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Actual specification includes **19** pages

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## 1 OBJECTIVE

This specification pertains to the delivery of two new layer of selective catalytic reduction (SCR) catalyst for Šoštanj power plant (Owner). The Owner intends to add this catalyst to the SCR reactor during an outage scheduled **December** 2020. The catalyst is required to be onsite by **20.11.2020** for one layer (152 elements) and for second layer in April 2021 (152 elements). Liquidated damages will pertain to late deliveries as will be described subsequently. At the Owner's sole discretion, any failure of the Supplier to comply with the requirements of this specification may cause the Supplier's Proposal to be disqualified.

## 2 BACKGROUND

Šoštanj is equipped with a boiler originally manufactured by GE Power. Typically, local lignite is fired. This is a tower boiler with a name plate capacity of 600 MW. The boiler may be used as a base loaded or load following unit. Approximately 3 cold start-ups and shutdowns occur during the year. The unit starts up on LS oil which remains in service until four coal pulverizers are in service.

### 2.1 SCR System Description

The boiler is equipped with a one reactor SCR system originally designed by GE. The reactor is located in a high dust position between the economizer outlet and the air heater inlet. Flow through the catalyst is vertically downwards.

The SCR system is in operation year-round. The SCR system can operate in a load range from approximately 42% BMCR to 600 MW. The system is not equipped with an SCR bypass. The system is equipped with a static mixer in the flue gas inlet duct and with a ceramic dummy layer in the reactor upstream of the top catalyst layer. The SCR system is not equipped with outage lay-up provisions. The Supplier shall indicate in their proposal whether this has any impact on their guarantees or warranties.

Each reactor level can house 152 standard sized catalyst modules in a 19 x 8 array. The reactor is equipped with 3 catalyst support levels (numbered sequentially from bottom to top). Currently there is catalyst installed in levels 1, and 2 of the reactor.

The flue gas flow distribution at the SCR inlet was designed to be within the following limits:

Molar distribution ( $\text{NH}_3/\text{NO}_x$ ) =	±10%
Velocity distribution =	±15% absolute
Temperature distribution =	±10°C
Flue gas angle of entry =	±15° from vertical

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## 2.2 Ammonia Supply

The reagent used for the SCR system is 24,0% up to max 24,9% aqueous ammonia. The ammonia injection grid consists of a one control zones.

## 3 QUALITY OF GOODS (guaranteed chemical and mechanical lifetime)

To fulfill the quality of delivered goods the following services have to be provided by the Supplier:

- Determination of the catalyst composition.
- Catalyst module/frame design and drawings. Supplier to assure and certify that the module/frame design is compatible with the existing reactor design (without modification). Supplier to provide preliminary or example frame drawings with the Proposal.
- Current Material Safety Data Sheets (MSDS) provided with Proposal.
- Correction curve for SO<sub>2</sub> to SO<sub>3</sub> conversion rate versus temperature for the range of 300°C to 390°C. Additional SO<sub>2</sub> to SO<sub>3</sub> conversion rate curves versus flue gas flow rate, SO<sub>2</sub> concentration, SO<sub>3</sub> concentration, and oxygen content are required. The Supplier shall provide the correction curves with the Proposal.
- ~~Correction curve for activity versus temperature for the range of 300° to 420° C. Additional correction curves for activity versus moisture, flue gas velocity and oxygen content are required.~~ The Supplier shall provide the correction curves with the Proposal.
- Correction curves for catalyst pressure drop versus flue gas temperature and flue gas volumetric flow rate.
- Production QA/QC testing and documentation. Results to be used to determine preliminary compliance with guarantees for activity and conversion rate, but final compliance may be verified independently.
- Activity guarantee testing at the initial and end of the guaranteed catalyst lifetime.
- Design of seals between the catalyst frames and between the catalyst frames and the reactor walls. Supplier to provide preliminary or example seal drawings with the Proposal.
- On-site advisor for the installation of the catalyst (two on-site days). The Proposal shall list the per diem rates for additional field service work.
- Supplier to supply at site of the power plant up to 2 modules within 5 working days, in case some modules are damaged during installation.
- Catalyst sample test two times per year which consist of:
  - Activity test in bench reactor
  - SO<sub>2</sub>/SO<sub>3</sub> conversion rate test in bench reactor
  - Determination of specific surface area
  - Chemical analysis of the catalyst surface
  - Chemical analysis of the catalyst bulk

Supplier has to come on plant site in outage and take the required catalyst samples needed for analysis.

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## 4 SCOPE OF SUPPLY

The following are to be provided by the Supplier delivered to the site for Unit 6:

- Plate type catalyst packed in 304 steel element frames suitable for the operating temperature specified and temperatures up to 390 °C.
- Removable grates for each module.
- Operation and maintenance manuals (1 printed copy and one electronic copy) including procedures for catalyst installation and storage.
- Performance guarantee and mechanical warranty requirements described herein.
- Protective packaging of catalyst for storage and shipment to the site.
- Shipping and handling of the scope of supply to the plant site, DDP to site.

### 4.1 Work Excluded

The following items will be provided by the Owner.

- Installation of catalyst, seals, and cover grates.
- Ammonia injection grid tuning and reagent system.
- Field performance tests.

## 5 DESIGN CRITERIA

### 5.1 General

The specified catalyst must be suitable for operation in a **high dust SCR system** downstream of a lignite coal-fired boiler. **Catalyst elements must be manufactured specifically for the very challenging requirements of a lignite coal fired power plan. They must be designed to withstand the mechanical stress that is caused by dust concentrations, which are 2-3 as high as for typical hard coal fired power plants.** Acceptable catalyst types include plate types of demonstrated successful operation in such applications. All catalyst delivered shall be new and unused. Supplier shall provide documentation of successful full-scale applications in a similar environment for the catalyst selected with the Proposal.

The SO<sub>2</sub> to SO<sub>3</sub> conversion rate and catalyst activity of the fresh catalyst shall be guaranteed. The activity shall be guaranteed as high as possible while not exceeding an SO<sub>2</sub> to SO<sub>3</sub> conversion rate of 1 % **at 390 °C** with the design flow conditions.

The activity and conversion rate guarantee shall be verified in the catalyst Supplier's laboratory. The Supplier shall provide the test conditions for the activity and conversion rate test in the full bench reactor with the Proposal. The Owner reserves the right to determine the conversion rate of the added layer by field testing of the catalyst, and, by the Owners sole choice, determine the activity in a third party's full bench reactor. In the case of a discrepancy regarding activity results the tests will be conducted in a mutually agreed upon facility.

### 5.2 Catalyst Geometry and Design Requirements

#### Plate stack

Specific surface [m <sup>2</sup> /m <sup>3</sup> ]	313,8	±1%
Plates per stack	71	±4%
Plate thickness [mm]	0,73	+5%
Pitch [mm]	6,51	+5%
Plate distance [m]	5,78	+5%
Nr. of spacers per plate	4	/
Spacer contact area	5	/
Plate length with spacers [mm]	456	±1%
Plate height [mm]	570	±1%
Surface per element [m <sup>2</sup> ]	38,17	±1%
Metal mesh thickness [mm]	0,25	+1%
Density catalyst material [kg/m <sup>3</sup> ]	1800	±1%
Mesh material	SS 1.4016	/

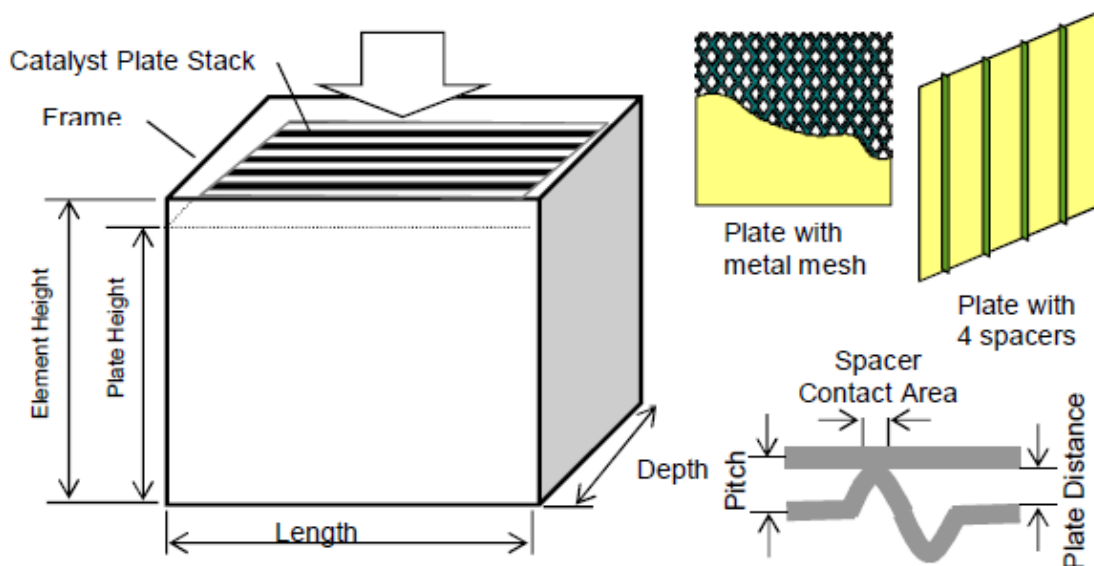
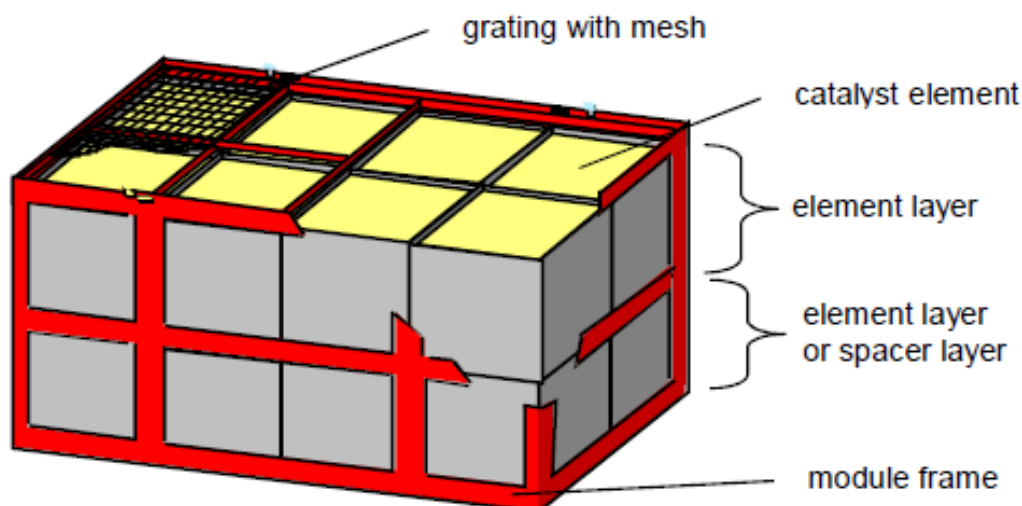
#### Element frame

Steel thickness [mm]	1	±5%
Length outside [mm]	464	±1%
Depth outside [mm]	464	±1%
Height	582	±1%

#### Plate type module (cross section 4 x 2 elements)

Plate height [mm]	570	±1%
Element height [mm]	582	±1%
Total Nr. Of element layer per module	2	/
Module length [mm]	1890	±1%
Module depth [mm]	950	±1%
Module height [mm]	1370	±1%
Total module weight [kg]	1080	±1%

In case of failure to meet the technical requirements in the abovementioned tables (with an acceptable tolerance of  $\pm$  %), the Contracting Authority will have to exclude the tender from further procedure.



The plate catalyst shall be manufactured such that chemically active components will not delaminate from the metallic substrates due to stresses induced by seismic, pressure, thermal or chemical conditions, or combinations thereof. This is a material aspect of the mechanical warranty. Plate catalyst frames shall consist of 1 or 2 sub-block layers of equivalent catalyst length. The use of 3 or more sub-blocks per layer will not be allowed.

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**IMPORTANT!** The position of lifting lugs for lifting device must be according to the drawing Plate type catalyst module.pdf.

### 5.3 Catalyst Frame Design

The catalyst frame design shall be of a “universal” size design with the approximate dimensions of one meter by two meters. The supplier shall submit a module drawing with his proposal. The catalyst sized for this application shall fit within the existing reactor without modification. Additional information can be provided to the Supplier upon request to ensure that the proper size of catalyst is supplied. The proper sizing of the module to fit within the reactor is the sole responsibility of the Supplier.

The catalyst module frame shall have a height of 1,370 mm. The maximum permissible weight of the catalyst module (clean condition) is 1,100 kg.

Each frame shall be designed with suitable handling provisions to allow for installation and removal of a frame. Lifting lugs which extend above the top of the cover grates shall not be used.

Catalyst frames shall feature angled deflectors at the bottom of the module on both short (nominally 1 meter) sides where the modules rest on the support beams. Dust deflectors shall be designed to minimize any potential for fly ash to build-up on support beams. Dust deflector shall be designed at an angle that is no more than 45° from vertical.

The catalyst module shall be designed to support the combined ash and pressure loading resulting from pluggage of 50 percent of the catalyst area for the entire depth of the catalyst element.

The catalyst frame shall be constructed of materials with suitable strength and mechanical properties to endure the rigors of operating at the full range of design conditions for more than 40,000 hours. Each frame shall be constructed of a suitable steel material so that it is compatible with the catalyst material and can handle the installation and removal processes. The catalyst supplier will clearly specify the steel material in his proposal, in order to bring evidence that the material is suitable for long term operation at the temperature conditions prevalent in the Šoštanj SCR reactor.

### 5.4 Test Elements

The catalyst frames shall be designed to allow the retrieval of test plates for laboratory analysis. For plate type catalyst it shall be possible to extract plate samples from any of the upper catalyst sub-blocks without manipulation of the steel sub-block frame.

### 5.5 Cover Grates

An individual cover grate shall be provided for each frame supplied. The cover grate shall be designed to allow maintenance duties to be performed without damage to the catalyst. The cover grate shall include



a sturdy steel frame, designed and suitable to walk on without bending or damage of the cover grate. The cover grate shall NOT be welded or permanently affixed to the catalyst frame and shall not interfere with or be overlapped by the catalyst module seals. The installation of the cover grate shall not require any clips or grinding. The cover grate shall be designed to lie flush and flat on top of the catalyst module. The cover grate shall be easily removed for inspection and maintenance of the catalyst. The cover grate design shall be clearly described in the Proposal. The cover grate shall be of suitable material for the specified operating conditions and shall function without significant deterioration for at least as long as the catalyst is in service. Cover grates that are made of expanded steel are not acceptable!

## **5.6 Catalyst Cleaning**

Steam soot blowers are installed for cleaning each catalyst layer. The catalyst design shall consider the dust loading specified in the flue gas data. Any qualifications regarding catalyst cleaning pertaining to guarantees shall be clearly stated in the Proposal.

## **5.7 Seals**

The Supplier shall supply the engineering and full delivery of the seal material in order to prevent flue gas from bypassing or leaking past the catalyst frames. The seal life shall be designed to last as long if not greater than the design life of the catalyst. The design shall allow for thermal expansion and contraction of the seal material without damaging the support structures, reactor walls or the catalyst frames. The seals shall be designed such that they do not interfere with removal of the cover grate.

## **5.8 Catalyst Lay-up**

The Supplier shall provide the temperature and humidity requirements, if any, to minimize deactivation when the SCR is not in service. The Supplier shall specify any special operating or lay-up requirements when the operating unit and reactor are out of service.

## **5.9 Flue Gas Data**

The following flue gas data shall be used for catalyst design.

		Reference coal	Worst coal max moisture	Worst coal max ash	Worst coal max sulphur
Load		100%	103%	103%	100%
Flue gas flow (wet)	Nm <sup>3</sup> /h	1.820.082	1.917.943	1.880.487	1.820.082
Flue gas flow (dry)	Nm <sup>3</sup> /h	1.468.842	1.510.204	1.495.575	1.468.842
O <sub>2</sub> - content in FG, dry	Vol.-%	2,43	2,43	2,43	2,43
FG-temperature upstream DeNOx	°C	386	391	390	390
Dust upstream DeNOx	g/Nm <sup>3</sup>	31,8	44,5	53,8	42,31
NO <sub>x</sub> in (6%O <sub>2</sub> ) dry	mg/Nm <sup>3</sup>	350	350	350	350
NO <sub>x</sub> out (6%O <sub>2</sub> ) dry	mg/Nm <sup>3</sup>	150	150	150	150
SO <sub>2</sub> upstream SCR (dry)	mg/Nm <sup>3</sup>	8092	8356	8342	13000
SO <sub>3</sub> upstream SCR (dry)	mg/Nm <sup>3</sup>	50,6	52,2	52,1	78

		reference coal	worst coal max moisture	Light fuel oil
		P	C'	
Load		42%	103% EOR	32%
flue gas flow (wet)	Nm <sup>3</sup> /h	1.065.758	1.999.686	744.960
flue gas flow (dry)	Nm <sup>3</sup> /h	902.146	1.580.220	692.918
O <sub>2</sub> -content in FG, dry	Vol.-%	7,02	2,76	10,77
FG-Temperature upstream DeNOx	°C	352	420	275
dust upstream DeNOx	g/Nm <sup>3</sup>	25,1	44,0	0
NO <sub>x</sub> in (6%O <sub>2</sub> )dry	mg/Nm <sup>3</sup>	400	350	350
NO <sub>x</sub> out (6%O <sub>2</sub> )dry	mg/Nm <sup>3</sup>	150	150	150
SO <sub>2</sub> upstream SCR (dry)	mg/Nm <sup>3</sup>	6067	8215	187
SO <sub>3</sub> upstream SCR (dry)	mg/Nm <sup>3</sup>	37,9	51,3	1,2

## 5.10 Fuel and Ash Data

The fuel is local lignite.

fuel analysis

			Fuel range	Reference coal	Worst coal max ash	Worst coal max moisture
				P	B'	C'
NCV	a.r.	MJ/kg	9,0 - 11,5	10,5	9,0	9,0
Moisture	a.r.	%	35,0 - 40,1	37,8	36,7	40,1
Ash	a.r.	%	12,3 - 23,5	16,3	23,5	19,8
Fixed Carbon	a.r.	%	15,8 - 23,7	20,2	17,5	17,6
Volatiles	a.r.	%	22,3 - 27,9	25,7	22,3	22,5
Sum	a.r.	%		100	100	100
Carbon C	a.r.	%		29,2	25,3	25,5
Hydrogen H	a.r.	%		2,35	2,04	2,05
Nitrogen N	a.r.	%	0,6 - 0,85	0,69	0,60	0,60
Sulphur S	a.r.	%	1,3 - 2,4	1,36	1,18	1,19
Oxygen O	a.r.	%		12,3	10,66	10,75
Chlorine Cl	a.r.	%		0,062	0,054	0,054
Sum	a.r.	%		100,1	100,0	100,0

ash analysis

			Coal range	Reference coal P
SiO <sub>2</sub>	in ash	%	36,0 – 50,0	44,2
Al <sub>2</sub> O <sub>3</sub>	in ash	%	15,0 – 25,0	21,0
TiO <sub>2</sub>	in ash	%	0,3 – 1,7	0,9
Fe <sub>2</sub> O <sub>3</sub>	in ash	%	7,0 – 10,0	8,5
CaO	in ash	%	9,0 – 20,0	16,5
MgO	in ash	%	1,5 – 4,0	2,5
SO <sub>3</sub>	in ash	%	1,0 – 6,0	3,4
Na <sub>2</sub> O	in ash	%	0,3 – 1,2	0,7
K <sub>2</sub> O	in ash	%	0,5 – 1,9	1,0
P <sub>2</sub> O <sub>5</sub>	in ash	%	< 0,5	
Sum	in ash	%		98,7

0,9%-1,73%

Light fuel oil (KO-EL) according to SIST 1011 for ignition and stabilisation.

Parameter	Unit	Value	Reference
Calorific value	MJ/kg	$\geq 42.600$	DIN 51900
Contamination (solid particles)	mg/kg	$\leq 30$	EN 12662
Water content	mg/kg	$\leq 200$	EN ISO 12937
Sulphur content	%	$\leq 0.20$	EN ISO 14596
Density (15°C)	kg/m <sup>3</sup>	$\leq 860$	EN ISO 3675 , 12185
Viscosity (20°C)	mm <sup>2</sup> /s	2.5-6.0	EN ISO 3104
Flame point	°C	$\geq 55$	EN ISO 2719

## 6 GUARANTEES

The design of the SCR catalyst layer shall be required to meet the performance guarantees specified without requiring washing, regeneration, or replacement for the required lifetime of the catalyst.

### 6.1 Activity

The Supplier shall guarantee catalyst activity prior to installation and plant performance after 24,000 hours of catalyst exposure to flue gas or a maximum of three years (aged catalyst); whichever occurs first. The guarantee shall be as listed in the proposal data. The activity test conditions shall be as defined in the proposal data. Quality assurance testing as described in Section 6 shall be used to verify the initial activity guarantee. The Owner shall also have the right to independently verify initial and aged (24,000 hours or **3 years**) catalyst activity by a third-party organization. The guaranteed activity and geometric surface area will be used to determine a guarantee basis reactive surface area or reactor potential that will be used for the evaluation of the Proposal.

### 6.2 SO<sub>2</sub>/SO<sub>3</sub> conversion rate

The Supplier guarantees a SO<sub>2</sub> to SO<sub>3</sub> conversion rate of the fresh catalyst of no more than 1 % **at 390°C** and the design flow conditions.

The SO<sub>2</sub> to SO<sub>3</sub> conversion rate is defined as:

SO<sub>3</sub> outlet concentration in PPM - SO<sub>3</sub> inlet concentration in PPM

SO<sub>2</sub> inlet concentration in PPM

Quality assurance testing as described in Section 6 shall be used to verify the catalyst SO<sub>2</sub> to SO<sub>3</sub> conversion rate guarantee. The Owner shall also have the right to independently verify the catalyst SO<sub>2</sub> to SO<sub>3</sub> conversion rate guarantee by plant measurements. The test may be witnessed by the Supplier.

### 6.3 Total geometrical surface area

The Supplier guarantees a total surface area no less than the value listed in the proposal data. This value will be checked and used for the evaluation of the proposals.

### 6.4 Operational Guarantee

The new catalyst shall not constrain the current operation of the boiler and SCR systems.

### 6.5 Pressure Drop

The Supplier guarantees that the pressure drop of the provided catalyst shall not exceed the value listed in the proposal data at design load operating conditions. The Owner will perform field testing at the plant to verify guaranteed performance. The test may be witnessed by the Supplier.

## 7 MECHANICAL WARRANTY

The Supplier shall provide their best possible mechanical warranty for the catalyst. The Supplier shall provide a mechanical warranty with specific remedy and terms. Limitations regarding regeneration, rejuvenation, and washing of the catalyst shall be clearly explained as part of the Proposal.

## 8 QUALITY ASSURANCE TESTING

The Supplier shall perform the following quality assurance testing at a minimum during manufacturing of the catalyst:

<u>Test Performed</u>	<u>Frequency</u>
Bench Catalyst Activity Test	Every 40 m <sup>3</sup> of catalyst
Bench SO <sub>2</sub> to SO <sub>3</sub> Conversion	Every 40 m <sup>3</sup> of catalyst
Chemical Composition Test	Every 40 m <sup>3</sup> of catalyst
Measurement of Physical Properties	Every 40 m <sup>3</sup> of catalyst
Measurement of Catalyst Geometry	Every 40 m <sup>3</sup> of catalyst
Measurement of Catalyst Dimensions	Every 40 m <sup>3</sup> of catalyst
Visual/Cosmetic Examination	100% of catalyst

The Supplier shall provide all test results to the Owner. The Owner shall be provided the opportunity to witness quality assurance testing. The Owner shall be provided two weeks advance notice of the start of quality assurance testing. Supplier shall provide information with the Proposal if the QA/QC program differs significantly from the above list and provide the differences. The Supplier shall provide acceptable manufacturing tolerances as required in the Proposal Data. Adherence to these tolerances will be strictly enforced.

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## 9 PERFORMANCE GUARANTEE TESTS AND REMEDIES

The Supplier shall conduct quality assurance testing per the requirements of Section 6 during production. The results of activity and conversion rate quality assurance testing shall be used to demonstrate preliminary compliance with performance guarantees prior to shipment of the catalyst. The Owner reserves the right to witness quality assurance testing. Quality assurance reports shall be submitted within 30 days of shipment.

The Owner reserves the right to have a third-party laboratory test catalyst samples for activity and SO<sub>2</sub>/SO<sub>3</sub> conversion rate to verify Supplier measurements. The samples will be removed by the Owner after delivery of the catalyst to site. The Supplier has the right to have someone present to witness catalyst test sample removal.

In the case of a discrepancy between Supplier's quality assurance results and the Supplier's third-party test results another set of tests will be conducted in a mutually agreed upon third party facility. The test results from the mutually agreed upon facility shall be binding. A list of suggested third party laboratories shall be provided by the Supplier with their proposal. The Owner has a preference for a third-party laboratory that has participated in the VGB round robin testing.

### 9.1 Fresh Catalyst Activity

A liquidated damage will be levied for every 1.0 Nm<sup>3</sup>/m<sup>2</sup>•h or fraction thereof that the measured fresh catalyst activity is below the guaranteed activity based on a measurement tolerance of 1.0 Nm<sup>3</sup>/m<sup>2</sup>•h. Should the fresh catalyst activity be more than 5.0 Nm<sup>3</sup>/m<sup>2</sup>•h below the guarantee value a full replacement of the catalyst will be required. The Owner reserves the right to have catalyst activity testing performed by a mutually acceptable third-party laboratory organization. The following schedule shall pertain to these liquidated damages and remedies.

- 1.0 Nm<sup>3</sup>/m<sup>2</sup>•h below guarantee = 3% of contract value.
- 2.0 Nm<sup>3</sup>/m<sup>2</sup>•h below guarantee = 7% of contract value.
- 3.0 Nm<sup>3</sup>/m<sup>2</sup>•h below guarantee = 13% of contract value.
- 4.0 Nm<sup>3</sup>/m<sup>2</sup>•h below guarantee = 20% of contract value.
- 5.0 Nm<sup>3</sup>/m<sup>2</sup>•h below guarantee = full replacement of catalyst.

For instance, should laboratory testing indicate after adjustment for off design conditions and measurement tolerance the average catalyst activity is 2.8 Nm<sup>3</sup>/m<sup>2</sup>•h lower than the guaranteed value a liquidated damage will be invoked by the Owner according to the following interpolation formula.

$$LD = \frac{2.8 - 2.0}{3.0 - 2.0} * (13\% - 7\%) + 7\% = 11.8\%$$

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If Owner's third part testing confirms that a full replacement of catalyst is required in accordance with the remedies noted in this section, the Supplier shall work with the Owner to provide the replacement catalyst in a timely manner that supports the Owner's outage schedule. The Supplier will be responsible for hauling away the original supplied catalyst.

## 9.2 End of Life Catalyst Activity

Two test samples will be measured at or near 24,000 hours for end of life activity testing (Ke). Alternatively, if the Owner believes the catalyst is not performing as design during the 24,000-hour life guarantee then two test samples will be removed for activity testing. A liquidated damage will be levied for every 1.0 Nm<sup>3</sup>/m<sup>2</sup>•h or fraction thereof that the measured end of life catalyst activity is below the guaranteed activity based on a measurement tolerance of 1.0 Nm<sup>3</sup>/m<sup>2</sup>•h. The Owner reserves the right to have catalyst activity testing performed by a mutually acceptable third-party laboratory organization. The following schedule shall pertain to these liquidated damages and remedies.

- 1.0 Nm<sup>3</sup>/m<sup>2</sup>•h below guarantee = 1% of contract value.
- 2.0 Nm<sup>3</sup>/m<sup>2</sup>•h below guarantee = 2% of contract value.
- 3.0 Nm<sup>3</sup>/m<sup>2</sup>•h below guarantee = 4% of contract value.
- 4.0 Nm<sup>3</sup>/m<sup>2</sup>•h below guarantee = 6% of contract value.
- 5.0 Nm<sup>3</sup>/m<sup>2</sup>•h below guarantee = 7% of contract value.

For instance, should laboratory testing indicate after adjustment for off design conditions and measurement tolerance the average catalyst activity is 1.5 Nm<sup>3</sup>/m<sup>2</sup>•h lower than the guaranteed value a liquidated damage will be invoked by the Owner according to the following interpolation formula.

$$LD = \frac{1.5 - 1.0}{2.0 - 1.0} * (2\% - 1\%) + 1\% = 1.5\%$$

## 9.3 Catalyst SO<sub>2</sub> to SO<sub>3</sub> Conversion Rate

A liquidated damage of 5% of the contract value will be levied per 0.1% higher than the fresh catalyst guaranteed SO<sub>2</sub> to SO<sub>3</sub> conversion rate. For instance, should field testing indicate after adjustment for off design conditions and after consideration of measurement tolerances that the average SO<sub>2</sub> to SO<sub>3</sub> conversion rate is 0.15% higher absolute than the guaranteed value a liquidated damage of 7.5% of the total contract value will be invoked by the Owner. If the measured conversion rate is greater than 0.5% above the guarantee value, then the Supplier shall replace the catalyst. Conversion rate liquidated damages are limited to 20% of the contract value.

## 9.4 Pressure Drop

The catalyst will be field tested by the Owner to determine compliance with the pressure drop guaranty requirements defined in this specification. The Supplier is responsible for the issuance of the performance or correction curves and for evaluating the test factors not covered by the specified correction curves defined in this specification. Pertinent correction curves shall be provided with the Supplier's proposal.

Field testing will be conducted at the Owners expense using plant instrumentation. The Owner will notify the Supplier two weeks prior to any tests being performed. The Supplier will be allowed the opportunity to observe the performance tests. Field testing will be performed within 90 days after catalyst installation. Each performance test shall be an average of three runs. It is the intent of the Owner to operate the unit in a stable manner at or near the design flow conditions.

The performance testing will be performed based on measuring the pressure drop across the new layer

Should measurements indicate an average pressure drop value greater than the guaranteed value a liquidated damage rate of € 13,500 per 5 mm wc will be invoked by the Owner. Pressure drop liquidated damages are limited to 10% of the contract value.

## **10 DATA SHEETS**

The following catalyst data table shall be provided by the Supplier as a Proposal submittal.

<b>Table 1: Plate Catalyst Data</b>	<b>Base Design</b>
Supplier:	
Catalyst Type:	
Catalyst Composition:	
Plate Substrate Mesh Material Type (e.g., 304 or 1.4301, etc.)	
Number of Frames	
Frame Material of Construction	
Element Boxes Material Type	
Frame Weight Including Catalyst, kg	
Volume, m <sup>3</sup>	
Element Layers/Module	
Catalyst Blocks/Element Layer	
Number of Plates/Box	
Block Width (plates running side to side), mm	
Block Depth (front to back of plate bundle), mm	
Plate Length, mm	
Pitch, mm	
Plate Wall Thickness, mm	
Number of Spacers (Waves)/Plate	
Spacer Contact Area, mm	
Catalyst Block Wall Steel Thickness, mm	



Specific Surface Area, m <sup>2</sup> /m <sup>3</sup>	
Open Frontal Area, %	
Linear Velocity in the Catalyst, m/s	
Space Velocity, Nm <sup>3</sup> / (h•m <sup>3</sup> )	
Area Velocity, m/h (Nm <sup>3</sup> basis)	
Maximum Operating Temperature, °C	
Maximum Temp Gradient, °C/ minute	
Maximum Temp Difference Catalyst to Flue Gas, °C	
Minimum Operating Temperature, °C	
Expected SO <sub>2</sub> /SO <sub>3</sub> Conversion Rate (390 °C and Ammonia On)	
Expected End of Life SO <sub>2</sub> /SO <sub>3</sub> Conversion Rate (390 °C and Ammonia On)	
Vanadium Content, %	

Table 2: Plate Catalyst Data	Base Design	
Supplier:		
Cover grate mesh material		
Cover grate opening size, mm		
Cover grate wire diameter, mm		
Cover grate removal method		
List Similar References. Provide unit name; size; fuel; temperature; year installed; and catalyst operating hours, pitch, length, NOx removal, ammonia slip, and conversion rate. Also provide contact information (name and phone number).	{Note: Append to proposal and designate location here.}	
Mechanical Warranty Duration, hr/yr	/	/
Detailed Terms of Mechanical Warranty	{Note: Append to proposal and designate location here.}	
Preferred 3 <sup>rd</sup> Party Laboratory (s) Name and Location		
Supplier Laboratory Location		
Description of how 2 spare modules will be supplied at site within 5 days	{Note: Append to proposal and designate location here.}	
Quality Assurance & Guaranty Testing Tolerances:		
Catalyst Activity Bench Reactor, Nm <sup>3</sup> /(h•m <sup>2</sup> )	+1.0	-1.0
SO <sub>2</sub> /SO <sub>3</sub> Conversion Rate Bench Reactor, %	+0.1	-0.1
Wall thickness, mm	+0.05	-0.05
Catalyst length, mm	+5	-5
Specific surface area, m <sup>3</sup> /m <sup>2</sup>	+5	-5
Pressure drop, mm wc	+2	-2

Supplier:	
Guarantees and Supporting Data:	Bench Reactor
Initial catalyst activity, Nm <sup>3</sup> /(h•m <sup>2</sup> )	
Aged (after 24,000 hours) catalyst activity, Nm <sup>3</sup> /(h•m <sup>2</sup> )	
Catalyst activity guarantee test conditions:	
Temperature, °C	390
Flow rate, Nm <sup>3</sup> /h	160
Area velocity, Nm <sup>3</sup> / m <sup>2</sup> h	
Oxygen and Moisture, %	
NO and SO <sub>2</sub> , ppm	
Molar Ratio, NH <sub>3</sub> /NOx	1.0
Test method for activity	Bench Reactor
SO <sub>2</sub> to SO <sub>3</sub> conversion rate guarantee at 390 °C	
Catalyst conversion rate guarantee test conditions:	
Temperature, °C	390
Flow rate, Nm <sup>3</sup> /h	160
Area velocity, Nm <sup>3</sup> / m <sup>2</sup> h	
Oxygen and Moisture, %	
NO and SO <sub>2</sub> , ppm	
Molar Ratio, NH <sub>3</sub> /NOx	0.0
Test method for conversion rate	Bench Reactor
Catalyst pressure loss guarantee, mm wc	
Average catalyst pluggage assumed for pressure loss guarantee, %	
Geometrical surface area guarantee, m <sup>2</sup> (value to exclude edge hardened surface area)	
Delivery Date, DDP to Site	

## 11 DELIVERY TIME

The Owner intends to add this catalyst to the SCR reactor during an outage scheduled for **December 2020**. The catalyst is required to be onsite by **20.11.2020** for one layer (152 elements) and for second layer (152 elements) in **15.04.2021**. Liquidated damages will pertain to late deliveries as will be described subsequently. At the Owner's sole discretion, any failure of the Supplier to comply with the requirements of this specification may cause the Supplier's Proposal to be disqualified.

	<b>TECHNICAL SPECIFICATION FOR SUPPLY OF TWO NEW SCR CATALYST LAYERS FOR UNIT 6</b>	Rev. 2 Date. 17.04.20 Page <b>19</b> of <b>19</b>
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## 12 CODES AND STANDARDS

The Supplier is responsible to determine, which codes and standards are applicable to the work provided. In addition to complying with all federal, state and local codes, the Supplier's Equipment shall comply with the relevant portions of the following codes:

ANSI	American National Standards Institute
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
CFR	Code of Federal Regulations, Title 29 - Labor, Chapter XVII Occupational Safety and Health Administration (OSHA), Parts 1910 and 1926
DIN	Deutsches Institut für Normung Standards
AWS and EN	American Welding Society or European Union Welding Standards dependent on location of fabrication
DOT	U.S. Department of Transportation
EPA	Environmental Protection Agency
VGB S-302-00-2013-04 DE	Anleitung zur Prüfung von DeNOx-Katalysatoren

**Korean, Indian, and Chinese codes and standards are not acceptable!**

## 13 ATTACHMENTS

- Plate type catalyst module.png
- General arrangement for SCR reactor.pdf
- DeNOx-Reactor-disposition.png