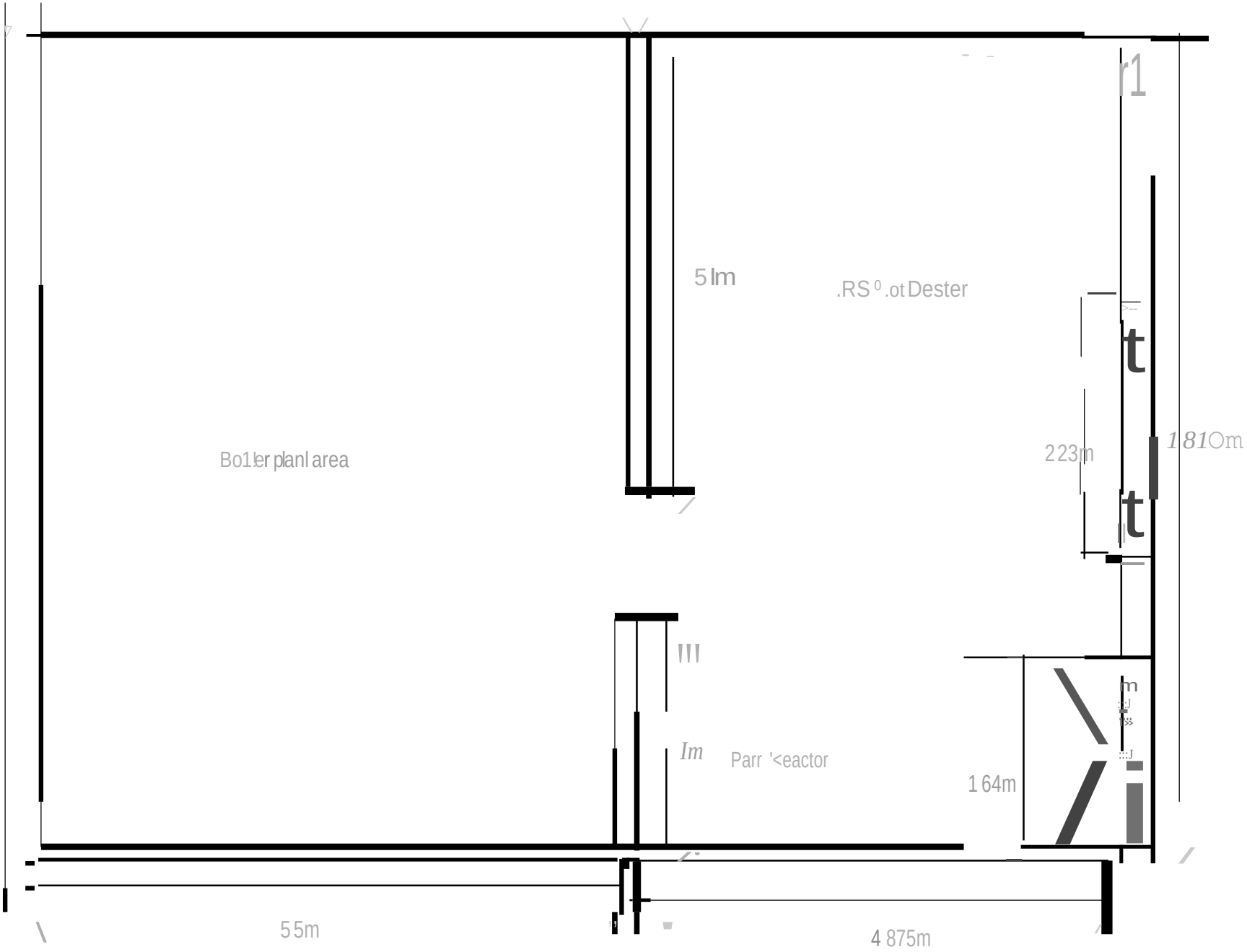


SECTION A-A
SHOWING FOOT PRINT

ITEM	QTY	PART NUMBER
3	1	1012B-003-ASM-03 COOLING TOWER
2	1	1012B-002-ASM-01 OXIDISER
1	1	1012B-001-ASM-01-KILN G.A.

PARTS LIST

Parent Assembly: NA				Mass: 8519.273 kg
Drawn by	Checked by	Approved by - date	Job Number	Date



Internal Measurements (Durban)