



***Technical Specifications: Laboratory-Scale Thermo-Chemical
Reactor System for Biomass, Biochar and Waste Conversion
Research***

1. Purpose

The Agricultural Research Council (ARC) intends to procure a fully integrated laboratory-scale thermo-chemical reactor system for research, development, optimization, and demonstration of thermo-chemical conversion processes involving biomass, agricultural residues, biochar, organic waste streams, and refuse-derived fuels (RDF).

The system shall support a wide range of thermo-chemical processes including:

- Pyrolysis
- Gasification
- Hydrothermal carbonization (where applicable)
- Thermal decomposition studies
- Biochar production
- Syngas generation and characterization
- Bio-oil production and recovery

The system shall be suitable for advanced research, process optimization, technology development, postgraduate training, and pilot-scale validation activities.

2. Scope of Supply

The supplier shall provide a complete turnkey thermo-chemical reactor system including:

- Reactor unit

- Heating system
- Gas supply and control system
- Condensation and liquid collection system
- Gas cleaning system
- Data acquisition and control software
- Control workstation
- Safety systems
- Installation and commissioning
- Operator training
- Calibration and validation
- All accessories required for immediate operation

The system shall be delivered fully operational upon completion of commissioning.

3. Functional Requirements

The thermo-chemical reactor system shall:

- Perform controlled thermo-chemical conversion of solid feedstocks.
- Operate under inert, oxidizing, reducing, and steam-assisted atmospheres.
- Support batch and continuous operating modes where applicable.
- Allow programmable heating rates and temperature profiles.
- Enable production and collection of:
 - Biochar
 - Syngas
 - Bio-oil

- Condensable fractions
- Non-condensable gases
- Provide real-time process monitoring.
- Automatically record all operational parameters.
- Support experimental method development.
- Permit unattended operation for extended runs with safety shutdown capability.

The system shall be capable of handling:

- Biomass
- Agricultural residues
- Wood chips
- Forestry residues
- Crop residues
- Animal waste
- Municipal organic waste
- Biochar feedstocks

4. Reactor System Specifications

4.1 Reactor Configuration

The supplier may offer any suitable reactor technology, including:

- Fixed-bed reactor
- Fluidized-bed reactor
- Rotary kiln reactor
- Auger reactor

- Tubular reactor
- Batch reactor
- Continuous reactor

Provided the system meets all performance requirements.

Minimum Requirements

Parameter	Requirement
Reactor type	Laboratory-scale thermo-chemical reactor
Operating mode	Batch and/or continuous
Feedstock particle size	Variable
Feedstock flexibility	Multiple biomass and waste streams
Process control	Fully programmable
Automation	Semi-automatic or fully automatic

4.2 Temperature System

The system shall include:

- Electrically heated furnace/reaction chamber.
- Programmable temperature profiles.
- Multi-stage heating programs.
- Independent temperature monitoring.
- Automatic temperature control.

Performance Requirements

Parameter	Requirement
Maximum operating temperature	$\geq 1200^{\circ}\text{C}$

Parameter	Requirement
Temperature control accuracy	$\pm 1^{\circ}\text{C}$
Temperature stability	$\pm 2^{\circ}\text{C}$
Heating rate	1–100 $^{\circ}\text{C}/\text{min}$ or better
Temperature measurement points	Minimum 3

4.3 Feed System

The system shall include:

- Feedstock loading mechanism.
- Sample introduction system.
- Feed rate control (for continuous systems).
- Airtight sealing mechanisms.
- Feed hopper where applicable.

Minimum Requirements

Parameter	Requirement
Feed capacity	≥ 500 g per batch
Feed rate control	Required
Air leakage prevention	Required
Feedstock flexibility	Required

4.4 Gas Supply and Control System

The system shall support:

Standard Gases

- Nitrogen
- Air

- Carbon dioxide

Preferred Capability

- Steam injection
- Hydrogen compatibility
- Oxygen enrichment capability

The gas control system shall include:

- Electronic mass flow controllers.
- Pressure regulation.
- Automatic gas switching.
- Gas flow monitoring.
- Safety interlocks.

Minimum Requirements

Parameter	Requirement
Number of gas lines	Minimum 3
Gas flow control	Electronic
Gas flow monitoring	Continuous
Automatic switching	Required

4.5 Condensation and Product Recovery System

The system shall include:

- Multi-stage condensers.
- Bio-oil collection vessels.
- Tar collection system.
- Liquid sampling ports.

- Product recovery containers.

The design shall maximize recovery of condensable products.

4.6 Gas Cleaning and Sampling System

The system shall include:

- Particulate removal system.
- Condensate traps.
- Gas sampling ports.
- Gas filtration system.

Preferred:

- Online gas analysis integration capability.

4.7 Gas Analysis System (Preferred)

The system should either include or be capable of integration with:

- CO
- CO₂
- CH₄
- H₂
- O₂
- H₂S (optional)

Gas Analysis Performance

Parameter	Requirement
Real-time monitoring	Preferred
Data logging	Required

Parameter	Requirement
Integration with reactor software	Preferred

4.8 Data Acquisition and Control System

The software shall provide:

- Real-time process visualization.
- Data acquisition.
- Historical data storage.
- Process control.
- Alarm management.
- Trend analysis.
- Report generation.

Parameters recorded shall include:

- Reactor temperature
- Gas flow rates
- Pressure
- Residence time
- Product yields
- Gas composition (if applicable)

Data export formats:

- Excel
- CSV
- PDF

The software shall support:

- Audit trail
- User access control
- Network connectivity
- Remote monitoring capability

5. Safety Requirements

The system shall include:

- Emergency shutdown system.
- Over-temperature protection.
- Over-pressure protection.
- Gas leak detection.
- Furnace interlocks.
- Electrical protection.
- Automatic fault diagnostics.
- Alarm notification system.
- Safe venting arrangements.

The system shall comply with applicable international electrical and laboratory safety standards.

6. Performance Requirements

Parameter	Minimum Requirement
Maximum operating temperature	$\geq 1200^{\circ}\text{C}$
Temperature accuracy	$\pm 1^{\circ}\text{C}$

Parameter	Minimum Requirement
Temperature stability	$\pm 2^{\circ}\text{C}$
Programmable heating profiles	Required
Continuous data logging	Required
Gas flow control	Electronic
Product recovery	Biochar, gas and liquid fractions
Process automation	Required
Safety interlocks	Required

7. Accessories Included

The quotation shall include:

- Complete thermo-chemical reactor system.
- Control workstation.
- Licensed software.
- Mass flow controllers.
- Gas regulators.
- Reactor vessels.
- Condensation units.
- Product collection containers.
- Sampling tools.
- Calibration kits.
- Spare seals and gaskets.
- Spare thermocouples.
- Tool kit.
- User manuals.

- UPS with minimum 30-minute backup.
- One-year starter consumables.

8. Installation and Commissioning

The supplier shall provide:

- Delivery to ARC site.
- Installation.
- Commissioning.
- Calibration.
- Performance verification.
- Operational qualification (OQ).
- Performance qualification (PQ).
- Demonstration of reactor performance using representative biomass feedstock.

9. Special Conditions

9.1 New Equipment

All equipment supplied shall be brand new, unused, and of current production. Refurbished, remanufactured, demonstration, or discontinued equipment will not be accepted.

9.2 Delivery, Installation and Commissioning

The successful bidder shall deliver, install, commission, calibrate, test, and demonstrate the complete laboratory-scale thermo-chemical reactor system at the Agricultural Research Council (ARC) site specified in the purchase order.

The supplier shall ensure that all components of the system are fully integrated, operational, and configured in accordance with the manufacturer's specifications and the requirements contained in this document.

All installation, commissioning, calibration, testing, and demonstration activities shall be carried out by suitably qualified personnel at no additional cost to ARC.

9.3 Warranty

The warranty period shall commence on the date of final acceptance by ARC and shall remain valid for a minimum period of **twenty-four (24) months**.

A manufacturer's or supplier's warranty certificate shall be provided upon delivery and commissioning of the system, confirming the warranty period and the terms and conditions of the warranty.

During the warranty period, the supplier shall repair or replace any defective equipment, software, components, instrumentation, or accessories at no additional cost to ARC.

9.4 Documentation and Handover

Upon completion of installation and commissioning, the supplier shall provide all applicable documentation required for the operation, maintenance, and support of the system, including but not limited to:

- User manuals.
- Operation manuals.
- Maintenance manuals.
- Calibration certificates.
- Commissioning reports.
- Software licences (where applicable).
- Warranty certificate.
- Any other documentation required for the safe and effective operation of the system.

All documentation shall be provided in English in both electronic and hard-copy format where applicable.

9.5 Acceptance Testing

Final acceptance of the laboratory-scale thermo-chemical reactor system shall be subject to successful installation, commissioning, testing, and performance verification by the Agricultural Research Council (ARC).

Acceptance shall be based on the successful demonstration of the following:

- Successful installation and commissioning of the reactor system.
- Safe operation under the specified design and operating conditions.
- Verification of temperature control performance.
- Verification of gas flow control accuracy.
- Successful production and recovery of biochar and condensable products.
- Successful completion of a demonstration run using representative biomass feedstock.
- Successful completion of the required operator training.
- Delivery of all required documentation and certificates.

The system shall only be regarded as fully accepted after ARC has verified that all technical, operational, safety, training, and documentation requirements have been satisfactorily fulfilled.

10. Compulsory Requirements

10.1 Manufacturer's Technical Datasheets

The bidder shall submit manufacturer's technical datasheets for the proposed laboratory-scale thermo-chemical reactor system. The datasheets shall clearly demonstrate compliance with all the minimum technical specifications contained in this document.

Proof required: Manufacturer's technical datasheets.

10.2 Warranty Letter

The bidder shall submit a signed letter on the company's letterhead confirming a minimum warranty period of **twenty-four (24) months** from the date of final acceptance by ARC.

Proof required: Signed warranty letter.

10.3 Training Commitment

The bidder shall provide a signed commitment on the company's letterhead confirming that a minimum of **five (5) days onsite operator training** will be provided upon installation and commissioning of the system.

The training shall include, as a minimum:

- Reactor operation.

- Process optimization.
- Feedstock preparation.
- Pyrolysis and gasification procedures.
- Product collection and analysis.
- Safety procedures.
- Preventive maintenance.
- Troubleshooting.
- Data analysis and reporting.

Training materials shall be supplied in both electronic and hard-copy format.

Proof required: Signed training commitment on the bidder's letterhead.

10.4 After-Sales Support Commitment

The bidder shall submit a signed commitment confirming the provision of after-sales support for the proposed system, including:

- Local technical support within South Africa.
- Maximum response time of **72 hours** for technical support requests.
- Preventive maintenance support.
- Software updates during the warranty period (where applicable).
- Availability of spare parts for a minimum period of **ten (10) years**.
- Annual calibration and validation support.
- Application and process development support.

Proof required: Signed after-sales support commitment on the bidder's letterhead.

10.5 Experience in Similar Projects

The bidder shall provide evidence of successfully supplying, installing, and commissioning laboratory-scale thermo-chemical reactor systems or comparable scientific laboratory equipment.

Proof required:

- At least two (2) reference letters or completion certificates for similar projects completed within the last five (5) years; and
- Each reference letter or completion certificate must be supported by the corresponding appointment letter or purchase order (PO) as evidence that the work was awarded to the bidder.

