Other Than Normal Operating Conditions (OTNOC) for Process Vents

1) Introduction

Under normal operating conditions the channelled emissions of organics to air will be virtually zero for the new HPE plant, due to the collection and distribution of all process vents to a thermal oxidiser (incineration unit) with a final emission point to air, HPE-1.

Abnormal operating conditions can exist for these process vents, mostly when the vents incinerator is unavailable to accept them, and under these circumstances they are diverted to their appropriate local vents (via scrubbing systems if contain residual chlorine/HCl)

i.e.	HPE-15	Dry non-chlorine containing vent
	HPE-21	Main plant wet vent
	HPE-22	Reactor dry vents
	HPE-23	ETP wet vent

Unavailability of the vents incinerator can happen in a planned way e.g. maintenance shutdown event, trip testing, etc. or in an unplanned manner e.g. breakdown of equipment.

In either case, measures will be put in place to minimise emissions to air as practically as possible. This document discusses these measures alongside proposed emission limits versus previous/current permit conditions.

2) Previous/current permit emission limits

Prior to the latest LVOC-revised permit, the DC3 and EDC1/2 plants were operated within the following daily EDC emission limits:-

Emission Point	EDC (kg/hr)	EDC (kg/day)	Comments
DC-13, 14a, 14b, 15	110	2650	Effluent, wet vent, DC reactors and dry vent systems diverted to atmosphere – intermittent when incinerator unavailable
DC-15, 16, 17, 20			Stack 49 road loading depressurisation, DC3 stock tanks – continuous
PT-09, 04, 01	100	2400	EDC1/2 reactor vents*, Residues and EDC stock tanks – continuous
VDC-09	20	480	Road Loading stock tank vent – continuous
Total	230	5530	

* This covers normal operating conditions only, higher specific limits existed for PT-09 during abnormal operation.

The overall daily limit was therefore 5530 kg from a mixture of continuous and intermittent (abnormal) channelled emission points. There was also allowance on the EDC1/2 plant PT-09 emission point for abnormal operation with the fridge unit unavailable which allowed an EDC limit of 800 kg/hr, which is equivalent to 19,200 kg/day. There was no specific daily limit set for the EDC1/2 plant for normal or abnormal operating conditions but there was an annual emission limit set at 500 tes of EDC in a year to provide a 'maximum quota' for the range of operating conditions.

In-line with the latest LVOC BRef, the current permit was duly reviewed to allow only minimal EDC emissions from continuous channelled emissions and therefore the emission limits are now 2650 kg/day for the intermittent vents on DC3 plant, simply transferred from the previous permit, as quoted in Table S3.1(a). This takes no account for the abnormal operating condition/limit that existed on the EDC1/2 reactors, as described above. However, the annual limit previously set for the EDC1/2 plant has been retained in the latest LVOC permit (presumably to account for abnormal conditions) at 500 tes of EDC in a year, as quoted in Table S3.4.

It should be noted that the DC3 and EDC1/2 plants were historically covered under different legacy permits, hence the reason for the variation in emission limit approaches. In terms of plant EDC production capacity the reactors on EDC1/2 were twice the size of the DC3 reactors. The new HPE plant reactors are replacing all previous EDC1/2 and DC3 reactors without any change in overall plant capacity and hence they are approx. three times the size of a previous DC3 reactor and operate similarly to this type of design, as a Low Temperature Direct Chlorination (LTDC) reactor. This needs to be considered for future abnormal operating conditions.

Lastly, the previous permit included a target timescale of <300hrs in a calendar year of DC3 intermittent vents to be diverted away from the incinerator. This target has also been retained in the latest LVOC pemit, as quoted in Table S4.3.

3) Expected emissions from the new HPE plant when process vents are diverted

In the early stages of Project Summer, the expected EDC emissions from the HPE plant when the incinerator is unavailable (abnormal operation) were presented to the Environment Agency on 12/5/2020 as part of the LVOC permit review process, as follows:-

Emission Point	EDC (kg/hr)	EDC (kg/day)	Comments
HPE-15	12	288	Spheres, Heavies Distillation Column
HPE-21	102.2	2453	New Wash system and Drying Column
HPE-22	87	2088	New 2 x LTDC reactors with fridge on-line (-18 degC)
HPE-23	128.6	3086	New effluent plant with full removal of EDC from waste water
Total	329.8	7915	Design rates

Following more detailed design work and a review of understanding what mitigation measures can be put in-place during such periods of operation, this data has been revised as described below:

a) HPE-15

Process vents will come from the Spheres, Heavies Distillation Column, Pure EDC Pumping Tank, EDC/Residues Stock Tanks, Out-of-service Residues (Contaminated) Tanks (D814A/B) and any Road tanker barrels being purged out of EDC service.

Equipment	Mitigation Measures
Spheres	Check vessel pressures, consider higher pressure controller set point to prevent venting; trim export rates vs production rates to avoid filling the vessel(s).
Heavies Distillation Column	Reflux drum level controlled, minimum displacement venting - DC3 plant Process Flow Diagram (PFD) shows no appreciable flow.
Pure EDC Pumping Tank	Pumping Tank level controlled, minimum displacement venting, as per Reflux drum above.

EDC/Residues Stock Tanks	Potentially trim crude EDC production vs distillation rate to avoid filling EDC stock tank; burning residues will be emptying the Residues stock tank but this is only on a campaign basis.
D814A/B	Automatic pressure control system increases vessel set pressure when the vents are diverted preventing emissions.
Road barrel purging	Stop barrel purging into the dry vent header.

Given the above, the overall updated EDC emission from this vent will be taken as typical emissions from 2 x EDC stock tanks as previously calculated using the API 2518 method which have been approx. 12 tes/annum in the last few years i.e. approx. 1.5 kg/hr. Along with residual amounts from the other vents following mitigation, then take 50 kg/day.

b) HPE-21

Process vents will come from the Wash system and Drying Still Overheads.

Equipment	Mitigation Measures
Wash drums	Each drum is level controlled, minimum displacement venting - HPE plant Process Flow Diagram (PFD) from OxyVinyls shows expected EDC flow of 2.5 kg/hr
Drying Still Overheads	Maximise cooling on the Vent condensers ensuring the water control valve is 100% open and minimise cooling water inlet temperature as far as possible - DC3 plant Process Flow Diagram (PFD) shows expected EDC flow of 161 kg/hr but this also includes the old C301 drying still, so pro-rota for just C351 duty gives approx. 70kg/hr

Given the above, the overall updated EDC emission from this vent will be taken as 72.5 kg/hr i.e. 1740 kg/day.

c) HPE-22

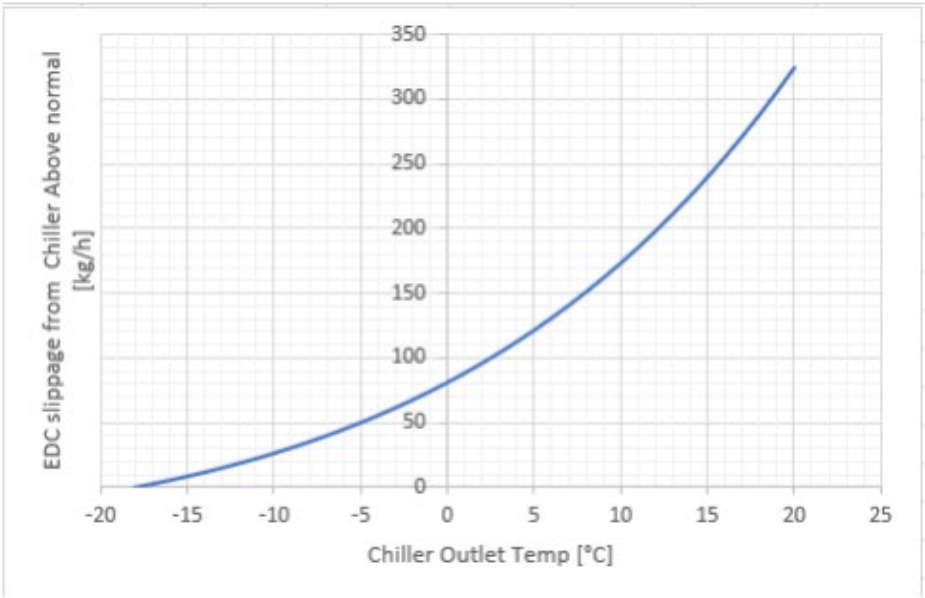
Process vents will come from each of the new LTDC reactors.

Equipment	Mitigation Measures
Reactor vent chillers	Ensure fridge system on-line to maintain -18 degC set point in the vent. Drop reactor rates if this cannot be achieved. If fridge system trips then automatic trip systems have been designed to reduce reactor rates or trip them off completely if the temperature gets too high to avoid excessive EDC loading in the vent. Following successful reactor shutdown, the nitrogen (safe inerting flow) could be reduced significantly after a set period or even stopped to prevent the majority of EDC carryover.

The HPE plant Process Flow Diagram (PFD) from OxyVinyls shows expected EDC flow in total reactor vents of 87 kg/hr.

Computer simulations were performed on EDC carryover into the vent system above the normal operating temperature of -18 degC so that the automatic trip system set points could be defined.

A simulation case study of the EDC slippage from a single reactor vent condenser is provided in the graph below against rising reactor vent temperature:



Based on this data, the first automatic set point of -10 degC has been chosen which will ramp down the reactor production rates to steady minimum (40%). If the reactor vents are already diverted to HPE-22 then the next automatic set point of -5 degC will trip the reactor(s) off-line. At -5 degC, the graph shows that the extra EDC emission in the vent will be 50kg/hr for each reactor i.e. 100kg/hr for both reactors.

If we take 2 hours to reach this condition and take the entire extra 100kg/hr for this period of time as well as assuming this happened at the end of a 24-hr day then this would add a further 200 kg to the day's emissions.

Therefore, given the above, the overall potential EDC emission from this vent will be taken as 2288 kg/day.

d) HPE-23

Process vents will come from the new Effluent Treatment Plant (ETP).

Equipment	Mitigation Measures
ETP stripper/vessels	Minimise EDC loading on ETP e.g. stop decanting water layer from crude EDC stock tank, use hold-up inventory where possible, etc. The ETP Process Flow Diagram (PFD) shows different cases of expected EDC flows in the vent from the stripper, assuming mitigation measures taken use case of typical organic loading to ETP but winter conditions which gives approx. 50 kg/hr

Given the above, the overall updated EDC emission from this vent will be taken as 50 kg/hr i.e. 1200 kg/day.

All the mitigation measures described above will form part of an operating instruction checklist that will be actioned by the Shift Manager during periods of vent diversions, and will also include generic plant-wide measures e.g. stop all nitrogen purging of any pumps/vessels for maintenance preparations, maintenance drums emptied of EDC and nitrogen purge/vents isolated, vent header KO drums emptied of any standing EDC, etc. The list may not be exhaustive and new optimisation work will be trialled in early life operation of the HPE plant.

Hence the expected EDC emissions from the HPE plant when the incinerator is unavailable (abnormal operation) have been refined to:-

Emission Point	EDC (kg/hr)	EDC (kg/day)	Comments
HPE-15	1.5	50	Spheres, Heavies Column, Pumping/Stock tanks, Purge bay
HPE-21	72.5	1740	Wash system and Drying Column
HPE-22	87 (+100 for 2 hrs)	2288	2 x LTDC reactors with fridge on-line (-18 degC) until last 2 hours
HPE-23	50	1200	Effluent plant in winter conditions
Total	211	5278	Design rates

Note that all these emissions are theoretical estimates and will need to be verified against sampling/analysis data gathered during abnormal operating condition periods post start-up of the HPE plant.

However, it is therefore proposed that the daily emission limit for EDC in the diverted vent emission points as listed above should be set at 5300 kg for the HPE plant, as opposed to the current 2650 kg listed in the LVOC permit for just the DC3 plant vents. This seems reasonable given the previous (DC3 and EDC1/2) plant daily limits were set at an equivalent of 5530 kg with no allowance for the abnormal conditions on EDC1/2 plant which could reach a value equivalent to 19,200 kg/day and the fact that the plant capacity has not changed as a result of the project. Hence continuous improvement can be demonstrated here (through technology change, operating methods, etc.) even during abnormal operating conditions.

4) Proposed annual mass emission limit versus time target

As already described in section (2) above, the DC3 plant had a target timescale of <300hrs in a calendar year for the process vents to be diverted away from the incinerator and the EDC1/2 plant had an annual emission limit of 500 tes of EDC. One of the issues with the time target is that the plant may be operating differently from one diversion event to another with high variances in the amount of EDC actually emitted. To promote minimising emissions where possible within a set timescale, a mass allowance is proposed instead for the HPE plant, similar to how the EDC1/2 plant's permit was set up.

To assess what this proposal might be requires a review of previous abnormal operation causes and durations of process vents diverted away from the incinerator. Therefore the last full five years prior to the DC3 plant shutting down were analysed for times when the incinerator was unavailable either for planned events (highlighted in blue) or unplanned plant upsets (highlighted in orange). The following tables display this breakdown of information and any events which have been resolved by the project (through re-design, replacement, repair, etc.) have been crossed-out.

2017

Approx. hrs Vents Diverted		Reason
Planned	Unplanned	
300		Natural Gas supply planned outage
10		Routine trip testing
	160	Site Power failure (Storm Doris) and recovery
	~~100~~	~~D751 steam drum gasket failure~~
	~~90~~	~~Fitting/removal of flue gas slip plate for Residues Quench repair~~
	65	Numerous short diversions for plant upsets (e.g. K755 trips, KO pot levels, reactor start-ups, pressure control, O2 levels, etc.)
310	225	TOTALS (excluding those crossed-out)

2018

Approx. hrs Vents Diverted		Reason
Planned	Unplanned	
~~210~~		~~Natural Gas supply planned outage~~
10		Routine trip testing
	~~450~~	~~Plant UPS failure~~
	~~400~~	~~P771 drains tank pump failure requiring Confined Space work~~
	100	Boiler Feed Water Leaks
	50	Numerous short diversions for plant upsets (e.g. K755 trips, KO pot levels, reactor start-ups, pressure control, O2 levels, etc.)
10	150	TOTALS (excluding those crossed-out)

2019

Approx. hrs Vents Diverted		Reason
Planned	Unplanned	
750		Incineration TAR (overhaul)
10		Routine trip testing
	~~420~~	~~TAR overrun (emergent repairs of C752 and E755)~~
	~~120~~	~~New stack analyser commissioning~~
	140	Boiler Feed Water Leaks
	~~490~~	~~P951 Boiler Feed Water Pump failure~~
	50	Numerous short diversions for plant upsets (e.g. KO pot levels, reactor start-ups, pressure control, O2 levels, etc.)
760	190	TOTALS (excluding those crossed-out)

2020

Approx. hrs Vents Diverted		Reason
Planned	Unplanned	
160		Maintenance work aligned with Inovyn Ethene TAR (overhaul)
~~50~~		~~Planned project work for new HCl off-loading facility~~
2		Routine trip testing
	~~84~~	~~P951 Boiler Feed water Pump failure~~
	54	7SDV1219 actuator failure
	160	Site power failure/steam loss and recovery
	~~50~~	~~Plant UPS battery failure~~
	~~4~~	Numerous short diversions for plant upsets (e.g. ~~DCS card failures~~, etc.)
162	214	TOTALS (excluding those crossed-out)

2021

Approx. hrs Vents Diverted		Reason
Planned	Unplanned	
130		Steam maintenance work aligned with MCP2 (overhaul)
15		Routine trip testing
	~~1155~~	~~P951 Boiler Feed Water Pump failure~~
	103	Speed sensor fault on K752
	130	Boiler Feed Water Leaks/repair
	100	Site steam/nitrogen failure
	~~16~~	Numerous short diversions for plant upsets (e.g. ~~C752 repair, C751 leak~~, etc.)
145	333	TOTALS (excluding those crossed-out)

Based on this data, if we consider unplanned events that may still be possible going forward then the 333 hrs in 2021 is the maximum. If we include the maximum routine trip testing amount of 15hrs, then this becomes approx. 350 hrs (~15 days). If we then include a 25% margin for error or potential other unplanned events, then this would equate to an annual mass emission of approx. 100 tes, using the proposed daily limit described in section (3) above. This is one-fifth of the annual mass emission limit still quoted in the current LVOC permit for EDC1/2 plant.

A lot of planned work has taken place in the last few years, including opportune maintenance work which has been aligned to other Site plant shutdowns. This work will always be carried out with the plant running at reduced rates (e.g. one reactor off-line) to reduce the daily emissions. Going forward, it has been rationalised that the incinerator TAR (overhaul) work is planned to take place every 2.5 years to coincide with other plants or reactor shutdowns. These can be up to 6 weeks duration due to the extensive repairs required to the furnace refractory or vessel shell given the operating demands. Using a reduced estimated daily emission limit in these circumstances as approx. 3600 kg gives a total mass emission of approx. 150 tes for a TAR event. Hence, including a planned TAR event, the annual mass emission limit is proposed to be 250 tes, which is still half the limit quoted for EDC1/2 plant in Table S4.3 of the current LVOC permit.