Best Available Techniques Assessment – ZP3527SS

Union Park Data Centre

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1.0 INTRODUCTION

This Best Available Technique (BAT) assessment has been prepared by HDR on behalf of the legal operator, Ark data centres Ltd. (Ark) in support of the application for a new bespoke Environmental Permit (Ref: ZP3527SS) for the following installation:

Union Park Data Centre
Bulls Bridge Industrial Estate
North Hyde Gardens,
Hayes, UB3 4DG,
Grid Ref: TQ 10436 79275

Ark, as the legal operator, is required to apply to the Environment Agency (EA) for a permit because the total net thermal input capacity of the site's combustion plant exceeds the 50MW threshold stipulated in the legislation[1].

The Union Park Data Centre is currently being constructed, with completion and handover expected in early 2025. The data centre will house various IT equipment that will require a constant stable electrical supply to operate effectively.

For a detailed description of the data centre and surrounding area, please refer to the Environmental Risk Assessment (ERA) and Site Condition Report submitted with the application. The Non-technical Summary (NTS) document provides a non-technical introduction to the site and the application for a permit.

1.1 Purpose of this report

It is a requirement that the operator demonstrates how they comply with the indicative BAT requirements, with the assessment to be completed as part of the application for an environmental permit. 'Techniques' include both the technology used and the way the installation is designed, built, maintained, operated, and decommissioned.

At the time of writing there are no relevant published BAT reference documents (BREF notes) for data centres. The previous guidance document: 'Combustion Activities (EPR 1.01)' was withdrawn in August 2018. To replace this, the EA have produced a working draft BAT guidance document specifically for data centres: 'Data Centre FAQ Headline Approach v21' (November 2022). This BAT assessment is structured using this guidance document and seeks to provide evidence of BAT or justification where the requirements have not been met.

Some of the design choices that have been made are in response to local planning requirements and are specific to the constraints and circumstances for the site location. This report is therefore specific for this site only and should not be taken to represent the BAT position for other data centre developments.

[1] The Environmental Permitting (England and Wales) Regulations 2016

2.0 SITE SUMMARY

The Union Park Data Centre and associated Energy Centre (EC3) outlined in Appendix A below, is one of three data centres to be constructed on the 'Union Park campus'. The other two data centres (EC1 and EC2) are under the control of a separate operator and thus are covered by a separate environmental permit (ref DP3442QV). This BAT relates solely to the Union Park Data Centre and associated Energy Centre (EC3).

The data centre will use Emergency Standby Generators or 'ESGs' to provide emergency power in the event of grid electrical failure. The ESGs will be located in the associated 'EC3' Energy Centre which provides emergency power to the UP3 data halls. At final fit-out, EC3 will house 12 no. ESGs. The model selected are Rolls Royce MTU DS4000. which have an electrical output rating of 3.2 MWe each. This equates to a net thermal input rating of 8.01MW and an aggregated total of approximately 96.11 MWth (See Appendix A).

At the time of writing, construction of EC3 is ongoing with commissioning due in Q1 of 2025. Formal handover from the contractor to Ark will follow some time in Q2 / Q3 of 2025.

The ESGs will be located in EC3 as seen below in Figure 2.1. The site plan with emissions points is shown in Appendix A.

The EC3 building will encompass 4 floors with 7 no. ESGs on the ground floor followed by the associated Selective Catalytic Reduction (SCR) units on the floor above to provide NOx abatement. This will be repeated with an additional 5 no. ESGs on the floor above and the SCR units on the final floor.

All of the ESGs due to be commissioned are over 1MWth and are therefore classed as new 'Medium Combustion Plant' (MCP) and Specified Generators. These ESGs are 'limited hour MCPs' as they are purely standby plant that will operate less than 500 hours per year and there is no capacity agreement in place. The operation of the ESGs is likely to be limited to monthly/annual maintenance and testing. The ESGs are capable of operating on diesel or biodiesel such as 'HVO' or Hydrotreated Vegetable Oil.

The installation is located within an Air Quality Management Area (AQMA) for NO_2 and near an Air Quality Focus Area (AQFA). As a result, during the planning process, the London Borough of Hillingdon (LBH) required that NOx abatement be fitted to the generators in the form of Selective Catalytic Reduction (SCR). Further details on the SCR system are presented in section 3.5.

Note: Each individual Emergency Standby Generator (ESG) is significantly below the threshold of 15MWth for large combustion plant. Therefore, the BAT requirements for large combustion plant are not relevant for this installation.

The Directly Associated Activities (DAA) include fuel storage tanks, urea storage tanks, associated pipework, and the surface water drainage network.

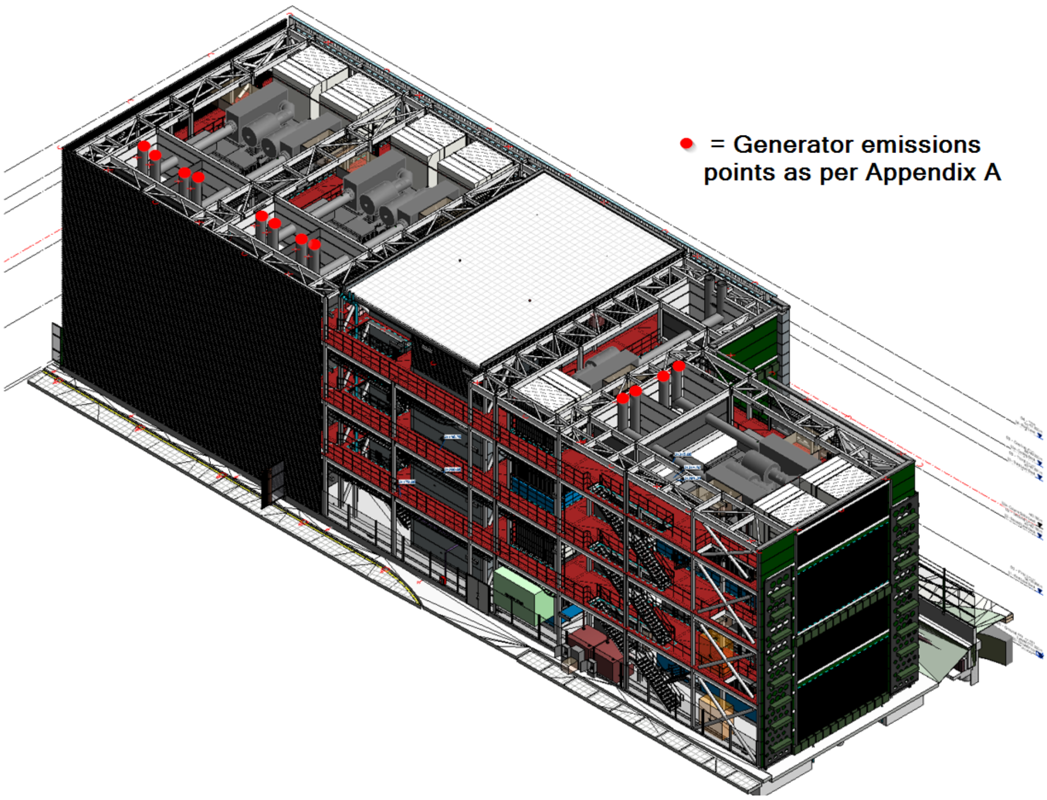

Figure 2.1 – Indicative EC3 Building layout

3.0 DATA CENTRE DESIGN

3.1 Uninterruptable power provision

The data centre functions by leasing data halls to customers to fill with various servers and associated IT equipment. This equipment requires a stable and constant supply of electricity to operate.

'Uptime' or power availability is a term used to explain how reliable a power source is. Data centres require a high level of uptime or uninterruptable power provision and being supplied by the national grid brings a risk of mains failure events (blackout) or fluctuations outside of acceptable limits (brownouts). Downtime i.e., power failures or voltage drops, even momentarily, may mean loss of service to customers such as banks. This could have significant negative implications to site services, both in terms of direct financial costs and indirectly through reputational damage. Therefore, an uninterruptible power supply is critical to a data centre's ability to operate.

Given this risk, the installation has ESGs to provide an electrical supply to the site. In the event of a loss of supply from the grid, the generators will start up, but they will not be able to take the electrical load immediately. Power is initially provided by the site's Uninterruptible Power Supply (UPS) (arrangement of batteries) until the generators start to take the site's electrical load. The generators start from 'cold' to take on the load from the UPS (typically within 30-120 seconds). The backup generators then provide ongoing power until a stable mains electrical supply is restored.

The Uptime Institute's Tier classification and performance standard[2] provides an objective basis for comparing one sites infrastructure vs another. The differing tiers are summarised in Figure 3.1 below.

	Tier I	Tier II	Tier III	Tier IV
Active Capacity Components to Support IT Load	N	N+1	N+1	N after any failure
Distribution Paths	1	1	1 active and 1 alternate	2 simultaneously active
Concurrently Maintainable	No	No	Yes	Yes
Fault Tolerance (single event)	No	No	No	Yes
Compartmentalization	No	No	No	Yes
Continuous Cooling*	load density dependent	load density dependent	load density dependent	Yes (Class A)

Figure 3.1 – Uptime Institute's Tier classifications

Uptime is calculated based on the amount of downtime a site experiences as a % of the year i.e., 99% or 'two 9's' corresponds to about 7 hours and 12 minutes of downtime per month. As the "nines" uptime increases – to three (99.9%). Four (99.99%) and five (99.999%) the downtime decreases. In general, five nines are considered a reasonably high reliability. With six nines, or 99.9999%, an average customer would experience 2.6 seconds of downtime per month, or less than 32 seconds per year.

The National Grid produce an annual report of performance. Below is the performance statement from the National Grid report for 2022/23.[3]

> *"The Overall Reliability of Supply for the National Electricity Transmission System during 2022-23 was: 99.999981%."*

The Union Park facility has been designed and will be operated as a Tier III facility, which requires the provision of ESGs.

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[2] https://uptimeinstitute.com/tiers

[3] https://www2.nationalgrideso.com/document/289196/download

3.2 Onsite electrical infrastructure

For resilience reasons, it is preferable to have numerous power supplies to the site as this provides an alternate route to switch to, should one supply be compromised during an outage. This can be provided in several ways, but the most common option is to have separate supply routes within one substation, or to have multiple substations onsite. If one supply route fails, the data centre can switch to the alternate supply that is unaffected. This ability to switch to the unaffected supply route reduces the duration for which the generators operate in the event of an outage.

The grid electrical infrastructure to the site are as follows (See Figure 3.2):

- Iver 275kV substation
- North Hyde 66kV substation

The relevant part of the Grid Substation has 3 incoming feeds to make 2 outgoing supplies to the on-site substation. Each supply can support the full site load, meaning that if one supply was to fail, electrical provision to the installation would not be compromised. A grid substation failure is considered extremely rare as it would require a catastrophic regional failure on the grid, or at the supplying power station, and would likely impact not only the site but the surrounding London area.

A grid reliability study has been completed to assess the reliability of the electrical infrastructure (See Appendix D). The report concluded that electrical grid supplies are highly reliable and have potential for meeting 99.999605% reliability. No grid outages from the grid supply have been reported to date. As such a grid outage is considered to be a highly rare event. Operation is therefore likely to be limited to testing and maintenance for approximately 7 hours / generator / year.

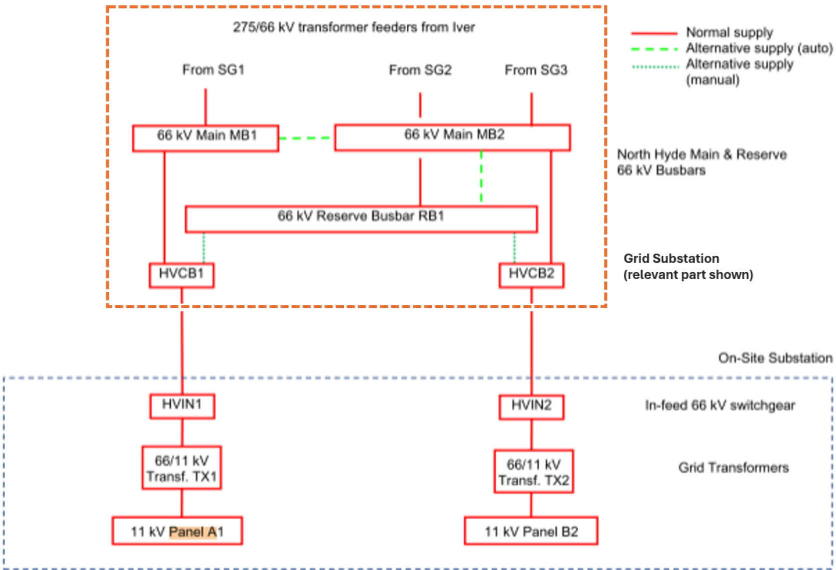

Figure 3.2 - Site electrical supplies

3.3 Redundancy arrangement

The main source of power at the installation will be electricity. This will be supplied via its' own dedicated substation, fed by the National Grid. To mitigate the risk of power failure on site, in line with the options outlined above, ESGs to provide electricity in event of grid failure are necessary. A UPS (in the form of a battery bank) will also be utilised to bridge the short gap between supply failure and the generators starting up.

The installation has incorporated redundancy / resilience as a risk measure to help ensure that power provision is not interrupted in the event of a loss of mains electricity supply. The number and capacity of the proposed generators are based on the likely maximum electrical demand by prospective customers. The generators can provide the maximum amount of power that the data centre could require at its current design.

The redundancy arrangement for the generators is N+1, where ‘N’ is the number of generators required to carry the maximum electrical load. At full capacity, each set would be running at a maximum of 85.7%. Thus, in an outage only 11 of the 12 ESGs are required to carry the maximum site load i.e. 1 of 12 ESGs are not required to operate.

In the event of a loss of supply from the grid, the generators will start up, but they will not be able to take the electrical load immediately. Power is initially provided by the site’s UPS until the generators start to take the site’s electrical load. The generators start from ‘cold’ to take on the load from the UPS (typically within 30-120 seconds). The backup generators then provide ongoing power until a stable mains electrical supply is restored. The redundancy arrangements are to safeguard power to the dedicated data halls as ESGs have up to a 15% probability of not starting and therefore +1 or +2 depending on total building load installed.

3.4 Technology selected to provide emergency power

ESGs capable of operating on diesel or HVO have been selected to provide emergency power to the installation in the event of grid failure. A BAT assessment, considering alternative technologies and why ESGs are considered BAT is presented below.

There are currently no BAT reference documents or BREF notes that have been made available by the European Commission for the specific provision of backup power in the data centre industry. We are therefore proposing an alternative which is based on the guidance in the EAs “*data centre FAQ v21 – Working Draft*”.

The key criteria used in the selection of the BAT to fulfil the backup power requirements are split into two categories:

- Operational requirements
- Environmental risks

The criteria for both categories have been chosen based on the main risks posed and in accordance with the risk assessment guidance for bespoke permits.

3.4.1 Operational requirements

Table 3.1 – Operational requirements

Criteria	Considerations	Weighting
Cost benefit analysis	The initial capital cost of the technology being considered, and the potential cost of potential mitigation measures need to be considered to ensure they are not disproportionately high compared to the environmental benefits. Otherwise, the operator will cease to be competitive.	High – impacts competitiveness
Proven as a reliable technology	The resilience requirements of data centres are such that the key operational criterion is for the technology used to be a proven and reliable technology. An indication of reliability of a technology can be taken from the number of instances that the technology in question has been successfully utilised in the industry, i.e., whether this is a tried and tested technology or is it new and emerging. The technology also needs to suit the prevailing model of the industry.	High – if technology is not proven it presents a risk to the operator
Cold start capability	The technology will need to have the ability to start operating quickly in the event of a sudden loss of power. A warm start configuration would necessitate 24/7 operation of generators at the site: creating unnecessary fuel costs and environmental impacts. A slow start technology would necessitate additional energy storage UPS capacity (in the form of batteries or flywheels), taking up additional space and creating additional cost.	High – the ability to provide instant power is critical to business functions
Space requirements	Space requirements are relevant as an environmental consideration as a technology that requires excessive use of space (in the form of generator units, energy storage UPS capacity, and fuel storage) will reduce the amount of space available at the data centre for the IT equipment it is designed to host. This will necessitate a larger site area or construction of additional sites to provide the same level of service.	High / Medium – space limitations often dictate the technologies that can be considered

Criteria	Considerations	Weighting
Fuel suitability	The fuel used needs to be capable of being stored / transported to and across the site without excessive risks to operations e.g., low risk of combusting.	Medium – low volatility and low risk is vital
Lifetime of stored fuel	The fuel will need to be stored onsite potentially over a long period of time as mains failure events are rare and as such the generators are not routinely operated, other than for maintenance and testing purposes. The fuel stored onsite may remain unused for a long period of time and should therefore be of a type that will remain useable under these conditions – rather than becoming a waste product in need of disposal.	Medium to low – whilst an added cost it is not top priority

3.4.2 Environmental risks

Table 3.2 – Operational requirements Environmental risks

Criteria	Considerations	Weighting
Air quality impact	Local air quality impacts from exhaust of combustion gases when operating the technology in combination with the fuel being combusted.	High – internal combustion engines perform poorly but they are run infrequently
Noise / odour	The technology should not incite regular Odour / Noise complaints from nearest sensitive receptors e.g., residences.	Low – complaints are unlikely due to infrequent operation
Global warming impact	The global warming impact of the fuel being combusted should compare favourably against the electrical output of the technology.	Medium – impact is high, but combustion of fuel is infrequent
Release to water (fuel spillage)	The risk of fuel escaping to the environment, e.g., local river course / ground should be low.	Low – fuel use is low due to infrequent operation
Fugitive emissions (leak of gaseous fuel)	The risk of fuel escaping to the air, e.g., gaseous escape should be low.	Low – fuel use is low due to infrequent operation
Security of fuel supply	Ability to store sufficient volumes to ensure security of supply. Supply also needs to be reliable i.e. guaranteed provision and cost effective.	High – security of fuel provision is critical to operation during an emergency

The following technologies were considered for the provision of emergency power to the data centre:

- Combustion Engine Generators (includes operation on HVO / other liquid fuels)
- Diesel rotary uninterruptible power supply engines (DRUPS)
- Natural Gas (piped) Fuelled Generator – Spark Ignition Engine
- Natural Gas (piped) Fuelled Generator – Gas Turbine (CCGT or OCGT)
- Liquid Petroleum Gas (LPG) Fuelled Generator – Spark Ignition Engine
- Hydrogen Fuel Cell Technology: Polymer Electrolyte Membrane (PEM) Fuel Cells
- Hydrogen Fuel Cell Technology
- Standby Gas Turbine Technology.

The conclusion of the assessment is that emissions-optimised ESGs (operating on diesel / HVO) have been selected again as BAT for this installation for the following reasons which are in line with the EA BAT guidance for data centres:

- Proven technology for providing reliable power supply
- Start-up time & cold start capability
- Space requirements
- Capital expenditure

- Environmental impact
- Fuel storage and security of fuel supply.

3.5 Generator emissions rates

The EA guidance for data centres is that 'new generators', as a minimum achieve the following standards:

> *"TA-Luft 2g' or Tier II USEPA with guaranteed emissions: this has requirements for 2000mg/m3 NOx; 650 mg/m3 for CO; particulates and dust 130 mg/m3 and 150 mg/m3 for hydrocarbons (all at reference conditions and 5% O2)."*

The generators that have been selected to support the site development are emissions-optimised and achieve the Tier II US EPA standard. For the size and output, the engines selected are best in class for NO_x emissions. The generator engine and emissions datasheets are found in Appendix D.

The installation is located within an Air Quality Management Area (AQMA) for NO_2 and near an Air Quality Focus Area (AQFA). As a result, during the planning process, the London Borough of Hillingdon (LBH) required that NOx abatement be fitted to the generators in the form of Selective Catalytic Reduction (SCR). Further details on the SCR system are presented in the following section.

3.5.1 Selective Catalytic Reduction system

The SCR system has been designed to achieve a NO_x emissions rate of $95mg/Nm^3$ (at 5% O_2). This level surpasses what can generally be achieved by a gas generator of equivalent size and output. The SCR specification sheet has been provided in Appendix C.

This SCR system is to be located on top of the generator container and connected to the generator flue system. The system works by dosing the exhaust gases with ammonia to convert NO_x to Nitrogen (N_2) and water (H_2O).

The SCR system will experience 'Ammonia Slip' which can occur as soon as urea dosing commences. It is expected that dosing would not commence during the first 15 to 20 minutes (generator warm-up time) (see Figure 3.6 below). For the purpose of the Air Quality assessment (see Section 10.3), it was assumed that ammonia slip would occur as soon as the SBGs operate. The NH^3 emission rates listed within the AQA are based on the emission concentration of $95mg.Nm^3$ (at 5% O_2), as presented in the SCR datasheet in Appendix D.

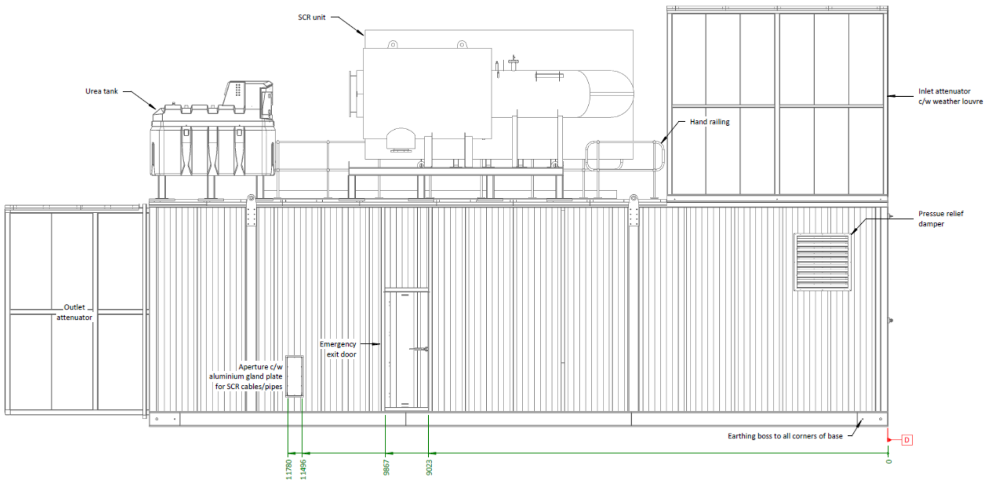

Figure 3.3 – Generator container with urea tanks and SCR unit

Figure 3.4 – SCR system on top of generator (Example from EC1)

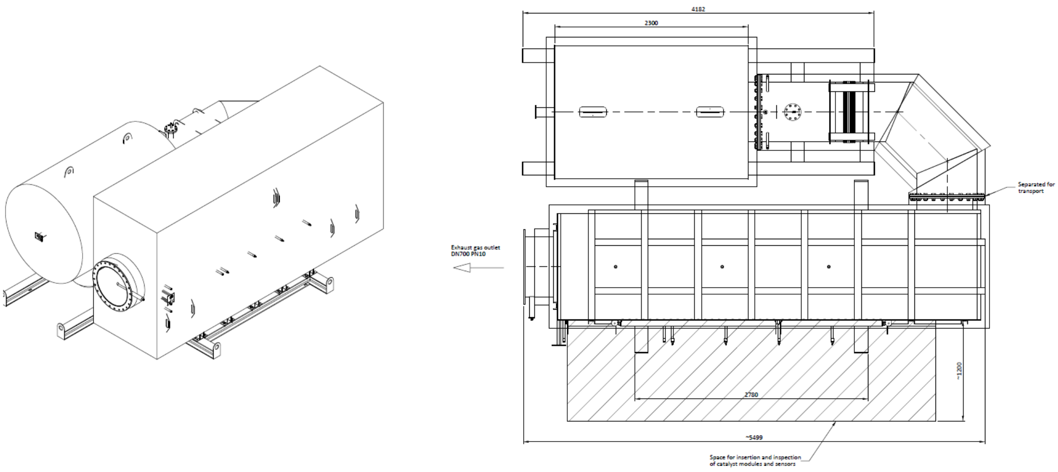

Figure 3.5 – Generator SCR System

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The below graph shows the NOx raw emissions before the CHP and the reduced NOx-emissions after the CHP in mg/Nm³ at 5% O2.

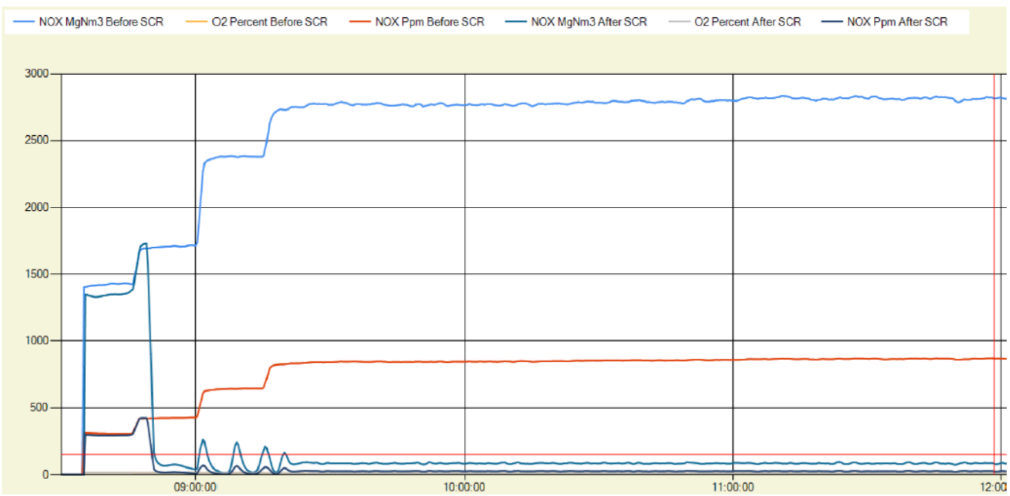


Figure 3.6 – Timeline graph of pollutant levels in exhaust gases post SCR

A summary of generator mass emissions rates that have been used in the Air Quality Impact Assessment (see section 10.3) recognising the performance of the SCR are presented in Table 3.3 below.

Table 3.3 - Air Quality Model Inputs & Generator emissions rates

Parameter	Unit	Emissions rates at 100% load	Emissions rates at 25% load
Power	KW	3307	827
Stack(s) height	m	21.1	21.1
Stack(s) diameter	m	0.7	0.7
Exhaust gas temperature	ºC	482	403
Exhaust Volumetric Flow (actual)	$m^3.s^{-1}$	11.9	3.69
Exhaust Volumetric Flow (dry, 5% O_2)	$Nm^3.s^{-1}$	2.57	0.74
NO_X emission rate (unabated concentration of 2362 $mg.Nm^{-3}$)	g/s	6.063	1.011
NO_X emission rate (concentration post SCR of 95 $mg.Nm^{-3}$)	g/s	0.244	0.070
Time weighted NO_X emission rate	g/s	2.18	0.38
PM_{10} and $PM_{2.5}$ emission rate	g/s	0.018	0.041
CO emission rate	g/s	0.276	0.322
Hydrocarbons (benzene) emission rate	g/s	0.0459	0.037
SO_2 emission rate	g/s	0.0028	0.001
*It has been assumed that 100% of the PM is emitted as both PM_{10} and $PM_{2.5}$ **Estimated assuming moisture content of 14% in exhaust gas			

3.6 Generator noise attenuation

The SCR system includes a silencer system to reduce the engine exhaust noise in line with the required levels. Target: 70dB(A) @ 1m from the perimeter of the canopy at 1.5m from the ground. This is achieved through the use of exhaust silencers to dampen the flow noise and lagging of SCR equipment to reduce the airborne noise. The lagging also reduces the touch temperature of the system to 60^{o}C

The project has gone through an extensive planning process which has led to significant requirements for acoustic mitigation on the ESGs. A summary is listed below:

- The generators are located in a less sensitive area away from Noise Sensitive receptors and towards the nearby noise sources.
- The generators will be installed within an acoustic canopy which includes attenuated inlet and outlet air paths and exhaust mufflers.
- The generators are to be used only in emergency purposes or during planned testing which can be scheduled in advance.

A noise impact assessment was undertaken for the 12no. ESGs and concluded that “noise levels are predicted to achieve the noise limits at the nearest noise sensitive properties and therefore noise impacts are not considered to be significant”. For more information on noise impacts, please refer to the noise impact assessment submitted with the application (‘Noise Impact Assessment’).

3.7 Generator flue and exhaust design

The flue arrangement for all 12 of the ESGs is as follows with drawings found below (See Figure 3.8)

- Each generator has its own dedicated flue
- Stacks will rise to 21.1m above ground, terminating at 1m above the building height
- Stacks are orientated vertically and are unimpeded by cowls or caps
- Thermally insulated twin wall stainless steel-clad flues rising within self-supporting multi-flue steep encased stacks

Dispersion of pollutants has been considered when designing the flues for the generators. The design of the flues is therefore considered to be BAT for this application.

During the design process, consideration was given to implementing a common windshield to group stacks as this is understood to improve dispersion in certain situations. Common windshields require additional support structure and the space constraints for the new generators could not support this. Additionally, if the common windshield was compromised for any reason, the data centre's requirement for redundancy could be compromised also. During normal operation, generators are tested individually to minimise air quality and noise impacts. Thus. A combined flue arrangement would have little impact on emissions.

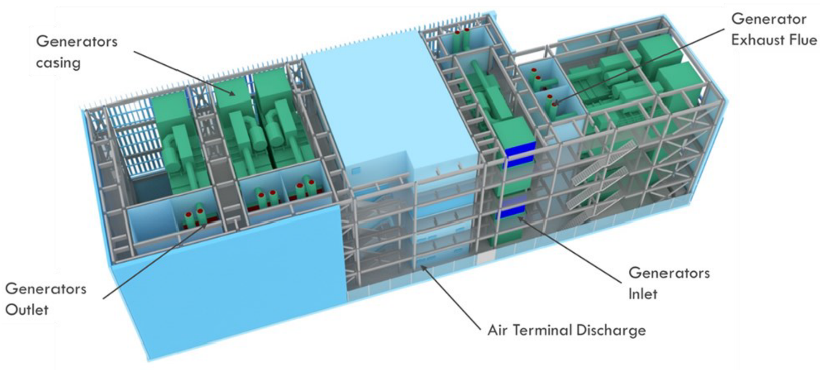


Figure 3.7 – Indicative generator flue layout

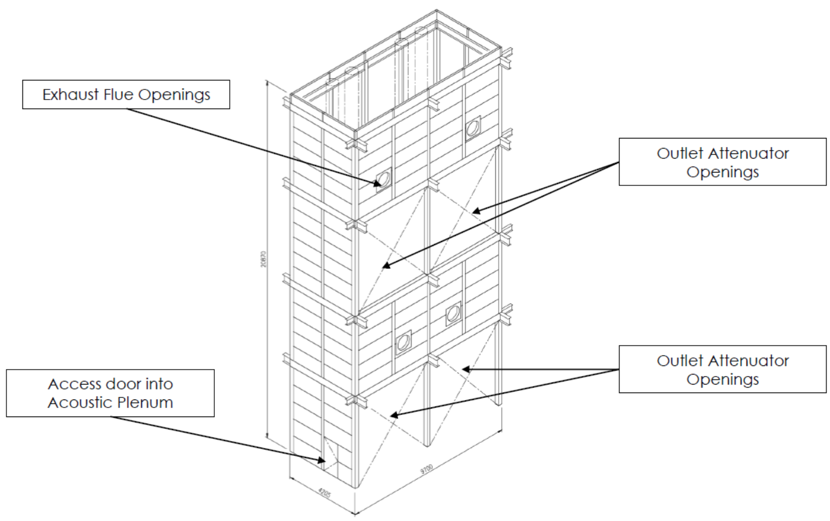


Figure 3.8 – Acoustic plenum which contain generator flues

3.8 Fuel storage

The ESGs will combust a liquid fuel in order to generate electricity in an emergency. The current plans are for the ESGs to operate on diesel or biodiesel such as 'HVO' or Hydrotreated Vegetable Oil.

The following sections provide details of the fuel storage arrangements for the ESGs.

3.8.1 Fuel tanks and storage capacity

Each of the 12 ESGs will have its own 52,000 litre (usable) bunded belly tank which sits below the generator. An example from EC1 (which is the same specification for EC3) is shown in Figure 3.9 with additional tank schematics and drawings in Appendix E.

The tanks have been sized to provide 72 hours of continuous operation at 100% rated load and offer a total useable storage capacity for the site of 624,000 litres. Please refer to Section 7.0 (Efficient Use of Raw Materials) for further details on the storage of Diesel and HVO.

The tanks shall conform to BS 799 pat 5 type J 2010 with a max working head above tank of 0.5m. The tank plates shall be constructed from Material 5mm sheet, fully welded internally and externally and manufactured to the water environment standard for oil storage.

Overfill prevention valves will be fitted to the belly tank line along with a leak detect float switch within the tank bund to provide leak detection.

The tanks are below the generator they serve which are contained within the Energy Centre building thus reducing the risk of spillages entering the environment.

Figure 3.9 – Example bunded belly tank which sits below the generator (from EC1)

Receiver / day tanks

The 12 no. belly tanks will be fed from 2 no. 2,500 litre (2,750 brim-full) receiver / 'day tanks' An example from EC1 is shown in Figure 3.10 with additional tank schematics and drawings presented in Appendix E.

Each tank will be integrally bunded to 110% and connected to one of the 2 no. fill points that each connect to all 12 no. belly tanks. The tank plates shall be constructed from 3mm sheet steel, fully welded internally and externally and manufactured to the water environment standard for oil storage.

A bunded pump cabinet with roller shutter door and internal leak detection shall be connected at the end of the fuel oil receiver tanks to contain the fuel transfer pump system. Pipework between the fill cabinet and the receiver tanks shall route via DN50 in DN80 pipe in pipe.

The tanks will also be fitted with an Overfill Protection Valve (OPV) to the tank fill line and a leak detect float switch within the tank bund.

The Tanks OLE gauge shall provide detailed fuel level information, and the tank bund shall incorporate a leak detection float switch to alarm if a leak is detected.

Figure 3.10 – Example of receiver tanks that feed generator belly tanks (taken from EC1)

3.8.2 Fuel fill points

The 12 no. bulk tanks will be refuelled via 2 no. independent fill point cabinets – fill system A and B. (see Figure 3.11) Should a malfunction occur using fill system A, the operator can switch to fill system B to continue operation.

The operator can choose which belly tank they wish to fill from the touch screen and when selected, the motorised valve associated to that belly tank is actuated and the fill operation can commence. There are 2 no. 24 motorised valves located on each belly tank and these shall connect to individual overfill protection valves. These valves shall be located within the bunded canopies providing an N+1 system.

The 2 no. fill points are to be located external to the installation to the east of the building and will be located in a lockable cabinet with a drip tray to capture minor spills. A fuel interceptor is to be installed at the loading ramp to prevent any spillages from entering the surface water drainage system, and forecourt separators installed at the fill points to prevent spillages from entering the foul water system (See Appendix G). The area will be covered in hard standing to help ensure any spillages are directed to the nearest drain.

Within each fuel fill cabinet, shall be a fuel control panel which shall display the current fuel level of all 12 belly tanks and both receiver tanks. The control panel can be used to select each tank for individual filling. This shall control the transfer pumps and motorised valves in each canopy and provide the overfill prevention controls / alarms at the fill cabinet for the fill operator.

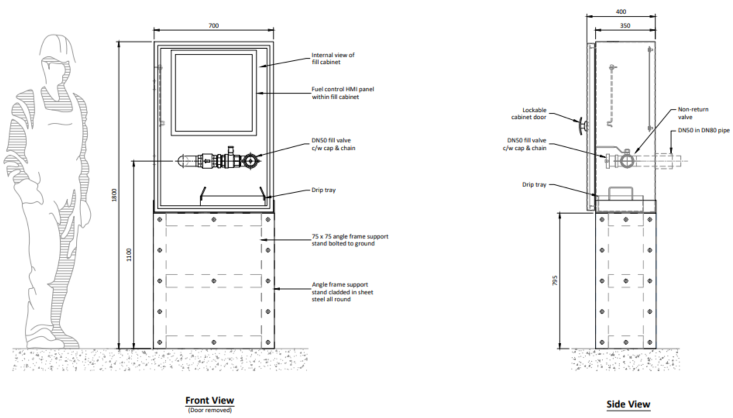


Figure 3.11 - Fuel fill point drawing

3.8.3 Fuel polishing

Each belly tank is fitted with an automatic fuel polishing system with an integrated pump and filter assembly, programmed to operate at pre-defined intervals. When operating, the polisher pump will draw fuel from the belly tank before passing it through a 10micron particulate and water separator before returning it to the opposite end of the belly tank.

This unit filters the fuel in the tank, removing moisture and particulates from the fuel and ensuring the generators run cleanly. The aim is to help maintain the fuel to a usable standard, preventing early degradation and ultimately extending the life of the fuel.

3.8.4 Overfill protection

The belly tank comes complete with probes suitable for alarming if the filling process exceeds the max levels and will close the valve to the generator at the same time. The tank bund shall incorporate a leak detect float switch to alarm if a leak is detected.

A float switch connected to the generator controller is situated in each individual belly tank. If the generator controller detects that the levels have risen to a pre-set high level within the belly tank an audible alarm will be provided once the pre-set level has been reached within the bulk tank. This will sound at the fill point cabinet via the tank alarm, alerting the person supplying the fuel to stop filling. If the fuel is still filling the tank above the pre-set level, an OPV has been installed to provide a failsafe and stop the tank from overfilling.

The float switch is configured in a fail-safe configuration as normally on signal. In the event of loss of signal from the switch, the generator controller will close the motorised valve if still open.

Where there is a high risk of spillage, spill kits containing drain seals, absorbent materials, disposal containers and other appropriate equipment should be held.

3.8.5 Fuel pipework

The 2 no. fill line headers that supply all 12 no. belly tanks, as well as the connected pipework from the header to the generator canopies shall be constructed of DN80 in DN125 double skinned welded pipe (Appendix F). As the pipework enters the canopies it shall step down to single skinned DN50 pipework and connects to the motorised valves and to the belly tank through a bunded area.

The generator supply and return lines shall consist of DN25 single skinned pipework connected through an internal connection between the belly tank and the generating set canopy.

3.8.6 Fuel management procedures and security

Fuel consumption is low in this installation due to the plant being used for emergency back-up power generation only. As such, fuel deliveries are on average less than once per year. When required, refuelling is conducted by trained fuel tanker drivers and supervised by a trained member of the site engineering team. The location and drainage for the refuelling area is presented below in Figure 3.12.

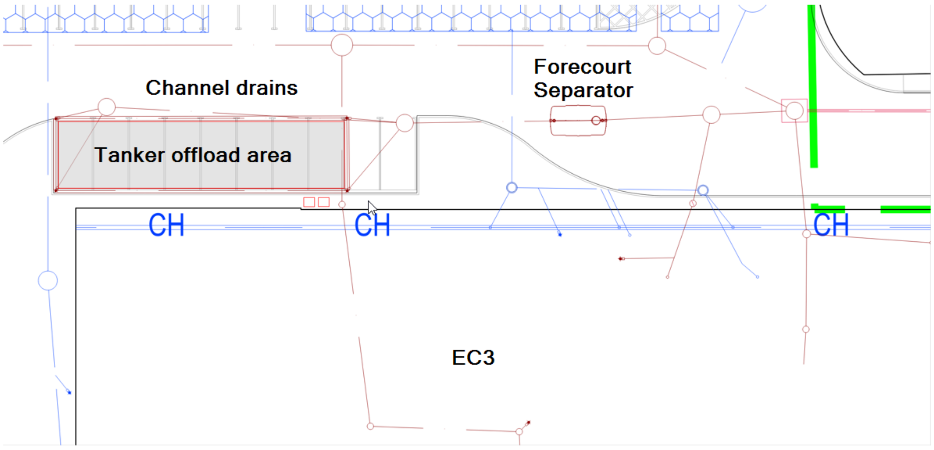


Figure 3.12 – Drainage systems in refuelling area north of EC3

A standard operating procedure (SOP) (or similar) is to be implemented to facilitate refuelling activities. This SOP is intended to help reduce the risk of a spillage during refuelling. These are supplemented by additional supplier procedures for fuel deliveries. In addition to this, additional controls are to be developed to help reduce the risk of an incident including an SOP for spill response and spill kits.

A periodic preventative maintenance (PPM) regime is to be implemented once operational that will include periodic visual checks for leaks / spills and checks for suitably stocked spill kits, and that these are located within close proximity of fuel storage tanks and fill points.

Spill kits and drain covers are to be located in the vicinity of the fill point to reduce the risk of spilt fuel entering the drainage network during refuelling or in an emergency.

The site will be operated 24-7 with a 24-7 managed security staff with CCTV and an alarm system in place. The site will have security office that allows operations to switch on all external luminaries on intruder detection by an operation switch.

The above controls and operating techniques are considered to meet the EA’s BAT requirements for this Data Centre.

3.9 Urea storage

As mentioned above, the ESGs have been fitted with an SCR system which uses urea as a raw material to provide NOX abatement. Each SCR will have its own 2,500L urea storage tank which contains sufficient urea to operate for 48 hours and enables a urea flow rate of 37 litres per hour. Each urea tank is to be bunded to 110% of the capacity of the tank.

Tank drawings and an example tank from EC1 is shown below in Figure 3.13 and Figure 3.14. The urea tanks will be located on top of the generator container as seen in Figure 3.3. Monitoring of the system is to be achieved remotely once connected to BMS (or similar system). As with the fuel tanks, these tanks will have appropriate overflow protection and leak detection devices.

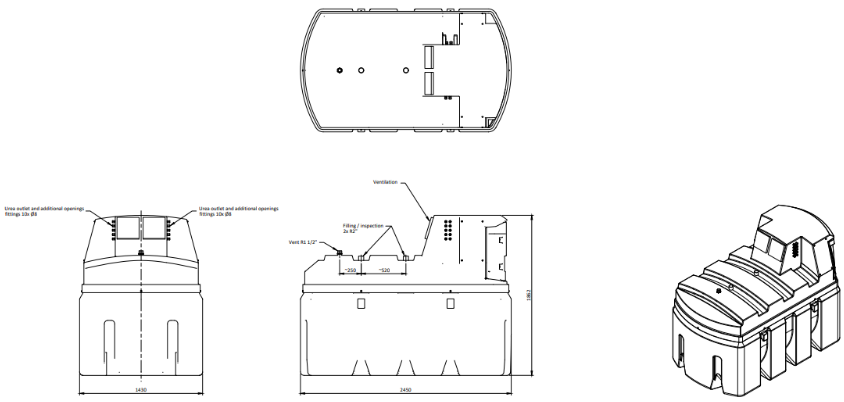


Figure 3.13 - Urea tanks general arrangement

Figure 3.14 - Example Urea tank from EC1

3.10 Drainage & tertiary containment

The site's drainage system is split into separate foul and surface water networks as shown in the sites drainage plan in Appendix F. This network serves the entire campus irrespective of the operator / permit boundaries as it was originally designed for a single operator for all 3 data centres.

The below ground surface water drainage network system collects surface water from buildings roofs and site hard landscaping surfaces including site access roads, carparks and footways. Site roads and carparks are permeable pavements (where heavy vehicle tracking allows) which provide treatment through a combination of Permafilter geomembrane, coarse graded aggregates and permaceptors.

Runoff from concrete loading bays (including fuel refuelling areas) is treated by full retention petrol interceptors and the fuel filling points at EC1, EC2 and EC3 are each bounded by channel drains so that in the event of a spill all of fuel/oils are intercepted for collection by a forecourt separator prior to connecting to the downstream surface water network. This arrangement can be seen in Figure 3.12.

The interceptor tanks will contain a sensor that will be linked to the BMS and trigger an alarm if the presence of fuel is detected. When contaminated water enters the unit, the internal design and configuration ensures lighter than water pollutants, i.e., oil, petrol and diesel rise to the surface of the water within the separator. Separated liquid is discharged through the core tube/coalescer assembly.

An oil probe should be positioned to detect the build-up of oil in no or low flow conditions so that the alarm operates when the oil has accumulated to 90% of the maximum recommended oil storage volume.

The admin building roofs are also provided with green roofs to treat the runoff from these areas.

The runoff from the site is controlled by a hydrobrake flow control which limits the discharge to the greenfield runoff rate (QBar) with cellular tanks provided to store the attenuated volume of surface water before discharge from the flow control. The network is designed so that there is no flooding for up to the 1 in 100 year return period with an additional 40% climate change and no surcharging in the 1 in 1 year return period.

The various SuDS features will be required to be maintained as per the requirements outlined in the Flood Risk Assessment and SuDS manual.

4.0 OPERATING TECHNIQUES

4.1 Generator operation

The generators are likely to be used purely as standby plant to provide emergency standby power in the event of a loss of supply from the grid. There is no capacity agreement in place or elective operation of the plant for generating revenue (e.g., STOR, Triad avoidance, Demand Side Response, Peak Demand etc.). As such, operation of the generators is likely to be limited to monthly maintenance and testing only.

4.2 Maintenance and testing

The maintenance schedule for the generators is based on manufacturer guidelines. These guidelines help to prolong the life of the equipment, reduce the use of raw materials (e.g., replacement parts, oil changes) and ensure the engines perform efficiently to prevent increases in pollutant levels or black smoke.

Testing regimes for monthly and annual testing are detailed below. Where possible and practicable, the intention will be to avoid testing during peak traffic periods when background NOx has the potential to be elevated. There may be instances where operational requirements dictate the time tests are to be undertaken.

The current test regime is considered to meet the BAT requirements (See **Table 4.1**).

Table 4.1 - Annual operational hours per generator

Generator Test Frequency	Description	Load Profile	Individual Test Duration	Total hours / gen
Monthly test	All gens in a unit start simultaneously – to prove all gens start on the "start signal" and run for 15 mins. No load.	0%	15 mins	**2**
Quarterly Test	All gens in a unit star simultaneously, to prove all gens start on the "start signal" and take load for 1 hour. Modelling load = 80% of design load *1/(N+1)	80%	1 hour	**3**
Annual test	Each gen started and run at 100% load against a load bank – to clear the system and prove operation at full load for 2 hours.	100%	2 hours	**2**
			Total hours of operation per generator	**7**

5.0 F-GAS

Fluorinated gases or ‘F-gas’ will not be used in the permitted activities e.g. generators and associated fuel storage.

There is potential that F-gases will be used in the chiller plant and or air conditioning units. This plant is to be maintained in accordance with manufacturer specifications and recommendations with relevant documentation retained. Once the site is operational, an F-gas register is to be maintained onsite, and will include details such as plant make, model and serial, the type and volume of refrigerant, and maintenance history. Any significant releases or leaks are to be recorded and notified to the EA as soon as possible under the F-gas regulations.

6.0 ENERGY EFFICIENCY

6.1 Energy management

As energy prices rise and customers demand more of their providers, there is increasing attention on energy efficiency and better energy management. The most prominent indicator of a data centre's energy efficiency is PUE (Power Usage Effectiveness), and this is often reported as a metric to customers. PUE is the ratio of the total energy delivered to the site compared with the energy used by just the IT equipment. A PUE of 2 means that 50% of the power delivered to the site is used to run the IT equipment. The closer the PUE is to 1, the more efficient the site is. As with current efficient data centres this facility is designed to achieve an annualised PUE <1.2 at IT loads above 60%.

Once operational. there are plans to implement an effective Environmental and Energy Management System (EMS / EnMS). A key focus of this will be improving energy efficiency particularly for high energy-consuming activities such as cooling. Further details are in Section 9.3.

6.2 UK ETS

The site will need to apply for a Greenhouse Gas (GHG) Permit from the EA to participate in the UK Emissions Trading System (UK ETS). This is required for installations with combustion plant in excess of 20MWth[4].

Participating in UK ETS will require extensive monitoring of generator operational hours and fuel use to determine CO_2e emissions per year. This data will likely need to be externally audited or 'verified' prior to submitting to the EA annually.

6.3 EED

The Energy Efficiency Directive (EED) provides an exemption for emergency back-up plant operating under 1500 hours per year. The current testing and maintenance plans do not exceed this limit and therefore EED requirements are not deemed to be applicable.

6.4 ESOS

The UKs Energy Savings Opportunities Scheme (ESOS) is a mandatory energy assessment scheme for organisations in the UK that meet the qualification criteria. At the time of writing these criteria are any company that either:

- employs 250 or more people
- has an annual turnover in excess of £44 million, and an annual balance sheet total in excess of £38 million

There is potential that this site could form part of an ESOS submission which would seek to identify opportunities to improve energy efficiency. Ark meets the ESOS requirements by operating an Energy Management System (EnMS) that is certified to ISO 50001 and this site will be included in the Ark EnMS. Further details are in Section 9.3.

6.5 Measures to improve energy efficiency

The electricity efficiency of the generators ranges from 30-40%. Heat recovery on generators is not a viable option since the generators are backup plant that operate infrequently (approx. <7 hours per year). To ensure the generators operate as efficiently as possible, the site follows a periodic preventative maintenance (PPM) regime. This involves regular checks of the generators to help ensure each generator is operating efficiently.

[4] https://www.gov.uk/government/publications/participating-in-the-uk-ets/participating-in-the-uk-ets#free-allocation

7.0 EFFICIENT USE OF RAW MATERIALS

The main raw materials that will be used within the permitted installation are as follows.

7.1 Diesel / HVO

The current plans are for the ESGs to operate on diesel or HVO with enough onsite storage to provide 72 hours of electricity when running at 100% continuous rated load.

Due to the highly reliable grid supply, it is unlikely that large volumes of fuel will be consumed by this installation. Fuel use will mostly be limited to the running of the generators during maintenance. The PPM regime in place will help seek efficient fuel use by the generators.

As per Section 4.2, each generator is tested for seven hours per year. The generator datasheets provide fuel consumption at 50, 75 and 100% load. Using 100% load, the estimated fuel consumed per generator for testing would be 5,726 litres pa / ESG (See Table 7.1).

Table 7.1 - ESG details

ESG details	50% l/hr	75% l/hr	100 l/hr	Hours per year	Litres / year
12 No. 3.2 MW	429	598	818	7	**68,712**
Approx fuel use per year (worst case)					**68,712**

This is a highly conservative estimate as it has been calculated using fuel consumption at 100% load. Recognising that an individual ESG will only operate at 100% load for 2 hours a year (under maintenance) it is estimated that actual annual consumption (all sets) will be in the range of 55,000 – 60,000 litres / year.

Diesel / HVO has been selected due to the ability to store sufficient volumes to ensure security of supply. Other fuels have been considered but do not currently provide the same level of security. Natural gas could not be stored in sufficient volumes and would be reliant on the National Transmission System. A contract for an uninterruptable supply would be excessively costly given the infrequency of use and would not necessarily guarantee gas supply in the event of a major grid outage, which would then result in a total loss of power supply to the data centre.

Further reasons for fuel selection are present within Section 3.4.2. Due to the limited hours of operation, any potential benefits from the lower impacts associated with emissions from natural gas are reduced.

7.2 Lubrication oils

The engines require lubrication oil to reduce wear and tear through friction. Periodic replacement of this oil is required. Waste oils are to be stored and disposed of responsibly and in accordance with applicable legislation.

7.3 Urea

Urea is to be used as the raw material in the SCR system to reduce the NO_x emissions. It is expected that there will be urea deliveries every 1 to 2 years as limited amounts will be required during routine site operation. Urea deliveries are to be controlled as part of the onsite procedures which seek to reduce the risks of accidents e.g. spillages occurring.

8.0 AVOIDANCE, RECOVERY AND DISPOSAL OF WASTES

8.1 Waste

Waste streams arise as a result of operation and maintenance of the combustion plant. Maintenance extends the life of the plant and resolves issues in a timely manner, reducing waste associated oils, lubricants and replacement parts. The installation does not produce significant amounts of waste due to the standby nature of the generators.

A licenced third-party maintenance contractor is responsible for removing waste produced as a result of generator maintenance. Ark retains Duty of Care information including waste carriers' licences and transfer notes.

Waste streams arising from this installation can include:

- Lubrication oils used in maintenance and servicing (minimal)
- Air and fuel filters (minimal)
- Fuel that has reached end of life (infrequent)
- Used spill kits (emergency only, unlikely)
- Decommissioned plant (end of life only).

In line with the permitting requirements, the operator will aim to minimise waste generation through efficient use of raw materials including diesel / HVO, filters, and lubrication oils.

The need to dispose of waste fuel will be reduced / minimised by utilising in-situ fuel polishers present within each fuel tank as described in Section 3.8.3.

9.0 GENERAL MANAGEMENT

9.1 Management Standards

The following management standards (or equivalent, including non-certified standards) are standard Ark practices and will be implemented on the site once it is operational:

- ISO 14001:2015 – specifies the requirements for an environmental management system that an organization can use to enhance its environmental performance through the development of an EMS.
- ISO 50001: 2018 is for organisations committed to addressing their impact, conserving resources, and improving the bottom line through efficient energy management. Designed to support organisations in all sectors, this ISO standard provides a practical way to improve energy use, through the development of an EnMS.
- ISO/IEC 27001:2022 – specifies the requirements for establishing, implementing, maintaining, and continually improving an information security management system within the context of the organisation. It also includes requirements for the assessment and treatment of information security risks tailored to the needs of the organisation. The requirements set out in ISO/IEC 27001:2022 are generic and are intended to be applicable to all organisations, regardless of type, size, or nature.
- ISO9001:2015 – specifies the requirements for establishing, implementing, monitoring, managing, and improving quality throughout the organisation.

9.2 Environmental Management System (EMS)

Once the site is operational, there are plans to implement an effective EMS, based on the EMS already employed by Ark on other permitted sites. The management system developed will be in accordance ISO 14001:2015, or a suitable equivalent standard.

Once implemented, the EMS will include the policies, management principles, organisational structure, responsibilities, standards / procedures, process controls and resources in place to manage environmental protection across the permitted activities at the installation.

Integral to the EMS will be an overarching environmental policy. This will seek to underpin the EMS and help ensure uptake by all staff with sufficient training provided as required.

The operator will maintain records associated with the management system. These records will be stored on their central system and will be updated in line with the management system's policies.

9.3 Energy Management System (EnMS)

Once the site is operational, there are also plans to implement an effective EnMS, based on the EnMS already employed by Ark on other permitted sites. The management system developed will be in accordance ISO 50001:2018, or a suitable equivalent standard.

Once implemented, the EnMS will include the policies, management principles, organisational structure, responsibilities, standards / procedures, process controls and resources in place to manage energy consumption across the permitted activities at the installation.

Integral to the EnMS will be an overarching policy for energy management. This will seek to underpin the EnMS and help ensure uptake by all staff with sufficient training provided as required.

The operator will maintain records associated with the management system. These records will be stored on their central system and will be updated in line with the management system's policies.

10.0 EMISSIONS

There will be no point source emissions to water, air or land, except from the sources and emission points identified in the site plan shown in Appendix A. Emissions identified as significant have been further expanded in the following sections.

10.1 Noise Impact assessment

A noise impact assessment (NIA) was completed in support of the application for an environmental permit. This report identifies sensitive receptors and potential sources of noise from the installation. The primary noise sources are the site's generators. The impact assessment concluded the following:

> *The noise levels are predicted to achieve the noise limits at the nearest noise sensitive properties and therefore noise impacts are not considered to be significant.*

Further information can be seen in the 'Noise Impact Assessment v1' submitted as part of this application.

10.2 Point source emissions to sewer / surface water

Point source emissions to sewer / surface waters are not anticipated given the controls and mitigation measures in place as described in Section 3.0.

The point source emissions points to surface water from the entire Campus are shown as 'SW1' and 'SW2' in the site plan & emissions points drawing provided with the application. Both of these emissions points are existing emissions points that reside within the boundary of the adjacent datacentre which holds a separate environmental permit (ref: DP3442QV).

For this reason, these emissions points will not be included in this application as there cannot be dual regulation of emissions points that are already covered under a separate permit. Therefore, as agreed during the enhanced pre-app meeting with the EA, several manholes have been identified that are close to the site boundary that could be considered to be the point at which the surface water drainage is discharged from ZP3527SS into the drainage system covered under DP3442QV.

There will be an arrangement between both operators regarding action to be taken should pollution be identified at any of the listed emissions points to determine the source of the pollution and which operator is at fault and thus responsible.

10.3 Air Quality Assessment

Emissions to air will occur from the operation of the generators. Due to the Data Centre's high levels of resiliency, it is expected that operation will be limited to maintenance and testing only, with no capacity agreement / 'elective operation' as detailed in Section 4.1.

An Air Quality Assessment (AQA) was completed in support of the permit application to predict the impacts of operating the generators, with their associated SCR, on short-term and long-term air quality. A summary of the findings is as follows:

Scenario 1: Testing scenario

- Monthly – All generators will be tested simultaneously for 15 minutes per month off-load, totalling 2 hours per year.
- Quarterly – All generators will be tested simultaneously for 1 hour per quarter on-load, totalling 3 hours per year.
- Annually – Each generator will be tested independently for 2 hours at maximum load capacity.

Scenario 2 – Emergency running scenario

All 12 of the generators would be used during emergency running. It has been assumed that the generators would be used for 72 hours of continuous, concurrent running at 100% load out of a year for power failure purposes. This is a conservative estimate as during an outage it is likely that the generators would run at less than 80% load at any one time.

The conclusion of the assessment is as follows:

> *A dispersion modelling assessment of the 12 No. standby generators was undertaken. Concentrations of NO2, PM, CO, C6H6, NO and SO2 were predicted at selected human receptors using a detailed dispersion model and compared with relevant long and short-term AQSs, EALs and AEGLs. Concentrations of NOx, NH3 and SO2 were predicted at selected ecological receptors.*
>
> *Long-term and short-term impacts from the generators were predicted to be insignificant during testing and maintenance and a prolonged grid failure at all relevant modelled receptor locations when assessed against all relevant long-term and short-term exceedance thresholds.*

Given the above, the site's ESGs are unlikely to have a significant impact on surrounding receptors and therefore represent the BAT.

10.4 Air Quality Management Plan

To help reduce the potential impacts during a prolonged outage, the Operator is to develop an Air Quality Management Plan (AQMP) once the site is operational. This procedural document is to be implemented in the event of an outage.

The AQMP will seek to identify what receptors may be affected and if notification is required. The plan is to be developed in conjunction with the Local Authority and its Local Air Quality Management Plan (LAQM) process. Once the AQMP is finalised, it shall be submitted to the EA for final approval.

11.0 MONITORING

11.1 Emissions limits and flue gas monitoring

The purpose of the emergency standby plant is to provide power in the event of failure of national grid supplies and will operate for less than 50 hours per year. As such, the generators are classed as “excluded generators” and are therefore exempt from meeting the BAT emissions limit values (ELVs) for new plant.

Monitoring of flue gas emissions is to be completed in accordance with EA requirements. Monitoring will be conducted in line with BAT guidance received during engagement with the EA and Medium Combustion Plant Directive guidance. It is expected that the operator will need to demonstrate that the engines are BAT by including the provision of flue gas sampling ports to allow for NO_x and CO monitoring, designed to meet BS EN 15259.

All generators will have SCR systems fitted. As such NOx sensors are installed both before and after the SCR to control the dosing rate necessary to ensure the required emissions rates are achieved (For more details see Section 3.5). These sensors are installed, maintained and calibrated according to manufacturer recommendation. For the permit requirements of monitoring NOx and CO every 1500hours of operation or once every five years (whichever comes first) the standard NOx sensor on the exhaust gas outlet side of the SCR is temporarily replaced with an MCERTs calibrated NOx and CO sensor, which is used for reporting these emissions. This approach means secondary emissions monitoring reports are not required.

Every five years or 1,500 hours of operation (whichever comes sooner) monitoring and testing will be undertaken by an organisation with the EA’s MCERTS accreditation for these measurements, so that the data meets the requirements of the MCERTS certification for emissions monitoring systems.

Total mass emissions for NO_x will be recorded by the SCR system and will be reported to the Local Planning Authority and EA annually. NOx will be reported as summarised above.

The monitoring port locations for the 5 yearly (1,500 hour) monitoring are presented in the figures below. The locations are downstream of the combustion zone where the gasses are well mixed. Figure 11.3 shows the location for monitoring CO and PM2.5.

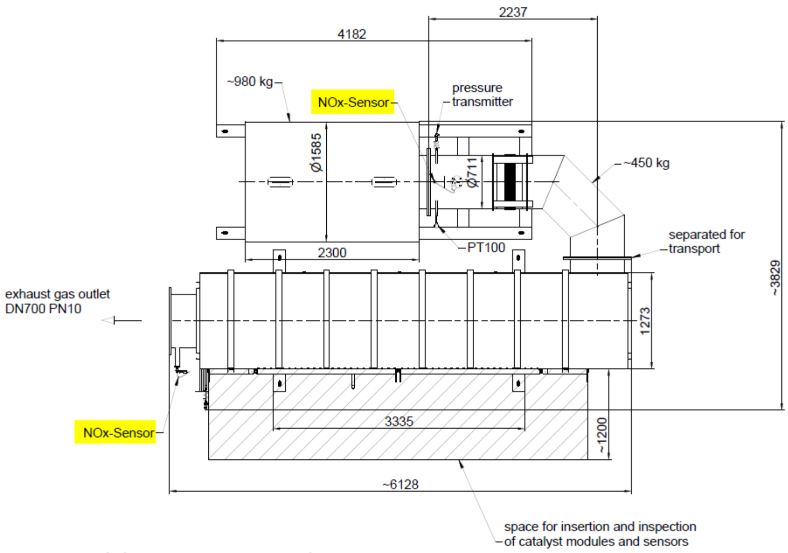


Figure 11.1 - SCR design with NOx monitoring sensors

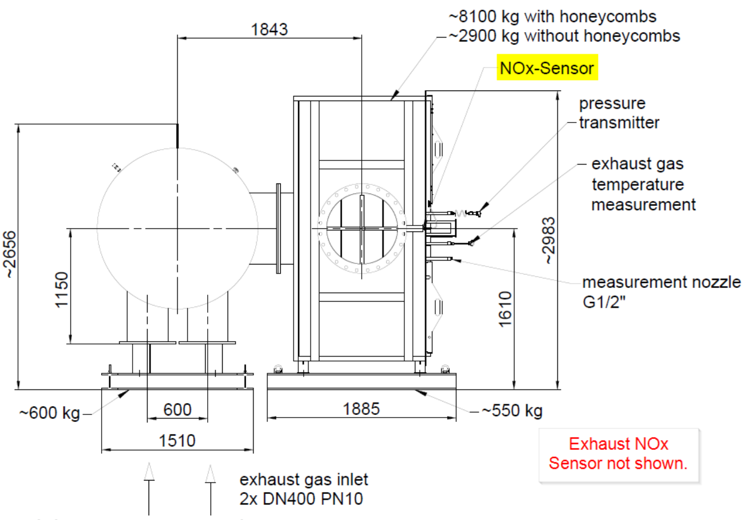


Figure 11.2 - SCR design with NOx monitoring sensors (cross section)

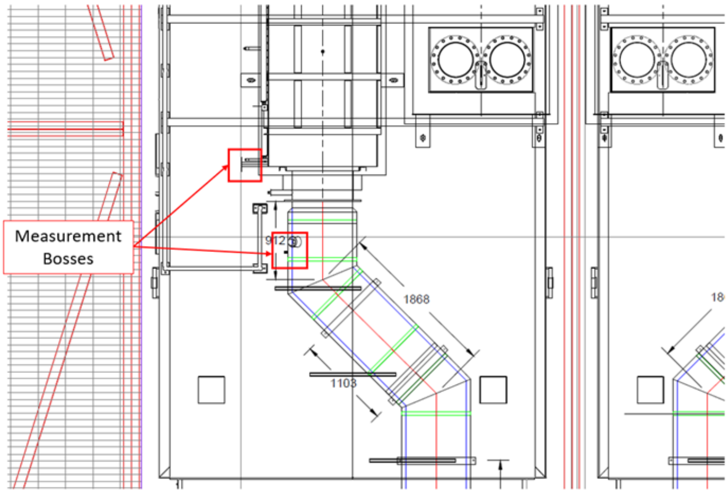


Figure 11.3 - Additional measurement bosses to facilitate monitoring of CO & PM2.5 etc

11.2 Generator operation

Generator operational hours and fuel consumption for maintenance, testing and during an outage are currently monitored for the 12 ESGs, with monitoring undertaken in a similar fashion. In addition to the annual report, outages should be notified to the EA within 24 hours of emergency operation commencing.

11.3 Discharges to sewer

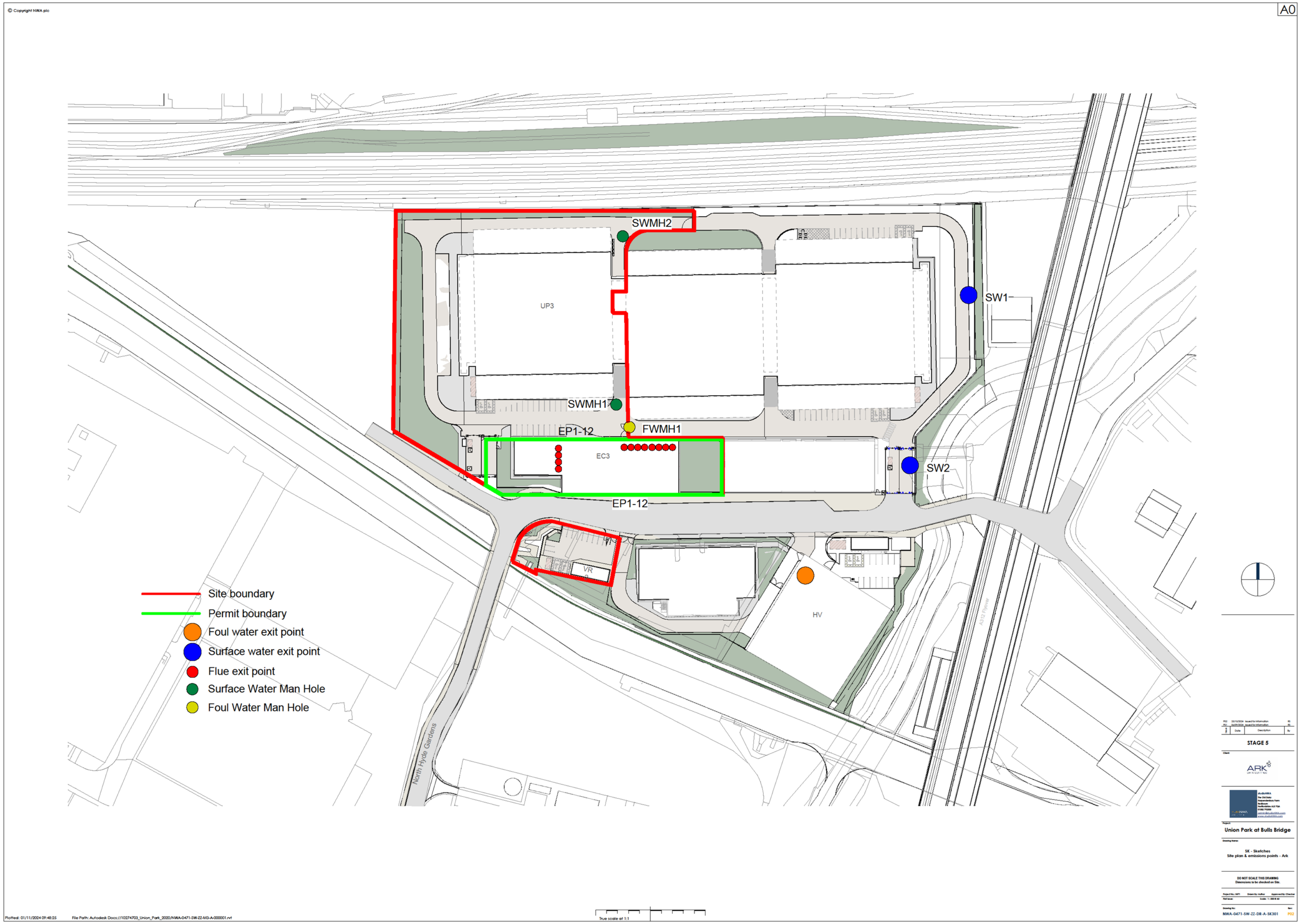
As per Section 3.10 and 10.2, discharges to sewer are not anticipated. Any surface water run off which discharges to surface drainage will first pass via the drainage interceptor. This will be subject to periodic visual inspections. The EA is to be notified by the operator where significant pollution incidents occur that have the potential to cause harm.

12.0 CONCLUSION

We have set out the proposed design and operating techniques for this installation and these are considered to meet the EA's BAT requirements for this Data Centre.

APPENDIX A

SITE PLAN & EMISSIONS POINTS


© Copyright NWA plc
A0
SWMH2
UP3
SW1
SWMH17
EP1-12
FWMH1
EC3
SW2
EP1-12
VR
HV
Site boundary
Permit boundary
Foul water exit point
Surface water exit point
Flue exit point
Surface Water Man Hole
Foul Water Man Hole
North Hyde Gardens
STAGE 5
ARK
Union Park at Bulls Bridge
SK - Sketches
Site plan & emissions points - Ark
DO NOT SCALE THIS DRAWING

APPENDIX B

THERMAL SCHEDULE

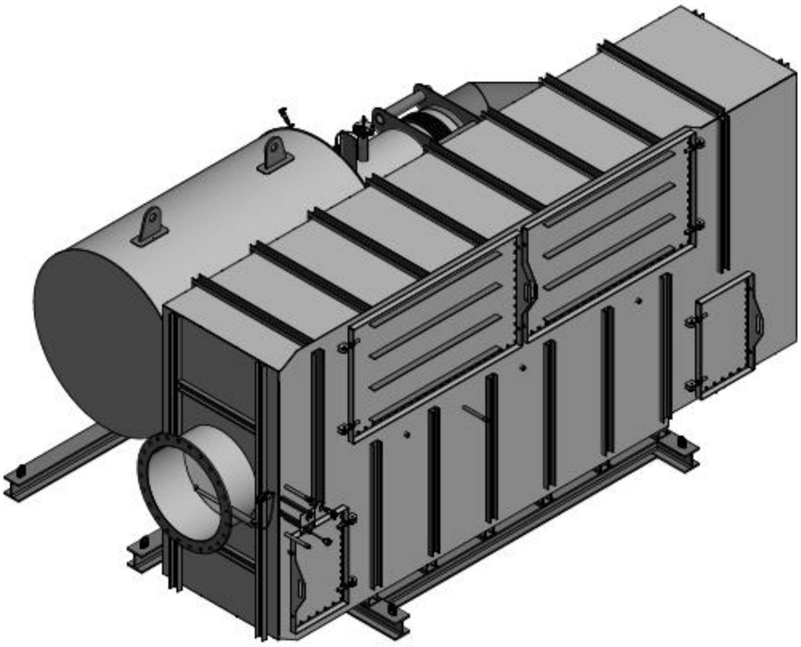
Thermal capacity - Ark Union Datacentre (permit ref: ZP3527SS)

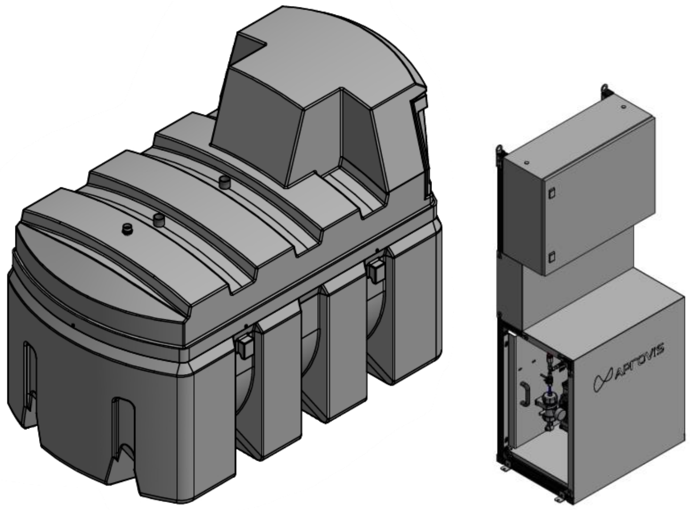
Ref	Emission Source Description	New / existing MCP	Manufacturer	Gen set model	Engine Model	output rating (kVA)	Output rating (kWe)	Max fuel (l/hr)	Thermal capacity (MWth)
EP1	EC3 Generator 1	New	Rolls Royce	MTU DS4000	20V4000G94LF	4000	3,200	818	**8.01**
EP2	EC3 Generator 2	New	Rolls Royce	MTU DS4000	20V4000G94LF	4000	3,200	818	**8.01**
EP3	EC3 Generator 3	New	Rolls Royce	MTU DS4000	20V4000G94LF	4000	3,200	818	**8.01**
EP4	EC3 Generator 4	New	Rolls Royce	MTU DS4000	20V4000G94LF	4000	3,200	818	**8.01**
EP5	EC3 Generator 5	New	Rolls Royce	MTU DS4000	20V4000G94LF	4000	3,200	818	**8.01**
EP6	EC3 Generator 6	New	Rolls Royce	MTU DS4000	20V4000G94LF	4000	3,200	818	**8.01**
EP7	EC3 Generator 7	New	Rolls Royce	MTU DS4000	20V4000G94LF	4000	3,200	818	**8.01**
EP8	EC3 Generator 8	New	Rolls Royce	MTU DS4000	20V4000G94LF	4000	3,200	818	**8.01**
EP9	EC3 Generator 9	New	Rolls Royce	MTU DS4000	20V4000G94LF	4000	3,200	818	**8.01**
EP10	EC3 Generator 10	New	Rolls Royce	MTU DS4000	20V4000G94LF	4000	3,200	818	**8.01**
EP11	EC3 Generator 11	New	Rolls Royce	MTU DS4000	20V4000G94LF	4000	3,200	818	**8.01**
EP12	EC3 Generator 12	New	Rolls Royce	MTU DS4000	20V4000G94LF	4000	3,200	818	**8.01**
								Total NET input Thermal capacity (MWth)	**96.11**

APPENDIX C

SCR TECHNICAL SPECIFICATION

APROVIS Exhaust gas treatment





Customer: AVK-SEG (UK) LTD

Project: E2020-1830 – Ark Union Phase 2

Pos. 1 **PRIMARY EXHAUST GAS SILENCER** **SDR-1585-9101/2300-3-2H-2A**

working principle: reactive

(horizontal version)

DESIGN PARAMETERS

engine type	20V4000G94LF	
number of cylinders	12	
rotating speed	1500	rpm
sound pressure level at silencer inlet *	**122 @ 1 m**	**dB(A)**
sound pressure level after silencer *	**91 @ 1 m**	**dB(A)**
flow rate (wet)	19196	kg/hr
inlet temperature	475	°C
max. operating temperature	505	°C
max. operating pressure	0.1	barg

DIMENSIONS

outside diameter	Ø 1585	mm
total length	+/- 2300	mm
inlet connection	2x 400/10	DN/PN
outlet connection	700/10	DN/PN

MATERIAL

exhaust gas silencer	Steel
flanges	Steel
surface treatment	priming coat

When the aforementioned design parameters are found to be inaccurate or require to be revised, we recommend recalculating the silencer. We do not accept any responsibility when our design is based on incorrect information.

* To realise an optimal acoustic performance it is of great importance that vibration free mounting and correct installation of the complete air-intake or exhaust gas system is given, to avoid possible transfer of vibration and/or constructional borne noise. The given sound pressure level/ sound attenuation at open field conditions is a theoretical value, which could turn out to be higher in practice.
Unfavourable layout of the exhaust line downstream of the silencer (e.g. narrow bends) can lead to an increased sound pressure level due to flow generated noise.
Tolerance according to engine data sheet.

measurement position according to DIN 45635-11
The reactive part of this silencer is **without heat insulation**. Because of the radiated heat and the structure-borne noise we recommend urgently insulation on site.

Pos. 2	CATALYST	SCR-700/1-A-S814.45-40-A47.15-10-DK

general data

Engine:	MTU 20V4000G94LF	
Fuel:	Diesel	
Operation of engine:	$\lambda > 1$	
Exhaust gas mass flow:	19196	kg/h
Exhaust gas temperature:	475	°C
Maximum Exhaust gas temperature:	505	°C
Maximum Exhaust gas pressure:	0,1	barg
Pressure Los (total):	**45**	**mbar**
Urea consumption (32,5%):	appr. 37	L/h
Urea consumption (32,5%):	appr. 900 L at 24hrs	
sound pressure level at SCR inlet	**91 @ 1 m**	**dB(A)**
sound pressure level after SCR *	**70 @ 1 m**	**dB(A)**

*only valid if SCR is fully equipped with all honeycomb rows

Emissions [5% O2]

	Before Catalytic Converter	**After Catalytic Converter**	
CO	< 111	< 111	mg/Nm³
NOx	< 2362	< 95	mg/Nm³
CH_2O	< 19	< 19	mg/Nm³
NH_3		< 5	mg/Nm³

Equipment SCR

SCR

Number of rows SCR	4	pc.
Number of empty rows	0	pc.

Oxi

Number of rows Oxi	1	pc.
Number of empty rows	0	pc.

Material

Material injection	Stainless steel
Material flanges injection	Stainless steel
Material housing	Steel
Material flanges housing	Steel

Installation and connection

Place of installation	Inside installation; no ex zone Outdoor installation by arrangement	
Min. ambient temperature	5	°C
Max. ambient temperature	40	°C
Exhaustgas piping inlet	700/10	DN/PN
Exhaustgas piping outlet	700/10	DN/PN

Dimensions of the overall set up on 2 frames:
(For detailed information please check the drawing)

L x W x H	+/- 5600 x 3900 x 3000	mm
Transport weight (incl. frames, incl. insulation, incl. honeycombs)	+/- 11000	kg
Operating weight (incl. frames, incl. insulation, incl. honeycombs)	+/- 11000	kg

Dimensions of dosing unit

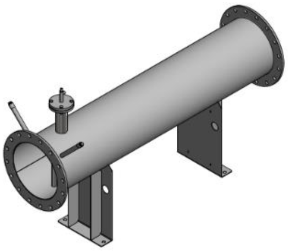
L x W x H	+/- 800 x 550 x 1925	mm
Transport weight	+/- 300	kg
Operating weight	+/- 450	kg

Pos. 2.1a **INJECTION SECTION**

Designed as complete assembly (with Pos. 2.1b);

Consisting of:

- Static mixers for homogeneus mixing of ammonia and exhaust gas
- Integrated measuring nozzles for:
  - 1x Pressure
  - 1x Temperature
  - 1x NOx


Design example

Pos. 2.1b **ATOMISING LANCE WITH TWO PHASE NOZZLE**

For injection of urea-water-solution with compressed air

Consisting of:

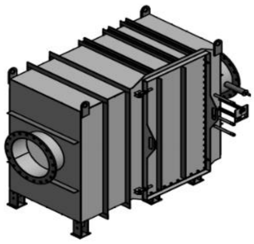
- Atomising lance with two phase nozzle

Pos. 2.2 **HOUSING**

For containing catalyst honeycombs

Consisting of:

- 1x opening (on the side), for catalyst insertion
- Integrated measuring nozzles for:
  - 2x Temperature
  - 1x Pressure
  - 1x NOx
  - 1x Reserve

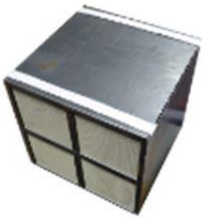

Design example

Pos. 2.3a CATALYST HONEYCOMBS SCR

Catalyst honeycombs will be preconditioned and integrated into the SCR at the factory.

Consisting of:

- SCR-Honeycombs
- incl. sealing



Design example

Pos. 2.3b CATALYST HONEYCOMBS OXI – TO REDUCE AMMONIA SLIP

Catalyst honeycombs will be preconditioned and integrated into the SCR at the factory.

Consisting of:

- OXI- Honeycombs
- incl. sealing

Design example

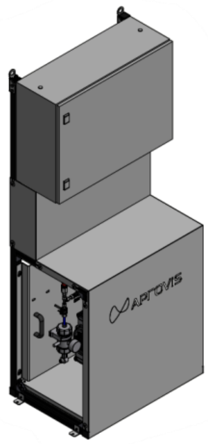
Pos. 2.4 DOSING UNIT

Dosing station and control cabinet pre-assembled and piped as a unit on a base frame

Consisting of:

- Ready-to-operate dosing station pre-assembled on base frame
- 1 electric dosing pump and all necessary fittings
- Assembly of the control cabinet
- Wiring of the electrical components on the base frame

Remark: Dosing unit only approved for indoor installation.



Design example

Pos. 2.5a	CONTROL BOX CONFORM 44BIMSCHV AND VDMA 6299

For controlling the entire SCR plant.

Consisting of:

- Control cabinet with SPS control and 10" touch panel for visualization of the system parameters

Design example

Data for control cabinet:

material:	Sheet steel, painted
Protection class:	IP54
Supply line:	**3~400V+N+PE 50Hz, TN-C-S**
Fuse protection:	16A

- Control elements: Main switch and touch panel
- Messages and displays on the control cabinet:
  - Signal light operation, message, fault
  - Visualization via touch panel including trend recording, alarm history, user administration and parameter switching
  - Message and fault display as plain text
  - Display of all actual values on the touch panel
  -

Integrated data recording for:

- Current NOx value
- Evaluated NOx values:
  - Daily average values incl. evaluation
  - Compliance with daily mean value
  - Validity Daily mean value
  - Compliance "not double limit value" exceeded
  - Downtime NOx Sensor
- Exhaust gas temperatures
- Exhaust gas back pressure
- Air pressure
- Pressure urea
- Storage of the daily mean value on an external storage medium - e.g. USB stick or SD card (external storage media not included in the scope of delivery; min. 16GB are required for recording the mean values over 6 years)

Required signals from the higher-level control:

- Engine load (analog signal)

Signals for higher-level control (potential-free contacts on terminal strip):

- Readiness
- Fault in the system
- Engine stop
- Pre-alarm - collective message
- Urea requirement
- Switch cabinet pre-assembled and pre-wired as a unit with dosing station on base frame

Remark: Switch cabinet only approved for indoor installation.

Pos. 2.5b	MEASUREMENT EQUIPMENT EXHAUST

For recording measurements

Consisting of:

- 2 pc. Pressure transducer for measuring the exhaust side back pressure
- 2 pc. NOx sensor for concentration measurement
- 2 pc. Temperature sensor for monitoring the temperature in the exhaust gas
  - 1x after SCR
  - 1x after OXI

Wiring is carried out by the customer or by arrangement

Pos. 2.6	COMMUNICATION BUS

Interface for signal transmission

Possible systems as interface are:

- ModBUS

Pos. 3	STORAGE TANK SYSTEM

Storage tank for the storage of urea-water mixture, vertical
7 storage tanks: 1 tank for 1 SCR

Capacity:	2500 Litre
Holding time:	48h for 1 SCR (with the above NOx data)
Height:	1862 mm
Width:	1430 mm
Length:	2450 mm
Material:	PE, double wall design
weight empty:	350 kg
eight incl. 2500 Liter Urea 32.5%	3100 kg

Following components are per tank:
- 1pc. Level transmitter and temperature transmitter
- 1pc. Overflow protection
- 1pc. Electrical magnet-membrane dosing pump
- 1pc. Foot valve
- 1pc. Vent
- 1pc. Leak protection
- 1pc. Heating and ventilation control by thermostat

When storing substances hazardous to water, the country-specific regulations must be observed!

Pos. 4	BASE FRAMES

Properties:

- IPB-profile
- material: carbon steel
- hot dip galvanized
- c/w lifting lugs

Pos. 10	NOISE AND HEAT INSUALTION

max. surface temperature	approx. 60 °C	°C
ambient temperature	25	°C

Consisting of:

- 100 mm thick mineral wool
- Omega spacer and damping for acoustic decoupling
- Cladded with 0,7 mm galvanized sheet metal
- Including removable caps for lifting lugs of the silencer

For outdoor installation

APPENDIX D

GENERATOR ENGINE & EMISSIONS DATASHEETS

Diesel Generator Set

MTU 20V4000 DS4000

11 kV/50 Hz/standby power/NEA (ORDE) + Tier 2 optimized 20V4000G94LF/water charge air cooling

Optional equipment and finishing shown. Standard may vary.

Product highlights

Benefits
- Low fuel consumption
- Optimized system integration ability
- High reliability
- High availability of power
- Long maintenance intervals

Support
- Global product support offered

Standards
- Engine-generator set is designed and manufactured in facilities certified to standards ISO 2008:9001 and ISO 2004:14001
- Generator set complies to ISO 8528
- Generator meets NEMA MG1, BS5000, ISO, DIN EN and IEC standards
- NFPA 110

Power rating
- System ratings: 3950 kVA - 4000 kVA
- Accepts rated load in one step per NFPA 110
- Generator set complies to G3 according to ISO 8528-5
- Generator set exceeds load steps according to ISO 8528-5

Performance assurance certification (PAC)
- Engine-generator set tested to ISO 8528-5 for transient response

100% load factor (DCC)

- Verified product design, quality and performance integrity
- All engine systems are prototype and factory tested

Complete range of accessories available
- Control panel
- Power panel
- Fuel system
- Fuel connections with shut-off valve mounted to base frame
- Starting/charging system
- Exhaust system
- Electrical driven radiators
- Medium and oversized voltage alternators

Emissions
- Tier 2 optimized engine
- NEA (ORDE) optimized

Certifications
- CE certification option

A Rolls-Royce solution

Application data [1]

Engine

Manufacturer	MTU
Model	20V4000G94LF
Type	4-cycle
Arrangement	20V
Displacement: l	95.4
Bore: mm	170
Stroke: mm	210
Compression ratio	16.4
Rated speed: rpm	1500
Engine governor	ADEC (ECU 9)
Max power: kWm	3308
Air cleaner	dry

Fuel system

Maximum fuel lift: m	5
Total fuel flow: l/min	27

Fuel consumption [2]	l/hr	g/kwh
At 100% of power rating:	818	205
At 75% of power rating:	598	200
At 50% of power rating:	429	215

Liquid capacity (lubrication)

Total oil system capacity: l	390
Engine jacket water capacity: l	260
Intercooler coolant capacity: l	50

Combustion air requirements

Combustion air volume: m^3/s	4.7
Max. air intake restriction: mbar	30

Cooling/radiator system

Coolant flow rate (HT circuit): m^3/hr	80
Coolant flow rate (LT circuit): m^3/hr	44
Heat rejection to coolant: kW	1270
Heat radiated to charge air cooling: kW	930
Heat radiated to ambient: kW	105
Fan power for electr. radiator (40°C): kW	105

Exhaust system

Exhaust gas temp. (after engine, max.): °C	482
Exhaust gas temp. (before turbocharger): °C	693
Exhaust gas volume: m^3/s	11.9
Maximum allowable back pressure: mbar	50
Minimum allowable back pressure: mbar	–

Standard and optional features

System ratings (kW/kVA)

Generator model	Voltage	NEA (ORDE) + Tier 2 optimized without radiator		
		kWel	kVA*	AMPS
Leroy Somer LSA54.2 ZL12 (Medium volt. Leroy Somer)	11 kV	3160	3950	207
Marathon 1040FDH7105 (Medium volt. Marathon)	11 kV	3200	4000	210
Leroy Somer LSA54.2 ZL14 (MV Leroy Somer oversized)	11 kV	3160	3950	207
Leroy Somer LSA54.2 ZL14 (Engine output optimized)	11 kV	3200	4000	210

* cos phi = 0.8

1 All data refers only to the engine and is based on ISO standard conditions (25°C and 100m above sea level).

2 Values referenced are in accordance with ISO 3046-1. Conversion calculated with fuel density of 0.83 g/ml. All fuel consumption values refer to rated engine power.

Standard and optional features

Engine

- ■ 4-cycle
- ■ Standard single stage air filter
- ■ Oil drain extension & shut-off valve
- ■ Closed crankcase ventilation
- ■ Governor-electronic isochronous
- ■ Common rail fuel injection
- ■ Tier 2 optimized engine
- ■ NEA (ORDE) optimized engine

Generator

- ■ 4 pole three-phase synchronous generator
- ■ Brushless, self-excited, self-regulating, self-ventilated
- ■ Digital voltage regulator
- ■ Anti condensation heater
- ■ Stator winding Y-connected, accessible neutral (brought out)
- ■ Protection IP23
- ■ Insulation class H, utilization acc. to H
- ■ Radio suppression EN55011, group 1, cl. B
- ■ Short circuit capability 3xIn for 10sec
- ■ Winding and bearing RTDs (without monitoring)
- ■ Excitation by AREP + PMI
- ■ Mounting of CT´s: 3x 2 core CT´s
- ■ Winding pitch: 5/6 winding
- ■ Voltage setpoint adjustment ± 5%
- ■ Meets NEMA MG-1, BS 5000, IEC 60034-1, VDE 0530, DIN EN 12601, AS1359 and ISO 8528 requirements
- ■ Leroy Somer medium voltage generator
- ☐ Marathon medium voltage generator
- ☐ Oversized generator

Cooling system

- ■ Jacket water pump
- ■ Thermostat(s)
- ■ Water charge air cooling
- ☐ Electrical driven front-end cooler
- ☐ Jacket water heater
- ☐ Pulley for fan drive

Control panel

- ■ Pre-wired control cabinet for easy application of customized controller (V1+)
- Y Island operation (V2)
- ☐ Automatic mains failure operation with ATS (V3a)
- ☐ Automatic mains failure operation incl. control of generator and mains breaker (V3b)
- ☐ Island parallel operation of multiple gensets (V4)
- ☐ Automatic mains failure operation with short (< 10s) mains parallel overlap synchronization (V5)
- Y Mains parallel operation of a single genset (V6)
- ☐ Mains parallel operation of multiple gensets (V7)
- ☐ Basler controller
- ☐ Deif controller
- ■ Complete system metering
- ■ Digital metering
- ■ Engine parameters
- ■ Generator protection functions
- ■ Engine protection
- ■ SAE J1939 engine ECU communications
- ■ Parametrization software
- ■ Multilingual capability
- ■ Multiple programmable contact inputs
- ■ Multiple contact outputs
- ■ Event recording
- ■ IP 54 front panel rating with integrated gasket
- ☐ Remote annunciator
- ☐ Daytank control
- Y Generator winding- and bearing temperature monitoring
- Y Modbus TCP-IP

Power panel

- ☐ Available in 600x600 mm
- ☐ Phase monitoring relay 230V/400V
- ☐ Supply for battery charger
- ☐ Supply for jacket water heater
- ☐ Supply for anti condensation heating
- ☐ Plug socket cabinet for 230V compatible Euro/USA

■ Represents standard features
☐ Represents optional features

Standard and optional features

Fuel system

- ■ Flexible fuel connectors mounted to base frame
- □ Fuel filter with water separator
- □ Fuel filter with water separator heavy-duty
- □ Switchable fuel filter with water separator
- □ Switchable fuel filter with water separator heavy-duty
- □ Seperate fuel cooler
- □ Fuel cooler integrated into cooling equipment

Starting/charging system

- ■ 24V starter
- □ Starter batteries, cables, rack, disconnect switch
- □ Battery charger
- Y Redundant starter 2x 15kW

Mounting system

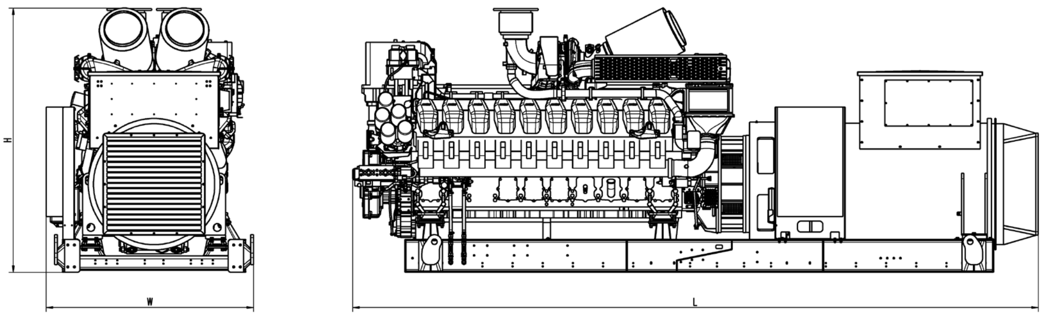
- ■ Welded base frame
- ■ Resilient engine and generator mounting
- ■ Modular base frame design

Exhaust system

- ■ Exhaust bellows with connection flange
- □ Exhaust silencer with 10 dB(A) sound attenuation
- □ Exhaust silencer with 30 dB(A) sound attenuation
- □ Exhaust silencer with 40 dB(A) sound attenuation
- □ Y-connection-pipe

■ Represents standard features
□ Represents optional features

Weights and dimensions



Drawing above for illustration purposes only, based on a standard open power 11 kV engine-generator set. Lengths may vary with other voltages. Do not use for installation design. See website for unit specific template drawings.

System	Dimensions (LxWxH)	Weight (dry/less tank)
Open power unit (OPU)	6339 x 1887 x 2415 mm	19350 kg

Weights and dimensions are based on open power units and are estimates only. Consult the factory for accurate weights and dimensions for your specific engine-generator set.

Sound data

— Consult your local MTU distributor for sound data.

Emissions data

— Consult your local MTU distributor for emissions data.

Rating definitions and conditions

— Standby ratings apply to installations served by a reliable utility source. The standby rating is applicable to varying loads for the duration of a power outage. No overload capability for this rating. Ratings are in accordance with ISO 8528-1, ISO-3046-1, BS 5514 and AS 2789.
Average load factor: ≤ 85%. operating hours/year: max. 500.

— Consult your local MTU distributor for derating information.

Subject to change. | 32310771 | Edition 01/21 | ESM 2021-01.

Contents

	Genset	Marine	O & G	Rail	C & I
Application	X				
Engine model	20V4000G94LF				
Rated power [kW]	3308				
Rated speed [rpm]	1500				
Application Group	3D				
Legislative body	NEA Singapore for ORDE				
Test cycle	D2				
Data Set No.	XZ54954100068				
Data Set Basis	NEA Singapore for ORDE				
Fuel sulphur content [ppm]	7				

Content **Page**

Disclaimer 2

Emission data sheet (EDS) 3

Not to exceed emission values 5

PDF	Name	Project no. 012260141		Size A4
Configurator	Lenhof, Torsten (TATC)	Order no. Ark Union		
Approver1	Kneifel, Alexander (TSLE)	EDS-ID 1101-24.01.2022		
Approver2	Breuer, Joerg (TVA)			
Approver3				
Approver4				
User	EMEA\williamsshan			
Engine model 20V4000G94LF		Title **Emission data sheet**		

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Description of Revision	Frequency
Data generated by EDS Creator version 1.0 and uniplot. Ref.-dataset: 420122_364_NEA_G94LF_D2.nc for 295 in EDS platfrom.	

		Emissionstage **NEA Singapore for ORDE**	Sheet **1**
Configuration-ID **295**	Documentation	Emissionstage basis **NEA Singapore for ORDE**	of **6**

General Disclaimers (valid for Measured and NTE values)

Please note that these data are physical and/or technical values only referring to and representing a normative defined operating condition. Any change in operating time and conditions will have impact on physical values and engine behavior, which must be considered and assessed within the complete propulsion system especially in regard to emission compliance and product safety.

Measurements listed in this EDS are representative of the listed engine rating at the time of testing. These measurements and results can change according to instrumentation, boundary condition, and engine to engine variability. In addition - changes to the engine family hard or software may occur which could result in changes to some of the listed values.

Emissions data measurement procedures are conducted according to applicable rules and standards as per “Emission Stage/Optimization”. Potential deviations from these procedures are documented internally.

The listed emission values relate to the corresponding certification data. Seller doesn´t take any responsibility or liability neither out or in connection with the contract nor on any other basis
- beyond these specified operating conditions of the engine
- and for any installation/modification of the entire propulsion system by the customer itself or any third party

and the customer will indemnify MTU on first demand for any third party claim out or in connection with this.

Seller reserves the right to amend specifications and information without notice and without obligation or liability. No liability for any errors, facts or opinions is accepted. Customers must satisfy themselves as to the suitability of this product for their application. No responsibility for any loss as a result of any person placing reliance on any material contained in this data sheet will be accepted.

Seller reserves all rights in the information contained in this data sheet. It shall not be reproduced, made available to a third party or otherwise used in any way whatsoever.

When applicable, emission values are measured after combined exhaust streams.

Measured Emissions data is based on single operating points and thus cannot be used to compare to regulations which use values based on a weighted cycle.

Field emission test data are not guaranteed to these levels. Actual field test results may vary due to test site conditions, installation, fuel specification, test procedures, and instrumentation. Over time deterioration may occur which may have an impact on emission levels.

The SO2 emission rates comprehend exclusively the SO2 content as found in the fuel source, oil consumption effects are not included. Variation of sulfur content in the fuel changes only the stated SO2 emissions, cross sensitivity to other emissions (e.g. particulates) is not possible.

All values based on metric units, inaccuracies for non metric values can occur, values are not binding.

Specific to gas engines: The listed emission values are based on gas composition at the time of certification measurement. Gas composition is as displayed in the EDS-document. Carbon dioxide and methane concentrations have direct influence on the corresponding displayed carbon dioxide and methane emissions.

EAT Specific Disclaimers (valid for EDS values)

NH3 emissions levels measured with AVL SESAM i60/ 4 FT Multi Component Exhaust Measurement System (FTIR) including EPA 40 CFR 1065 legislation compliant automated checks for linearity.

Generators or engines with exhaust after-treatment systems require a stabilization period of approximately 1 hour to ensure stable temperatures across SCR prior to performing an emissions test. Performing emissions measurements before a stable temperature has been achieved can result in inconsistent emission values. NOx Values only applicable if temperatures across SCR reached for DEF Dosing.

NTE Disclaimers (valid for NTE calculated values)

Calculated not to exceed values (NTE) are not proven by tests and therefore the accuracy is not guaranteed.

All emission data shown in chapters Emission Data Sheet, Not to Exceed Values, and Type Approval were gathered from a corresponding certification engine under test conditions shown above and complying to corresponding TEN data.

PDF	Name	Project no. **012260141**		Size **A4**
Configurator	Lenhof, Torsten (TATC)	Order no. **Ark Union**		
Approver1	Kneifel, Alexander (TSLE)	EDS-ID **1101-24.01.2022**		
Approver2	Breuer, Joerg (TVA)			
Approver3		Title **Emission data sheet**		
Approver4				
User	EMEA\williamsshan			
Engine model **20V4000G94LF**				

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Description of Revision	Frequency
Data generated by EDS Creator version 1.0 and uniplot. Ref.-dataset: 420122_364_NEA_G94LF_D2.nc for 295 in EDS platfrom.	

Configuration-ID	Documentation	Emissionstage	Sheet
295		**NEA Singapore for ORDE**	**2**
		Emissionstage basis: **NEA Singapore for ORDE**	of **6**

Engine data

	Genset	Marine	O & G	Rail	C & I
Application	X				
Engine model	20V4000G94LF				
Application Group	3D				
Legislative body	NEA Singapore for ORDE				
Test cycle	D2				
Fuel sulphur content [ppm]	7				
mg/mN^3 values base on residual oxygen value of [%]	5				

Engine raw emissions*

Cycle point	[-]	n1	n2	n3	n4	n5
Power	kW	3307	2480	1653	827	331
Power relative	[-]	1	0.75	0.5	0.25	0.1
Engine speed	1/min	1500	1499	1499	1500	1499
Engine speed relative	[-]	1	1	1	1	1
Filter smoke number	Bosch	0.2	0.23	0.62	0.97	0.07
Exhaust temperature after ETC	grdC	474.5	420.2	420.8	386.2	264
Exhaust back pressure after ETC (static)	mbar	39	23	9	6	2
Exhaust back pressure after ETC (total)	mbar	52	32	14	5	0
Exhaust mass flow wet	kg/h	19195.7	15929.6	12082.7	7484.8	5323.4
NOX-Emissions specific	g/kWh	6.6	5.94	4.79	4.41	9.06
SO2-Emissions specific	g/kWh	0.003	0.003	0.003	0.003	0.004
CO-Emissions specific	g/kWh	0.32	0.39	1.02	1.45	2.79
HC1-Emissions specific	g/kWh	0.05	0.07	0.09	0.16	0.72
NMHC-Emissions specific	g/kWh	0.05	0.06	0.08	0.16	0.71

PDF	Name	Project no. 012260141
Configurator	Lenhof, Torsten (TATC)	Order no. Ark Union
Approver1	Kneifel, Alexander (TSLE)	Size A4
Approver2	Breuer, Joerg (TVA)	EDS-ID 1101-24.01.2022
Approver3		
Approver4		
User	EMEA\williamsshan	
Engine model 20V4000G94LF		Title **Emission data sheet**

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Description of Revision	Frequency
Data generated by EDS Creator version 1.0 and uniplot. Ref.-dataset: 420122_364_NEA_G94LF_D2.nc for 295 in EDS platfrom.	

Emissionstage **NEA Singapore for ORDE**

Emissionstage basis **NEA Singapore for ORDE**

Configuration-ID **295** | Documentation

NOX+HC1-Emissions specific	g/kWh	6.65	6.01	4.88	4.57	9.78
NOX+NMHC-Emissions specific	g/kWh	6.65	6.01	4.88	4.57	9.76
CO2-Emissions specific	g/kWh	645.7	632.1	669.3	721.6	844.5
PM-Emissions specific (Meas.)	g/kWh	0.02	0.029	0.098	0.178	0.052
NOX-Emissions (based on 5% O2)	mg/m3N	2362	2172	1639	1375	2411
NOX+HC1-Emissions (based on 5% O2)	mg/m3N	2381	2195	1668	1426	2598
NOX+NMHC-Emissions (based on 5% O2)	mg/m3N	2381	2195	1667	1425	2594
CO2-Emissions (based on 5% O2)	mg/m3N	223605	223062	222523	222036	219217
CO-Emissions (based on 5% O2)	mg/m3N	111.4	138.5	339.2	444.6	723
HC1-Emissions (based on 5% O2)	mg/m3N	18.5	23.1	28.8	50.4	186.9
SO2-Emissions (based on 5% O2)	mg/m3N	1	1	1	1	1
PM-Emissions (calculated) (based on 5% O2)	mg/m3N	16.9	20	34.2	52.1	31.8
PM-Emissions (based on 5% O2)	mg/m3N	6.9	10.3	32.7	54.6	13.5
Oxygen (O2)	%	9.9	11.2	11.9	13.1	15.8

PDF	Name	Project no. 012260141	Size A4
Configurator	Lenhof, Torsten (TATC)	Order no. Ark Union	
Approver1	Kneifel, Alexander (TSLE)	EDS-ID 1101-24.01.2022	
Approver2	Breuer, Joerg (TVA)		
Approver3			
Approver4			
User	EMEA\williamsshan		

Description of Revision | Frequency

Data generated by EDS Creator version 1.0 and uniplot.
Ref.-dataset: 420122_364_NEA_G94LF_D2.nc for 295 in EDS platfrom.

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Engine model
20V4000G94LF

Title
Emission data sheet

Emissionstage
NEA Singapore for ORDE

Emissionstage basis
NEA Singapore for ORDE

Configuration-ID
295

Documentation

Engine data

	Genset	Marine	O & G	Rail	C & I
Application	X				
Engine model	20V4000G94LF				
Application Group	3D				
Legislative body	NEA Singapore for ORDE				
Test cycle	D2				
Fuel sulphur content [ppm]	7				
mg/mN³ values base on residual oxygen value of [%]	5				

Not to exceed emission values*

Cycle point	[-]	n1	n2	n3	n4	n5
Power	kW	3307	2480	1653	827	331
Power relative	[-]	1	0.75	0.5	0.25	0.1
Engine speed	1/min	1500	1499	1499	1500	1499
Engine speed relative	[-]	1	1	1	1	1
NOX-Emissions specific	g/kWh	8.58	7.72	6.23	6.61	17.21
CO-Emissions specific	g/kWh	0.55	0.67	1.94	2.89	5.57
HC1-Emissions specific	g/kWh	0.09	0.11	0.16	0.33	2.09
NMHC-Emissions specific	g/kWh	0.09	0.11	0.16	0.32	
NOX+HC1-Emissions specific	g/kWh	8.67	7.84	6.39	6.94	19.3
NOX+NMHC-Emissions specific	g/kWh	8.67	7.83	6.39	6.93	
PM-Emissions specific (Meas.)	g/kWh	0.03	0.046	0.147	0.266	0.192
NOX-Emissions (based on 5% O2)	mg/m3N	3071	2824	2130	2063	4581
NOX+HC1-Emissions (based on 5% O2)	mg/m3N	3103	2863	2185	2164	5123
NOX+NMHC-Emissions (based on 5% O2)	mg/m3N	3102	2862	2184	2162	

PDF	Name	Project no. 012260141	Size A4
Configurator	Lenhof, Torsten (TATC)	Order no. Ark Union	
Approver1	Kneifel, Alexander (TSLE)	EDS-ID 1101-24.01.2022	
Approver2	Breuer, Joerg (TVA)		
Approver3			
Approver4			
User	EMEA\williamsshan	Title **Emission data sheet**	
Engine model **20V4000G94LF**			

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Description of Revision	Frequency
Data generated by EDS Creator version 1.0 and uniplot. Ref.-dataset: 420122_364_NEA_G94LF_D2.nc for 295 in EDS platfrom.	

Emissionstage **NEA Singapore for ORDE**

Emissionstage basis **NEA Singapore for ORDE**

Configuration-ID **295** | Documentation

CO-Emissions (based on 5% O2)	mg/m3N	189.4	235.5	644.5	889.1	1446
HC1-Emissions (based on 5% O2)	mg/m3N	31.5	39.2	54.7	100.8	542
PM-Emissions (based on 5% O2)	mg/m3N	10.4	16.4	49	81.9	49.8

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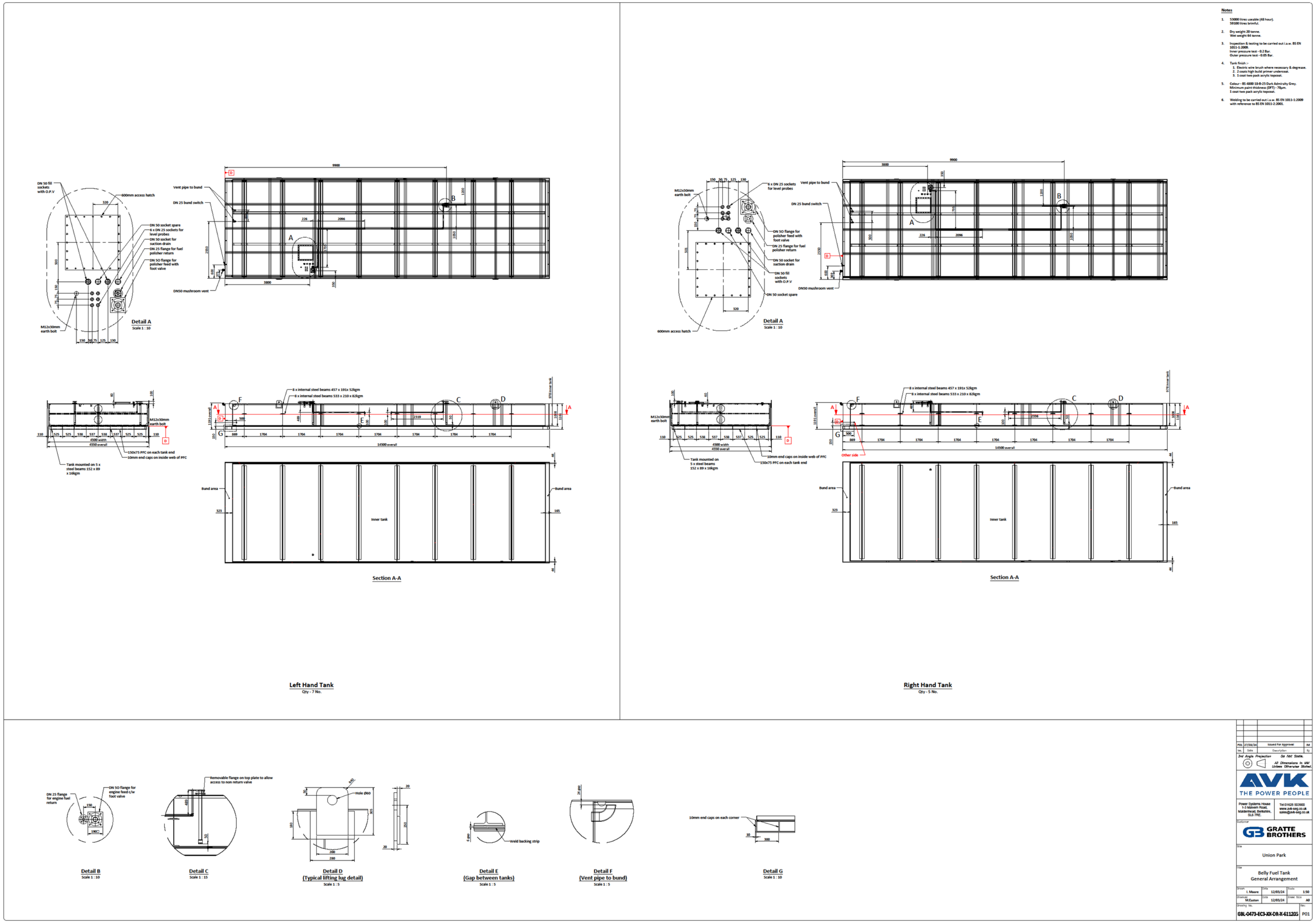
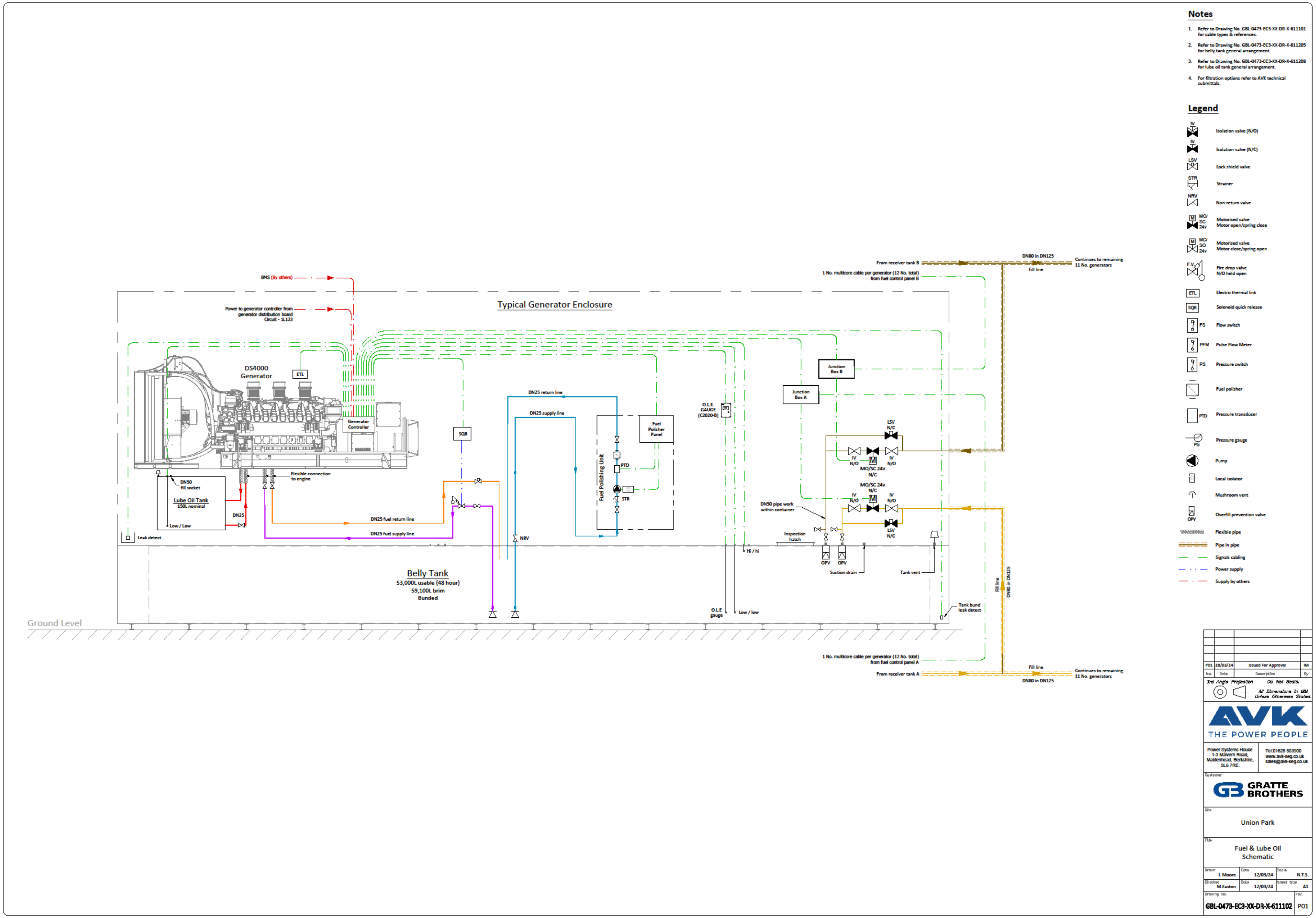
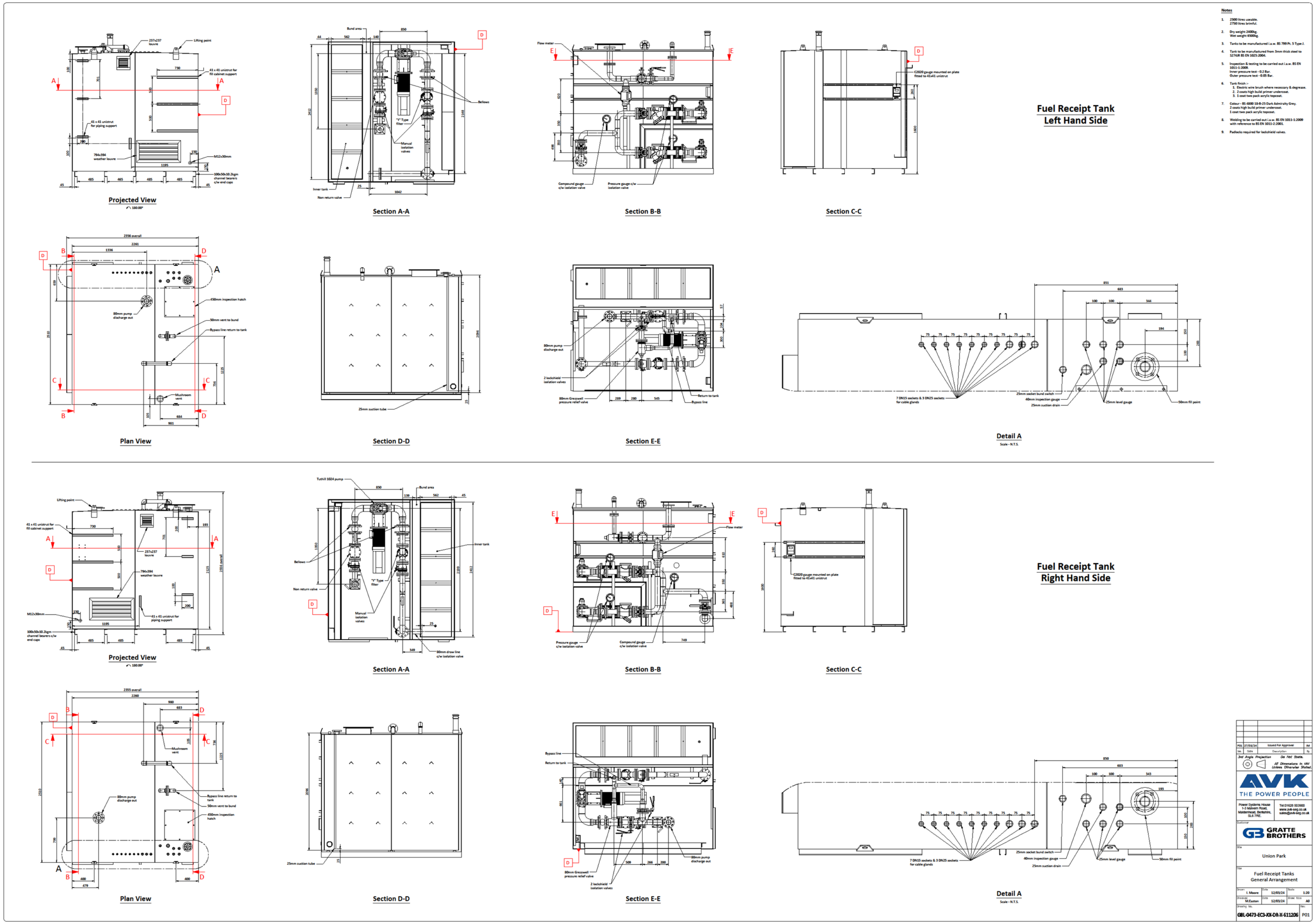
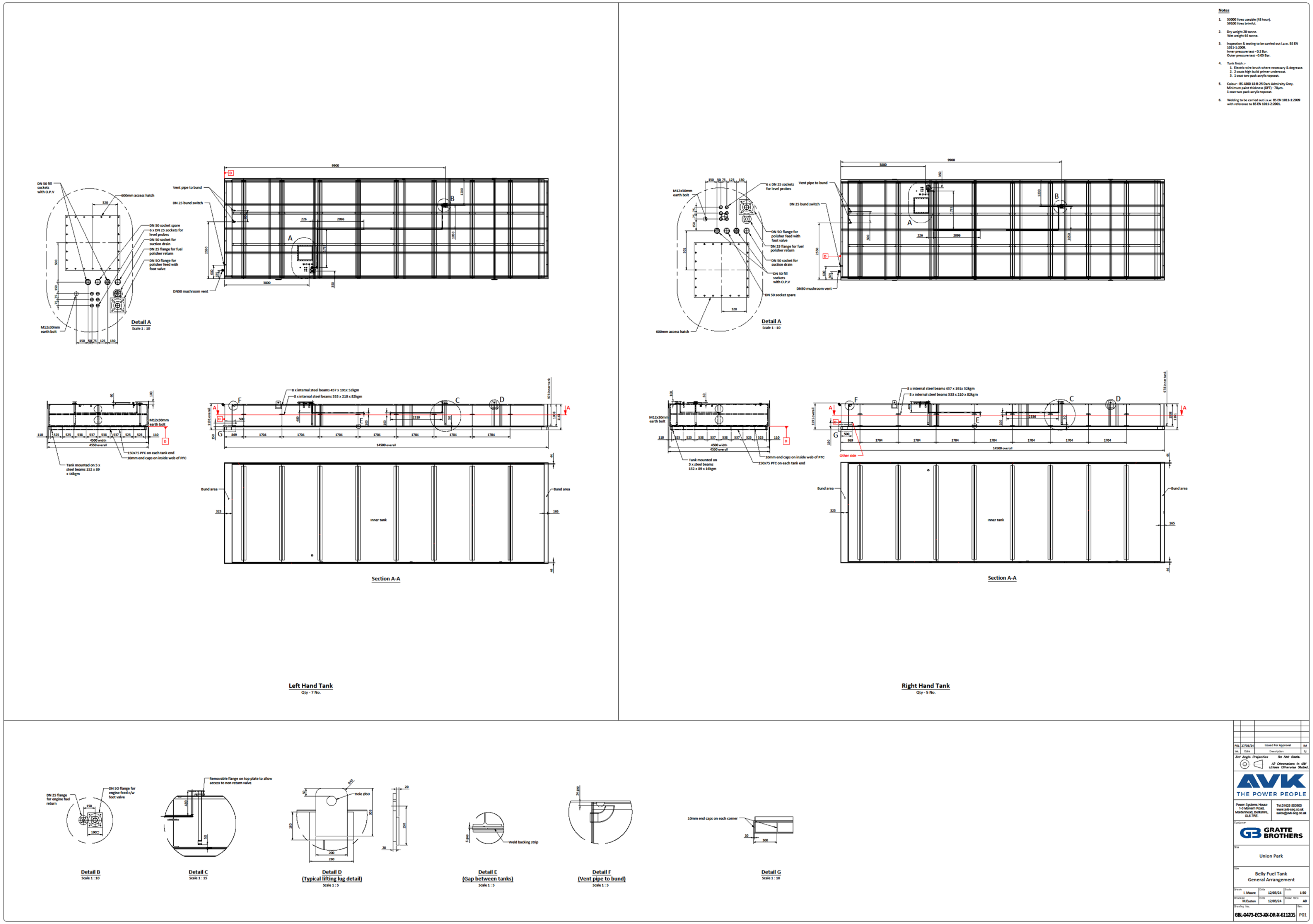
APPENDIX E

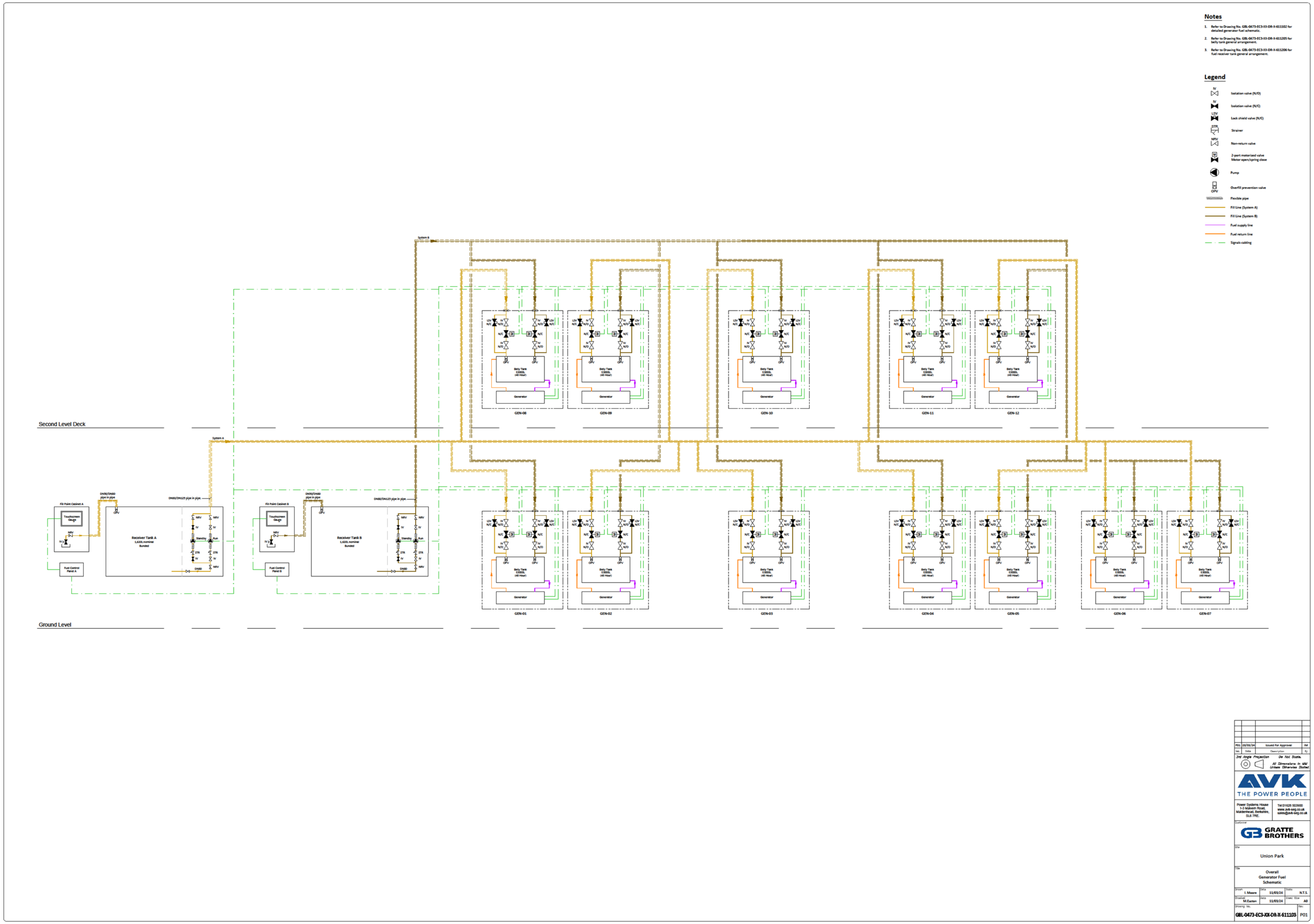
FUEL TANK DRAWINGS AND SCHEMATICS


Detail A
Section A-A
Left Hand Tank
Right Hand Tank
Detail B
Detail C
Detail D
(Typical lifting lug detail)
Detail E
(Gap between tanks)
Detail F
(Vent pipe to bund)
Detail G
Notes
THE POWER PEOPLE
GRATTE BROTHERS
Union Park
Belly Fuel Tank
General Arrangement


Typical Generator Enclosure
DS4000 Generator
Generator Controller
ETL
SQR
BMS (By others)
Power to generator controller from generator distribution board Circuit - 1L123
Lube Oil Tank
150L nominal
DN50 fill socket
Leak detect
Flexible connection to engine
DN25 fuel return line
DN25 fuel supply line
DN25 return line
DN25 supply line
Fuel Polishing Unit
Fuel Polisher Panel
PTD
STR
NRV
O.L.E. GAUGE (C2020-B)
Junction Box A
Junction Box B
Belly Tank
53,000L usable (48 hour)
59,100L brim
Bunded
Ground Level
Hi / hi
Low / low
Inspection hatch
Suction drain
Tank vent
Tank bund leak detect
DN50 pipe work within container
OPV
From receiver tank B
From receiver tank A
1 No. multicore cable per generator (12 No. total) from fuel control panel B
1 No. multicore cable per generator (12 No. total) from fuel control panel A
DN80 in DN125
Fill line
Continues to remaining 11 No. generators
Notes
1. Refer to Drawing No. GBL-0473-EC3-XX-DR-X-611101 for cable types & references.
2. Refer to Drawing No. GBL-0473-EC3-XX-DR-X-611205 for belly tank general arrangement.
3. Refer to Drawing No. GBL-0473-EC3-XX-DR-X-611208 for lube oil tank general arrangement.
4. For filtration options refer to AVK technical submittals.
Legend
Isolation valve (N/O)
Isolation valve (N/C)
Lock shield valve
Strainer
Non-return valve
Motorised valve Motor open/spring close
Motorised valve Motor close/spring open
Fire drop valve N/O held open
Electro thermal link
Solenoid quick release
Flow switch
Pulse Flow Meter
Pressure switch
Fuel polisher
Pressure transducer
Pressure gauge
Pump
Local isolator
Mushroom vent
Overfill prevention valve
Flexible pipe
Pipe in pipe
Signals cabling
Power supply
Supply by others
P01 28/03/24 Issued For Approval IM
Iss. Date Description By
3rd Angle Projection
Do Not Scale.
All Dimensions In MM Unless Otherwise Stated.
AVK THE POWER PEOPLE
Power Systems House 1-3 Malvern Road, Maidenhead, Berkshire, SL6 7RE.
Tel:01628 503900
www.avk-seg.co.uk
sales@avk-seg.co.uk
Customer
GRATTE BROTHERS
Site
Union Park
Title
Fuel & Lube Oil Schematic
Drawn I. Moore
Date 12/03/24
Scale N.T.S.
Checked M.Easton
Date 12/03/24
Sheet Size A1
Drawing No. GBL-0473-EC3-XX-DR-X-611102
Rev. P01

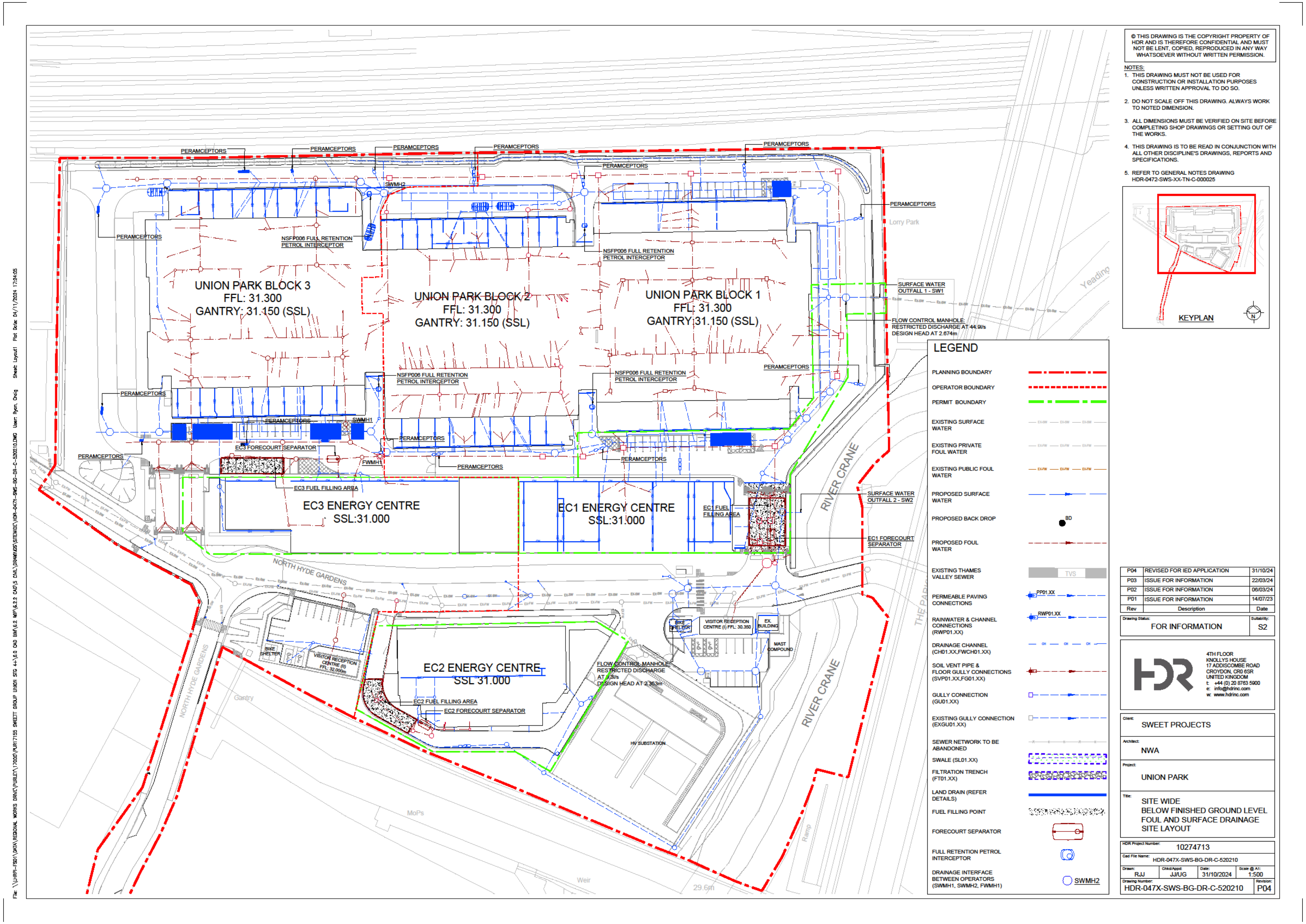

Projected View
Section A-A
Section B-B
Section C-C
Fuel Receipt Tank
Left Hand Side
Plan View
Section D-D
Section E-E
Detail A
Projected View
Section A-A
Section B-B
Section C-C
Fuel Receipt Tank
Right Hand Side
Plan View
Section D-D
Section E-E
Detail A
AVK
THE POWER PEOPLE
GRATTE BROTHERS
Union Park
Fuel Receipt Tanks
General Arrangement


Detail A
Section A-A
Left Hand Tank
Detail A
Section A-A
Right Hand Tank
Detail B
Detail C
Detail D
(Typical lifting lug detail)
Detail E
(Gap between tanks)
Detail F
(Vent pipe to bund)
Detail G
THE POWER PEOPLE
GRATTE BROTHERS
Union Park
Belly Fuel Tank
General Arrangement


Second Level Deck
Ground Level
Receiver Tank A
Receiver Tank B
P01 28/03/24 Issued For Approval IM
3rd Angle Projection
Do Not Scale.
All Dimensions in MM Unless Otherwise Stated.
THE POWER PEOPLE
Power Systems House 1-3 Malvern Road, Maidenhead, Berkshire, SL6 7RE.
Tel:01628 503900 www.avk-seg.co.uk sales@avk-seg.co.uk
GRATTE BROTHERS
Union Park
Overall Generator Fuel Schematic
I. Moore 11/03/24 N.T.S.
M.Easton 11/03/24 A0
GBL-0473-EC3-XX-DR-X-611103
P01

APPENDIX F

DRAINAGE PLAN


UNION PARK BLOCK 3
FFL: 31.300
GANTRY: 31.150 (SSL)
UNION PARK BLOCK 2
FFL: 31.300
GANTRY: 31.150 (SSL)
UNION PARK BLOCK 1
FFL: 31.300
GANTRY: 31.150 (SSL)
EC3 ENERGY CENTRE
SSL:31.000
EC1 ENERGY CENTRE
SSL:31.000
EC2 ENERGY CENTRE
SSL 31.000
PERAMCEPTORS
NSFP006 FULL RETENTION PETROL INTERCEPTOR
SWMH2
SWMH1
FWMH1
EC3 FORECOURT SEPARATOR
EC3 FUEL FILLING AREA
EC1 FUEL FILLING AREA
EC1 FORECOURT SEPARATOR
EC2 FUEL FILLING AREA
EC2 FORECOURT SEPARATOR
SURFACE WATER OUTFALL 1 - SW1
SURFACE WATER OUTFALL 2 - SW2
FLOW CONTROL MANHOLE: RESTRICTED DISCHARGE AT 44.9l/s DESIGN HEAD AT 2.674m
FLOW CONTROL MANHOLE RESTRICTED DISCHARGE AT 3.2l/s DESIGN HEAD AT 2.353m
Lorry Park
Yeading
NORTH HYDE GARDENS
RIVER CRANE
THE PARADE
BIKE SHELTER
VISITOR RECEPTION CENTRE (I) FFL: 30.350
EX. BUILDING
MAST COMPOUND
HV SUBSTATION
Gantry
MoPs
Weir
Ramp
29.6m
LEGEND
PLANNING BOUNDARY
OPERATOR BOUNDARY
PERMIT BOUNDARY
EXISTING SURFACE WATER
EXISTING PRIVATE FOUL WATER
EXISTING PUBLIC FOUL WATER
PROPOSED SURFACE WATER
PROPOSED BACK DROP
PROPOSED FOUL WATER
EXISTING THAMES VALLEY SEWER
PERMEABLE PAVING CONNECTIONS
RAINWATER & CHANNEL CONNECTIONS (RWP01.XX)
DRAINAGE CHANNEL (CH01.XX,FWCH01.XX)
SOIL VENT PIPE & FLOOR GULLY CONNECTIONS (SVP01.XX,FG01.XX)
GULLY CONNECTION (GU01.XX)
EXISTING GULLY CONNECTION (EXGU01.XX)
SEWER NETWORK TO BE ABANDONED
SWALE (SL01.XX)
FILTRATION TRENCH (FT01.XX)
LAND DRAIN (REFER DETAILS)
FUEL FILLING POINT
FORECOURT SEPARATOR
FULL RETENTION PETROL INTERCEPTOR
DRAINAGE INTERFACE BETWEEN OPERATORS (SWMH1, SWMH2, FWMH1)
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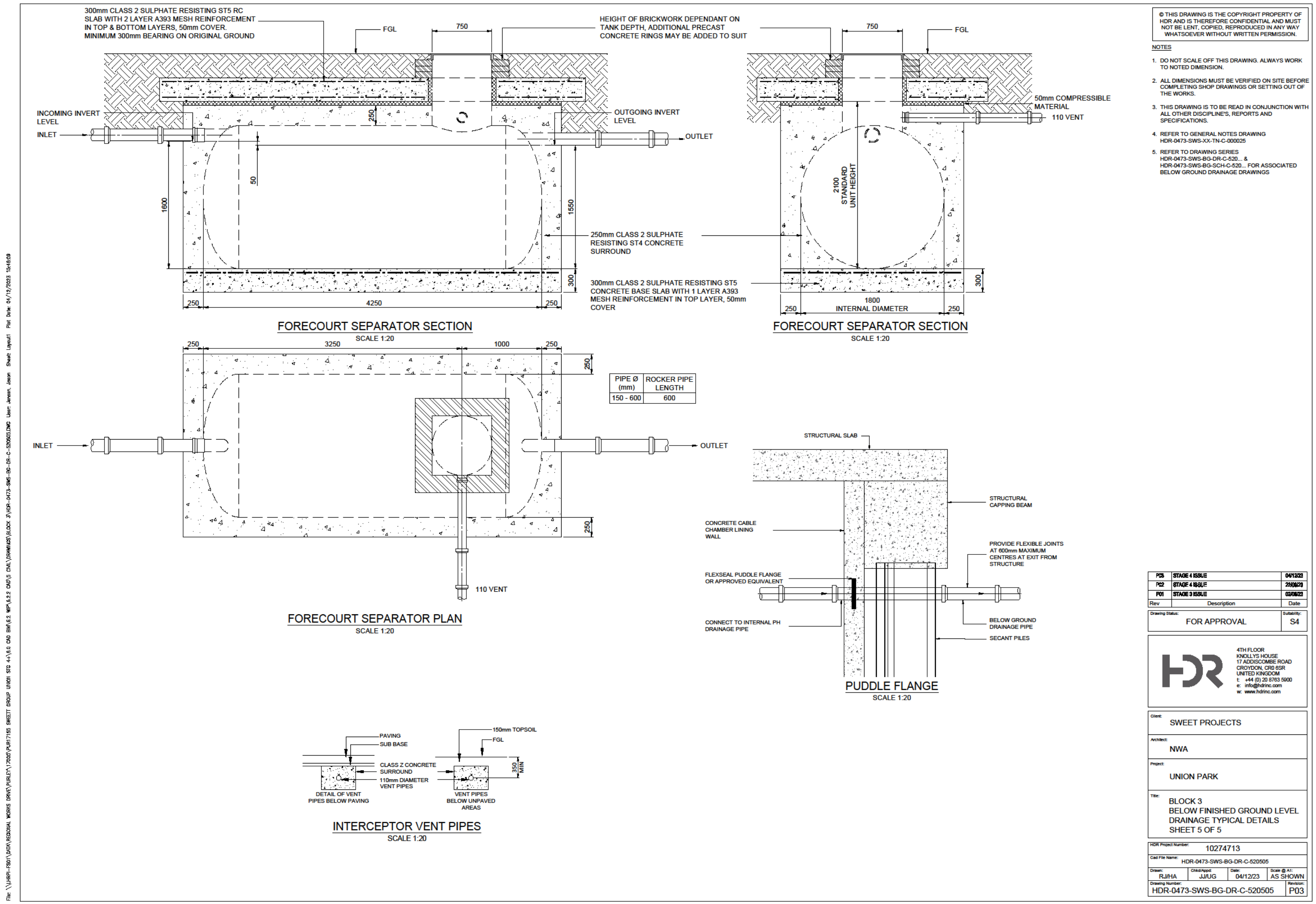
5. REFER TO GENERAL NOTES DRAWING HDR-0472-SWS-XX-TN-C-000025
KEYPLAN
P04 REVISED FOR IED APPLICATION 31/10/24
P03 ISSUE FOR INFORMATION 22/03/24
P02 ISSUE FOR INFORMATION 06/03/24
P01 ISSUE FOR INFORMATION 14/07/23
Rev Description Date
FOR INFORMATION S2
HDR
4TH FLOOR KNOLLYS HOUSE 17 ADDISCOMBE ROAD CROYDON, CR0 6SR UNITED KINGDOM
t: +44 (0) 20 8763 5900
e: info@hdrinc.com
w: www.hdrinc.com
Client: SWEET PROJECTS
Architect: NWA
Project: UNION PARK
Title: SITE WIDE BELOW FINISHED GROUND LEVEL FOUL AND SURFACE DRAINAGE SITE LAYOUT
HDR Project Number: 10274713
Cad File Name: HDR-047X-SWS-BG-DR-C-520210
Drawn: RJJ Chkd/Appd: JJ/UG Date: 31/10/2024 Scale @ A1: 1:500
Drawing Number: HDR-047X-SWS-BG-DR-C-520210 Revision: P04

APPENDIX G

FUEL INTERCEPTOR DRAWING


300mm CLASS 2 SULPHATE RESISTING ST5 RC SLAB WITH 2 LAYER A393 MESH REINFORCEMENT IN TOP & BOTTOM LAYERS, 50mm COVER. MINIMUM 300mm BEARING ON ORIGINAL GROUND
FGL
750
HEIGHT OF BRICKWORK DEPENDANT ON TANK DEPTH, ADDITIONAL PRECAST CONCRETE RINGS MAY BE ADDED TO SUIT
INCOMING INVERT LEVEL
INLET
OUTGOING INVERT LEVEL
OUTLET
250
50
1600
1550
250mm CLASS 2 SULPHATE RESISTING ST4 CONCRETE SURROUND
300
300mm CLASS 2 SULPHATE RESISTING ST5 CONCRETE BASE SLAB WITH 1 LAYER A393 MESH REINFORCEMENT IN TOP LAYER, 50mm COVER
250
4250
250
FORECOURT SEPARATOR SECTION
SCALE 1:20
50mm COMPRESSIBLE MATERIAL
110 VENT
2100 STANDARD UNIT HEIGHT
1800 INTERNAL DIAMETER
FORECOURT SEPARATOR SECTION
SCALE 1:20
250
3250
1000
250
PIPE Ø (mm)
ROCKER PIPE LENGTH
150 - 600
600
INLET
OUTLET
110 VENT
FORECOURT SEPARATOR PLAN
SCALE 1:20
STRUCTURAL SLAB
STRUCTURAL CAPPING BEAM
CONCRETE CABLE CHAMBER LINING WALL
PROVIDE FLEXIBLE JOINTS AT 600mm MAXIMUM CENTRES AT EXIT FROM STRUCTURE
FLEXSEAL PUDDLE FLANGE OR APPROVED EQUIVALENT
CONNECT TO INTERNAL PH DRAINAGE PIPE
BELOW GROUND DRAINAGE PIPE
SECANT PILES
PUDDLE FLANGE
SCALE 1:20
PAVING
SUB BASE
CLASS Z CONCRETE SURROUND
110mm DIAMETER VENT PIPES
DETAIL OF VENT PIPES BELOW PAVING
150mm TOPSOIL
FGL
350 MIN
VENT PIPES BELOW UNPAVED AREAS
INTERCEPTOR VENT PIPES
SCALE 1:20
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4. REFER TO GENERAL NOTES DRAWING HDR-0473-SWS-XX-TN-C-000025
5. REFER TO DRAWING SERIES HDR-0473-SWS-BG-DR-C-520... & HDR-0473-SWS-BG-SCH-C-520... FOR ASSOCIATED BELOW GROUND DRAINAGE DRAWINGS
P03 STAGE 4 ISSUE 04/12/23
P02 STAGE 4 ISSUE
P01 STAGE 3 ISSUE
Rev Description Date
FOR APPROVAL
S4
4TH FLOOR KNOLLYS HOUSE 17 ADDISCOMBE ROAD CROYDON, CR0 6SR UNITED KINGDOM
t: +44 (0) 20 8763 5900
e: info@hdrinc.com
w: www.hdrinc.com
SWEET PROJECTS
NWA
UNION PARK
BLOCK 3
BELOW FINISHED GROUND LEVEL DRAINAGE TYPICAL DETAILS
SHEET 5 OF 5
10274713
HDR-0473-SWS-BG-DR-C-520505
RJ/HA
JJ/JG
04/12/23
AS SHOWN
HDR-0473-SWS-BG-DR-C-520505
P03