SPECIFICATION FOR REACTOR

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1. Purpose

1.1 Scope

This document provides the minimum requirements for the technical specifications of the *Jumbo Reactor* used in "Pars Carbon Black Plant" project.

1.2 Project description

The existing plant of Pars Carbon Black consist of four Soft reactors and also four Hard reactors in the production unit. Due to the fact that the old technology of this plant and lower the performance of the production unit, it is decided to renovate the technology and also revamping the capacity of hard carbon black unit to 20000 metric ton per year. Another necessary consideration is capability of production of N-200 series carbon blacks after revamping. According to the contract, basic design is carried out by TARH O FARAYAND KIMIA Co.

Project:	Basic Design of Pars Carbon Black Hard Reactor Revamping
Client:	Pars Carbon Black Co. (DSP).
Consultant:	Tarh o Farayand Kimia Co (TOFKA).
Vendor/Supplier:	Refers to firm or person who will supply and/or fabricate the equipment or material.
Will:	Is normally used in connection with the action by the "Company" rather than by a contractor, supplier or vendor.
May:	Is used where a provision is completely discretionary.
Should:	Is used where a provision is advisory only.
Shall:	Is used where a provision is mandatory.

1.3 Unit and Language

International system of units (SI) shall be use in accordance with NIOEC-SP-00-10, unless otherwise specified.

1.4 Site Location

SAVEH City, KAVEH Industrial Estate, Pars Carbon Black Co.

2. Applicable Code, Standard, Specification

2.1 Unless otherwise stated on the equipment data sheets the following codes and standards shall apply.

ASME Section II	Ferrous Material Specifications
ASME Section V	Non-destructive Examination
ASME Section VIII, Division 1	Rules for Construction of Pressure Exchangers
ASME Section IX	Welding & Brazing Qualifications
ASMEB16.5	Pipe Flanges and Flanged Fittings
ASMEB16.20	Metallic Gaskets for Pipe Flanges
ASMEBI6.21	Non-Metallic Flat Gaskets for PipeFlanges
ASMEB16.47	Large Diam. Steel Flanges NPS 26 thro' NPS60
ASMEB31.3	Piping- Process Piping
ASTM A-388/A-388M	Standard Practice for Ultrasonic Examination of Heavy Steel Forgings
ASTM A-435/A-435M	Standard Specification for Straight-Beam Ultrasonic Examination of Steel Plates
BS EN 10204	Metallic Products Types of inspection documents
EJMA	Standards of the Expansion Joint Manufacturers Association
NACE STD MR 0175	Sulfide Stress Cracking Resistant Metallic Materials for Oilfield Equipment
Welding Research Council Bulletin Nos. 107 & 297	Local Stresses in Spherical and Cylindrical Shells due to External Loads
ISO 900 I: 2000	Quality Management Requirements Systems
ISO 9001:1994	Quality Systems Model for Quality Assurance in Design, Development, Production, installation and Servicing.

2.2 The following specifications shall be used in conjunction with this technical specification document:

DSP-FK-BE-ME -DCR-501	Mechanical Design Criteria

DSP-FK-BE-ME -SPC-505	Specification for Air Preheater
DSP-FK-BE-ME -SPC-506	Specification for Oil Preheater
DSP-FK-BE-ME -PRC-511	Welding Procedure Specification
DSP-FK-BE-IN-SPC-604	Specification for I&C of Package Unit
DSP-FK-BE-PR-RPT-303	Site technical survey
DSP-FK-BE PI-SPC-426	Specification for Shop & Field Painting

2.3 In the event of a conflict of technical requirements within the requisition documents, the order of precedence shall be:

(a) Local Authority or Statutory Regulations

(b) Requisition I Purchase Order

(c) Reactor Data Sheet

(d) This specification

(e) Referenced Project Specifications

(f) Referenced Design Codes and Standards

3. Gerneral Description

Main process takes place in the reactor section. Carbon black particles and gaseous products of process are formed, all the reactions are interruped and main process stream is cooled to adequate temperature level for collection section entering.

Hard grade reactor consists of a furnace head (receiving chamber of preheated combustion air) and a furnace body lined with refractory materials. The furnace body inside is divided into several chambers: combustion chamber, throat, reaction and quenching chamber.

Carbon black is produced in reactor - furnaces by thermic decomposition of hydrocarbon feedstock in vapour state, at a very high reaction temperature (range 1400- 1800°C) . Heat, necessary for reactions of carbon black formation, is supplied by natural gas combustion, with an excess of combustion air.

Combustion air is furnished by air blower at a constant pressure. Preheated combustion air is fed to the reactors at a controlled flowrate mentioned in the data sheet.

Natural gas is fed to the reactor gas burners at controlled flow and it is burned inside combustion chamber with controlled excess of combustion air.

Quantity of oil feedstock for each reactor, as one of the most important process parameters, is metered by mass-flowmeter and controlled from the main control panel. The preheated oil feedstock, along with carbon black structure modifying additive, is atomized into stream of hot flue gases by spray nozzles, and reactions of carbon black formation take place inside reaction chamber.

Carbon black particles are generated by thermal decomposition of oil feedstock, but all the reactions result also in gaseous products of process.

Necessary reaction time is very short and ranges from a few milliseconds for hard grades up to a few tenth of seconds for some soft grades of carbon black.

The main process variables that influence the yield and quality of produced carbon black are:

- Amount and temperature of feedstock oil
- Amount and temperature of combustion air
- Amount and calorific value of natural gas
- Type and position of oil spray nozzles
- Quality of oil atomization
- Reactor additive quantity (concentration and flow rate)
- Primary quench position

Beside these direction influencing variables, there are also some indirect ones, such as: combustion ratio. Flame temperature, reacting gases velocity, geometery of reactor, etc.

In order to reduce the temperature of carbon black/ flue gas stream (700- 800°C) and to interrupt any further reaction between the hot gases and carbon black particles, process stream is quenched by direct sparying of water into quenching chamber of furnace, at carefully chosen distance from the oil inlet.

After the outlet of air-preheaters at a temperature of 640°C (max.), process stream is collected and fed into water quench column, where it is cooled to 260°C by direct spraying of water. This temperature is controlled at the desired level, which is determined by filter bags manufacturer requirements.

Reactor Additive System

Potassium carbonate (K_2CO_3) is used as carbon black structure modifying additive. Potassium carbonate solution is prepared by dissolving a certain amount of K_2CO_3 in a certain amount of demineralized water. Concentration of potassium carbonate solution depends on carbon black type produced. Reactor additive solution is metered into oil feedstock stream by reactor additive pump and at the controlled flowrate to keep carbon black structure within narrow limits.

4. Design

4.1 Reactor Shell

4.1.1 Functionally, hard grade reactor consists of a furnace head (receiving chamber of preheated combustion air) and of furnace body, lined with refractory materials and divided into several process chambers.

4.1.2 Constructively, H.G. reactor consists of steel shell, with numerous connection and of refractory material built process space, divided into several chambers.

4.1.3 For details of sections and compartments, please refer to “Preliminary General Arrangement for reactor, DSP-FK-BE-ME-DWG-528.

4.1.4 Fabrication details of shell is presented in section 6.

4.1.5 Thermal expansion of the reactor shell has to be considered in design. At least one side of reactor shall be free to expand.

4.1.6 In connection of reactor to air pre-heater, necessary thermal requirement shall be calculated and submitted by vendor.

4.1.7 Segments should be connected by plate flange. Expansion impact has to be taken into account.

4.1.8 For all nozzles on the reactor body, expansion joints/ housing shall be considered.

4.2 **Refractory**

4.2.1 General Requirements

The refractory shall be designed for continuous operation under the specified conditions.

Any work, which is reasonably supplied and is evidently necessary for satisfactory completion of work, shall be furnished as specifically shown on drawings and/or called for in the data sheets. The work shall be done in site

4.2.2 Refractory design shall meet minimum requirements and conditions specified on "Mechanical Data Sheet for Reactor", DSP-FK-BE-ME-DSH-521 and the design basis of the project.

Materials shall be identified in accordance with ASTM standard and the material specification should be sufficiently completed to permit technical evaluation.

4.2.3 Refractory Bricks

Vendor Shall submit shop/ detail drawings for refractory bricks in different segment. These drawins shall include quantity, arrangments and dimensions. Spare parts shall also be included.

Refractory bricks shall be in accordance with following standards:

ASTM C 27	Classification of Fire Clay and High-alumina Refractory Brick
ASTM C 155	Classification of Insulating Fire Brick
ASTM C 467	Classification of Mullite Refractories Properties
ASTM C 16	Testing Refractory Brick under Load at High Temperatures
ASTM C 24	Test for Pyrometric Cone Equivalent (PCE) of Refractory Materials
ASTM C 113	Test for Reheat Change of Refractory Brick
ASTM C 122	Panel Spelling Test for Super Duty Fireclay
ASTM C 133	Test for Cold Crushing Strength and Modulus of Rupture of Refractory Brick and Shapes
ASTM C 134	Test for Size and Bulk Density of Refractory Brick
ASTM C 210	Test for Reheat Change of Insulating Fire Brick
ASTM C 573	Chemical Analysis of Fireclay and High Alumina Refractories

4.2.4 Mullite Refractories

4.2.4.1 This refractory shall be used for reaction section with maximum hot face temperature of 1650 - 1800°C (continuous duty). This classification covers refractory products consisting predominantly of Mullite ($3A1_20_3$ $2Si0_2$) crystals formed by fusion.

4.2.4.2 Material used shall be standard shapes : straight, arch as well as special shapes, according to Data Sheets and particular Specifications.

4.2.4.3 Following categories shall be used :

- Mullite refractory
- Mullite refractory HF

4.2.5 Fireclay And High Alumina Refractory Bricks:

4.2.5.1 This refractory shall be used for quench and after quench sections with maximum hot face temperature of 1430° C. This classification covers machine-made fireclay and high alumina refractory.

4.2.5.2 Following categories shall be used :

- superduty fireclay bricks - HF
- superduty fireclay bricks
- intermediate fireclay bricks
- high alumina refractory bricks

4.2.6 Castables

Castable refractories are classified in ASTM C 401. The properties enumerated in the following paragraphs refers to the following methods of test:

ASTM C 134 Test for Size and Bulk Density of Refractory Brick

ASTM C 268 Test for Modulus of Rupture of Castable Refractories

ASTM C 269 Test for Permanent Linear Change on Firing of Castable Refractories

4.2.7 Refractory Mortars

Refractory mortars to be used shall be air-setting type, except for reactor bore section. The mortar properties are covered in the following ASTM methods of tests:

ASTM C 198 Test for cold bonding strength of airsetting refractory mortar (wet type)

ASTM C 199 Test for refractoriness of air-setting refractory mortar (wet type)

ASTM C 606 Test for Lap-joint Strength of Refractory Mortars at Elevated Temperatures

The mortars shall be delivered in sealed containers bearing marks indicating products name, bagging date, weight, source, check marks and manufacturer's trademark.

4.2.8 Installation

4.2.8.1 The interior surfaces of all vessels shall be thoroughly cleaned by power wire brushing or as may be required, to remove all loose mill scale, rust, dirt and/or any other foreign matter prior to the installation of the refractory materials.

4.2.8.2 All brickwork shall be laid up with butter - thin joints. All joints between bricks or between brick and metal surfaces shall be completely filled with cement, suitable shapes of bricks shall be used so that tight joints can be made with a minimum of cutting.

4.2.8.3 All air setting mortars shall be freshly mixed as needed, and where the mortar has taken his initial set prior to its use, it shall be discarded and not reworked for use on the job.

4.2.8.4 The work shall be in charge of a competent and experienced foreman. All work shall be done in a first-class manner by experienced workmen skilled in their trades.

4.2.8.5 To avoid temperature and humidity changes during installation, bricks and tiles should be stored near the job under the temperature conditions given below for approximately 48 hours before using.

4.2.8.6 The temperature of equipment that will be bricked-lined should be maintained between 5°C and 25 °C. Lower and higher temperatures will influence the correct curing of the mortar.

4.2.8.7 At temperatures below 5 °C the equipment should be heated, preferably electrically by hot air. This heating should avoid uncontrolled moisture development and create an unoppressive environment for the labour force.

4.2.8.8 If the equipment to be lined is at a temperature above 25 °C, the mortar shall be mixed in small quantities in some other location and kept between 15 °C and 20 °C before use. Temperatures which are too high shorten the 'pot-life' of the mortar.

4.2.8.9 On completion of the work, the Vendor shall thoroughly clean the inside of all vessels and equipment in which he has worked. All loose cement, brick cutting, scaffolding and any and all foreign material shall be removed, leaving the work in a clean and orderly condition.

4.2.8.10 Any work deemed not satisfactory by the site inspector will be rejected and the refractory Vendor shall remove such refractory and replace it in a manner suitable to the Client. All such work shall be done at the Vendor's expense.

4.2.8.11 Any material damaged through negligence in workmanship and/or in handling shall be repaired and/or replaced, if necessary, at the expense of Vendor

4.3 **Gas Burner**

4.3.1 Special designed tangential burner are used in H.G. reactor which tie together reactor shell and refractory lined combustion chamber. Reactor is supplied with gas burners positioned tangentialy on the perimeter of the combustion chamber. The burner consists of the following parts:

- Buner brick
- Brick support
- Air baffle
- Burner cone
- Burner support
- Gas supplying pipe with nozzles
- Glass covered peephole
- Inlet guide.

4.3.2 This burner type enables efficient mixing of various air/ gas ratios, which results in maximum temperature at very short flame. The burner gas pipe is tied to a gas supplying manifold by a flexible metal hose connection. It also enable easy lighting and burner firing inspection through the glass covered peephole.

4.3.3 Vendor shall introduce suitable considerations for ignition system for the client review and approval.

4.4 **Combastion Gas System**

4.4.1 Combastion gas system of reactor consists of the gas branching with belonging instrumentation, gas manifold surronding the reactor and flexible hose connection distributing natural gas to each gas burner.

4.4.2 Pressure switches, corresponding alarms on the MCP, and the automatic black valves are part of the reactor trip system. Override switch on the MCP enables bridging over the trip conditions of the shut-off valve. Local pressure indicator is located after control valve and indicates gas pressure at the burner.

4.4.3 Gas manifold surrounding the reactor enables good distribution of natural gas to each burner.

4.5 **Combustion Air System**

4.5.1 Combustion air system consists of air blower with fan, air manifold, branching to preheaters with hot air lines to reactor and belonging instrumentation.

4.5.2 Air temperature measuring device shall be used for air flowrate calculation and control.

4.5.3 At the discharge line of air blower, a control valve and pressure sensor are installed, which are used together with the controller on the MCP.

4.6 **Oil Spray Tube Assembly**

4.6.1 An oil spary tube assembly consists of the oil tube and oil spary nozzle at the tip and of retracting mechanism. Oil spray tube with nozzle passes through the jacket air line to the adequate depth inside combustion chamber.

4.6.2 Retracting mechanism consists of the compressed air forced piston, which enables lifting and lowering of the oil tube with spray nozzle.

4.6.3 This function is of importance, because the position of the oil spray nozzle inside of the combustion chamber is one of the process parameters. On the other hand, the retracting mechanism is controlled by trip system, which initates lifting of the oil tube with nozzle in case that oil is not passing through it preventing it to be burnt up.

4.6.4 The retracting mechanism is equipped with position switches and corresponding oil tube position indication on the main control panel. This mechnism is operated by trip system but indirectly it can be operated by hand switches. Lower oil tube position is normal operating condition and it corresponds to action “Oil to Reactor”. Upper Oil tube position corresponds to process condition “Oil to Return”.

4.6.5 The retracting mechanism is fastened at the reactor top cover and it is equiped with a spray nozzles depth measuring device.

4.6.6 For spray nozzle types, quantity and arrangement of oil sprays, process equipment data sheet for reactor, DSP-FK-BE-PR-DSH-311 is presented as recommendation. Vendor shall endorse.

4.7 **Water Quench Spray Lances**

4.7.1 There are two types of water quench spray lances which can be used at hard and soft reactors. Monofluid type consists of a steel pipe with an extension and axial type of spray nozzle on the tip.

4.7.2 This type is used as primary quench, for quick temperature lowering of the process stream. Monofluid spray nozzle is used at max. water pressure.

4.7.3 Bifluid quench spray lance consists of steam pipe, inside which is located water pipe and the bifluid nozzle on the tip. Bifluid spray nozzle may be used as secondary quench, for process stream temperature adjustment. They operate at ~3.4 bar of steam pressure and at 2-4 bar of water pressure range. One or several bifluid spray nozzles may be used, depending on the water quantity required and theperature of process strean after quenching.

4.7.4 Both of monofluid and bifluid sprays are allowed to be employed in secaondary quench section. Vendor has to provide his own design to receive approval from the Client/ MC.

4.7.5 These water quench spray lances (both types) are introduced into quenching zone of reactor through special designed connector with ball valve. Each reactor quenching position is equipped with such connector, what enables the insertion of a new nozzle or changing a nozzle during normal reactor operation.

4.7.6 Monofluid and bifluid water quench lances are flexibly tied to coresponding water or steam pipeline located along reactor quench zone.

4.8 **Reactor Additive System**

4.8.1 Reactor additive suystem consists of reactor additive drum, mixer, dosing pump and pipelines for process water and additive solution, with belonging fittings and instrumentation.

For more details please refer to process design basis, DSP-FK-BE-PR-DBS-301.

4.8.2 Reactor additive drum is made of plastic and it is equipped with several connections: DEMI water inlet, additive adding inlet, additive solution return, mixer position, sucking lance for dosing pump and drain with valve. Each drum is also equipped with local level indicator enabling accurate additive solution preparation.

4.8.3 Sucking lance of reactor additive pump contains low level switch which indicates additive solution low level on the main control panel. Start of the reactor additive dosing pump is enabled by override switch which bridges over trip condition causing pump stoppage. (Oil to return)

4.8.4 Change of additive dosing pump capacity can be done remotely by a controller from MCP but additive actual flowrate is measured at the discharg line and indicated on the MCP.

4.8.5 Additive solution line is flexiblly connected (by injection valve assembly) to oil feedstock line before conection to ractor.

4.8.6 Necessary data for K_2CO_3, is available on “Process flow diagram, DSP-FK-BE-PR-PFD-306”

4.9 SUPPORTS

4.9.1 Due to high operating temperature of the reactor and also its dimension, the inrease in legnth according to the thermal expansion shall be considered in design of the supporting saddles. Although the rolling saddles are the prefered design, sliding saddles may also be considered.

4.9.2 In case the saddles are designed as rolling saddles, propoer rails shall be considered.

4.9.3 Proper base plates material shall be considered for sliding saddles to prevent damages to the saddles.

PTFE / Teflon material may be considered as a aditional protective layer on basplate to ease sliding and prevent extra damages. Other materials can also be proposed by Vendor for the Client review and approval.

4.9.4 Vendor shall present his own document and calculation for the contractor approval but the guarantee of design will be in vendor scope of work.

4.9.5 Supports and bearing plates shall be continuously welded to the shell. Each saddle wrapper plate or section thereof shall have one air release hole 10mm diameter.

4.10 Control

4.10.1 Proper control strategies shall be considered for safe opration of reactor. All defects or fails in any sections or parts of reactor must initiate proper feedbacks to keep the rest of reactor safe of damages.

4.10.2 Vendor to advise his own control logic diagram.

5. Loads

5.1 DESIGN WEIGHT CLASSIFICATION

5.1.1 The following weights are to be determined and incorporated in all design calculations and general arrangement drawings. Fabricated weights shall computeed based on the finalized design of the reactor from which empty, operating, and test weights can then be more accurately established.

5.1.1.1 **Fabricated Weight** shall be the weight of the reactor including vessel supporting elements, nozzles, internal and external fixed attachments, and all other non-removable appurtenances, excluding insulation

5.1.1.2 **Shop Test Weight** shall be the fabricated weight.

5.1.1.3 **Erected Weight** shall be the fabricated weight plus any removable internal components, plus the weight of platforms, ladders, piping supported from reactor, insulation and all other removable external appurtenances.

5.1.1.4 **Operating Weight** shall be the erected weight plus refractory bricks, and weight of piping supported from the reactor

5.2 WIND, WEIGHT AND SEISMIC LOADINGS

5.2.1 Allowable load shall be according to the ASME section VIII, Div. 2.

5.2.2 Reactor shall be self supporting (i.e. without additional bracing or guys) and designed to withstand the design wind load based on the maximum vertical projection of exposed surfaces, which shall include, platforms, ladders, pipework and other equipment associated with the reactor.

5.2.3 Wind speed specified on the reactor data sheet shall be used for design.

5.2.4 Wind loads shall be determined in accordance with the requirements of the Uniform Building Code.

5.2.5 Reactor shall be designed for seismic loads as specified on the data sheets.

5.2.6 Eccentric moments induced by the weight of equipment supported from the reactor and attached piping, together with resultant moments due to piping thrusts, shall be additive to wind moments.

5.2.7 The reactor shall be designed to withstand the following combined loadings:

5.2.7.1 Totalled bending moment, internal design pressure, and empty weight at the coincident design temperature with the reactor in the corroded condition.

5.2.7.2 Totalled bending moment, external design pressure if applicable, and operating weight at the coincident design temperature with the reactor in the corroded condition.

5.2.7.3 Totalled bending moment and operating weight at the coincident design temperature (pressure shutdown) with the reactor in the corroded condition.

5.2.7.4 30% of wind moment plus eccentric moments and hydrostatic test pressure with the reactor in the corroded condition.

Coincident wind and earthquake loadings shall not be considered.

5.2.8 Reactor supports shall be designed for the following conditions of loading:

Wind or earthquake moment, whichever is the greater, plus other moment loadings, if applicable, and the operating weight for design of the support and its attachment weld to the reactor.

5.2.9 The maximum static deflection allowed shall be 1:200 of length when the vessel is subject to the design wind loading.

6. Fabrication

6.1 FORMING

6.1.1 Formed sections, shall be fully radiographed and stress-relieved after completion of all welding and forming, before welding to shells (according to Code). If the vessel is to be post weld heat treated, the head need only be radiographed before welding to the shell.

6.1.2 Hot spun heads shall, on completion, be stress relieved unless the vessel is fully stress relieved. Heat treatment of hot-pressed heads is not required.

6.1.3 The assessment of the metallurgical condition of formed heads shall be based on the materials of construction, and the selection of heat treatment requirements shall be based on the need to:

- Develop adequate strength
- Develop adequate resistance to fracture (i.e. toughness)
- Avoid formation of any undesirable metallurgical structures

6.2 CUTTING AND WELDING

6.2.1 Plates and other stock may be cut by machining, flame cutting or shearing.

6.2.2 Any materials which are cut by burning must be dressed back by grinding or machining by at least 3 mm.

6.2.3 Shearing may only be used on plate less than 25 mm thick, and enough extra material shall be left on the edge to permit machining, grinding or chipping to a depth of at least 50% of the thickness for stainless steels, or 25% for carbon and low alloy steels.

6.2.4 All weld preparations shall be checked for flaws, cracks, and laminations by 100% MPI or DPI techniques.

6.2.5 All welding shall be in accordance with the latest edition of the relevant design code and shall be electric fusion shielded arc or submerged arc unless otherwise stated. Only qualified procedures shall be used.

6.2.6 Only welders who are qualified, in accordance with code requirements, in the accepted welding procedures shall be employed on the subject vessel.

6.2.7 Welding electrodes shall deposit a composition compatible with the material being welded**. Full details of electrodes i.e. chemical composition and physical properties together with specification must be included in the welding procedures.**

6.2.8 When the ambient temperature is 0°c or below, the base metal shall be pre-heated to 15°C minimum before welding unless a higher pre-heat temperature is dictated by the code.

6.2.9 The VENDOR shall determine the degree of pre-heating required, if any, other than as dictated by the code to prevent cold cracking, excessive hardness in the heat-affected zone and excessive distortion.

6.2.10 Size of welds for all internal attachments shall include the corrosion allowance specified on the vessel data sheets.

6.2.11 Longitudinal welds in separate strakes of a vessel shell and meridional or chordal welds of heads joining the shell must not be aligned with one another, but must be staggered by a distance at least equal to three times the thickness of the thickest plate with a minimum displacement of 100 mm.

6.2.12 When welding heads from several plates, welds located on a chord shall not be more than 0.2 of the head diameters away from the center line of the head.

6.2.13 The position of longitudinal welds in horizontal vessels shall be in the upper 220 degrees of the vessel cross section.

6.2.14 All vessel seams shall be located to clear nozzles and manholes and, where practical, their reinforcement. Where in isolated cases reinforcing pads cover vessel seams, these shall be ground flush and fully radiographed for a distance of 150mm measured each side of the covered weld area prior to the attachment of the pad. Vessel seams shall also be located to clear lengthy internal attachment welds and any obstructions preventing examination of welds, such as saddle bearing plates, support brackets, etc... Where this is not possible the affected seams shall be treated as for seams covered by reinforcing pads.

6.2.15 The minimum distance between the edges of attachment welds and main seams, or between the edges of adjacent attachment welds shall be the greater of 50mm or three times the thickness of the main component (e.g. the shell).

6.2.16 When sound back-welding is not feasible due to inaccessibility, single welded joints which utilize a gas tungsten arc welded or gas metal arc welded root pass, shall be used.

6.2.17 Weld backing rings shall not be used except where internal access is not possible for a final closing seam and where prior agreement has been obtained from the CONTRACTOR.

6.2.18 The maximum weld deposit for any pass shall not exceed 6mm.

6.2.19 All welding, both externally and internally, shall be completed prior to any post weld heat treatment unless otherwise agreed with the VENDOR.

6.2.20 The reinforcement (i.e. height of weld cap) of weld seams of vessels shall not exceed the following values:

- For metal thickness up to 12 mm: 1.5 mm
- For metal thickness from 12 to 25mm: 2.5 mm
- For metal thickness from 25 to 50mm: 3.5 mm
- For metal thickness over 50mm 5.0mm

6.2.21 Sharp transfers in weld joints are not permissible. Edges of joints shall have a smooth transfer to base metal.

6.2.22 Vessels subject to cyclic loading shall have all full penetration butt welds ground smooth internally and externally and, all other welds ground so as to blend smoothly into the parent material.

6.3 NON-DESTRUCTIVE EXAMINATION

6.3.1 The extent of non-destructive testing (NDT) shall be as stated on the vessel data sheet, and in accordance with the Code. All non-destructive testing for code/process (i.e. vessels in sour service) acceptance purposes shall be performed after any post weld heat treatment.

6.3.2 The following abbreviations are used throughout this section:

Magnetic Particle Inspection (Wet)	MPI
Dye Penetrant Inspection	DPI
Ultrasonic Inspection	UT
Radiographic Testing	RT

6.3.3 More details and requirements are provided in NDT procedure DSP-FK-BE-ME-PRC-520.

6.3.4 The NDT techniques employed and defect acceptance levels shall meet the requirements of the relevant codes.

6.3.5 Any defects found during inspection shall be reported to the CLIENT. Where defects are to be repaired, the repair shall be to a procedure which has been approved by the CLIENT. Re examination shall include any additional radiographs or tests required by the applicable codes.

7. Lifting and Shipment

7.1.1 Reactor shall be provided with all required lifting and tailing lugs, to facilitate handling during transportation and erection at site.

7.1.2 Each compartment shall have separate lifting lugs.

7.1.3 Sling angles shall preferably be not less than 60 degrees to the horizontal, but shall never be less than 45 degrees.

7.1.4 VENDOR shall also check stresses generated in the reactor wall by the lifting lug.

7.1.5 Temporary steelwork for transportation, lift etc. shall be identified by color coding. Removal instructions shall be provided by the VENDOR.

7.1.6 Each compartment shall be prepared for shipment individually.

7.1.7 The refractory brick shall be packed separatly for installation on site.

7.1.8 Refractory materials shall be stored with protection from extreme weather conditions and exposure to sun. In winter, plastic mouldable refractory materials may freeze and must be thawed before use. This is done by removing only the outside packaging, not the foil, and storing in a warm place. Thawing may take several days; the material is ready when it can easily be deformed by hand.

7.1.9 “Packing, Marking and Shipping Procedure, DSP-FK-BE-ME-PRC-512” shall be followed by vendor.