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Technical Specification

“Delivery of cooling staves for Blast Furnace no. 2 in Dąbrowa Górnicza”

concerns the project entitled “Development and demonstration of an intelligent cooling system for a metallurgical unit by closing and integrating water circuits, increasing the operational reliability of the metallurgical process and improving the efficiency of industrial cooling water use.” (project no. POIR.01.01.01-00-0034/18), co-financed from the funds of the European Regional Development Fund and as part of the Smart Growth Operational Program 2014-2020, sub-measure 1.1.1 (the call for proposals organized by the National Centre for Research and Development, no. 2/1.1.1/2018)

This specification is attached as Annex 5. to the request for quotation no **1/034/2021**

ArcelorMittal Poland S.A.
Dąbrowa Górnicza

TABLE OF CONTENTS

1. INTRODUCTION	3
1.1. PROJECT OBJECTIVE	4
1.2. SPECIFICATION CONTENT	4
2. STANDARDS, UNITS OF MEASURE, NORMS and REGULATIONS	4
2.1. DOCUMENTATION STANDARDS	4
2.2. INVESTOR'S STANDARDS.....	5
3. ENVIRONMENT- RELATED DATA	5
4. TECHNICAL INFORMATION:	5
4.1. AVAILABLE BACKGROUND DOCUMENTATION	5
5. HEALTH & SAFETY	5
6. CONTRACTOR'S SCOPE OF WORK	6
6.1. WORKS OBJECT	6
6.2. WORKS SCOPE	6
6.2.1. Cast iron staves	6
6.2.2. Copper staves.....	13
6.2.3. Supervision on cast iron and copper staves erection.	17
6.2.4. Transportation	17
6.2.5. Binding rules and standards	18
6.3. OFFER-RELATED REQUIREMENTS	18
6.4. REQUIRED CONTENT OF THE TECHNICAL DOCUMENTATION SUPPLIED BY SERVICE PROVIDER:	19
7. WORKS PERFORMANCE DEADLINE, IMPLEMENTATION STAGES	19
8. WORKS SCHEDULE	19
8.1. PRELIMINARY SCHEDULE	19
8.2. DETAILED SCHEDULE	19
9. RIGHTS OF THE CUSTOMER	19
10. DELIVERY AND QUALITY GUARANTEE	20
11. PERFORMANCE PARAMETERS AND CONDITIONS FOR PAC (PROVISIONAL ACCEPTANCE CERTIFICATE) SIGNING	20
12. CONTACT PERSONS	25
13. OTHER TOPICS (NOT DISCUSSED ELSEWHERE).....	25
13.1. CONTRACTOR'S PROPERTY SECURITY	25
14. APPENDICES	25
1. Appendix 1 - Legal acts	25
2. Appendix 2 - Location and environmental data	25
3. Appendix 3 - BE drawings.....	25

SPECIFICATION NO. 1/034/2021

1. INTRODUCTION

ArcelorMittal Poland S.A. (AMP), as part of its project "Modernization of Blast Furnace No. 2" is interested in purchase and delivery of cast iron and copper cooling staves for Blast Furnace No. 2 (BF#2). Detailed scope of the works covered by this Request for Quotation is given below.

ArcelorMittal Poland S.A. (AMP) operates in various branches in Poland, mainly concentrating steel production in Krakow and in Dąbrowa Górnicza and other important production units that are responsible for the production of various types of steel products in Poland.

The subject matter of the contract indicated in this specification concerns the project entitled "Development and demonstration of an intelligent cooling system for a metallurgical unit by closing and integrating water circuits, increasing the operational reliability of the metallurgical process and improving the efficiency of industrial cooling water use." (project no. POIR.01.01.01-00-0034/18), co-financed from the funds of the European Regional Development Fund and as part of the Smart Growth Operational Program 2014-2020, sub-measure 1.1.1 (the call for proposals organized by the National Centre for Research and Development, no. 2/1.1.1/2018)

The subject of the contract is the purchase and delivery (in accordance with DDP INCOTERMS 2010) of cooling staves for blast furnace no 2 located in Dąbrowa Górnicza.

Due to the Company's obligation to apply the competition principle, this technical specification constitutes a detailed description of the subject matter of the contract allowing for the preparation of tenders by the Bidders.

This specification has been drawn up with the utmost care in order to provide a full, unambiguous and exhaustive description of the subject matter of the contract so as to enable economic operators to determine all their obligations and risks and to calculate the price and other elements of the offer in a responsible way.

All of the purchases, services and supplies which are the subject of this enquiry must be incorporated and cooperate with the existing infrastructure and equipment in the Company and also must meet the same technological standards. Therefore, the need to maintain the same technological conditions and the need to maintain the unification of equipment resulting from the expansion of the existing infrastructure have determined the provisions of this specification. The provisions applied are justified by the need to ensure the smooth running of the project. The provisions indicated do not impose an obligation on Economic Operators to apply the solutions indicated but only inform about minimal parameters and standards. Using certain types of solutions is not obligatory but only exemplary. The indications in relation to the expected technical parameters, as well as indications concerning specific types and manufacturers' names are of a general nature, referring only to sample indications of equivalent products and do not constitute the only acceptable solution. On this basis, the contracting authority shall accept equivalent solutions.

Bidders are expected to submit an offer taking into account the requirements of this Technical Specification

The offer must be complete in all respects and must include all components/devices necessary to achieve the sound design, operation and maintenance of the installation.

The Bidder must read this specification and ensure that the installation is technically feasible and also accept full responsibility for the guaranteed performance of the delivered installation and equipment in terms of efficiency, performance, smooth and reliable operation.

The detailed scope of the work subject to the Enquiry is presented later in this paper.

1.1. PROJECT OBJECTIVE

The purpose of the project is extend the BF2 useful life minimum by 20 years campaign. The investor intends to achieve this objective among other by purchasing and replacing of copper and cast iron cooling staves.

1.2. SPECIFICATION CONTENT

This specification provides the environment-related data, information on Investor's location in Dąbrowa Górnicza, required technical norms and standards, technical data of BF#2 in operation, scope of Contractor's works, Customer's rights, requirements related to Contractor's technical potential, preliminary works schedule, requirements related to availability, replaceability, quality and safety and other information as required for the purposes of the Technical Offer (e.g. function guarantee).

2. STANDARDS, UNITS OF MEASURE, NORMS and REGULATIONS

- 1) All other technical requirements should comply with the standards applied by ArcelorMittal Poland S.A., and should meet engineering standards such as DIN, ASME, GOST, BS and PN.
- 2) Contractor's devices and technologies will be supplied based on the Contractor's knowledge of technology and standards effective world-wide and in Poland.
- 3) Devices, materials and parts used for the repair and revamping works should meet all technical and safety standards required by Polish law.
- 4) Project information is given in units and dimensions of the international metric system.
- 5) List of actual legal acts is presented in appendix 1.

2.1. DOCUMENTATION STANDARDS

File formats - AMP standard:

1. Documents: *.doc, *.pdf, *.xls (Microsoft Word 2010, Adobe Reader, Microsoft Excel 2010);
2. Time schedules: *.mpp; (Microsoft Project 2010);
3. Mechanical documentation: *.dwg, *.dwt (AutoCAD ver. 13 or higher, Autodesk Design Review) is must;
4. Electrical documentation: *.zd1 ; (EPlan ver.5.5/P8);
5. Pictures, images: *.jpeg;

2.2. INVESTOR'S STANDARDS

The Contractor is required to be familiar with and respect Investor's standards, in particular H&S standards and performance standards (Investor's standards are available at www.arcelormittal.com/poland, tab "FOR CONTRACTORS"). Furthermore, Investor's standards are enclosed with the Contractor's Safety Manual and will be provided to the Contractor by the Investment Purchasing Office. The Contractor is obliged to respect and follow them at all times on a regular basis at all stages of the investment:

- ST 000 H&S Policy
- ST 001 Insulation
- ST 002 CONFINE SPACE
- ST 003 WORK AT HEIGHT
- ST 004 SECURE OF TRAIN RAILS
- ST 005 Audits
- ST 006 VEHICLES AND ROAD TRAFFIC
- ST 007 OVERHEAD CRANES AND LIFING EQUIPMENT
- ST 008 Contractor
- ST 009 Alarm
- ST 010 Safety indicators
- ST 011 Incident/Accident investigation
- ST 012 WORK AT GAZ HAZARDOUS AREA
- ST 014 HIRA (ang. Hazard Identification and Risk Assessment)
- ST 015 Golden Rules
- ST 018 Loading protection
- ST 201 H&S specification
- ST 301 Mobile phones

NOTE: In case norms/standards define different requirements for the same topic which comply with the requirements above, the stricter norms/standards should be applicable!

3. ENVIRONMENT- RELATED DATA

Investor's local environmental data for Dąbrowa Górnicza location, defined for project purposes, can be found in appendix 2 "Location and environmental data".

4. TECHNICAL INFORMATION:

4.1. AVAILABLE BACKGROUND DOCUMENTATION

- 1) Investor has Basic Engineering prepared by Primetals. It is attached to RFQ.
- 2) Background technical documentation is available in softcopy (PDF) or paper version. The cost of printing out the documentation necessary for Bid preparation is to be borne by the Potential Contractor.
- 3) Documentation provided by the Investor may not be complete, therefore it is necessary for Contractors to rely on their own stocktaking. Documentation provided by the Investor should not restrict the launch of works.

5. HEALTH & SAFETY

During the implementation of specific project phases, manufacturing and delivery to ArcelorMittal Poland S.A. Dąbrowa Górnicza Unit, the supplier has to fulfill safety

requirements defined in ArcelorMittal Poland S.A. documentation. For this scope, below points mainly refer to site visits and supervision during staves installation:

- 1) Works contractors, before they start work, must receive trainings in scope of OH&S and fire protection regulations effective at AMP;
- 2) Regulations on personnel, vehicle and material traffic effective in the premises of AMP must be followed;
- 3) OH&S and fire protection for the site and works must comply with the regulations effective at AMP.
- 4) During investment realization period at AMP site, supplier must respect and apply all H&S rules mentioned in H&S book, including all appendix described in Investor Standards mentioned in point 2.2.
- 5) Necessity to equip of all employees i.e. fire protection clothes, proper shoes, helmet with 4-point belt locked under the chin, safety glasses, gas detector CO and CO₂, in case of working at height - (individual) harness with safety ropes, shock absorber and other equipment which will be agreed during elaboration of project documentation or during execution at site.

6. CONTRACTOR'S SCOPE OF WORK

6.1. WORKS OBJECT

The purpose of these technical assumptions is to present the scope of works related to:

1. Preparation of detail engineering for cast iron and copper staves with accessories.
2. Delivery of cast iron staves with accessories. Staves are used for cooling blast furnace in the following zones: hearth, tuyeres line and shaft. AMP is interested in purchase 533 pcs. of cast iron staves.
3. Delivery of copper staves with accessories. Staves are used for cooling blast furnace in the following zones: tap hole area, bosh, belly and lower shaft. AMP is interested in purchase 165 pcs. of copper staves for rows: Bo6-S9 and in tap hole area.
4. Supervision on cast iron and copper staves installation. Contractor will cooperate with other company, which will be responsible for staves installation.

Cooling agent to be used: chemically treated soften water in a closed circuit with forced circulation.

Stave designs should include reusing existing or new designed furnace shell holes.

6.2. WORKS SCOPE

6.2.1. Cast iron staves

1) Design & scope of delivery

New type cooling staves are designed as cast-iron staves with embedded pipes (referred to as coils) through which water flow takes place.

At stave outlet there is a protective pipe for coils.

Cooling staves in the area of blast furnace shaft from the inside (BF inside) are provided with a surface having horizontal "swallow-tail" shaped recesses where ceramic bricks will be laid.

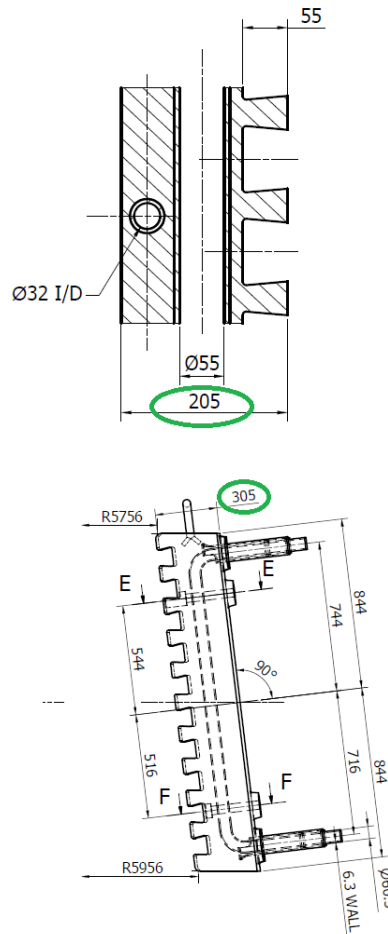
Cooling staves in the area of blast furnace hearth bottom, hearth and tuyeres line are provided with a smooth surface (without recesses).

Contractor will offer Detail Engineering and delivery of: cast-iron staves (with refractory inserts), compensation system, mounting system (contractor will proposed hollow bolts for tap hole area), casing, backfilling strips, pressure and temperature measurement pipes, templates and gauges for inspections purposes, all patterns, steel anchors (quantity and layout for each stove) All Detail Engineering will be based on Basic Engineering and RFQ delivered to the Contractor by ArcelorMittal Poland.

Contractor will deliver cast-iron staves in amounts as in the table below:

Row	Area	Type	Number of staves	Main stove thickness [mm]
H1	Hearth Staves	Type H-A	48	160
H2	Hearth Staves	Type H-A	30	160
H2	Taphole Staves	Type TH-G	1	160
H2	Taphole Staves	Type TH-H	1	160
H3	Hearth Staves	Type H-A	32	160
H3	Hearth Staves	Type H-B	2	160
H3	Taphole Staves	Type TH-J	1	160
H3	Taphole Staves	Type TH-K	1	160
H4	Hearth Staves	Type H-C	48	160
Tu5	Tuyere Staves	Type Tu5	32	160
S10	Stack Staves	S10	42	305
S11	Stack Staves	S11	42	305
S12	Stack Staves	S12	42	305
S13	Stack Staves	S13	42	305
S14	Stack Staves	Type S14-A	1	305
S14	Stack Staves	Type S14-B	3	305
S14	Stack Staves	Type S14-C	39	305
S15	Stack Staves	Type S15-A	34	305
S15	Stack Staves	Type S15-B	1	305
S15	Stack Staves	Type S15-C	1	305
S15	Stack Staves	Type S15-D	3	305
S15	Stack Staves	Type S15-E	3	305
S16	Stack Staves	Type S16-A	40	305
S16	Stack Staves	Type S16-B	1	305
S16	Stack Staves	Type S16-C	1	305
Tr17	Throat Staves	Type Tr17-A	22	335
Tr17	Throat Staves	Type Tr17-B	1	335
Tr17	Throat Staves	Type Tr17-C	1	335
Tr17	Throat Staves	Type Tr17-D	1	335
Tr17	Throat Staves	Type Tr17-E	1	335
Tr17	Throat Staves	Type Tr17-F	8	335
Tr17	Throat Staves	Type Tr17-G	8	335

Main staves thickness illustration:



Install support steel plates on the cold face of staves for gunning of the joints
Contractor will deliver mounting elements, steel anchors, including compensators, fixing elements, sealing elements, SiC bricks according to the prepared DE accepted by Customer.

Contractor will deliver complete drawings package in paper and electronic version, both languages (Polish, English).

Contractor will prepare schedule for the offer including: Detail Engineering period, acceptance of DE, Production schedule and delivery.

2) Material

2.1.Coils

At the stage of the offer Contractor will propose solutions for coils: protection coating, etching and passivation. For all of these methods there is a necessity to get ArcelorMittal Poland approval. Coils should be made of seamless pipes for boilers, according to DIN standard proposed by Contractor and accepted by ArcelorMittal Poland, of lower carbon content limit (0.16%). Dimensions of the pipe have to be taken from BE drawings delivered by ArcelorMittal Poland with this RFQ.

Pipes for coils must have material attestation and are subject to selection. Their surface must be smooth, without cracks, roll-ins, mechanical damage or corrosion, and without any signs that they have been repaired by a manufacturer.

What is allowed without necessary removal are single small scratches and outer surface irregularities and marks left by straightening on skew roller type straightener if they are not more than 0.2 mm deep.

2.2 Cooling stave casts

All cooling staves should be made of spheroid ferritic cast-iron (EN-GJS-400 15U (GGG40)) according to DIN EN 1563 standard, having the following composition and properties:

C = 3.3% ÷ 3.7%

Si = 1.8% ÷ 2.2%

S = max 0.02%

P = max 0.10%

Mn = max 0.3%

Mg ≥ 0.04 - 0.080%

Cr: <0.06%

Rm = ca. 400 MPa tensile strength

Ro2 = ca. 250 MPa yield strength

A5 above 15% elongation

Hardness = 130 ÷ 180 HB

Any deviations from the cast iron chemistry require acceptance from the ArcelorMittal Poland and the Engineering Office.

3) Manufacture and acceptance

3.1. Coils

Coils must be made according to documentation. The following dimension tolerances are acceptable:

Width tolerance according to Basic Engineering

Length tolerance according to Basic Engineering

After coil bending, pipe bends to be tested by ultrasounds.

It is allowed to join coils if:

- total coil length is greater than maximum pipe lengths available in the market as a standard,
- it is required by coil bending technology.

After bending, a coil should undergo a water pressure test at 1.5 MPa (15 atm) for a period of 10 minutes. In case of any leaks, a coil is not suitable for use.

After tightness tests, one should test whether a coil is not obstructed inside in any way whatsoever by blowing through it a polyamide ball (diameter from BE delivered by Customer). A coil must undergo stress relief annealing at 750°C in the period of 1 hour.

Then pipe ends φz (dimension from BE delivered by Customer) should be put on the coils in the places as outlined in the coil drawings. Pipe ends should be placed centrally relative to a coil and kept in position by three spot welds. Space between pipe end and coil should be filled in with fibrous insulation material proposed by Contractor and accepted by ArcelorMittal Poland.

A pipe end prepared this way must be transferred to a manufacturer of cooling staves.

3.2 Coils coating with a coat

For cooling staves coils should be covered with an Al_2O_3 and ceramic coat. Due to weak coating strength, it must be applied in the casting shop directly before pouring cast iron over the coils.

Before coating is applied, coils must be cleaned by shot-blasting according to standard proposed by Contractor and accepted by ArcelorMittal Poland. Immediately after shot blasting a coil must be coated to prevent any surface rust. Coating method will be agreed between customer and contractor.

Coating thickness must be from $0.25 \div 0.55$ mm. While coating application and coil transportation special precautions should be taken due to the fact that the coating is not resistant to impact or scratches.

Coating manufacturer is required to provide the following coating parameters:

- coating thickness
- melting point
- heat conductivity

and acceptance procedure for the coatings.

3.3 Acceptance Certificate

Acceptance conditions:

Ceramic coating quality should be defined in following steps:

- visual inspection
- coating thickness measurement

Visual inspection of coating quality involves checking whether there are no surface defects or any coating damage in 100% of coils.

Surface defects should be understood as gas pores, cavities, cracks and delaminations. Such defects eliminate a coil and it must not be used for the process of cast iron pouring over. Coating color and color homogeneity should be checked. Graphite color and coating hardness are a sign that moisture from an adhesive agent has evaporated.

Coating thickness to be measured by a thickness gauge A-91 or B-60.

Correct ceramic coating should be from $0.04 \mu m$ to $0.06 \mu m$ thick.

For coils coated with oxides, acceptance procedure should be as defined under 3.2. 100% of coil surfaces to be checked.

3.4. Cooling staves

Before coils are laid, a visual check should take place as to whether coil coatings have not been damaged in transportation.

Casts should be made according to structural drawings, maintaining width tolerance and length tolerance according to standard proposed by Contractor and accepted by Customer.

Casting radiuses which are not specified there should be made as $R = 10$ mm, and stave contour radiuses should be as $R = 30$ mm except the front edge (from the side of coil outlets). Cast staves should be removed from molds after cooling to a temperature of 400°C. While casting, cast iron samples are to be taken according to standard, proposed by Contractor and accepted by Customer, from each ladle used for casting.

Casting should be done in a cautious way, without cracks or pits on the cast or without coil melting.

Riser heads for cooling stave mounting bolts must be solid and smooth.

Dimensions of all cooling staves must be checked with a documentation by a manufacturer.

In the process of staves casting (spheroid ferritic cast iron), ready-made casts are to undergo stress relief annealing in order to eliminate any actual casting stresses.

Coils in molds should be put on supports to prevent their bending while casting. Maximum coil bending is 10 mm.

No internal or external defects on the side and inside surface (where recesses are) of a cooling stave are acceptable. The acceptable ones may be located on the outer surface of an unprocessed stave (on the coil outlet side):

according to manufacture defect class according to standard proposed by Contractor and accepted by Customer; (maximum depth of 5 mm),

unprocessed surface defects according standard proposed by Contractor and accepted by Customer;

- W-204 - orange peel
- W-202 - external pore:

What to assess	Where to asses	Allowable value
Pore depth (open pore)	Above cooling pipe	8 mm or less
	Between cooling pipes	15 mm or less
	Riser head - pipe inlet	15 mm or less
	Riser heat - bolt	20 mm or less
Pore surface (open pore)	Riser head - pipe inlet	20% or less
	Riser head - bolt	25% or less
	Total surface	3% or less

Each stave should be marked with a separate row and position number painted clearly in a bright paint on both stave sides.

3.5 Cooling stave checking

- Contractor will allow Customer the possibility of manufacturing inspection at the stage of zirconite and casting

- cast staves must undergo inspection and dimensions check with templates checking dimension tolerances;
- all staves must be checked in respect of contact with the contact surface using a template. The condition is fulfilled if three or four riser heads for bolt touch a template. If three riser heads touch a template, some rework by grinding should be done until a distance between a template and a riser head for bolt is less than 3 mm. Parallel, wall thickness tolerance of ± 6 mm is to be checked.
- defect rate class is acceptable according to standard proposed by Contractor and accepted by Customer;
- after casting a coil should be rechecked for whether it is not obstructed in any way whatsoever by blowing through it a polyamide ball diameter 36 for pipes φ z 60 mm,
- cast stave must undergo a pressure test by supplying water at 1.5 MPa (15 atm) to coils and sustaining this condition for around 10 minutes, and then pressure can be gently reduced to a working pressure of 0.6 MPa (6 atm) and a stave can be hit gently with a 0.75 kg hammer. During the test a stave must not show any symptoms of sweating, leakages or pressure drop
- after positive test results, inside coil walls should be degreased, pickled and passivated as specified under items 2 and 3 of standard proposed by Contractor and accepted by Customer, and then compressed air should be blown through and the coils should be secured against obstruction by plugging coil ends.
- The dimensions of “swallow tail” shaped recesses must be checked with a template.

A stave prepared in such a way can be transferred for shipment.

In case a stave does not meet the required conditions, a cast must be destroyed in a permanent way.

The customer will perform non-destructive test on randomly chosen cooling staves, that is will check cast iron structure, stresses and internal cast defects.

The Customer will perform destructive test on one stave. The Customer will pick the way of section cutting. In case a stave does not meet required conditions, a customer has right to reject all lot.

All the aforesaid requirements are subject to In-Plant Technical Inspection in the course of technical acceptance procedures.

Each stave should be provided with attestation specifying the following:

- cast iron chemistry test results,
- mechanical properties test results measures on samples from every ladle,
- results of pipes attestation tests,
- results of chemistry test results for pipes protection material and coating thickness,
- results of coil bend ultrasound tests,
- pressure test results,
- results of a visual inspection of a stave,
- cooling stave calibration,
- results of dimension tolerances measurements for cooling staves.

6.2.2. Copper staves

1) General Scope

This technical specification describes and defines the services to be provided to AM POLAND with regard to the:

- Engineering, manufacturing and delivery of the copper staves for the row Bo6, Be7, S8, S9 and tap hole staves in BF2.
- Including compensators, fixing elements (contractor will proposed hollow bolts for tap hole area), sealing elements, backfilling strips, distance pipes, thickness measurements, pressure measurement pipes and thermocouple studs provided with guiding pipe for thermocouples. Also, including the “state-of-art” for hot face protection for all these rows.

2) Engineering and documentation

The contractor has to explain how he will proceed to manufacture the stove coolers and how he will guarantee the tolerances.

The used solutions must incorporate the BAT’s (Best Available Techniques) of the steel sector. Besides staves must implement the following design details:

The extension and deadline to submit the documentation by the Contractor shall be in accordance with the following provisions:

3) Manufactures and supplies

a) General

The successful bidder, either through its own means and/or of others, shall perform the supply and manufacture of the copper staves for the tap holes area and the rows 6, 7, 8, 9 and their accessories.

The Contractor is responsible for the complete supply of equipment including manufacturing, testing, painting, packing, shipping and transport to AM POLAND.

The fact that some parts of the equipment and other services related to the supply may be subcontracted will in no way diminish the Contractor’s responsibility.

The name of the manufacturing unit has to be informed to AM POLAND.

The design of cooling staves shall be based on recently developed and continuously improved technique.

In total there will be:

- 30 staves manufactured for the tap holes. Those staves can be drilled or casted (hearth level)
- 9 staves manufactured for the row 6 (bosh level). These copper staves will have 4 cooling channels. Specific type of staves (thermocouple, thickness measurements, with groove for pressure gauge, or mixed) will be defined during DE with contractor.
- 42 staves manufactured for the row 7 (belly level). These copper staves will have 4 cooling channels.
- 42 staves manufactured for the row 8 (shaft level). These copper staves will have 4 cooling channels.
- 42 staves manufactured for the row 9 (shaft level). These copper staves will have 4 cooling channels and 1 serpentine pipe in second cooling layer

(serpentine pipe with maximum coverage of stove). Those staves shall be casted.

- And all the accessories for these staves

Row	Area	Type	Number of staves	Main stove thickness
H2	Taphole Staves	Type TH-A	7	80
H2	Taphole Staves	Type TH-B	7	80
H3	Taphole Staves	Type TH-C	4	80
H3	Taphole Staves	Type TH-D	4	80
H3	Taphole Staves	Type TH-E	4	80
H3	Taphole Staves	Type TH-F	4	80
Bo6	Bosh Staves	Type Bo6	9	140
Be7	Belly Staves	Type Be7	42	145
S8	Stack Staves	Type S8	42	145
S9	Stack Staves	Type S9	42	205

Advise comments and requests from AM POLAND expressed during the design stage will be taken in account as far as possible. Implementation will not relieve the contractor manufacturing quality and planning responsibility.

The drawings made by the contractor shall be transmitted to AM POLAND for comments. Only upon receipt of released for construction drawings, the contractor shall start the actual fabrication.

Important remark:

The Contractor will report frequently to AM POLAND to assure a fluent cooperation of engineering, manufacturing and delivery and to assure the delivery time.

The Contractor will also report the way they will do and have done the quality control.

b) Fixing and sealing elements

The fixing and sealing elements are adapted to the solicitation encountered in the zone in order to assure best performance. They are designed to be fully gastight and to minimize the introduction of stresses in cooling pipes and welds.

The contractor provides design and manufacturing of all sealing and fixing elements.

c) Materials

Cu staves: composition and properties similar to SE copper for all the staves as per DIN1787

The same quality is guaranteed for the two different production techniques.

High purity copper, purity > 99.9%

Conductivity: minimum 98% IACS for rolled staves

Conductivity: minimum 80% IACS for casted staves

Steel parts to be weld on Cu parts: Steel 35.8

d) Pipes

All pipes will have threaded ends for outside pipe connections, and must be protected by metallic caps for erection phase and storage.

The cooling pipes in casted S9 staves shall be Monel 400 or different

e) Staves

- Out-coming cooling pipes (for copper staves) have to be provided with steel sleeves to allow the welding of the compensators on site.
- The staves have to be delivered with metallic caps to protect the cooling pipes thread during transport and erection.
- Cooling channels have to be drilled from the bottom side of the copper stave. Then only plugs at the bottom are allowed (Bo6, Be7 and S8). Staves S9 have to be casted.
- The curvature of the staves according to the radius of the shell of the blast furnace,
- Protruding horizontal blade above the upper edge,
- Hot face protection for the staves S9 - 50% in upper half of stave with protruding metal elements beyond the ribs outline is obligatory.
- Other options of hot face protection for other rows which are also accepted:
 - Bolts in ribs
 - Proprietary technical solutions
 - Naked
- Min. thickness of cold face 15mm, min. thickness of hot face 20mm, Min. thickness of ribs 55mm. For S9 min. thickness of cold face 15mm of copper, min. thickness of hot face 20mm of copper, Min. thickness of ribs 55mm.
- Cylindrical cooling channels
- Improved plug design for staves Bo6, Be7, S8 and tap holes
- Vertical slicing
- Delivery of support steel plates on the cold face of staves for gunning of the joints
- Protection pipe for casted staves S9 staves
- Screw-in bolts on the hot face as additional protection

f) Identification of staves

All staves will be identified according the following procedure:

- At the cold side identification data engraved on a well determined location giving complete information about row n°, pattern type, n° in the given row and n° of cast of raw material.

Identification will be as follows:

- Two positions for n° of row: S2 ROW 6 / S3 ROW 9 / S4 ROW 9
- One position for the type of stave: A , B
- Two positions for n° of stave in row (01 to 42): 01
- Two positions for the number of the cast of raw material.
- At the hot side the same identification except cast number will be painted with indelible paint.
- The same identification shall be visible on the packages.

g) Tolerances on the staves

Dimensions, geometrical locations and positions of all types of holes, geometry length and shape of outlet and inlet tube will be made according the approved drawings and according the tolerances as indicated.

A template, contractor's design and delivery, will be used in the workshop to control all those dimensions and tolerances.

Special specified tolerances are as follows; as a general statement, tolerances are related to stave axes.

Length	± 2 mm
Width	± 2 mm
Thickness	± 1 mm
Flatness	± 2 mm/m
Lug (distance ring) height, for the lugs touching the shell	± 1 mm
Size of groove	± 0.5 mm
Drill for cooling channel	± 0.5 mm
Cooling channel position in stave body	± 1 mm
Straightness of cooling channel (width)	± 1 mm/1.000 mm
Inlet to outlet of pipe measured on the cold side surface	+0/-2 mm
Pipe length outside of stave, all pipes	± 5 mm
Position of outcoming pipes, in all directions at the tips	± 5 mm
Blowholes / porosity' s	not allowed
Depth of thermocouple hole	± 1 mm
Position of instrumentation facilities	± 1 mm
Position of fixing elements at tips	± 1 mm

h) Measure thickness cooper bar

Cooper bar will be installed on site the contractor will supply 4 cooper bar per row.

i) Welding

Welding has to be done following officially approved welding procedures, with officially approved welders for these procedures, and with utmost care to insure fully water and gas tightness of final product. The steel sleeve on the copper pipes has to be welded on both sides in minimal two welding runs, second run to start 180° from the starting point of the first weld and with overlapping of 20 mm.

Pressure test has to be done by drilling a hole in the sleeve prior to the welding. After pressure check, a welding spot must plug the drilling. The location of the point of drilling is indicated in the drawings of details.

j) Pickling and rinsing

Due to the heating of the stave by welding tubes and stops some oxidation inside the channels occurs. An appropriate pickling has to be done afterwards to remove the oxides.

k) Errors in design

If the contractor makes errors in design then the contractor shall be responsible and liable for every corrective action that may be necessary to remedy the impact of the error, both in design stage and manufacturing stage.

The approval by AM POLAND of design documents does not relieve contractor of this responsibility and obligation.

6.2.3. Supervision on cast iron and copper staves erection.

Contractor will offer supervision for staves installation during BF2 repair. Offer should include 30 days of supervision (24h/day, 7 days/week).

Contractor will cooperate with other company, which will be responsible for staves installation.

Technical scope of supervision:

1. Inspection of staves accessories and staves before installation:

- Inspection of gaskets,
- inspection of hot face elements,
- inspection of PINs,
- Inspection of threads,

2. Inspection during installation

- Inspection of shell openings,
- Inspection of lifting operation and installation of stave in proper position on shell,
- Inspection of staves fixing operation,
- Inspection of gap between cooling inlet/outlet and shell opening,
- Inspection of PIN ring and welding process
- Inspection of gaskets after stave installation
- Inspection of backfilling /ramming strips installation

6.2.4. Transportation

Contractor will ensure transport from place of manufacturing to one from three available destinations: Seaport in Rotterdam, Seaport in Gdynia or directly to Dąbrowa Górnicza. Offer has to include proposed price for each destination.

Before the delivery SiC bricks have to be installed in all staves as well as steel anchors (if applicable).

During the transportation staves need to be protected against dislocation. Particular plates have to be separated by means of wooden spacers.

During the loading operation it should be checked if the coil inlets are appropriately blinded (caps) and the ends not damaged.

- delivery in containers max. 20 ft,
- staves secured against displacement,
- attaching staves to the container, easy to remove from containers (disconnecting, cutting off),
- staves fastened (attached) to wooden pallets,
- staves on pallets with the possibility of unloading with a forklift,
- deliveries of cast iron and copper staves in separate shipments
- staves accessories in packages max. 3.5 t,

- shipment of containers to the Blast Furnace Plant in the morning, successively approx. 8 - 10 containers a day, detailed determination of deliveries and the number of containers, after customs clearance, notification of drivers,

6.2.5. Binding rules and standards

All Standards (DIN, EN, ISO, PN) needed to be proposed by Contractor at the stage of offer and accepted by Customer.

6.3. OFFER-RELATED REQUIREMENTS

- 1) Technical offer should include:
 - a. General description and information about the service offered;
 - b. Scope of works under the bid (with defined quantity);
 - c. List of elements/works and quantity;
 - d. Exclusions (work to be performed by the buyer);
 - e. Responsibility matrix (i.e. division of work which clearly specifies Seller's and Customer's scope);
 - f. Necessary drawings
 - g. Works schedule (on a weekly basis at least) with the milestones;
 - h. Performance parameters;
 - i. Submission of at least 1 credential issued by company for whom detail engineering for staves was prepared and cast iron and copper staves were delivered as a General Bidder from the last 5 years (name of the purchaser, location, value, year, description of staves, quantity). If it is not possible to provide a reference certificate, submit a declaration containing a reference list with a list of completed documentation and deliveries of cooling staves in the last 5 years. The list must contain: buyer's name, location, value, year, staves description, quantity and contact details of the buyer's representative (name, email address, telephone number) enabling AMP to validate the information contained in the reference list.
 - j. List of spare parts for at least two years of normal operation and for commissioning;
 - k. Declaration that Contractor's knowledge, experience and site visit are sufficient to perform the whole scope of work;
 - l. Declaration that the whole scope of work will comply with good construction practices and with the effective law;
 - m. Information on labor consumption related to task performance, in the break-up into individual areas;
 - n. Bid validity period;
 - o. List of potential subcontractors for AMP approval
 - p. Other information disclosed by the Contractor which does not include any cost data that could influence the quality of the offer.
- 2) Supplier will present in detail all the elements of their offer which vary from the technical conditions set forth here if they are not able to fully meet all conditions.
- 3) The offer in the final part must contain an index of all changes that will appear in the content as a result of technical meetings, arrangements. The index must contain a brief description of the change and the locations of the change in the offer text.

- 4) Indication of subcontractors or partners in the case of a consortium, together with an indication of the relevant work packages
- 5) The commercial part will have a price breakdown consistent with the breakdown of the request for quotation, including additionally for the supply of materials and labor.
- 6) Final offer must be prepared in English and Polish languages.

6.4. REQUIRED CONTENT OF THE TECHNICAL DOCUMENTATION SUPPLIED BY SERVICE PROVIDER:

- 1) Works schedule;
- 2) Manufacturing inspection documentation.
- 3) Quality Assurance Plan for Investor's approval;
- 4) Division of works into tasks being the responsibility of the Contractor and Customer;
- 5) List of spare part for 2 years period of standard operation
- 6) Minimum monthly progress reports prepared according to the Customer's guidelines and defining the percentage of works done relative to the plan;
- 7) Final report.

7. WORKS PERFORMANCE DEADLINE, IMPLEMENTATION STAGES

Contractor is obligated to perform the task no later than:
within 39 weeks from Contract signature - delivery of cooling staves to AMP.

8. WORKS SCHEDULE

The Contractor should deliver with the offer the draft works schedule for Investor's consultation and approval.

In time schedule all important milestones will be highlighted including preparation of DE, start of manufacturing, FAT, start and finish of shipment.

8.1. PRELIMINARY SCHEDULE

The offer should include a preliminary schedule with specific time slots in which the Contractor will provide the Investor with drawings, documents and other materials, as well as time slots for the implementation of the specific Investment phases. Schedule dates will be guaranteed by the Contractor and will be subject to specific commercial clauses in the Commercial Offer.

8.2. DETAILED SCHEDULE

Detailed schedule of the works scope should be provided for approval by the Investor as part of Contractor's work performance, taking into consideration all stages of the contract execution. This schedule should also include the description (specification) of the so-called critical path tasks and the so-called investment milestones.

9. RIGHTS OF THE CUSTOMER

- 1) All valuable materials /scrap/objects of archeological value recovered or found during works performance are the customer's property and will be handed over to them.
- 2) Customer reserves the right to restrict access to the plant for any person associated with the Contractor found to be e.g. under the influence of alcohol or in a condition that may create a threat to themselves and other people performing work or a group of people. Detailed information will be presented in Health & Safety Policy applied at ArcelorMittal. This policy shall constitute an integral part of the contract concluded with the Contractor.

10. DELIVERY AND QUALITY GUARANTEE

- 1) Delivered solutions will be free of any defects being the result of faulty engineering, materials and/or poor quality of manufacturing. The Contractor will guarantee the delivery by the date and in the form as defined in the order.
- 2) The Contractor will guarantee the use of the state-of-the-art solutions.
- 3) The Contractor will guarantee high quality of the structural solutions, high quality of materials in the proposed solutions and high quality of performance for all individual and assembled elements of equipment parts, specific machines and equipment, offered by them on the basis of the required performance guarantees defined in the specification of the offer.
- 4) Performance guarantee will cover all individual elements and weighing and metering systems, as far as their accuracy, nominal values/capacity and integrated operation are concerned.
- 5) The minimum warranty period expected by the Investor is 18 months from the moment of signing the Preliminary Acceptance Certificate.

11. PERFORMANCE PARAMETERS AND CONDITIONS FOR PAC (PROVISIONAL ACCEPTANCE CERTIFICATE) SIGNING

INSPECTION AND TEST PLAN FOR CAST IRON STAVES

Part of position	Test Item	Test Frequency	Acceptation Standard	Method or tool	Anomalies treatment	Report
Cooling pipe	Chemical composition & mechanical properties	Two samples of each type/bach	Steel grade: 10 (acc. GB/T8163-1999) $\sigma_s \geq 205 \text{MPa}$, $\sigma_b \geq 335 \text{MPa}$, $\delta_5 \geq 30\%$	Tensile test Chemical analysis	Reject	Y
	Tube size	Two check of each type/batch	(acc. GB/T8163-1999) Outside diameter: $\pm 1\%$ Wall thickness: $\pm 12,5\%$	Slide caliper	Reject	Y
	Bending of pipes - Shape & dimensions	100%	According to bending drawing	Jig	Check jig and repair mould	Record
	Bending of pipes - Bending radius	One check of each type	$R \pm 5$	Template	Repair mould	Record
	Ball test	100%	Straight pipe: $80\% X \phi_i$ Serpentine pipe: $65\% X \phi_i$	Plastic ball	Reject	Record
	Wall thickness of bending area	15% of each type	$t_b \geq 80\% X t$	UT	Reject	Y
	Cracks on bending area	100%	No cracks	MT	Reject	Y
	Cracks on the whole pipe	100%	Pressure test 15 bars held for 5min, no pressure drop	-	Reject	Record
	Sand blasting (SB)	100%	Min. Sa 2.5	Compare with standard sample	Sand blast again	Record

	Dry coating thickness measure and report: <ul style="list-style-type: none"> 4 points every 300mm on straight part and 4 points on each bend for straight pipe 4 points on each bend and 4 points between bends for serpentine pipe 	100%	1 st coat Al 0.05-0.15mm (2 nd coat Ceramic 0.20-0.40mm) Total: 0.25-0.55mm Do coating within 4 hours after sand blasting	Thickness detector	Reject	Y
Protecti on Tube	Chemical composition & mechanical properties	Two samples of each type/bach	Steel grade: 10 (acc. GB/T8163-1999) $\sigma_s \geq 205\text{MPa}$, $\sigma_b \geq 335\text{MPa}$, $\delta_5 \geq 25\%$	Tensile test Chemical analysis	Reject	Y
	Pipe size	Two check of each type/batch	(acc. GB/T8163-1999) Outside diameter: $\pm 1\%$ Wall thickness: $\pm 12,5\%$	Slide caliper	Reject or discuss	Y
	Widening of pipe opening, dimensions	100%	According to drawing	Measure	Repair and remanufacturing	Record
	Cracks on pipe widening	100%	No cracks	MT	Reject	Record
	Sand blasting (SB)	100%	Min. Sa 2.5	Compare with standard sample	Sand blast again	Record
	Dry coating thickness measure and report: 2 points on cast-in area for both internal and external of the tube	100%	1st coat Al 0.05-0.15mm (2nd coat Ceramic 0.20-0.40mm) Total: 0.25-0.55mm Do coating within 4 hours after sand blasting	Thickness detector	Too thin: More coating Too thick: 1. Only local: AMP decides 2. Large area: sand blast again and re-coat	Y
Thermo couple tube	Dry coating thickness	100%	Sane as protection tube	Thickness detector	-	-
Lifting lug & threaded block	Dry coating thickness	100	1st coal Al 0.05-0.15mm (2nd coat Ceramic 0.45-1.25 mm) Total: 0.50-1.40mm	Thickness detector	-	-
Stave cooler	Seal between protection pipe and cooling pipe	-	Ceramic fibre rope, asbestos free	-	Reject	Record
	Casting temperature	Each pouring	Target pouring temperature: EN-GJS-400 (GGG40): 1260-1290 °C	-	Adjust	Y
	Pouring duration	Each pouring	-	Stopwatch	-	Record
	Knock-out temperature	Each stave	Max. 500 °C	-	Adjust	Record
	Nitrogen protection	Each cooling pipe	4-5 m ³ /h on each pipe during casting for 30min, and then sand caps to be installed after casting	Flow meter	Adjust flow	-
	Mechanical properties	One for each heat	For EN-GJS-400 15U (GGG40) $\sigma_b \geq 370\text{MPa}$, $\delta \geq 11\%$	Tensile test	If any of test fail, re-test. If small deviations, concession request.	Y
	Metallurgical analysis	One for each heat	For EN-GJS-400 15U (GGG40): Ferrite content $\geq 90\%$, Graphite size > 4, Graphite type min. 80% type V+VI	Polished and etched samples	Concession request if small deviations	Y
	Chemical composition	One for each heat	For EN-GJS-400 15U (GGG40): C: 3.30-3.70% Si: 1.80-2.20% Mn: $\leq 0.30\%$ P: $\leq 0.10\%$	Spectrometer and/or wet analysis	Chemical analysis shall be considered subordinate to mechanical properties and	Y

			S: ≤0.02% Mg: 0.040-0.080% Cr: <0.06%		metallographic requirements. These figures are a target chemical composition. They are not the reason for rejection if the mechanical properties and microstructure are OK.	
Hydrostatic pressure test of pipes	100%	15 bars held for 15minutes, no pressure drop allowed	-	Reject	Y	
Ball test	100%	Straight pipe: 75%XØi Serpentine pipe: 60% XØi	Plastic ball	Re-test after pickling. Reject if fail.	Y	
Surface quality	100%	Hot face: Max. 5mm deep and less than 1% of surface Cold face: Depth: Max. 15mm deep just above pipes and max. 30 mm between pipes and on pipe boss and bolt boss Area: Max 5% of surface on single pipe boss and bolt boss, max. 15% of that boss area	VT	Within tolerance - remove defects by grinding/chiseling Out of tolerance - reject. Welding and resin repair is not allowed without AMP's approval.	-	
Position of cooling pipes inside stave along the thickness direction (4 points per straight pipe and 4 points per serpentine pipe)	100%	Tolerance (check from cold face): ± 15mm (for stave thickness >160mm) ±10mm (for stave thickness ≤160mm)	UT	Reject/Concession request if small deviations	Y	
Internal quality Detection and determination of internal shrinkage from hot and cold face	10% of each type	As per procedure D-00017295 GGG40: <50% loss in attenuation Through transmission achieved Internal defects: max. 5% cold face surface area	UT	Reject/discussion. Check another 10% of the staves.	Y	
Dimension and position tolerance	100%	1. Length +5/-10mm 2. Width ±6mm 3. Grooves size 0/+3mm 4. Distance between inlet and outlet of pipes: Vertical +0/-10mm 5. Pipe deviation on tips: ±10mm in all directions 6. Fixing element centerline: ±2mm 7. Position of thermocouples: ±3mm 8. Lugs touching the shell +0/+5mm 9. Free lugs +0/-5 mm	Template	Discuss	Y	
		1. Thermocouple well to hot face: ±3mm	Ruler/Template	Discuss	Y	
		Hole diameters on template: 1. Hole for	Ruler	Re-fabrication of template	-	

			protection tube: +14mm 2. Hole for thermocouple tube: +8mm 3. Hole for screw hole: +8mm			
Stave cooler	Welding of rings between cooling and protection tube	100%	EN 1291, level 3	MT	Grinding & re-welding	Y
	Bolt anchors - after casting	100%	According to drawing	Thread gauge/bolt	Repair / Discuss	Y
	Lift lugs test - before casting	100%	Check for cracks	MT	Reject	Y
	Lift lugs loading test - after casting	10% of each row	Load: 2 times stave weight	-	If any lifting lug fails, all lugs should be tested	Y
	Lift lugs visual inspection - after casting	100%	No grinding mark	VT	If with grinding mark, then loading test	Y
	Pickling & passivation of cooling pipes	100%	No presence of scale cinder and cover the pipe end with plastic cap after pickling	Endoscope	Re-pickling	-
	Destructive test	As agreement	<ul style="list-style-type: none"> • Extraction test of cooling pipes • Mechanical properties of cooling pipes: elongation >20% • Position of cooling pipe: <ul style="list-style-type: none"> ± 15mm (for stave thickness >160mm) ±10mm (for stave thickness ≤160mm) • Recarburization of cooling pipes: <ul style="list-style-type: none"> Carburization depth: ≤0.80mm • Recarburization of protection pipes: <ul style="list-style-type: none"> Carburization depth: ≤0.80mm 			Y
Packing	Cleanness inside pipes and holes (thread holes, protection tubes and cooling pipes)	100%	No spoil and covered with plastic caps	VT	Cleaning & covering	-

INSPECTION AND TEST PLAN FOR COPPER STAVES

All controls and inspections are part of CONTRACTOR's scope of work. AM POLAND or its formal designed inspector will always have the right to inspect the various manufacturing stages and witness all and any inspection and control. The contractor will inform AM

POLAND of scheduled inspections with enough time in advance. Inspection release notes to continue the work shall not release or reduce CONTRACTOR's responsibility. Possible visible or invisible defaults noticed later on will be promptly corrected by the contractor up to full satisfaction and no cost to AM POLAND.

Cu-material:

- Test samples for quality control and chemical analysis will be made on each casting charge.
- Prior to prepare the charge, a spot control will be made on the copper to determine the chemical analysis.

Control of the staves:

- All the staves will be controlled by the contractor's quality assurance services on dimensions and tolerances in order to deliver the certificates. Dimensional control will be made by means of a template (design, drawings and delivery on supplier's cost). For instance, the good contact of the lugs (distance pipes) onto the shell has to be checked against a centred plate simulating the blast furnace shell. The template has to be consistent during handling, preferably made of metal sheet.
- Certificates will be transmitted one week before an eventual visit of a buyer's delegation to control staves taken at random.
- Besides the main dimensions and positions, following items have to be checked with the template:
 - The position of the ends of the out coming pipes,
 - Length of the tubes
 - Angle between tube and cold surface
 - Angles of the different interdependent surfaces,
 - Angles of the holes for thermocouple, bolts and supporting pins
- Five staves row 6 BF"2", five staves row 7 BF"2", five staves row 8 BF"2", five staves row 9 BF"2" and eight tap hole staves at random will be controlled. Depending of the results the inspection will be extend to the complete supply.
- Dimensions and tolerance control.
- The threaded ends of the copper pipes shall be checked with a Go-NoGo gauge.
- The water passages in each Stave shall be checked and any residue, chips, etc. shall be removed. Endoscope inspection is required.
- Checking the holes for pin, threaded holes for bolts and lifting eye.
- Hydraulic testing. Each stave cooler shall be hydraulically tested at 15 bar pressure during 15 minutes. No pressure drop is allowed.
- Two (2) staves of each row shall be selected at random to and tested demonstrate the pressure drop.
- Ultra sonic test for cooling channel position. Control according to indicated tolerances (± 1 mm from centerline of stave).
- All (100%) welds must be visually checked and tested via dye penetrate and ultrasonic waves.
- Gas tightness control for steel sleeves welded on copper tubes for all the welds. No leakage will be allowed.
- After tightness tests, one should test whether a coil is not obstructed inside in any way whatsoever by blowing through it a polyamide ball (only S9)
- The contractor will explain how he proceeds to do this.

General appearance of the staves:

- No blow holes are allowed.
- No cracks are allowed.

Reject: If a stove cooler does not comply with the test conditions, it will be rejected and a new one will be made on supplier's expenses.

Tests and certificates

- DIN 50049.3.1B (EN 10204.3.1B) for the material.
- Welding procedures.
- Inspection of welds and test by dye penetrate and ultrasonic waves.
- Pressure test for each element, 15 bar and 15 min.
- Gas tightness test for each weld of the sleeves.
- Measuring inspection certificate with indication of tolerances per stove.
- Size and straighten inspection of the cooling channel.
- Visual inspection of machined surface.
- Visual inspection of raw surface.
- Certificate of conformity for final staves.
- Weight of all staves.

12. CONTACT PERSONS

Item	Name and surname	Responsibility	Plant/Department	Phone / e-mail
1	Marek Berliński	Support Manager - Technical Leader	BF Plant AMP DG, Al. J. Piłsudskiego 92 41 - 308 Dąbrowa Górnicza	+48 795 525 180 Marek.Berlinski@arcelormittal.com
2	Michał Kocot	Project Manager - Blast Furnaces Dept.		+48 32 776 89 49 / +48 608 360 025 Michal.Kocot@arcelormittal.com
3	Michał Kolasa	Project Manager - Engineering Office	Engineering Office Al. J. Piłsudskiego 92 41 - 308 Dąbrowa Górnicza	+48 32 776 87 30 / +48 668 850 792 Michal.Kolasa@arcelormittal.com
4	Marta Bodnar	Lead Buyer - Purchasing Office	EPO Al. J. Piłsudskiego 92 41 - 308 Dąbrowa Górnicza	+48 668 562 376 Marta.Bodnar@arcelormittal.com

13. OTHER TOPICS (NOT DISCUSSED ELSEWHERE)

13.1. CONTRACTOR'S PROPERTY SECURITY

In the course of the Investment's duration, the Contractor is responsible for securing their own property and the property of their subcontractors, parts, subassemblies and entire equipment stored in the Investor's premises and planned for project purposes in the period of commissioning and hand-over to the Investor.

14. APPENDICES

1. Appendix 1 - Legal acts
2. Appendix 2 - Location and environmental data
3. Appendix 3 - BE drawings