Wormington SCR Technical Feasibility Study

PJ20602 – NG SCR Pre-FEED Study

[redacted]

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Overview

In this document, [redacted] has proposed a SCR and CO catalyst solution that can be retrofitted to both Avon 1533 units at the National Grid Wormington site. The basis of the design has used exhaust data provided by National Grid and emissions limits stated in legislation.

[redacted] have opted to proceed with a vertical catalyst due to site space constraints. Each unit will have a dedicated exhaust stack and catalyst unit. The exhaust gases must be cooled before entering the catalyst unit, this will be achieved with the entrainment of ambient air. Entrainment removes the need for cooling fans.

This document refers to the previous pre-FEED study carried out by [redacted] on the National Grid Kirriemuir site. Differences between the design and values used have been discussed.

Revision History

Revision	**Date**	**Reason**
Preliminary	10/6/22	Draft release for initial review
A	22/6/22	Initial formal submission

Contents

References

Reference Number	Reference
1	Pre-FEED Study of Selective Catalytic Reduction Innovation Project – Technical and Commercial Report, Document No: GB00358019, [redacted] Control No: MX16008, date 27/03/2017
2	TQ_20602_008_R (Process Duty Point Data, attached at end of report)
3	TQ_20602_016 (Electricity costs)
4	TQ_20602_020 (Wormington SCR Pre-FEED Study Update 3, attached at end of report)
5	SCR_review_scopev5(16.11.21)
6	Dwg. 72600803000004 (ATEX Drawing)

Abbreviations

FEED	Front End Engineering Design
[redacted]	[redacted]
SCR	Selective Catalyst Reduction
NOx	Nitrogen Oxides
CO	Carbon Monoxide
IED	Industrial Emissions Directive
MCPD	Medium Combustion Plant Directive
GT	Gas Turbine
MW	Mega Watt
ATEX	Explosive Atmospheres
TQ	Technical Query
CFD	Computational Fluid Dynamics
CEMS	Continuous Emissions Monitoring System
DAHS	Data Acquisition & Handling System

1. Introduction

The purpose of this pre-FEED study is to assess the feasibility of introducing Selective Catalyst Reduction (SCR) and a CO Catalyst to existing gas turbine exhausts at the National Grid Wormington Compressor Station. The combined SCR and CO Catalyst will be known as the "Catalyst Unit" from this point on [redacted] will also note differences between this Wormington study and the [redacted] Kirriemuir report titled: *Pre-FEED Study of Selective Catalytic Reduction Innovation Project – Technical and Commercial Report,* [redacted] *27/03/2017.*

There is a need to look at catalyst technology as from January 1st 2016, plants with a thermal input greater than 50MW will need to comply with the IED regulations. There is one case, duty point C8, at Wormington that exceeds this thermal input value and accounts for approximately 5% of yearly running hours. The other cases considered have net thermal input values less than 50MW, meaning the MCPD could apply.

The current Avon 1533 gas turbines do not meet the new NOx emissions limits in their current configuration for both regulations above. The CO limits are not met if considering the IED. There are no minimum legislative CO limits when considering the MCPD.

[redacted] will design the SCR solution to meet the IED regulations in this Pre-FEED study as the worst-case scenario. However, it will be mentioned later in this document that the exhaust temperature of duty point C8 will be limited, this may bring down the net thermal input meaning the MCPD can be applied in a future FEED study.

2. Basis of Design

The following design parameters have been taken into consideration for the design of the combustion exhaust & catalyst unit. The catalyst unit inlet conditions differ from the values used in the [redacted] Kirriemuir report because [redacted] were provided different process duty points for the Wormington site. [redacted] have been provided with a greater maximum exhaust gas temperature at 654ºC (duty point 8), compared to the maximum temperature of 546ºC seen at Kirriemuir. After discussions with National Grid, the maximum exhaust gas temperature was limited to 600ºC as temperatures significantly above this are unrealistic for an Avon 1533 gas turbine. Furthermore, duty point C10 was excluded from this study because the approximate total shaft power required to meet C10 duty is 27.8 MW. This is only possible when the Electric VSD (15MW ISO rated) and the Avon gas turbine (12.34 MW ISO rated) are operating in lead configuration, with the ambient temperature at a level which allows the Avon output power to be at least 12.78 MW. [redacted] scope considers use of both Avon gas turbines in backup configuration to meet the full range of process duty, C10 represents a process duty that cannot be met by the gas turbines operating in parallel because they would require at least 13.89 MW per unit to achieve the PDS duty – higher than the capability of the Avon gas turbines even in the most favourable ambient conditions.

As the 600ºC maximum temperature at Wormington is higher than Kirriemuir, meaning the catalyst unit solution and specification of ancillary equipment may differ from the proposed design in the [redacted] report and some aspects may not be directly comparable.

2.1. Gas Turbine Data

Gas Turbine:	Avon 1533, rated at 12.34MW
Unit Number:	Unit A & B
Location:	Wormington, England

2.2. Catalyst Unit Inlet Conditions

Gas Flow:	36.67 – 78.92 kg/s
Temperature:	411 – 600 ^{o}C
NOx:	78.65 – 188.64 mg/m3
CO:	164.02 – 481 mg/m3

2.3. Catalyst Unit Emissions Limits

NOx Emissions:	35 mg/Nm3 (annual average)
CO Emissions:	100 mg/Nm3 (annual average)
NH3 Emissions:	3 mg/Nm3 (annual average)

2.4. Catalyst Unit Design Data

Cooling Air Flow (Entrainment):	27.5 kg/s (Max)
Catalyst Unit Total Gas Flow:	105011 – 305562 m3/hr
Catalyst Unit Air Temperature:	411.13 – 454.44^{o}C
Reagent Selected:	Aqueous Ammonia
Reagent Concentration:	24.5% by weight
NOx Removal:	55.50 – 81.45%
Catalyst Unit Voltage:	400V/3Ph/50Hz
Hours of Operation:	2500 hours per year (Base Case)

2.5. Catalyst Unit System Performance

NOx Emissions:	35 mg/m^3 Annual average
CO Emissions:	100 mg/m^3 Annual average
NH3 Emissions:	3 mg/m^3 Annual average
Pressure Drop of Catalyst Unit:	<=6.9 mbar
Reagent Flowrate:	9 – 60 kg/hr

Compressed Air Consumption (Maximum Steady State):	1 SCFM
Compressed Air Consumption (Maximum Instantaneous):	5 SCFM

2.6. Environmental Design Data

Site Temperature Range:	-20 to +40 ^{o}C
Relative Humidity:	Up to 100%

2.7. Design Codes

Design Code:	In accordance with Eurocode EC0, BS EN 1990:2002
Fabrication & Execution Code:	In accordance with BS EN 1090-2:2009 & BS EN ISO 3834-2:2005.
NDE Requirements:	NDE requirements in line with Eurocode EC0, BS EN1990:2002 & [redacted] EI-096
Structural Code:	In accordance with Eurocode EC3, BS EN 1993:2007
Access Code:	In accordance with BS EN ISO 14122:2010
Load Combinations:	In accordance with Eurocode EC1, BS EN 1991-4:2006
Operating Effective Wind Speeds:	In accordance with Eurocode EC1, BS EN 1991-4:2006
Snow and Ice / Maintenance (access) Loads:	In accordance with Eurocode EC1, BS EN 1991-4:2006
Seismic g Loads:	In accordance with Eurocode EC8, BS EN 1998-1:2004
PED:	Equipment to be supplied in accordance with the Pressure Equipment Directive 97/23/EC. This product may be used within the European Economic Area and is subject to operating pressures above 0.5 barg, therefore the product and associated documentation must adhere to the full requirements of the PED.

2.8. Electrical

Equipment Zone Area:	Zone II
Electrical Code:	In accordance with BS EN 7671:2008

Earthing Code:	In accordance with BS EN 7430:2011
CE Marking:	Required
ATEX:	EU ATEX directives 94/9/EC and 1999/92/EC must be adhered to such that the equipment is suitable for the automatic operation and protections of rotating machinery in a Category 3 hazardous area.

2.9. Noise Design Data

[redacted] propose that the new exhaust system should have an 85dB(A) noise limit. This will be an average at 1m from the new exhaust and 1.5m above grade (ground level).

Similarly, to [redacted] if this pre-FEED study progresses to a FEED study, [redacted] propose to carry out a noise assessment survey and reverse engineer the exhaust package to meet the noise level requirements. During FEED study stage, the acoustic attenuation of the catalyst unit should be determined and National Grid will also have to confirm the required noise limit.

2.10. Load Conditions

For the basis of design, 9 process duty points have been considered. The values seen in Table 1, are the critical parameters needed to specify the catalyst unit. These values were provided by National Grid in TQ20602_008_R.

Note, as stated in Section 2. Basis of Design, the maximum exhaust temperatures were limited to 600^{o}C because temperatures higher than this are unrealistic for an Avon 1533.

Table 1: Load Conditions of the 9 Process Duty Points

Inlet Exhaust Gas Conditions	**Case 1**	**Case 2**	**Case 3**	**Case 4**	**Case 5**	**Case 6**	**Case 7**	**Case 8**	**Case 9**
Fuel Type:	Natural Gas								
Operating Hours / Year Base:	353	235	588	294	529	59	235	118	59
Operating Hours / Year Mild Winter:	141	94	235	118	212	24	94	47	24
Operating Hours / Year Severe Winter:	459	306	765	382	688	76	306	153	76
Exhaust Mass Flow Rate (kg/s):	36.67	55.73	68.05	55.84	54.75	62.12	70.99	78.92	69.18
Gas Temp at Catalyst Face (C)	411.13	520.89	591.82	521.51	515.25	557.68	600	600	598.37
Inlet NOx, mg/m3	78.65	128.27	160.33	128.54	125.72	144.90	168.00	188.64	163.29
Inlet NOx, kg/s	5.77	14.30	21.82	14.35	13.77	18.00	23.85	29.78	22.59
Inlet CO, mg/m3	481.00	288.29	214.56	287.54	295.23	247.29	199.80	164.02	208.76
Inlet CO, kg/s	35.27	32.13	29.20	32.11	32.33	30.72	28.37	25.89	28.89
Outlet Emissions Requirements	**Case 1**	**Case 2**	**Case 3**	**Case 4**	**Case 5**	**Case 6**	**Case 7**	**Case 8**	**Case 9**
Outlet NOx, mg/Nm3	35mg/Nm3 (annual average)	35mg/Nm3 (annual average)	35mg/Nm3 (annual average)	35mg/Nm3 (annual average)	35mg/Nm3 (annual average)	35mg/Nm3 (annual average)	35mg/Nm3 (annual average)	35mg/Nm3 (annual average)	35mg/Nm3 (annual average)
Outlet CO, mg/Nm3	100mg/Nm3 (annual average)	100mg/Nm3 (annual average)	100mg/Nm3 (annual average)	100mg/Nm3 (annual average)	100mg/Nm3 (annual average)	100mg/Nm3 (annual average)	100mg/Nm3 (annual average)	100mg/Nm3 (annual average)	100mg/Nm3 (annual average)
Outlet NH_3 slip, mg/Nm3	3mg/Nm3 (annual average)	3mg/Nm3 (annual average)	3mg/Nm3 (annual average)	3mg/Nm3 (annual average)	3mg/Nm3 (annual average)	3mg/Nm3 (annual average)	3mg/Nm3 (annual average)	3mg/Nm3 (annual average)	3mg/Nm3 (annual average)

3. Equipment Description

[redacted] have chosen to cool the exhaust gases using air entrainment. The exhaust gases need to be at or below 454°C so not to degrade the catalyst bed. Due to the higher temperatures seen at the Wormington site, a 600kW fan was initially needed to cool the exhaust gases sufficiently. This electrical capacity was not available on site and the fans would be uneconomical to run.

[redacted] have chosen a vertical exhaust system as space constraints at the Wormington Site means that it is not possible to position a horizontal catalyst without compromising turbine removal or other site activities. This decision was not influenced by the initial 600kW fan sizing estimate.

All sub-sections within Section 3, apart from Section 3.5, are [redacted] designs. Section 3.5 is derived from [redacted] catalyst supply partner.

3.1. Venturi Nozzle

The existing exhaust stack is to be removed and discarded in accordance with local disposal regulations.

The gas turbine outlet will interface with a new spool piece which guides the exhaust gases external to the enclosure and act as a venturi nozzle. The outer circumference of the venturi nozzle will act as the inner ring of the circular silencer that allows air to enter the plenum and be entrained into the exhaust gas flow. The ring will have perforate on the outer surface and filled with acoustic mineral wool behind a permeable glass cloth. See drawing 1600-000230 Section B-B.

Fabricated from 10mm S355J2 carbon steel. Perforate to be 2mm carbon steel.

Surface treatment: Aluminium metal sprayed with high temperature sealer.

3.2. Plenum

The plenum will surround the venturi nozzle and annulus. The main purpose of the plenum is to provide environmental (wind and rain) protection to the venturi. The bottom section of the plenum will act as the outer ring of the circular silencer. The ring will have perforate on the inner surface and filled with acoustic mineral wool behind a permeable glass cloth.

Fabricated from 6mm S355J2 carbon steel. Perforate to be 2mm carbon steel.

Surface treatment: Aluminium metal sprayed with high temperature sealer.

3.3. Transition and Annulus

An annulus, part of the venturi section, will be situated at the bottom of the transition. The transition will be free floating at the bottom and interface with the 6.7 x 6.7m catalyst unit at the top. The annulus will be situated one times the diameter of the venturi nozzle above the venturi nozzle exit face. A circular hollow section band will be placed around the circumference of the annulus entry face to smooth entering air. Within the transitioning section, a pepper pot will be used to evenly mix and distribute the flow. Further CFD analysis of the pepper pot design is required to ensure an even and well distributed flow.

The transition will be internally lined with mineral wool insulation and stainless steel cladding sheets.

Transition casing to be fabricated from 6mm S355J2 carbon steel. Stainless steel cladding sheets will be S/S 321, this has been chosen as it displays higher corrosion and work resistance between 400 - 800°C.

Surface treatment: Carbon steel to be aluminium metal sprayed with high temperature sealer. Stainless steel to be left self-finish.

3.4. Support Steelwork

The steelwork will be used to support the entire exhaust stack. Support interfaces to be defined during detailed design.

Fabricated from S275J2 or S355J2 carbon steel dependant on section sizes. J2 required for the minimum ambient conditions experienced on site (-20^{o}C).

Surface finish: Hot dipped galvanised.

3.5. Catalyst Unit

3.5.1. Flow Distribution Grid

A further flow distribution grid can be located in the catalyst unit if an even and distributed flow is not completely achieved by the pepper pot. The flow distribution grid is not included in the catalyst unit quote.

3.5.2. Vertical Catalyst Section

This section houses the multi-pollutant catalyst. It will have a cross section of 6.7m x 6.7m to minimise the back pressure on the gas turbine and will be 4m high.

Fabricated from stainless steel, grade and finish to be confirmed during detailed design.

3.5.3. Catalyst

The catalyst will be a multi-pollutant catalyst. This enables the reduction of NOx and CO emission using only one catalyst bed. Each catalyst module will be 3.25 x 1.65 x 0.89 m (W x L x D, Depth in flow direction) in size. There will be a total of 8 catalyst modules, arranged in a 2 x 4 grid, in the catalyst bed.

3.5.4. Catalyst Test Coupons

Test coupons, similarly to the [redacted] report, are used to monitor and assess catalyst degradation. The test coupons can be removed and sent away for testing. Spare coupons are provided for this testing period.

3.5.5. Ammonia Vaporisation Skid

The ammonia vaporiser, injection fans and related ammonia injection equipment are mounted on the ammonia vaporisation skid.

Fabricated from S275J2 or S355J2 carbon steel dependant on section sizes and hot dipped galvanised.

3.5.6. Ammonia Vaporiser

The ammonia vaporiser turns the 24.5% aqueous ammonia into vapor. This is done using compressed air and turbine exhaust gases. There is only one ammonia vaporiser per catalyst unit. The temperature of the ammonia is initially raised by an immersion heater. The dilution chamber, where the air is mixed with the ammonia, will be made from SA-36.

3.5.7. Blowers

Two 100% duty blowers will be used to blow the vaporised ammonia into the ammonia injection manifold. Each blower will have filter silencers on their inlets to reduce aperture noise.

Equipment also includes:

- Manual butterfly valve (one per blower)
- Manual check valve (one per blower)

3.5.8. Ammonia Injection Grid and Manifold

The ammonia injection manifold distributes the vaporised ammonia to each section of the ammonia injection grid

The ammonia injection grid sits directly in the exhaust gas flow. It introduces the vaporised ammonia across the entire catalyst cross section via a series of spray bars. Each spray bar has a manual throttling valve so that the amount of ammonia introduced can be optimised.

Fabricated from stainless steel and will be self-finish.

Equipment also includes:

- Expansion joints in the main header
- Pressure gauge near manifold inlet
- Orifice plate at each spray bar branch
- Throttling valve at each branch
- Differential pressure gauge at each branch

3.6. Catalyst Unit Outlet Transition

The Catalyst Unit Outlet Transition will reduce the cross-sectional area from 6.7m x 6.7m to that of the Exhaust Silencer.

Transition casing to be fabricated from 6mm S355J2 carbon steel. Stainless steel cladding sheets will be S/S 321, this has been chosen as it displays higher corrosion and work resistance between 400 - 800^{o}C.

Surface treatment: Carbon steel to be aluminium metal sprayed with high temperature sealer. Stainless steel to be left self-finish.

3.7. Exhaust Silencer

A rectangular exhaust silencer will be located downstream of the outlet transition to provide acoustic attenuation to the exhaust gas flow before exiting the exhaust. The silencer will contain rectangular splitters which provide the acoustic attenuation.

Silencer casing to be fabricated from 6mm S355J2 carbon steel. Splitters to be made from stainless steel 321 with acoustic infill behind a permeable glass cloth.

Surface treatment: Carbon steel to be aluminium metal sprayed with high temperature sealer. Stainless steel to be left self-finish.

3.8. Weather Cowl

A weather cowl has been positioned at the top of the exhaust stack. It prevents water from entering further down the stack while the unit is not in operation.

As the weather cowl will be subjected to hot exhaust gases and moisture from rain, it will be fabricated from S/S 321 as it provides a high level of corrosion protection at elevated temperatures.

Surface treatment: Weather cowl is to be left self-finish.

3.9. Stair Access

Stair access will be provided to allow operators to reach the access platform. The stairs will comply with BS EN ISO 14122.

Fabricated from S275J2 or S355J2 carbon steel dependant on section sizes and hot dipped galvanised.

3.10. Access Platform

The access platform will be used by the operators during the changing of catalyst unit cassettes, maintenance activities and to access the CEMS.

Fabricated from S275J2 or S355J2 carbon steel dependant on section sizes and hot dipped galvanised.

3.11. Lifting Equipment

Details of lifting equipment to be determined during FEED study as layout details of the catalyst unit are not determined at pre-FEED stage

3.12. Control Panel

The control panel will be located in the main onsite control room.

3.13. Ancillary Equipment

3.13.1. Ammonia Storage Tank

Two ammonia storage tanks are to be provided, one per turbine unit. These storage tanks are located on the opposite side of the road to the controls building. This is a suitable location as the ammonia tanker can only offload to the left-hand side and therefore does not require the lorry to turn onsite with a full load. The disadvantage of positioning the ammonia storage tanks at this position is that the ammonia will need to be piped across site to the catalyst unit. The ammonia should be piped around the left-hand side of the control building, as confirmed by National Grid and outlined in TQ20602_020. A further site survey will be required to determine the exact path of the ammonia pipes and any pipe bridges required.

The storage tanks are to be atmospheric type tanks as they are located within a non-ATEX zone. The benefits of atmospheric tanks are that they are less expensive, require less frequent inspections and are a simpler design/construction than pressurised tanks. The tanks can be made from carbon steel to reduce cost, the outer surface will have to be painted to provide corrosion protection.

Each storage tank has a specified capacity of 38m3. This value is derived from advice from CF Fertilisers. This capacity allows for a full 28 tonne delivery, plus three times the daily use (to allow for a 48-hour delivery lead time), plus the minimum amount of ammonia required to maintain the integrity of the equipment. Using the average top up frequency of 3.9 years, this tank will contain ammonia for 1435 days of operation.

The storage tanks are to be situated in a concrete bunded area, this will act as containment should the tanks fail. The volume of the concrete bund is to be the total capacity of the tanks plus 10%. Therefore, the bunded area will have a capacity of 84m3. There will also be a pump to remove any water that may collect in the bund.

3.13.2. Packing

Packing is to be in accordance with [redacted] Standard Spec 22.

4. Process Flow Diagram

See 1600-000238 at end of report

Table 2: Process Flow Values

Location	1	2	3	4	5	6	7
Description	Inlet	Waste Heat	Ammonia Injection Air	Catalyst Inlet	Stack Outlet	Ammonia	Compressed Air
Temperature (^{o}C)	411.13 – 600	411.13 – 600	-	411.13 – 454.44	TBC	Ambient	Ambient
Flow (Nm3/hr)	105011 – 305562	428 – 1191	653 – 1416	105011 – 305562	105011 – 305562	-	225
NOx (mg/m3) *@ 15%O2*	78.65 – 197.84	-	-	78.65 – 197.84	35.0	-	-
NH3 (mg/m3) *@ 15%O2*	-	-	-	-	3.0	-	-
NH3 (kg/hr)	-	-	-	-	-	9 - 60	-

5. SCR Outline Mass and Energy Balance

See Dwg. 1600-000238 at end of report

Table 3: Mass and Energy Balance for all 9 Process Duty Points

Case		**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Cooling Air	Kg/s	-	9.5	23.9	9.6	8.5	16.4	28.0	40.3	25.4
Exh. Temp *(After adding cooling air)*	ºC	411.13	454.44	454.44	454.44	454.44	454.44	454.44	454.44	454.44
Exh. Mass Flow	kg/s	36.67	55.73	68.05	55.84	54.75	62.12	70.99	78.92	69.18
Exh. Vol. Flow	Nm3/hr	105011	159593	194874	159908	156787	177892	203293	226002	198110
NOx at GT	mg/m3 ***@ 15%O2***	78.65	128.27	160.33	128.54	125.72	144.90	168.00	188.64	163.29
NOx at GT	Kg/hr	9.02	22.36	34.13	22.45	21.53	28.16	37.31	46.57	35.34
SCR Cooling Temp	ºC	10.56	10.56	10.56	10.56	10.56	10.56	10.56	10.56	10.56
SCR Cooling Air	Nm3/hr	0	25452	64548	25704	22860	44028	71496	79560	68688
Exh. Stack Total Flow	Nm3/hr	105011	185045	259422	185612	179647	221920	274789	305562	266798
Exh. Stack Temp	ºC	TBC	TBC	TBC	TBC	TBC	TBC	TBC	TBC	TBC
NOx at Stack (design)	mg/m3 ***@ 15%O2***	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0
NOx Removal	%	55.50	72.71	78.17	72.77	72.16	75.85	79.17	81.45	78.57
NOx at Stack	Kg/hr	4.01	6.10	7.45	6.11	5.99	6.80	7.77	8.64	7.57

NH3 Concentration	%	24.50	24.50	24.50	24.50	24.50	24.50	24.50	24.50	24.50
NH3 Flow	kg/h	9.0	27	43	27	26	35	47	60	45
Inlet CO	mg/m3	481.00	288.29	214.56	287.54	295.23	247.29	199.80	164.02	208.76
CO at Stack (design)	mg/m3 ***@ 15%O2***	100	100	100	100	100	100	100	100	100
CO Removal	%	79.21	65.31	53.39	65.22	66.13	59.56	49.95	39.03	52.10

6. Equipment General Arrangement, Plan & Process Drawings

General Arrangement: 1600-000230

Process Drawing: 1600-000238

7. Outline Process Description

The exhaust gases exit a venturi nozzle which entrains ambient air from the plenum. The air enters the plenum via an aperture at the bottom, this inlet has two rings of silencing elements to reduce the aperture noise. The ambient air is required to cool the maximum exhaust temperature down from 600^{o}C to 454^{o}C.

The exhaust gases and ambient air mix then enters an annulus. A pepper pot mixes and conditions the exhaust gas mixture but further CFD will be required to optimise the pepper pot design.

The duct then transitions to a 6.7 x 6.7m square, this is the cross-sectional area of the catalyst unit.

If the flow is not suitably conditioned, a further conditioning grid can be installed at the inlet face of the catalyst. The vaporised ammonia is injected into the flow via an ammonia injection grid which comprises of multiple spray bars, the amount of ammonia injected by each bar can be adjusted to optimise efficiency.

The mixture is then passed through a multipollutant catalyst bed, this reduces the amount of NOx and CO in the exhaust mixture.

The ducting then transitions down to a silencer that reduces aperture noise emitted from the top of the stack.

Another transition is required to connect the silencer to the weather cowl. This transition will contain the probes required for the Continuous Emissions Monitoring System (CEMS). The CEMS samples are taken back to the operations room via heated and ATEX zone II rated lines. The samples are then analysed and results provided by the Data Acquisition and Handling System (DAHS).

The exhaust gases then leave the stack via the weather cowl, the cowl prevents water entering the stack which the turbine is not in operation.

8. Justification for Selection of Catalyst

The catalyst is to be a multi-pollutant catalyst. This means only one catalyst section is needed to both reduce NOx and CO emission, allowing the catalyst unit to be shorter in height and require less material for construction.

Below shows the compounds before and after the multi-pollutant catalyst:

$$4NO + 4NH_3 + 0_2 \rightarrow 4N_2 + 6H_2O$$

$$2NO + 2NO_2 + 4NH_3 \rightarrow 4N_2 + 6H_2O$$

$$6NO_2 + 8NH_3 \rightarrow 7N_2 + 12H_2O$$

CO oxidation to CO_2

VOC oxidation to CO_2 and H_20

9. Justification for Selection of Reducing Agent

Several reductants are currently used in SCR applications including anhydrous ammonia, aqueous ammonia or urea.

24.5% aqueous ammonia was chosen as it's concentration is below the 25% threshold which requires more stringent storage regulations. Aqueous ammonia is safer to store and transport than anhydrous ammonia but must be vaporised in order to be used with an SCR system. Aqueous ammonia is available in two variants, normal water based or distilled water based. It is imperative for the longevity of the SCR system that distilled water is always used.

Pure anhydrous ammonia is extremely toxic to humans and aquatic life and difficult to safely store under pressure but does not need further conversion to work with an SCR system. Specialist input would be required for the storage tank and transfer/control the product. It would also fall under more stringent site regulations, so a greater burden for the site operations team.

Urea is the safest reductants to store. However, it requires thermal decomposition to be converted to an effective reductant. Therefore, it requires more volume to create the ammonia level required. It is more expensive than the alternative above because it is a "created/engineered" product.

10. Projected Electrical Loads

Table 4: Projected Electrical Loads per Unit

Device (each)	Voltage	kW Consumption
Immersion Heater	400V	180kW
Injection Fan (x2)	400V	15kW
NH3 Pump (x2)	400V	<10kW (rated)
Total		230kW

11. Projected Service Requirements

[redacted] cannot provide a recommended parts list as the Catalyst Design is not in detailed design phase. Therefore, components are not defined.

12. Outline Civil & Structural Design or Requirements

As this is a pre-FEED study, [redacted] will not produce a foundation load drawing, as per PJ20602_TQ020, because loads are likely to change during detailed design. [redacted] have indicated position where the steelwork columns could land and still provide access to the enclosures.

13. Outline Interface/Tie-in Requirements

Table 5: Interface and Tie-In Requirements

Item	Service Required	Service Conditions	Location
Ammonia Supply	24.50% Aqueous Ammonia	60 kg/hr Max.	Skid Battery Limit
Compressed Air Supply	Instrument Air	80 – 125 PSIG	Skid Battery Limit
Electrical Power	400V, 50 Hz, 3 Phase	230kW	Skid Battery Limit

14. Major Maintenance Requirements

Maintenance is required to ensure optimal efficiency of the catalyst unit and to achieve the emissions targets. [redacted] agree with the recommendation in the [redacted] Report, these recommendations are listed below.

14.1. Daily Maintenance

- Visually inspect overall system. Look at exterior surfaces, noting any colour changes, leaks, etc. which might require attention.
- Inspect fans. Listen for excessive noise, vibration, or other symptoms of developing problems.
- Review controls. Note any changes in operating temperatures or pressure drops which might provide an indication of developing problems. Log pressure and temperature readings.

14.2. Monthly Maintenance

- Visually inspect fan belts for signs of wear, looseness, fraying, etc.
- Check fan bearings by feeling for excessive heat and/or vibration.
- Inspect all electrical switches and contacts; clean if necessary.
- Inspect all piping, valves, and ductwork for leaks, deterioration or damage.

14.3. Quarterly Maintenance

- Grease fan bearings. Use grease recommended in fan manual.
- Open fan access door(s) and inspect fan wheel for signs of build-up and wear.

14.4. Semi-Annual Maintenance

- Inspect atomising nozzle orifice for plugging.
- Inspect catalyst for signs of plugging or damage.
- Inspect static mixer and silencer (if required) for signs of plugging or damage.

14.5. Annual Maintenance

- Inspect lining. Pack small pieces of blanket material into cracks or gaps which may have opened up in linings.

14.6. Refractory Maintenance

The use of refractory is yet to be determined as part of the design, therefore no guidance can be provided.

15. How Weather and Environmental Conditions May Impact the Catalyst Unit Performance

Weather or environmental conditions should not impact the performance of the catalyst unit. Entrainment protection has been provided by the plenum with an air intake on the bottom face, this will minimise the amount of water drawn into the exhaust and protect the venturi from the wind.

Similarly to the [redacted] report, the maintenance instructions above should be performed to mitigate weathering factors and there is no issues with the reagent choice with regard to environmental temperatures (24.5% aqueous ammonia does not freeze above -56^{o}C).

16. How the Performance of the Catalyst will be Monitored to Determine the Rate of Degradation

The catalyst unit will function at a higher efficiency when first commissioned. This efficiency will drop over time. If the exhaust gases are passed through the catalyst unit at too high a temperature, it could lead to the accelerated degradation of the catalyst.

To monitor the efficiency of the catalyst over its design life (based on the operational hours), removable test modules will be periodically tested. These can then be tested by the original equipment manufacturer or a testing laboratory. Replacement modules can be provided to fill in the missing test modules.

17. Emissions Monitoring Provisions, Including Outline Scope of Continuous Emissions Monitoring and Data Acquisition & Handling System

17.1. CEMS

CEMS stands for Continuous Emission Monitoring System. The samples will be collected using a sample probe made from stainless steel 316 and will be mounted to the exhaust system using a DN65 PN6 flange. The probe is rated for ATEX zone 1.

Heated sample lines are used to transfer the sample between the probe and analyser. The heated sample lines are maintained at 180^{o}C to prevent condensation forming, condensations could have an impact on the results. An ATEX Zone II rated heater line controller unit is required to regulate and limit the temperature of the sampling lines.

An analyser panel is required to compute the sample results. The panel is IP54 rated and air-conditioned. The air-conditioning is required so that the sampling analysers work at ambient temperature, so there is no influence due to a change in the sample pressure. The analyser can measure CO, NOx, H_2O and NH_3 levels.

17.2. Integrated PLC Control

Similarly, with the [redacted] report, the CEMS controls are integrated with the catalyst unit controls for seamless operation.

17.3. DAHS

A Data Handling and Acquisition System can be provided by the CEMS supplier. The DAHS continually acquires data from the CEM panel and generates the necessary reports. A PC can be provided with the complete data acquisition and reporting software. This can be located anywhere on site but it is advised to be located within the control room.

18. CFD Modelling of Exhaust Gas Flow Through SCR

Not required as per *"SCR_review_scopev5(16.11.21)"*

19. Air Dispersion Emissions Modelling Inputs

Not required as per *"SCR_review_scopev5(16.11.21)"*

20. Actual and Typical Guaranteed Levels for Pollutant Abatement

The maximum guaranteed level for NOx abatement for this application is 81.45%. The actual NOx reduction efficiency is 55.5 – 81.45%. These are lower NOx reduction efficiencies compared to the [redacted] report because [redacted] overly reduced the allowable NOx levels below 35 mg/m^3 threshold.

The maximum guaranteed level for CO abatement for this application is 79.21%. The actual CO reduction efficiency is 39.0 – 79.21%.

The catalyst specified satisfies both NOx and CO emissions as per the IED regulations.

21. Ammonia Slip Typical Levels Over Operating Life and Management Controls

Ammonia slip levels will remain consistent over the life of the catalyst, the catalyst is designed to ensure that the ammonia slip levels do not exceed 3 mg/m^3 (Annual average). The catalyst has an operating life of 26280 hours based on the supplier standard. Assuming that the turbines at Wormington run at the base hours per year, the ammonia slip levels will stay consistent for 10 years.

The ammonia slip levels can be monitored by the CEMS.

22. Safety and Environmental Hazards Identification Summary

22.1. Electrical

The electrical components will be specified to meet the ATEX area classification.

22.2. Ammonia

All equipment will be suitable selected for use with ammonia in it aqueous or vaporised forms. Similarly, to the [redacted] report, exposure to ammonia in either liquid form or vapours will be limited and controlled.

22.3. Rotating Machinery

All rotating machinery will provide adequate personnel protection to rotating parts. This will be mainly concerning the ammonia pumps and injection blowers.

22.4. Pressure

The only high-pressure parts of the system are the compressed air and ammonia piping. The pipe will be sized for the pressure experienced in these systems.

The catalyst unit operates under a low positive pressure.

22.5. High Temperature

Any hot surface of the catalyst system that could be touched by site operators will be thermally insulated so that the maximum temperature of any surface is 60^{o}C. Any surface unable to be thermally insulated will be cordoned off so that operators cannot touch it and have suitable warning signs attached.

22.6. EMF

All panels to be tested for compliance with adequate shielding to comply with standards for radiation.

22.7. Confined Space

The catalyst unit and the ammonia storage tanks are the only confined spaces of this system. The doors will carry signs indication that they are confined spaces and National Grid personnel must have adequate training to access these confined spaces.

23. General Hazardous Areas Compliance Statement

Equipment shall comply with the ATEX Zone they are situated within. The ATEX Zones used for this report were from National Grid drawing 72600803000004.

24. CE Marking Compliance Statement

[redacted] can provide a Declaration of Incorporation and ATEX certificates where possible.

All [redacted] supplier electrical equipment will be CE marked.

25. Ex-works Cost Estimates

Equipment prices delivered ex-works [redacted] domestic packed to [redacted] standards, based upon current material and labour rates, May 2022, are detailed below. Prices are prudent budgetary costs and do not constitute a formal proposal or quotation.

Table 6: Ex-works Cost Estimates

Item	Description	Price (£, Total for Site)
1	Catalyst Unit	[redacted]
2	Exhaust Stack	
3	Ammonia Tank	
4	Steelwork and Access Platform	
5	Bund Pump	
6	CEMS	
7	DAHS	
	Total	

Cost per Unit [redacted]

Costs have been estimated May 2022, after September 2022 costs should be revalidated.

26. Delivery Cost Estimate

As some of the new exhaust equipment exceeds standard load sizes. During the future FEED study stage, splitting equipment should be explored so that the sizes conform to standard UK lorry load dimensions, therefore [redacted] cannot provided all delivery costs at time of writing.

The delivery cost of the catalyst unit is not available as the location of manufacture has not been determined.

27. Installation & Training Cost Estimate

Installations and training prices based upon current day labour rates are detailed below. Prices are prudent budgetary costs and do not constitute a formal proposal or quotation.

Table 7: Installation and Training Costs

Item	Description	Price (£,Total for Site)
1	Installation Supervision	[redacted]
2	Installation Labour	
3	Craneage	
4	Access Equipment	
5	Site Establishment	
6	Lifting Equipment	
7	Power & Welding	
8	General Tools	
9	Plant Hire & Equipment	
10	Misc Materials	
	Total	

Cost per Unit: [redacted]

Costs have been estimated May 2022, after September 2022 costs should be revalidated.

28. Operating Cost Estimate

Operating costs are based upon the 9 duty points provided. Only reagent, energy and catalyst replacement costs will be provided.

28.1. Reagent Usage Cost

The reagent costs are based on the average top up frequency.

Table 8: Reagent Usage

Case		1	2	3	4	5	6	7	8	9	Average
Aq. Ammonia Concentration	%	24.5	24.5	24.5	24.5	24.5	24.5	24.5	24.5	24.5	24.5
Aq. Ammonia Flow	kg/hr	9	27	43	27	26	35	47	60	45	35
Operating Hours per Year (Base)	hr/yr	353	235	588	294	529	59	235	118	59	274
Aq. Ammonia Consumption	kg/yr	3177	6345	25284	7938	13754	2065	11045	7080	2655	8815
Ammonia Tank Storage Volume	m^3	38	38	38	38	38	38	38	38	38	38
Ammonia Tank Storage Capacity	kg	34656	34656	34656	34656	34656	34656	34656	34656	34656	34656
Top Up Frequency	yrs	10.9	5.5	1.4	4.4	2.5	16.8	3.1	4.9	13.1	3.9

Bulk annual consumption is 2470 kg.

Over a 5 year period, the tank will have to be filled up 1.282 times. 1 tonne of 24.5% aqueous ammonia costs [redacted], delivered to site. This means over a 5 year period, it will cost [redacted] per unit per year.

28.2. Yearly Energy Costs

To determine the yearly energy costs, the price of electricity (p/kWh) is multiplied by the equipment power rating (kW) and total operating hours per year (2500 hours).

Price of electricity has been provided by National Grid via TQ20602_016.

Table 9: Energy Costs for 5 Year Period

Year	2022	2023	2024	2025	2026
kWh	575000	575000	575000	575000	575000
Projected cost per kWh (p/kWh)	[redacted]				
Cost per Year (£)					

28.3. Catalyst Replacement Costs

1m^3 of catalyst bed costs [redacted]. There is approximately 15 m^3 of catalyst bed, meaning the total replacement cost will be [redacted]. Replacement period should be based on 26280 operational hours.

28.4. 5 Year Total Projected Operating Costs

Table 10: Yearly costs

Year	2022	2023	2024	2025	2026
Reagent (£)	[redacted]				
Energy (£)					
Total (£)					

29. Typical Delivery Lead-Time from Placement of Order

At time of writing, [redacted] believe the lead time will be driven by the catalyst unit. We have been advised that the lead time will be 1 year. The delivery of the other exhaust equipment and steelwork will depend on [redacted] engineering and production capacity at time of contract agreement. Time estimates have been provided in Section 30.

30. Outline Programme from Placement of Order to Turnover the Client

The following timescales have been based on the time taken to design, progress through the G35, procure and manufacture sections of the exhausts for the National Grid Aylesbury site. Some of the activities may be run concurrently, but this cannot be determined at the time of writing because future [redacted] and suppler resource is not known.

Table 11: Exhaust Section Timescales

Section	Days
Exhaust (Not Catalyst)	202
Vent Pipework and Sample Points	114
Steelwork	156
Civils	68
Stairs and Platform	100
Lighting	185
Lightning Protection	56
CEMS	185

The following table details timescales for other activities.

Table 12: Activity Timescales

Activity	Days
Hazard Studies	42
Site Setup and Decommissioning	102
Installation (per Unit)	182
Commissioning (per Unit)	20

All timings are subject to change.

31. Detail Typical Equipment Guarantees

31.1. Catalyst Unit Performance

Performance of the catalyst unit is based on the 9 process duty points. If the conditions vary significantly from the points provided, the catalyst unit performance will be different and thus this guarantee is null and void.

[redacted] guarantees that the catalyst unit provided will provide the required NOx and CO abatement required to satisfy IED regulations and therefore the MCPD if the total net thermal input can be reduced under 50MW for Case 8, providing that the system is installed and operated under the guidelines of the Installation and Operating Manuals, which includes but is not limited to:

- Operation under specified temperature ranges and maintaining high temperature excursions und the time periods specified.
- Use of reagent grade aqueous ammonia as per the specifications
- [redacted] will not be responsible for operating non-conformance resulting from the introduction of materials not identified by the purchaser into the equipment covered by this warranty.

31.2. Differential Pressure

[redacted] will not provide the pressure drops for the stack silencer and cowl as the designs are likely to changes during FEED study stage as an acoustic survey will be performed and a final acoustic limit provided.

Table 13: Differential Pressure of Equipment

Description	ΔP Calculated (Pa)
Transition (Pre Catalyst unit)	726.2
Catalyst	690
Transition (Post Catalyst to Silencer)	2.4
Transition (Silencer to Weather Cowl)	10.8

32. Summary of Major Project and Technical Risks

The risks [redacted] can foresee at time of writing are:

- Unable to limit the exhaust temperature to 600^{o}C, this will impact the design of the exhaust equipment.
- The steelwork design will be complex due to high dead and wind loads with the addition of careful foot placement to maintain access to the enclosures.

33. Areas of Potential Project Opportunity or Improvement

The following are areas of potential opportunities/improvements

- Further investigation high temperature exhaust readings.
- Limit exhaust gas temperature to 600^{o}C (National Grid Action).
- Limit C8 net thermal input power to below 50MW so that the MCPD can be applied (National Grid Action).
- Explore direct injection ammonia, will removed the need of the vaporiser.
- Acoustic survey and design of silencer.
- Determine acoustic attenuation of catalyst unit.
- Acoustic noise limit provided by National Grid.
- Further design of steelwork.
- Refinement of exhaust equipment based on the actions above.

34. List of Exclusions or Areas Which Would be Expected to be Provided by National Grid

The following items and/or services are not included under the scope of this proposal and shall included in future studies/RFQs or be furnished by the purchaser or others of their choice:

- Limiting gas turbine exhaust temperature.
- Steelwork and access platform costs (including lighting).
- Vent pipework.
- Project management or electrical design costs (report account for mechanical design, production and installations hours only).
- All transport costs for [redacted] build equipment.
- Foundations and concrete work.

- Grounding, electrical hook-up or power regulation. Motor starters and motors with space heaters.
- Lightning protection.
- Control room and other enclosures.
- Performance and/or compliance testing.
- Demolition and/or removal of any existing concrete.
- Cross-site ammonia line and equipment.
- All other items not specifically listed as included herein.

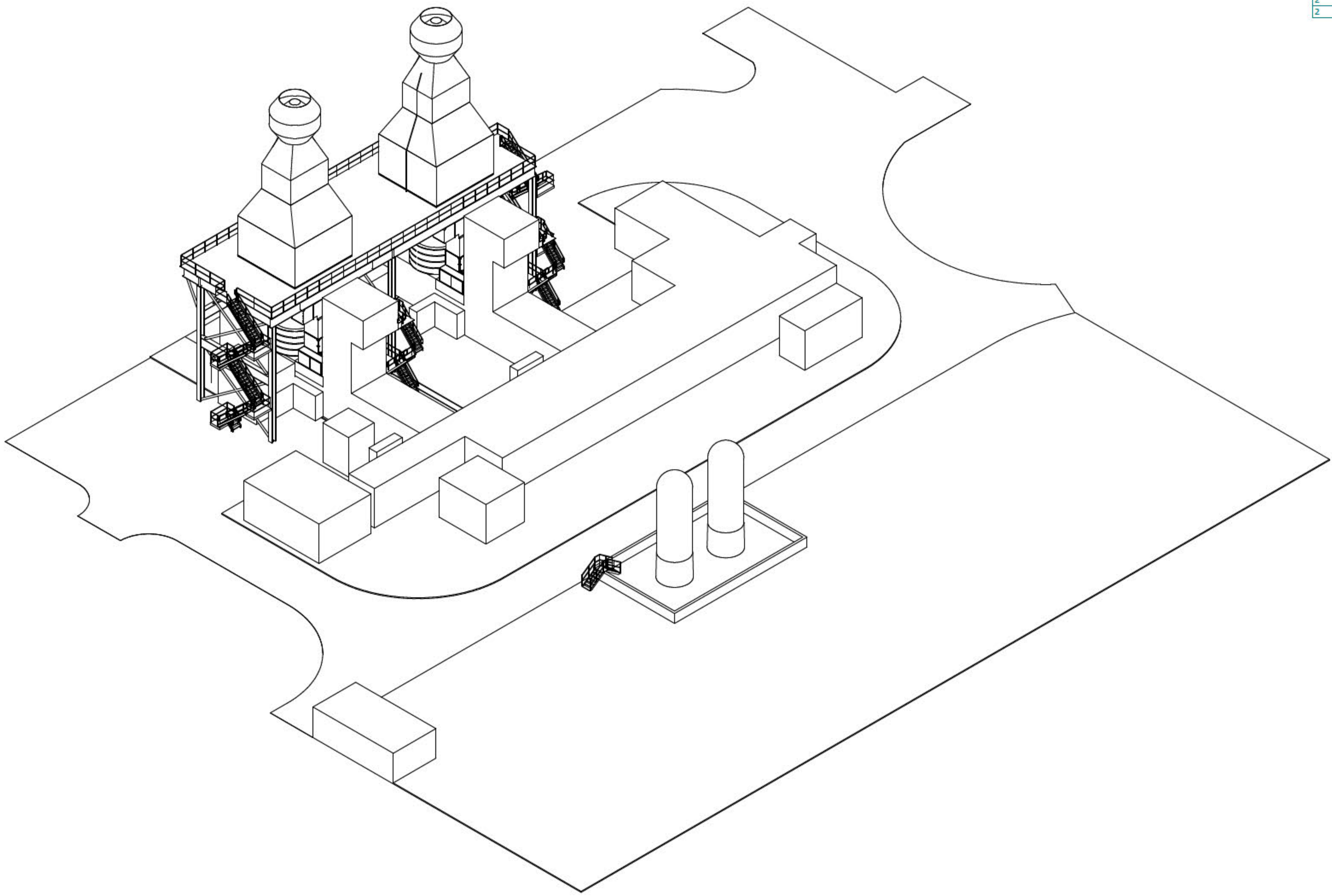
Appendices

This section includes:

- Drawing 1600-000230
- Drawing 1600-000238
- TQ_20602_008_R
- TQ_20602_016 (Email extract)
- TQ_20602_020

PARTS LIST

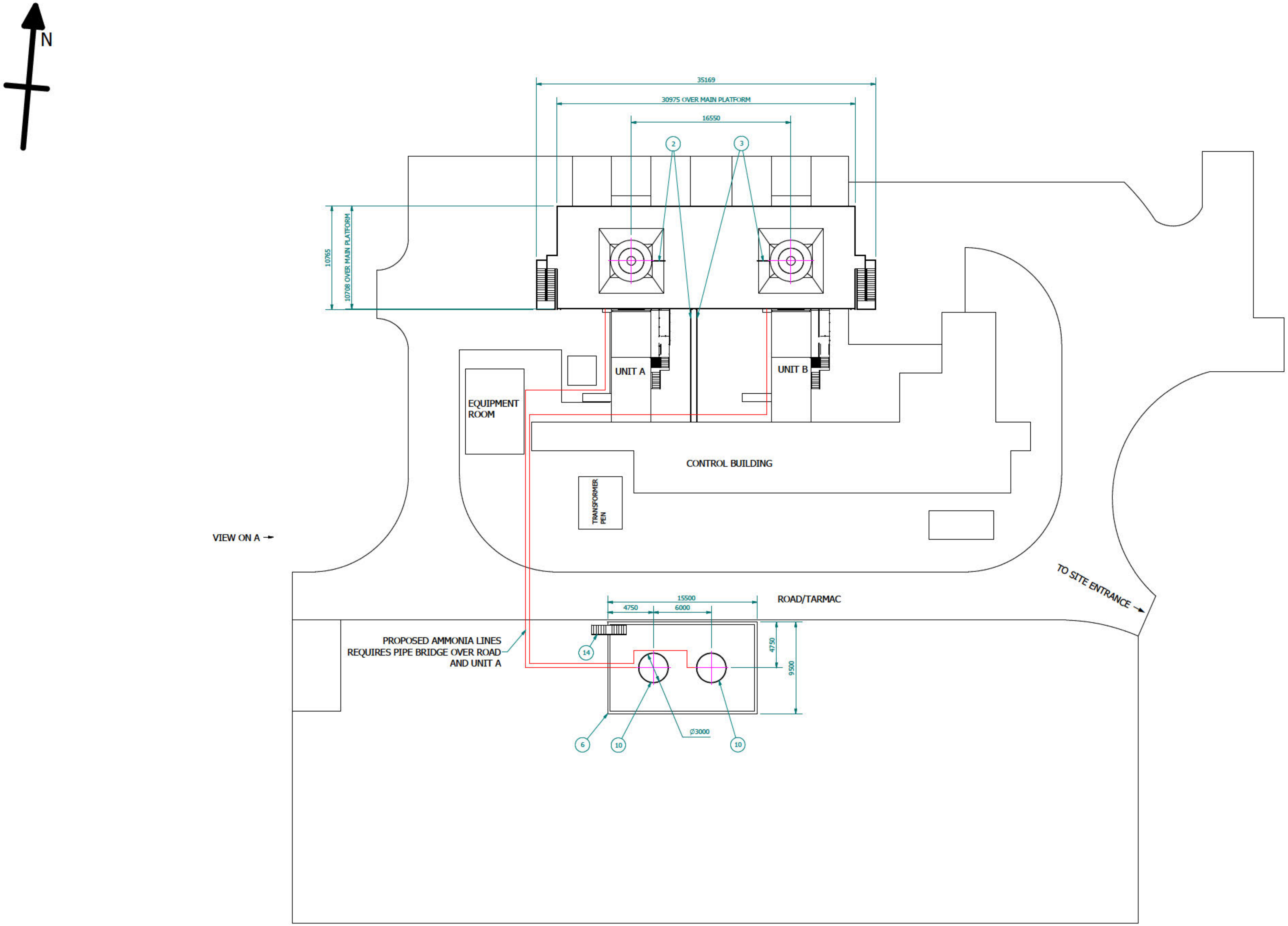
ITEM QTY	DESCRIPTION	MATERIAL	MATERIAL FINISH	ITEM
2	CATALYST UNIT	316L	Natural Finish	1
1	UNIT A CEMS SYSTEM	316L	Natural Finish	2
1	UNIT B CEMS SYSTEM	316L	Natural Finish	3
2	RECTANGULAR TO ROUND TRANSITION	321	Natural Finish	4
2	WEATHER COWL	321	Natural Finish	5
1	AMMONIA TANK CONCRETE BUND	Concrete	Natural Finish	6
2	NEW VENT INTAKE REFERENCE MODEL	N/A	N/A	7
2	NEW WORMINGTON STAIRS	N/A	N/A	8
1	WORMINGTON SITE LAYOUT	N/A	N/A	9
2	AQUEOUS AMMONIA STORAGE TANK	S275	Painted	10
1	FLOORING	S275	Galvanized	11
1	UNIT A STEELWORK	S275J2	Galvanised	12
8	ACCESS STAIRS	S355J2	Galvanised	13
1	BUND ACCESS STAIRS	S355J2	Galvanised	14
2	CIRCULAR SILENCER OUTER RING AND PLENUM	S355J2	Aluminum - Metal Spray	15
2	CONTRACTION TRANSITION	S355J2	Aluminum - Metal Spray	16
2	EXPANSION TRANSITION	S355J2	Aluminum - Metal Spray	17
8	LANDING	S355J2	Galvanised	18
2	LOWER ACCESS STAIRS	S355J2	Galvanised	19
2	PEPPER POT	S355J2	Aluminum - Metal Spray	20
2	STACK SILENCER	S355J2	Aluminum - Metal Spray	21
2	VENTURI SECTION	S355J2	Aluminum - Metal Spray	22



ISOMETRIC VIEW (1 : 200)

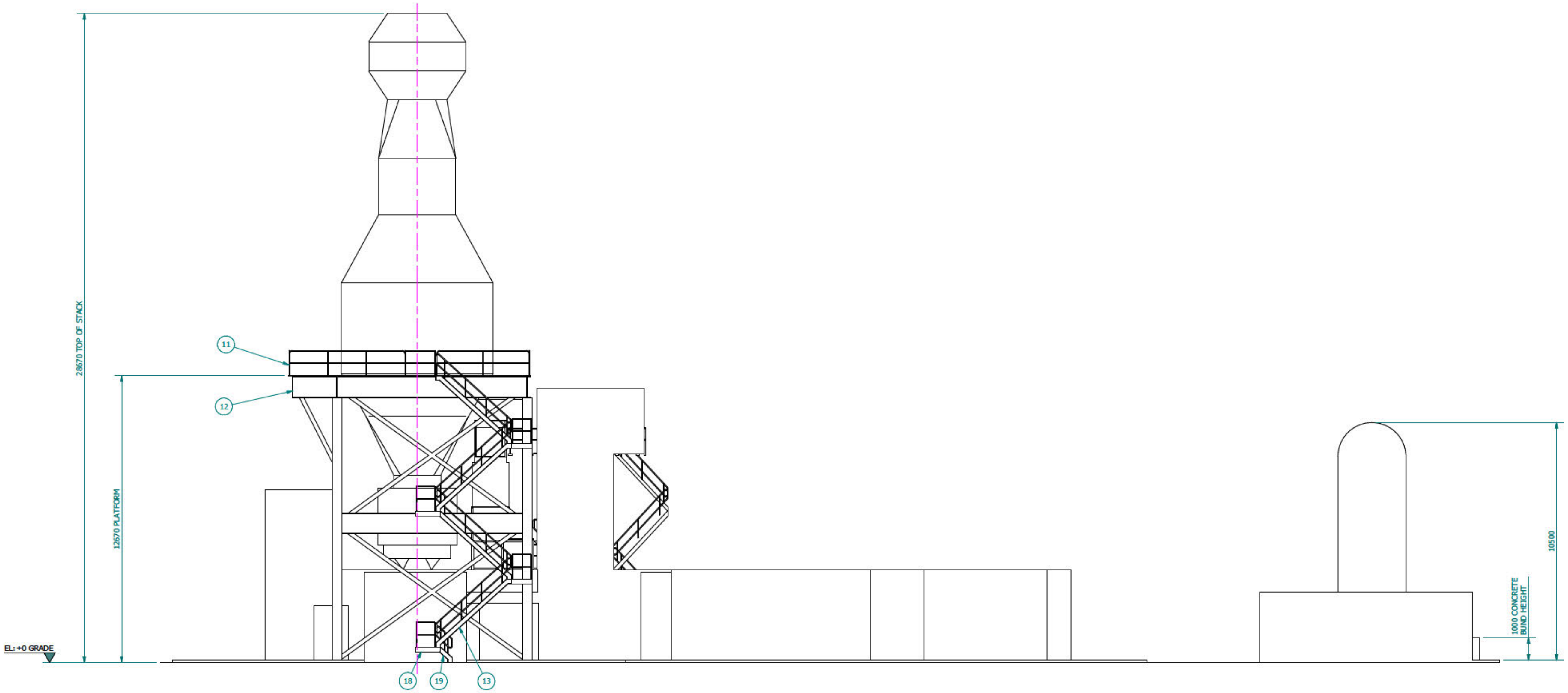
[redacted]

[redacted]



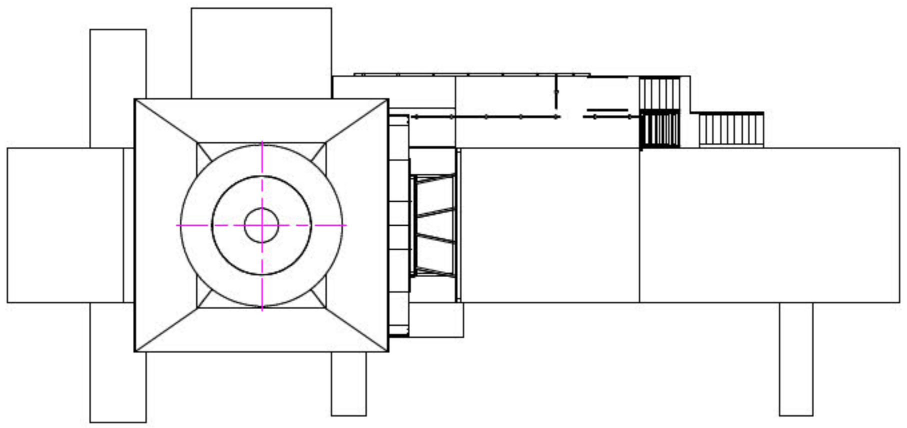
PLAN VIEW OF SITE (1 : 200)

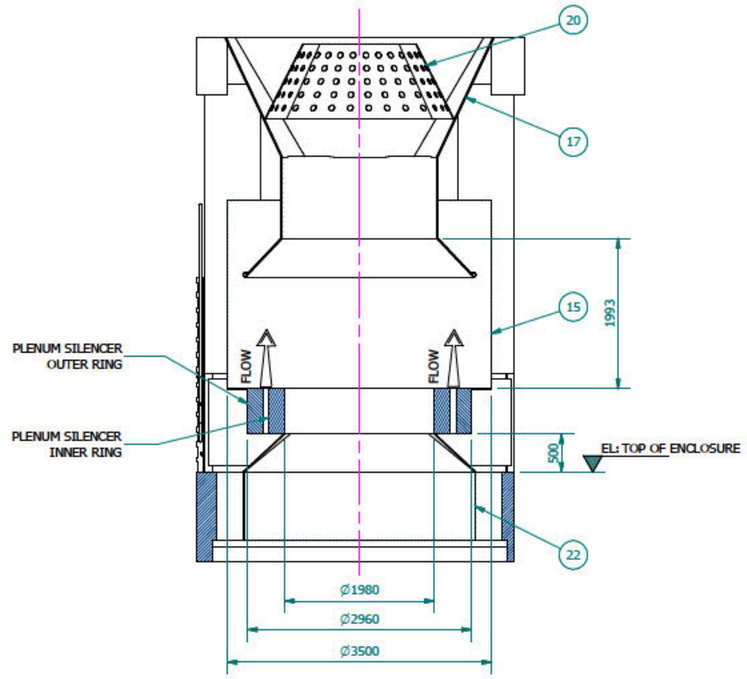
[redacted]



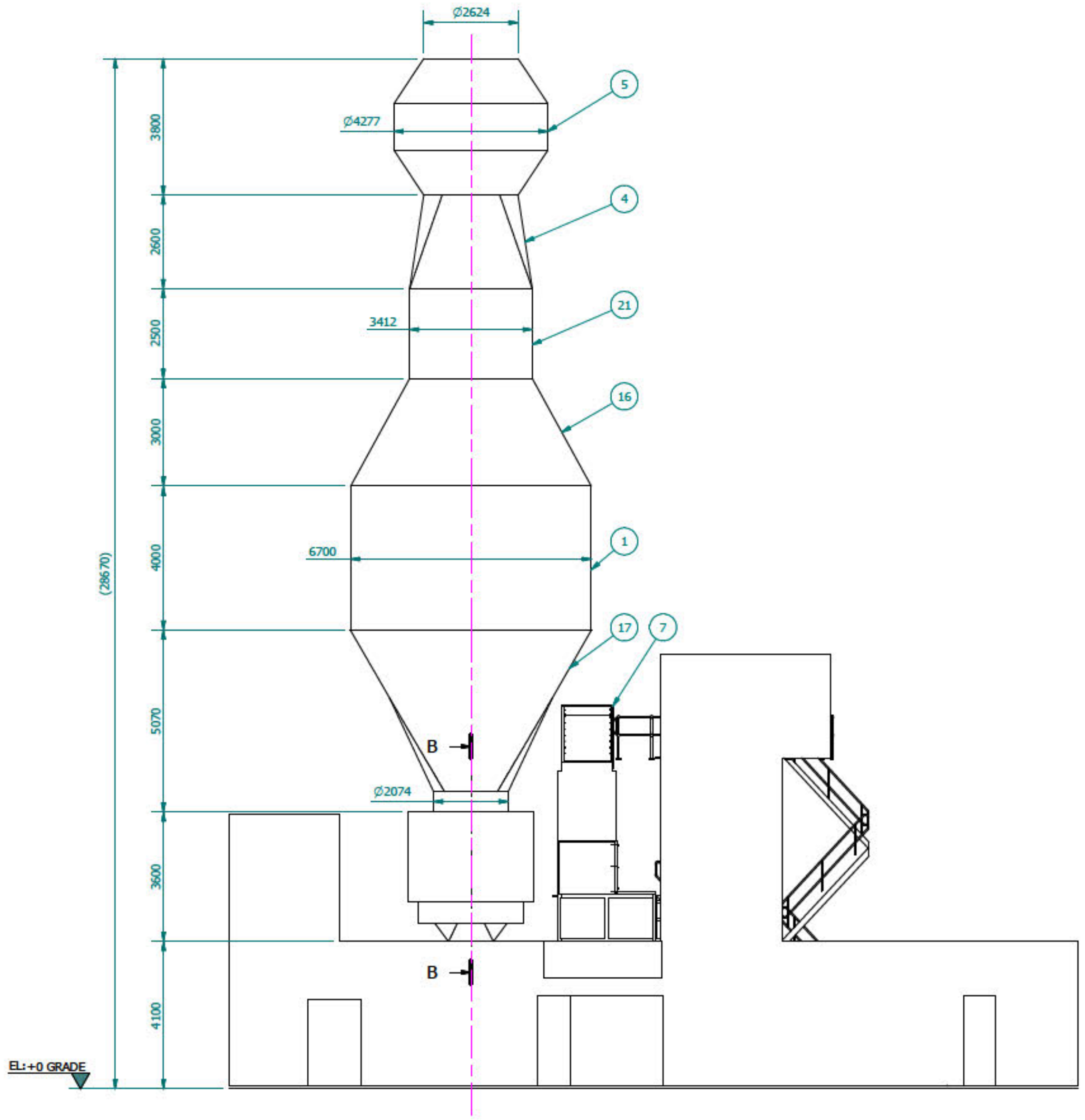
VIEW ON A (1 : 100)
ROTATED 90° CCW

[redacted]

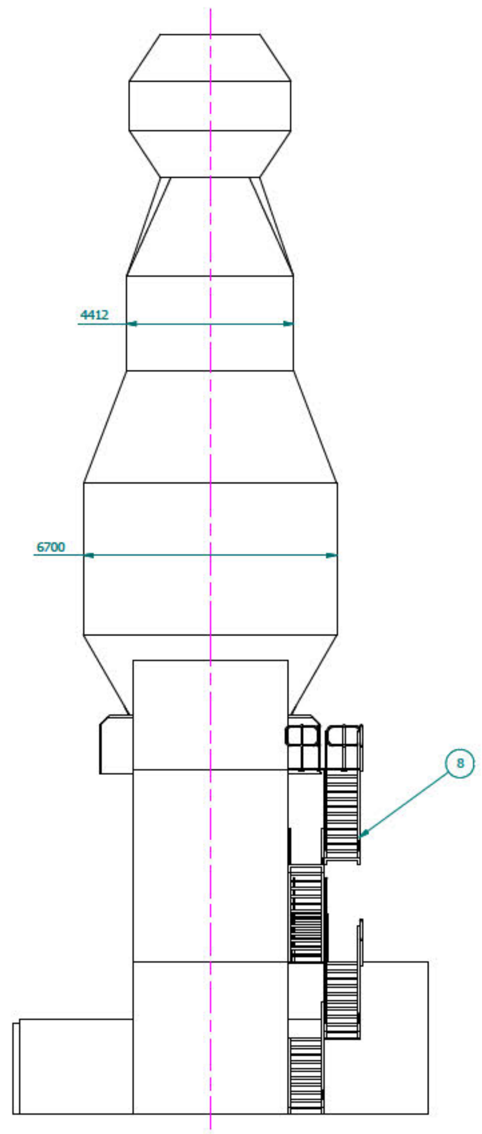




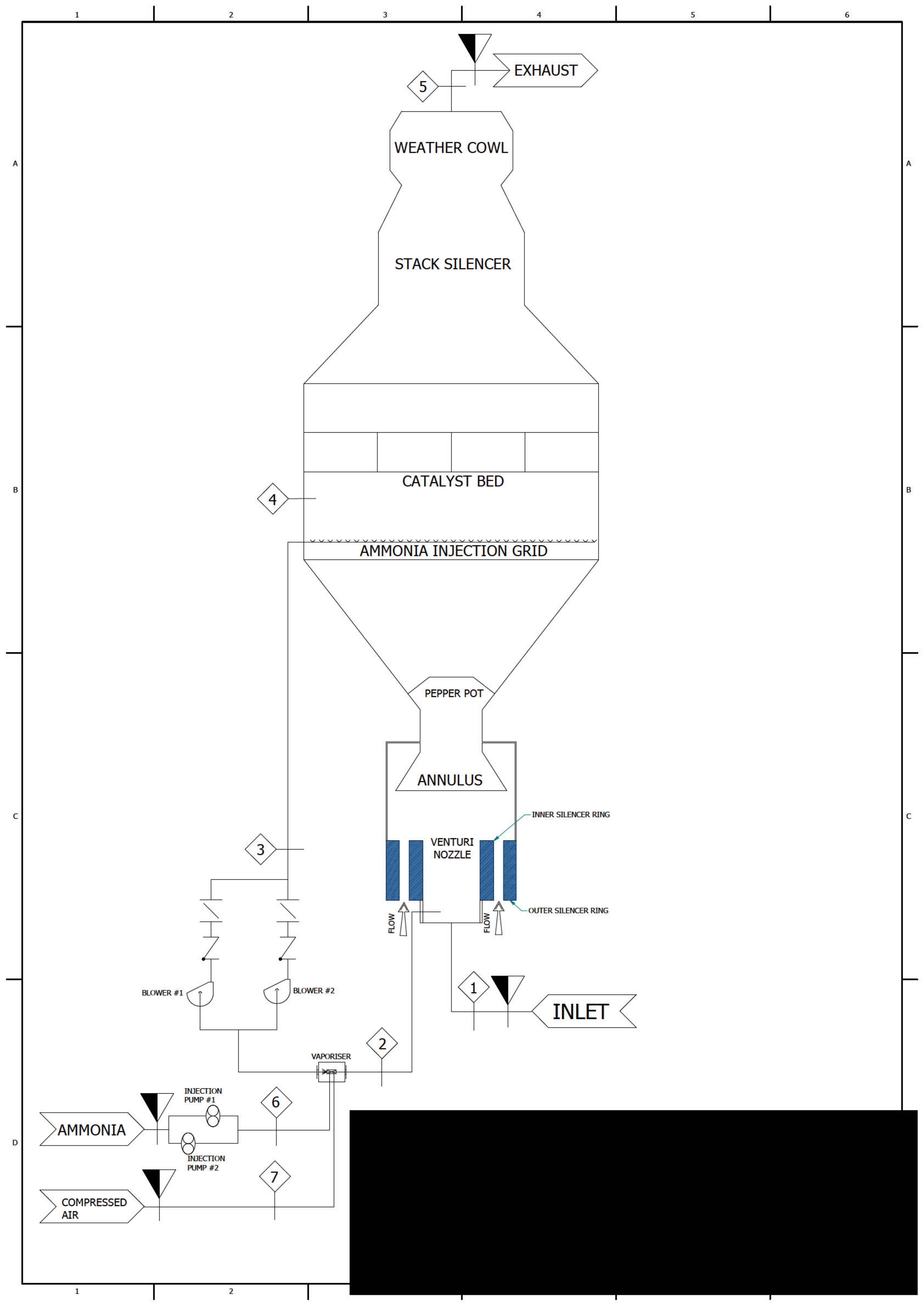
SECTION B-B (1 : 50)



SIDE ELEVATION (1 : 100)



[redacted]


EXHAUST
WEATHER COWL
STACK SILENCER
CATALYST BED
AMMONIA INJECTION GRID
PEPPER POT
ANNULUS
INNER SILENCER RING
VENTURI NOZZLE
OUTER SILENCER RING
FLOW
FLOW
INLET
BLOWER #1
BLOWER #2
VAPORISER
INJECTION PUMP #1
INJECTION PUMP #2
AMMONIA
COMPRESSED AIR
1
2
3
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[redacted]

Technical Query	TQ-No:	TQ/20602/008	
	Issue / Date:	1	10/01/22
PROJECT: NG SCR FEED STUDY		2 Pages	

From: [redacted]			To: National Grid	
Co-ordinator: [redacted]	Email: [redacted]		Co-ordinator: [redacted]	Email: [redacted]
Reply to TQ No: **N/A**	Issue:	Reply Required: Yes / ~~No~~	Action (Name & Department)	
Close TQ No: **N/A**	Issue:	Date: 13/1/22	Info (Name & Department)	
Author (Name & Department) [redacted]			Approval (Name & Department)	
Subject:	Process Duty Points			
1) References - 2) Discussion or Reply - 3) Action Required & By When - 4) Attachments				

References

None

Discussion

As per the SCR Technical Feasibility Study - 2021 Review and Update: Outline Scope document. For [redacted] to be able to form the Basis of Design, can National Grid provide the process duty points with the same information fields as figure 2, section 2.10 (see picture below) in the [redacted] report for the following sites:

- Wormington
- Kings Lynn
- St Fergus
- Peterborough

2.10. LOAD CONDITIONS

For the basis of design, 10 process duty points for Kirriemuir unit C201-A have been considered, as per Costain document ref: 7063-0200-01-0001-001-Rev P3, as shown below in figure 2:

Required information fields

Case		1	2	3	4	5	6	7	8	9	10
Gas Molar Flow	MSCMD	28.33	32.47	33.20	32.77	34.98	35.43	37.03	43.34	42.63	55.19
Gas Volumetric Flow	m^3/h	16024	18696	19556	20900	21617	23209	24142	26738	29142	34518
Compressor Head	kJ/kg	7.05	12.93	18.01	22.61	30.49	21.00	28.58	25.23	20.95	17.18
Compression Power	MW	2.39	4.52	6.27	7.67	11.62	7.55	11.03	10.72	8.81	9.90
Compressor Suction Pressure	bara	62.63	61.32	60.05	55.65	57.83	54.65	53.11	56.72	53.37	55.37
Compressor Suction Temp.	°C	12.1	11.9	11.4	9.4	12.0	10.3	4.5	7.9	13.5	5.1
Compressor Disch. Pressure	bara	66.68	68.74	70.29	67.68	74.86	65.50	68.25	70.73	63.75	64.57
Gas Specific Gravity		0.622	0.629	0.638	0.628	0.644	0.645	0.639	0.624	0.639	0.621
Ambient Temperature	°C										
Running hours (average)	h/year	46	52	99	44	33	79	78	106	119	218
Running hours (cold winter)	h/year	5	4	27	3	18	59	180	248	63	32
Running hours (mild winter)	h/year	21	47	108	1	0	65	0	66	141	31
Running hours (extended)	h/year	42	142	233	48	166	205	165	222	403	1309
Compressor Speed	RPM	3100	4005	4503	5124	5730	4800	5726	5488	5247	5282
Gas Generator Speed	RPM	3695	5284	5586	5818	6098	5716	6096	5990	5875	5892
	%	49.3%	70.5%	74.5%	77.6%	81.3%	76.2%	81.3%	79.9%	78.3%	78.6%
Gas Turbine Efficiency	%	11.4%	18.3%	21.3%	23.1%	26.7%	23.2%	25.9%	25.9%	24.2%	24.7%
Net Thermal Input	MW	20.86	24.67	29.40	33.16	43.53	32.51	42.66	41.45	36.34	40.03
Fuel Flow	kg/s	0.45	0.54	0.64	0.72	0.95	0.71	0.93	0.90	0.79	0.87
Exhaust Gas Temperature	°C	412.7	433.2	456.1	480.1	560.3	475.5	554.7	546.3	505.1	535.5
Exhaust Mass Flow	kg/s	38.93	55.66	58.84	61.28	64.23	60.21	64.22	63.09	61.89	62.06
CO_2 Mass Flow	kg/s	1.20	1.42	1.70	1.92	2.51	1.88	2.46	2.39	2.10	2.31
NOx Mass Flow	g/s	2.33	3.59	4.13	4.69	6.60	4.53	6.47	6.16	5.20	5.83
CO Mass Flow	g/s	21.62	25.73	22.37	19.17	11.18	19.55	11.61	12.09	15.96	12.82
UHC Mass Flow	g/s	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NOx Concentration	mg/Nm^3	73.3	79.0	85.9	93.8	125.9	92.2	123.3	119.6	102.8	115.0
CO Concentration	mg/Nm^3	680.5	566.3	465.6	383.3	213.2	397.6	221.5	234.7	316.0	253.1
UHC Concentration	mg/Nm^3										

Figure 2 – Basis of design 10 process duty points for Kirriemuir unit A (Costain document ref: 7063-0200-01-0001-001-Rev P3).

Technical Query	TQ-No:	TQ/20602/008	
	Issue / Date:	1	10/01/22
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Actions & Date

National Grid to advise on the above. Response to be by the 13/1/22 via formal TQ document (supplied below).

Attachments Response 25-01-22

Data for Wormington and Peterborough is provided in the attached:

TQ008_NG%20Response.xlsx

[redacted]

Here are the prices for electricity, based on BEIS prices (link below) – Reference Case.

https://www.gov.uk/government/publications/updated-energy-and-emissions-projections-2019

	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2
Electricity (baseload) [4]	5.520021	5.686205	5.846983	5.636029	5.777145	5.715619	5.605205	5.779323	5.681668	5.703681	5.523458	5.513042	5.562359	5.679251	5

I will follow up with site capacity later today.

[redacted]

Technical Query	TQ-No:	TQ/20602/020	
	Issue / Date:	1	27/5/22
PROJECT: NG SCR FEED STUDY	1 Pages		

From: [redacted]			To: National Grid	
Co-ordinator: [redacted]	Email: [redacted]		Co-ordinator: [redacted]	Email: [redacted]
Reply to TQ No: N/A	Issue:	Reply Required: ~~Yes /~~ No	Action (Name & Department)	
Close TQ No: N/A	Issue:	Date:	Info (Name & Department)	
Author (Name & Department) [redacted]			Approval (Name & Department)	
Subject:	Wormington SCR pre-FEED study Update 3			
1) References - **2)** Discussion or Reply - **3)** Action Required & By When - **4)** Attachments				

References

Discussion

1. **Costs**
   a. [redacted]
   e. [redacted] **exhaust ducting – Being estimated internally at time of writing**

2. **Lead times – [redacted] have been advised that the greatest lead time will be 1 year for the catalyst unit. This is subject to change.**

3. **Draft reports**
   a. [redacted] **will aim to submit a draft Wormington report on the 10/6/22. We will endeavour to include delivery times and costs.**
   b. **Peterborough and Kings Lynn draft report target date are early to mid August.** [redacted] **will assess internal resource and revisit the project plans.**

4. **Technical**
   a. **Run ammonia pipes to the left of the building**
   b. **Steelwork and foundation loads to be excluded from Pre-FEED studies as the vertical stack steelwork will require a detailed design.**

Actions & Date

None

Attachments