Battery Energy Storage Facility, Doagh Road, Kells – Fire Risk Assessment Addendum

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BATTERY ENERGY STORAGE FACILITY, DOAGH ROAD, KELLS
FIRE RISK ASSESSMENT ADDENDUM

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INTRODUCTION

The project is a new battery energy storage facility for Kells BES Limited located off the Doagh Road, Kells, Co. Antrim.

The number of containers and batteries within each container is now proposed to be changed from the Fire Risk Assessment Report (R1 Issue 7) dated July 2020 for this site.

The project now consists of the installation of 13 steel storage containers with Lithium-ion Batteries as part of the Battery Energy Storage Facility (BESF) which is reduced from the previously proposed 25 containers.

The maximum power across the 13 containers at the grid connection will remain 50MW.

The substation building is not proposed to change and will be provided in line with the Fire Risk Assessment Report (R1 Issue 7).

The purpose of this addendum is to document our review of the reduced site layout configuration (13 BES units) against the previously approved (25 BES units) and that despite the alteration within the BESS compound, it does not affect the overall conclusions of our submitted FRA dated July 2020 and complies with condition 7 of the planning approval in relation to fire safety. This is discussed in the following sections.

EXECUTIVE SUMMARY

The key fire considerations for the facility relates to means of escape for persons within it; external fire spread and the risk to adjacent properties in respect to fire spread across relevant boundaries; and fire fighters engaged in fire fighting operations.

It is unlikely that a fire would spread to affect all the racks within a container as discuss within the fire spread section below. However, means of escape will be compliant with Building Regulations guidance and the design has been developed in respect to external fire spread based on a worst-case scenario of all containers being simultaneously involved in fire. The firefighting access provisions for each container will also still comply with code guidance. Therefore, the provision of lithium-ion batteries on the Kells site is considered reasonable from a fire strategy perspective. This is discussed further below.

MEANS OF ESCAPE

The occupancy numbers within each container will remain unchanged from the original FRA report.

The proposed containers are split into two areas, the battery zone and zone for the inverters and control cabinets. There will be a single exit from each zone of the containers with a door between. Each exit door will achieve a minimum 750mm clear opening width providing capacity for 50 occupants based on Building Regulations code guidance. Therefore, sufficient exit capacity will still be available.

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Travel distances will remain within the recommended limits.

As per the original FRA, the containers will adopt a simultaneous evacuation strategy.

FIRE SAFETY SYSTEMS

As discussed in the original FRA, automatic suppression systems are not required to meet the recommendations of the TBE in industrial buildings. However, an inert gas fire suppression system will still be provided within the containers. This active fire safety provision will provide an enhanced standard of safety compared to provisions in buildings that are designed to comply with Building Regulations.

A water injection system is also now proposed to be provided to each rack. The system consists of an external water storage tank and piping which distributes water inside each module directly as shown in Figure 1 below. The system will operate automatically at a given temperature that resembles the limit for thermal run away.

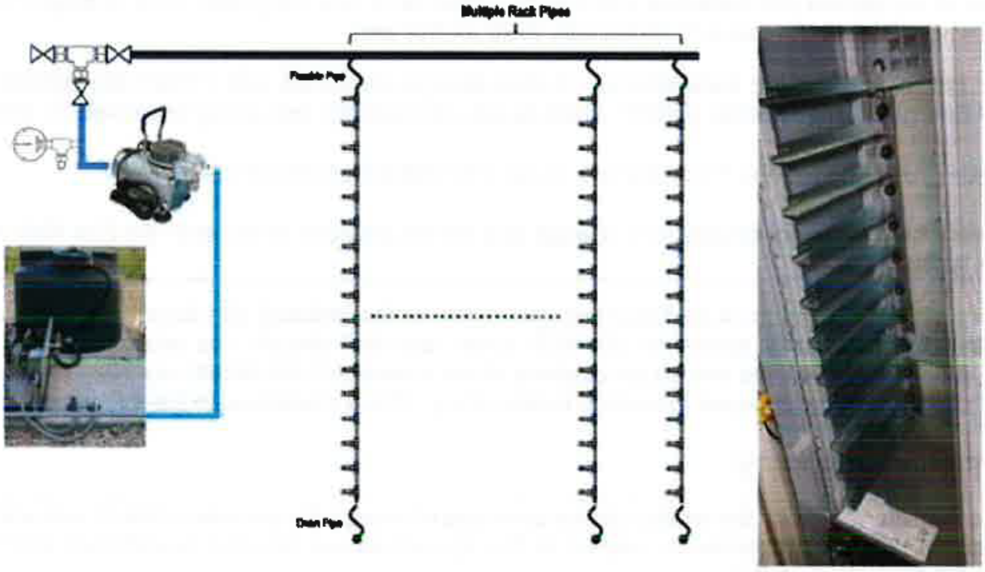


Figure 1: Water Injection System

This will cool the affected cells and modules and reduce the likelihood of a fire spreading to neighbouring modules. Therefore, this active fire safety provision will also provide an enhanced standard of safety compared to provisions in buildings that are designed to comply with Building Regulations.

Automatic fire detection (AFD) will be provided in each container which will include heat detection and a smoke alarm. A Multi-sensor (optical and ionization) smoke alarm will be installed and a Visual Alarm Device (VAD) will be mounted to warn staff not to enter the facility. This will have "Do Not Enter" signage displayed and will be covered during staff/personnel induction.

As discussed in the original FRA, the provision of AFD is not required to comply with the recommendations of TBE. AFD and the other proposed monitoring systems will be provided primarily for property protection purposes. However, it will also alert occupants to a fire at an early stage by way of an alarm as well as a flashing beacon. The proposed measures will also reduce the required safe escape time and subsequently increase the level of fire safety for building occupants.

Therefore, this active fire safety provision will provide an enhanced standard of safety compared to provisions in buildings that are designed to comply with Building Regulations.

Emergency lighting and signage will also be provided as outlined in Section 4.2.1 of the original Fire risk assessment.

LITHIUM-ION ENERGY STORAGE SYSTEM

There are 13 lithium-ion energy storage system units proposed on the Kells Battery Energy Storage Facility site. Each unit will contain two face to face rows of 10 battery racks as well as other supporting equipment including Switchgear Assembly, inverters and Battery Management Systems (BMS).

The NMC battery cells operates at a nominal voltage of 3.68V and has a capacity of 235.5Wh. Each module contains 28 x 64Ah Battery Cells connected in series and parallel (i.e. 14S2P). Based on this each battery module operates at a nominal voltage of 51.5V and has a capacity of 6.594kWh.

Each module is formed by configuring the cells in series and by connecting a battery management system (BMS) to form a rack mountable module assembly. The 24 module assemblies are combined into a rack and each rack contains a rack-level BMS. On this basis, each rack will have a maximum nominal voltage of 1236V and a maximum capacity of 158.256kWh.

The maximum power across the 13 containers at the grid connection will remain 50MW.

There will also still be a ventilation system, automatic fire suppression system with smoke and temperature sensors and alarms, water injection system, climate control with air conditioning, humidity monitoring, lighting and access control contained within each unit. See Appendix A of this addendum for the unit layout.

As noted in the original FRA report, the purpose of this addendum is to carry out a risk assessment of the lithium-ion batteries and determine if the new rack distribution within the units will compromise the life safety of the site.

FIRE RISK ASSESSMENT

Fire growth parameter

The fire growth rate for the proposed number of batteries has been calculated in line with analysis in Section 6.1.1 and 6.1.2 of the FRA report.

Based on Figure 3 of the FRA, the highest heat released rate has been taken into account therefore, a heat release rate of 42.2kW (i.e. worst case scenario) per battery cell will be considered for calculation purposes, after 429 seconds which is the ignition time.

As discussed above, there will be 24 modules per rack containing 28 lithium-ion battery cells. Therefore, based on 672 battery cells per rack, a maximum heat release rate of 28,358.4kW would be achieved after 429 seconds in accordance with Figure 3 of the FRA.

This involves a conservative approach based on the following: -

- A fire involving the whole rack at the same ignition time has been considered for calculation purposes. This is highly unlikely, as this ignition time and the time when the maximum heat release rate is achieved corresponds to the first cell exposed to fire within one module. Therefore, there will be a delay between the ignition of this cell and the next one beside, significantly reducing the fire growth rate.
- Additionally, each module will be enclosed within a non-combustible steel case, which will prevent the instantaneous ignition to the next module located along the same rack.

Therefore, based on Equation 1 given in the original FRA, the fire growth parameter obtained is $\alpha=0.154$ which is considered a fast fire growth rate according to Table 2 of BS 7974-1.

It should be noted that the heat release rate of the NMC batteries will not present a quadratic profile with the time as outlined in Figure 3 of the original FRA and therefore, this approach will overestimate the total combustion heat released from the battery.

Fire Spread

The aim of this section is to demonstrate that, the initial fire should not spread between the rack aisles in the unit as had been outlined in the FRA for the previous number of batteries. This is discussed in Section 6.1.3 of the FRA report.

The critical heat flux value received by the adjacent rack should not exceed 12.6 kW/m2. The results contained in Appendix B show that, even considering the conservative assumptions outlined above, this maximum value will not be reached along the adjacent racks aisle as long as the maximum temperature within the radiation surface does not exceed 453°C. This has been based on the distance between racks aisles decreasing to 0.764m.

The temperatures measured by the thermocouples (1-6) in the calorimeter test carried out for the NMC lithium-ion battery cells show that the maximum temperature achieved by a battery cell is approximately 800°C in a lapse of 20s. This is not a constant temperature in the time, but it is achieved due to the second explosion and rapidly after it this temperature is reduced and stabilised to a maximum value below 400°C. This temperature profile is shown in the Figure 4 of the FRA report.

A large radiation surface has been considered as this scenario involves the ignition of all racks simultaneously, even when the fire will be based on a single module. This case is very unlikely, as the peak temperature radiated by a battery cell in a short period of time will not be able to induce a constant temperature of almost 400°C along all the racks surfaces at the same time.

The cells will also be contained within a non-combustible steel module case and each module contained within a partly enclosed non-combustible metal rack. The racks will also be located adjacent to each other in two rows.

The main vehicle for fire growth is flame spread from the original source of the fire to adjacent rack units due to radiant heat transfer. As each rack is partly enclosed in a non-combustible steel case, the flame height and the maximum fire size will be initially limited to the case dimensions.

A fire involving the ignition of all racks along the aisle has been considered. As discussed in the FRA, this scenario is considered an onerous approach and an unlikely situation based on the fact that each module unit will be enclosed within a non-combustible steel case, which will delay the ignition of the next module unit located within the same rack before it could spread to another rack. This also does not account for any automatic fire suppression systems which will restrict fire growth, limit fire spread, and limit heat and smoke generation. As detailed in the FRA, an inert gas fire suppression system will be incorporated as well as a water injection system. In addition to this and as noted in the FRA report, the above does not consider that the units will have high levels of management and security. This is discussed further below.

DISCUSSION

Fire Load and Fire Risk

As discussed in the original fire risk assessment, the fire load in a building varies dependent on its use. It is generally accepted that high fire loads can be present in industrial buildings and should be considered. Both TBE and BS 9999 acknowledges this by considering that the heat output would be similar in an industrial building fire and in a shop, commercial or storage building fire.

Guidance on fire growth rates in BS 7974 recommends fast fires for retail, medium for offices and slow for a picture gallery and fire load densities although not directly equivalent to fire growth are representative of this trend.

As demonstrated above the fire growth rate calculated within the containers would be considered a fast fire growth rate. Therefore, based on the recommendations of BS 7974 this would equate to the fire growth rates of retail units and large industrial buildings. However, the fire risk and load within the proposed container will be small compared to these buildings.

For example, in a code compliant retail unit with a maximum compartment size of 2000m^2, a sprinkler system would not be required. Therefore, large amounts of cellulosic fuel may be present which would be significantly higher than in each container unit which would have a compartment size of only 33m^2. Even if the entire 13 containers are considered to form a single compartment, their compartment size would still be less than a quarter of a code compliant retail unit (429m^2). This is also significantly less than the original proposed area of the 25 containers (750m^2).

Additionally, in large single storey industrial buildings, code guidance would not require sprinklers to be provided or compartment sizes to be limited to a certain area. Therefore, compared to a code compliant industrial building which may contain material that results in an ultra fast fire growth rate, the fire load and associated fire risk within the containers would be considered relatively low.

Irrespective of the fire growth rate, it has been assumed that a fire could develop to involve all the combustible materials within each container i.e. flashover. Code guidance assumes this when assessing the unprotected areas in a building i.e. the entire compartment has flashed over and unprotected areas such as glazing will shatter. The container elevations will comply with code guidance. This is discussed further below.

Also due to the close proximity of the containers, their north west and south east elevations have been considered a single radiating panel for external fire spread calculations. There is no requirement under Building Regulations to limit the amount of unprotected area on opposing elevations of industrial buildings on the same site. Therefore, this approach is considered onerous as it assumes that all containers on these elevations are one flashed over compartment rather than individual compartments.

Also, due to the small size, simple layout and automatic fire detection within each container, any occupants would be alerted to a fire at an early stage and will be able to escape away from the fire.

This is before considering the benefits of the automatic fire suppression systems within each container which as noted above will be effective for restricting fire growth, limiting fire spread heat output and smoke generation, and may also extinguish the fire.

CONCLUSIONS

A Fire Risk Assessment has been carried out on the newly proposed energy storage system containers to assess the risk of the lithium ion batteries on site.

The fire growth parameter of the fire involving a full rack of batteries simultaneously has been evaluated considering a proportional increment of heat release rate with the square of time as proposed by BS 7479-1.

As a result, a fire growth parameter of α=0.154 has been obtained, which corresponds to a fast classification according to BS 9999. However, this is considered onerous when compared to other industrial buildings and retail units with the same growth rate which have greater risk of fire and the potential for much larger compartment sizes to have a fully evolved flashed over fire. Also, this does not consider the provision of a fire suppression system within each container which will also reduce the heat release rate.

The recommendations of code guidance assume that a fire will occur in a building and therefore takes into account the use of the building and the associated risk to life. Therefore, as means of escape provisions for each unit complies with code guidance, the provision of lithium-ion batteries would not be a greater risk to life safety than in other buildings with similar fire loading which are designed to comply with Building Regulations guidance.

Therefore, based on the above, the proposed changes to the original design on the Kells site is considered reasonable from a fire strategy perspective.

INTERNAL FIRE SPREAD – LININGS

The proposed containers will comply with Table 3 of the Fire Risk Assessment report.

EXTERNAL FIRE SPREAD

As discussed in Section 8 of the FRA report, the amount of permitted glazing and other unprotected areas has been calculated based on the methods described in BR 187, "External fire spread: building separation and boundary distances." The enclosing rectangle method was used to calculate the maximum amount of unprotected areas on the elevations.

As the number of containers on site has reduced the distance between them and the site boundary has increased compared to the original layout. Therefore, most elevations can now be fully unprotected however, the containers located furthest south east are closer to the site boundary and therefore their south east elevation will be limited to 61% unprotected area. The amount of allowable unprotected area is greater than the original container layouts elevations which required this elevation of the containers to be fully protected.

These protected areas will achieve at least 60 minutes integrity and 15 minutes insulation which will provide sufficient protection to each of the required elevations to prevent fire spread to the adjacent site.

PASSIVE FIRE SAFETY MEASURES

The containers would be considered single storey industrial buildings. Therefore, the relevant period of fire resistance for elements of structure is still 60 minutes.

However, as discussed in the FRA report, in any building elements of structure excludes parts of the building frame which are not essential for the stability of compartment walls, floors (upper storeys) or an external wall which cannot be fully unprotected. These parts of the frame and any structure which only supports a roof do not need to be fire resisting.

As detailed in the FRA report, there is no requirement for compartmentation within the containers however, the south east elevations of some of the containers should be fire protected for external fire spread purposes as discussed above. Therefore, any structure of the containers that this elevation relies on will be fire protected. There is no requirement for the building frames of the remaining containers to be fire protected on the basis that they do not incorporate any compartment walls, upper storeys or fire protected elevations.

FIRE BRIGADE ACCESS AND FACILITIES

As discussed in Section 10.1 of the FRA report, access for a pump appliance will be provided to a minimum of 15% of the building perimeter. This will also apply to the new layout and therefore will be sufficient. Access to the site will be available from Doagh Road with an access road providing sufficient access to each unit.

The vehicle access roads will have a minimum width of 3.7m and 3.1m where there is any gate crossing and carrying capacity of 12.5 tonnes for pump appliances.

A supply of water should be available for fire fighting from the water mains via hydrants located around the site.

FIRE SAFETY MANAGEMENT STRATEGY

Section 11 of the Fire Risk Assessment report will still apply to the proposed container changes.

Also, we can confirm that this will be an unmanned site with personnel attending on an intermittent basis for maintenance and site checks. In the event of fire, the system will send an alarm signal through the Energy Management System, which will notify the 24/7 monitoring team. The team will perform a call out of an on-ground service as well as the fire brigade, while the system is automatically shutting down to reach a safe state. Additionally, to ensure early notification the EMS also provides the option of an autodial facility direct to the NIFRS, any requirements for this will be discussed and agreed with the NIFRS in advance of the site being operational.

A Fire Emergency Response Plan will also be posted onsite which will outline the protocol to be followed in the event of a fire. The number for the emergency contact as well as the number of the fire brigade will be included in this document. The NIFRS will be engaged with on this Emergency Response Plan in advance of the site being operational.

ADDITIONAL INFORMATION

Emergency Shutdown

In the case of a fire event the system will send an alarm signal through the Energy Management System, which will notify the 24/7 monitoring team, and the system will automatically shut down to reach a safe state. There will also be two manual shut downs at two levels:

1) Locally by pressing the emergency stop button (LOCAL EMERGENCY STOP) located inside and at each entrance of the container concerned (in this case, it will be the only one to be disconnected),
2) or globally by pressing another emergency stop push button (GLOBAL EMERGENCY STOP).

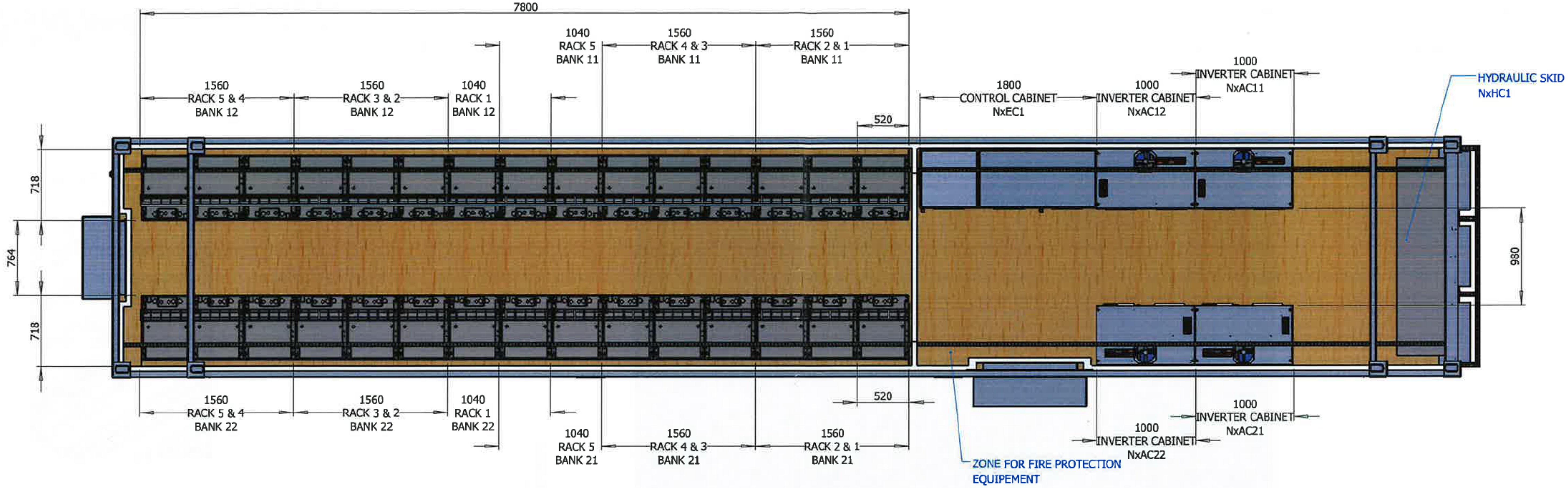
These emergencies stop buttons disconnect the containers from the medium voltage supply, preventing risks of electrical shock, as well as disconnection of the inverters. The global stop button disconnects all of the 13 containers. The two local shut down buttons are located close to each entrance in each of the containers. One inside the Battery Room and another inside the PCS room. The global emergency stop button is located before the entrance of the battery compound.

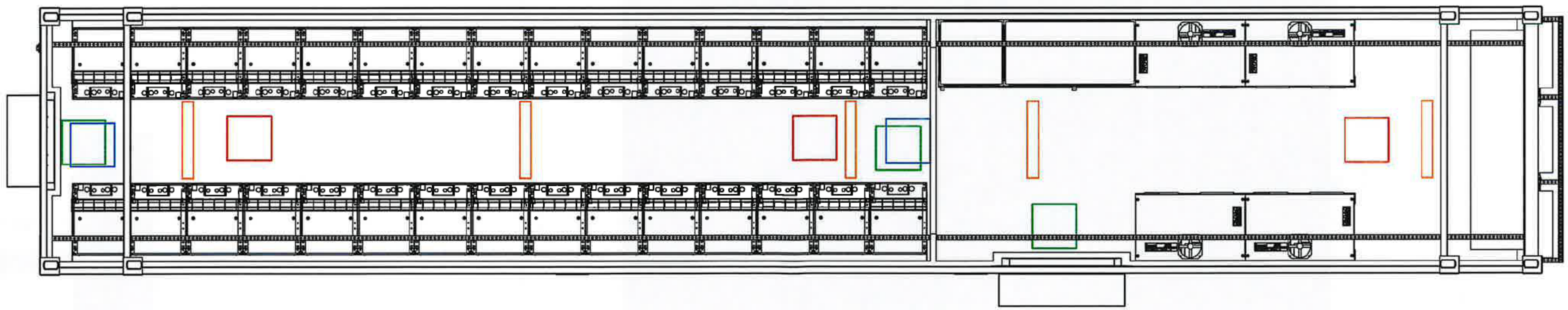
As the batteries will be disconnected directly there is no discharging of the system. The system will be disconnected at its then existing SoC. In general, the batteries will be operated on average below a SoC of 80% which results in a reduced risk compared to them being at 100% SoC.

CONCLUSIONS

We can confirm having reviewed the reduced site layout configuration (13 BES units) against the previously approved (25 BES units), that despite the alteration within the BESS compound, it does not affect the overall conclusions of our submitted FRA dated July 2020 and complies with condition 7 of the planning approval in relation to fire safety. Therefore, in conduction with this addendum technical note there is no reason why the FRA submitted in August 2020 in order to comply with condition 7 cannot now be discharged.

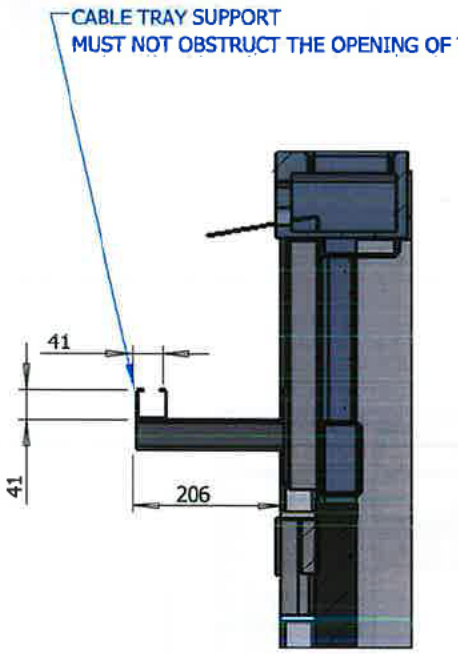
APPENDIX A CONTAINER LAYOUT PLANS



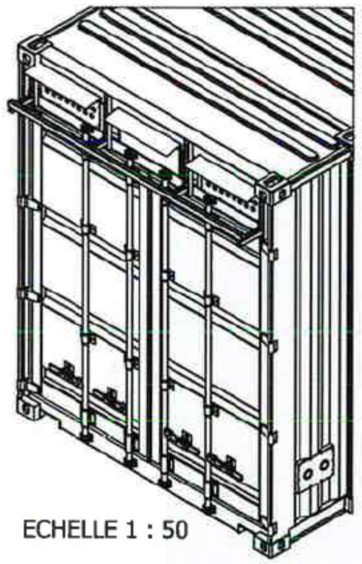


TEMPERATURE SENSOR | DEHUMIDIFIERS | LIGHT | ESPB | EMERGENCY EXIT

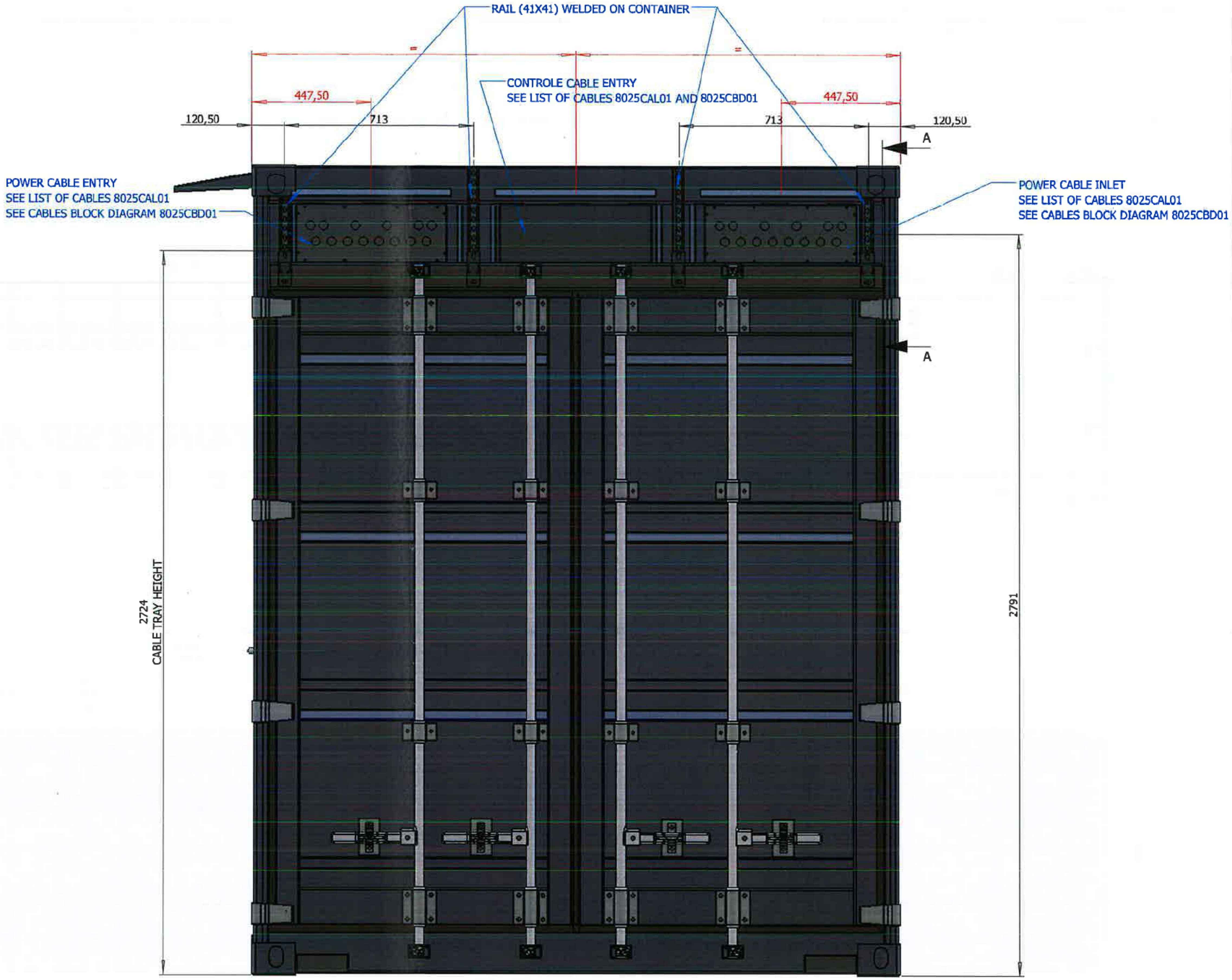
Nidec All for dreams	ABO WIND	INDEX / INDICE : 00	ABO WIND KELLS BATTERY PROJECT	DOC. N° / N° DOC. : 8025MED12	FOLIO 7
		DATE : 28/06/2021	50 MW 25 MWH INTERNAL LAYOUT	CUST. DOC. N° / N° DOC CLIENT :	SCALE / FORMAT : A3



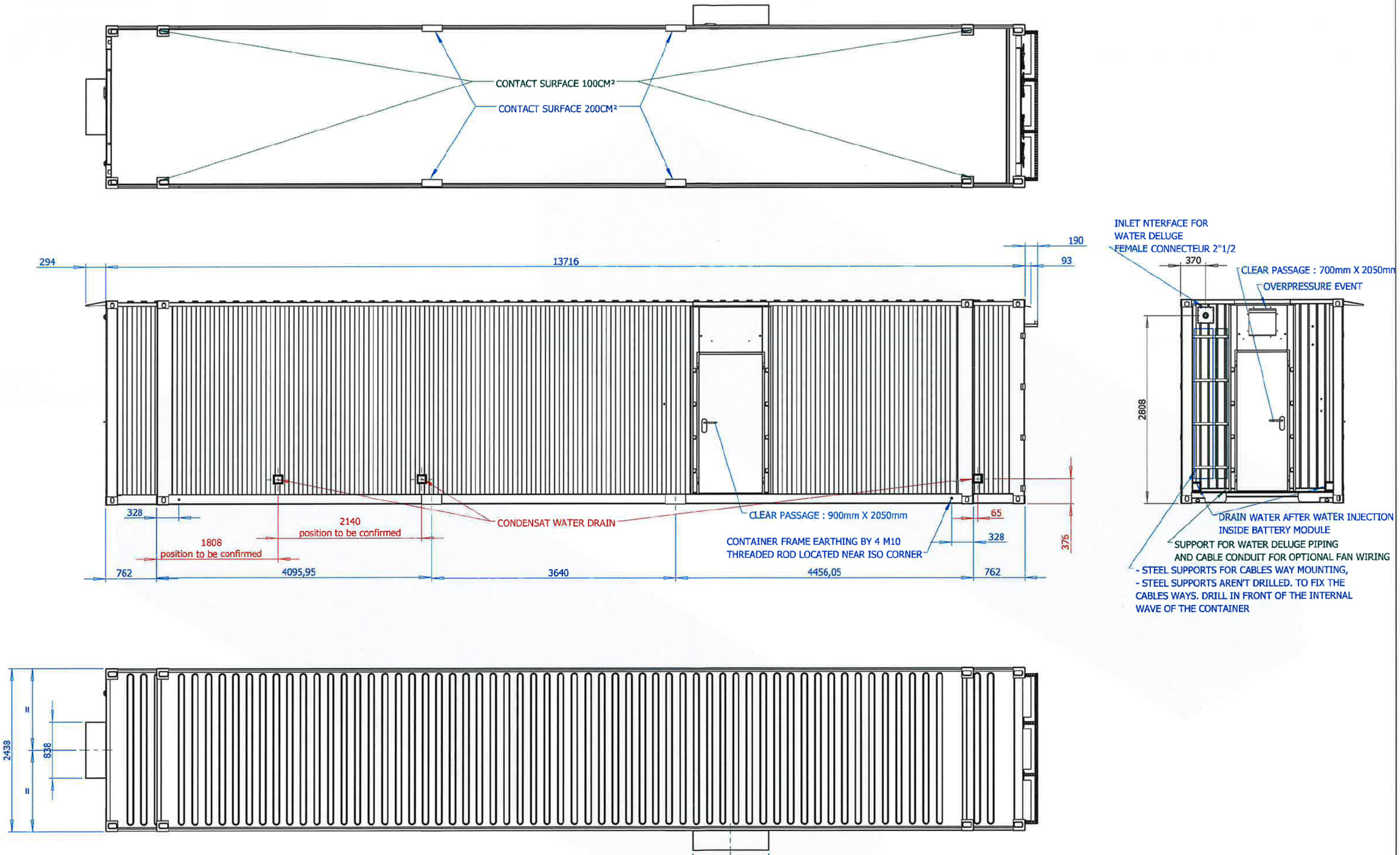
COUPE A-A
ECHELLE 1 : 10



ECHELLE 1 : 50



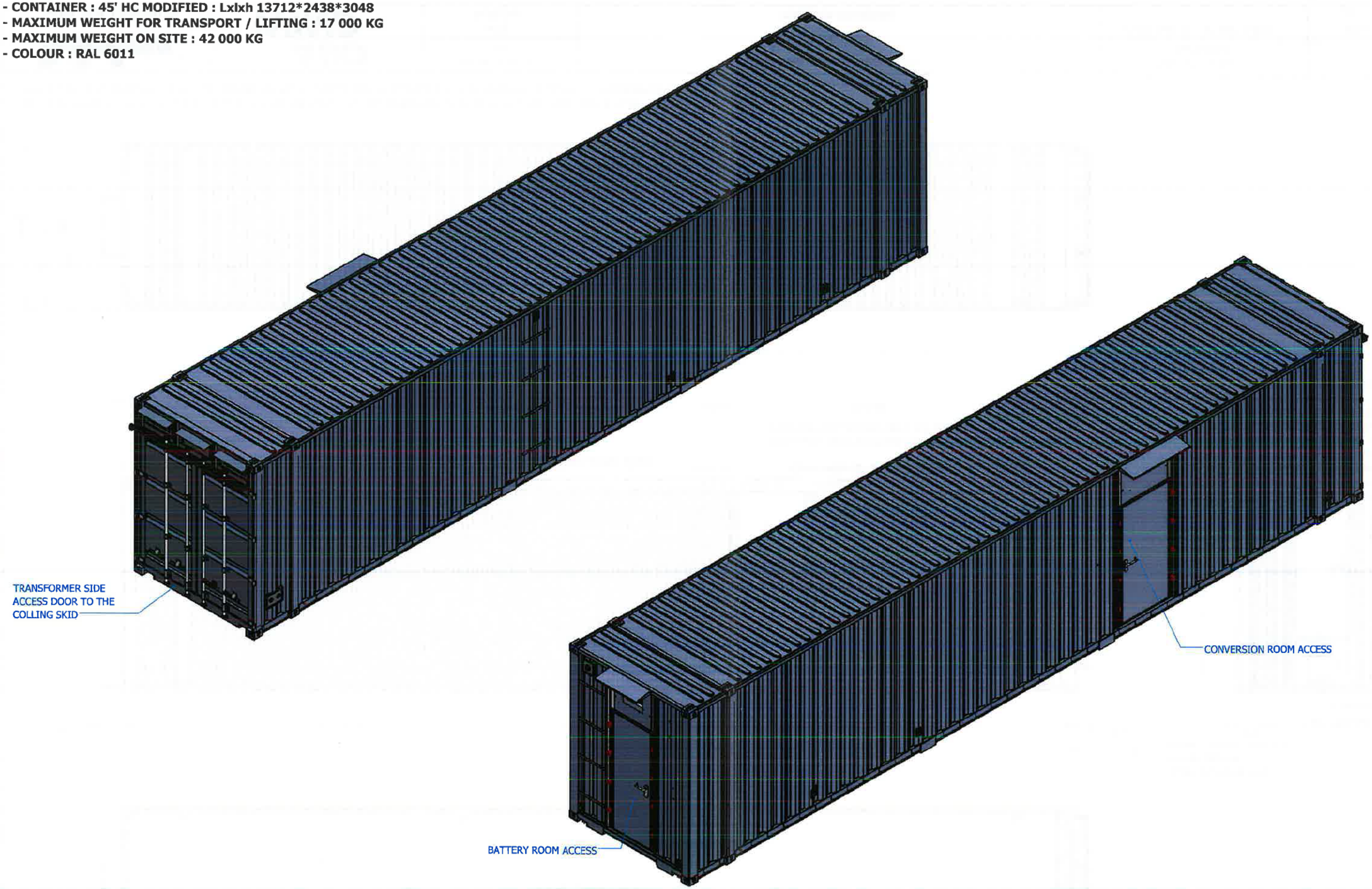
Nidec — All for dreams	ABO WIND	INDEX / INDICE : 00	ABO WIND KELLS BATTERY PROJECT 50 MW 25 MWH CABLE ENTRIES POSITION	DOC. N° / N° DOC. : 8025MED12	FOLIO 6
		DATE : 28/06/2021		CUST. DOC. N° / N° DOC CLIENT :	SCALE / FORMAT : A3



ALL EQUIPMENT THAT EXCEEDS ISO CORNERS HAVE TO BE DISMOUNTED BEFORE TRANSPORTATION
TOUS LES EQUIPEMENTS QUI DEPASSENT DES COINS ISO DOIVENT ETRE DEMONTE AVANT LE TRANSPORT

Nidec — All for dreams	ABO WIND	INDEX / INDICE : 00	ABO WIND KELLS BATTERY PROJECT 50 MW 25 MWH CONTAINER DIMENSIONS	DOC. N° / N° DOC. : 8025MED12	FOLIO 5
		DATE : 28/06/2021		CUST. DOC. N° / N° DOC CLIENT :	SCALE / FORMAT : A3

- CONTAINER : 45' HC MODIFIED : Lxlxh 13712*2438*3048
- MAXIMUM WEIGHT FOR TRANSPORT / LIFTING : 17 000 KG
- MAXIMUM WEIGHT ON SITE : 42 000 KG
- COLOUR : RAL 6011



Nidec — All for dreams	ABO WIND	INDEX / INDICE : 00	ABO WIND KELLS BATTERY PROJECT 50 MW 25 MWH OVERALL LAYOUTS	DOC. N° / N° DOC. : 8025MED12	FOLIO 3
		DATE : 28/06/2021		CUST. DOC. N° / N° DOC CLIENT :	SCALE / FORMAT : A3

APPENDIX B FIRE SPREAD CALCULATIONS

Heat Transfer Calculations

The critical heat flux value received by the adjacent rack should not exceed 12.6 kW/m^2. The results contained below show that, even considering the conservative assumptions outlined within this report, this maximum value will not be reached along the adjacent racks aisle as long as the maximum temperature within the radiation surface does not exceed 453°C.

Radiation Calculations

BRE187: 2014 - Section 4

Configuration Factor

$$\phi = \frac{2}{\pi}\left(\frac{X}{\sqrt{1+X^2}}\tan^{-1}\left(\frac{Y}{\sqrt{1+X^2}}\right)+\frac{Y}{\sqrt{1+Y^2}}\tan^{-1}\left(\frac{X}{\sqrt{1+Y^2}}\right)\right)$$

	S	0.8	m
Width of radiation panel	W	7.8	m
Height of raidation panel	H	2.0	m
Height ratio	Y	1.3089	
Width ratio	X	5.1047	
Configuration factor	ϕ_i	0.7907	

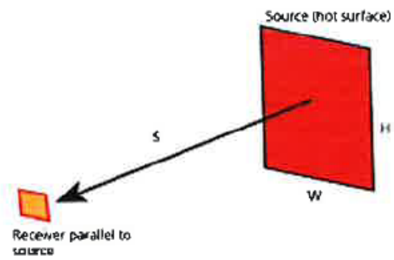


Figure A2: Parallel source and receiver: Centre

Heat Transfer $I = \phi \varepsilon \sigma T^4$

Configuration factor	ϕ_i	0.7907	
Emissivitivity	ε	1	
Stefan Boltzmann Constant	σ	5.7E-11	kW/sqm/K
Compartment Temperature	T	830	degree C
Compartment Absolute Temperature	T	1103	K
Radiant heat flow per/ unit area incident	I	66.71	kW/sq m

Ignition Radiant heat flow per/ unit area incident	Imax	12.5000	kW/sq m
Maximum Compartment Temp	T	453	degree C