Wheelabrator TECHNOLOGIES

Deadline 7: Applicant's Response to the Examining Authority's Further Written Questions (ExQ4)

Appendix A – Kemsley K3 CHP R1 Supporting Information, April 2019

Wheelabrator Kemsley (K3 Generating Station) and Wheelabrator Kemsley North (WKN) Waste to Energy Facility Development Consent Order

PINS Ref: EN010083

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August 2020 – Deadline 7

Wheelabrator KEMSLEY

2020

Kemsley K3 CHP

R1 APPLICATION SUPPORTING INFORMATION

30TH APRIL 2020

1 Design Data

The following data for the Kemsley K3 CHP Facility has been used for the purposes of the R1 calculation.

Description	Value	Units
Boiler Lines	2	lines
Operational hours	8,000	hours/year
Non-operational Hours	760	hours/year
Waste consumption (nominal design capacity)	35	tonnes/hour per line
Waste NCV at design point	10,500	kJ/kg
Gross power generation	49.9	MWe
Parasitic load	6.4	MWe
Steam exported	560,000	tonnes/year
Steam export temperature	220	^{o}C
Steam export pressure	11.3	bara
Condensate returned	560,000	tonnes/year
Condensate enthalpy	209	kJ/kg
Fuel oil consumed on cold start up per line	36,200	kg per line
Fuel oil consumed on warm start up per line	18,100	kg per line
Fuel oil consumed on shut down per line	14,800	kg per line
Fuel oil consumed for other uses. Including; - Maintaining furnace T2S temperature above 850^{o}C - Routine burner testing	125,000	kg per line
Fuel oil NCV	42,800	kJ/kg
Fuel oil density	0.82	kg/l
Primary air flow	86,337	Nm3/hr per line
Primary air temperature	175	^{o}C
Primary air density	0.79	kg/Nm3
Secondary and Tertiary air flow	28,760 & 28,693	Nm3/hr per line
Secondary and Tertiary air temperature	175	^{o}C
Secondary and Tertiary air density	0.79	kg/Nm3
Soot blowing steam flowrate (average per line per hour)	1.18	tonnes/day per line
Soot blowing steam temperature	430	^{o}C
Soot blowing steam pressure	30	barg
Steam produced by each boiler at 100% MCR	135.5	tonnes/hr per line
Steam supply to ActiLAB for reactivation of unspent lime	0.125	tonnes/hr per line
Steam supply to ActiLAB enthalpy	2752.65	kJ/kg
Superheated steam temperature at outlet of boiler	430	^{o}C

Superheated steam pressure at outlet of boiler	75	barg
Boiler feedwater flowrate	133.7	tonnes/hr per line
Boiler feedwater enthalpy	585.76	kJ/kg
Boiler design efficiency	88.3	%

2 Supporting evidence

- Process flow diagram (Water and steam): AAK-04-0202_64P0003-C-PFD WATER AND STEAM (Case 10). This is based on the design case (DP2) with a Gross electrical output of 49.9MWe with 68.75tonnes/hr steam export.
- Process flow diagram (Air and flue gas): AAK-04-0202_65P0001-L-PFD AIR AND FLUE GAS (Normal operating conditions)
  This is based on the design case (DP2) with a Gross electrical output of 49.9MWe with 68.75tonnes/hr steam export. See section Point DP2 Nominal.
- Sootblowing steam consumption: AAK-04-14580102_FFG0003-A-DETAILED CHARACTERISTICS SOOTBLOWING SYSTEM.
  Note that this document includes the steam consumption for all sootblowers within the facility. This equates to 112 sootblowers in total (56 per boiler line).
  The document bases its calculation on completing 3 sootblowing cycles every 24 hours with a 56.67 tonnes (36.41 + 14.51 + 5.75) of steam consumed in a 24 hour period. This equates to a consumption of 1.18 tonnes/hr per line.
- Fuel oil datasheet: Gas Oil BS2869 Spec Dec 2017

3 Assumptions

The following assumptions on the design and performance for K3 CHP have been used for the purposes of the R1 calculation. These assumptions are based on developed design data and performance guarantees provided by the EPC contractor. Where applicable, conservative assumptions on operational parameters based on our experience of similar facilities have been made.

- The availability of the facility will be 8,000 hours/year.
- The auxiliary fuel will be fuel oil. No other auxiliary fuels will be combusted at the facility.
- Power demand during outage periods comprises of 30% of the parasitic load.
- There will be 6 start ups / shutdowns per line per year consisting of 3 cold start ups and 3 warm start ups.
- It is assumed 125,000 kg of fuel oil will be consumed per line per annum for maintaining furnace T2S temperature above 850^{o}C and for carrying out routine burner operating tests.
- The minimum steam export supply will be 560,000 tonnes/year
- Sootblowing sequence will be completed 3 times per day per line.

4 Calculations

4.1 Gross Electricity

The gross electrical generation of the facility was calculated as follows:

Gross electrical generation = Gross power generation (MW_e) x Operating hours

= 49.9 (MW_e) x 8,000 (hours)

= 399,200 MWh

4.2 Electricity Exported

The electricity exported – net output of the facility was calculated as follows:

Electricity exported = (Gross power generation – Parasitic power) (MW_e) x Operating time (hours)

= (49.9 (MW_e) – 6.4 (MW_e)) x 8,000 (hours)

= 348,000 MWh

4.3 Electricity Imported

The electricity imported – net input to the facility was calculated as follows:

Electricity imported = Parasitic power (MW_e) x Requirement during outage period x Non-operating time (hours)

= 6.4 (MW_e) x 0.3 x 760 (hours)

= 1,459.2 MWh

4.4 Auxiliary Fuel Inputs

The annual auxiliary fuel input was calculated as follows:

$$\text{Auxiliary fuel input} = \frac{[\text{Cold Start up fuel (kg/line)} + \text{Warm Start up fuel (kg/line)} + \text{Shut down fuel (kg/line)} + \text{other fuel use (kg/line)}] \times \text{Lines}}{\text{Fuel density (kg/litre)}}$$

$$= \frac{[(36{,}200 \times 3(\text{startups})) + (18{,}100 \times 3(\text{startups})) + (14{,}800 \times 6(\text{shutdowns})) + 125{,}000] \times 2\ (\text{lines})}{0.82\ (\text{kg/litre})}$$

= 918,780 litres

4.5 Primary Combustion Air (Heated)

The annual heated primary combustion air flow was calculated as follows:

Primary combustion air = Primary combustion air (Nm_3/hour) x Lines x Operating time (hours)

= 86,337 (Nm_3/hour per line) x 2 (lines) x 8,000 (hours)

= 1,381,392,000 Nm_3

4.6 Secondary & Tertiary Combustion Air (Heated)

The annual heated secondary and tertiary combustion air flow was calculated as follows:
Secondary & Tertiary combustion air = Secondary & Tertiary combustion air (Nm_3/hour) x Lines x Operating time (hours)

= (28760 + 28693) (Nm_3/hour per line) x 2 (lines) x 8,000 (hours)
= 919,248,000 Nm_3

4.7 Soot Blowing

The annual steam used for soot blowing was calculated as follows:
Steam for soot blowing = Soot blowing steam (tonnes/hour) x Lines x Operating time (hours)

= 1.18 (tonnes/hour per line) x 2 (lines) x 8,000 (hours)
= 18,880 tonnes

4.8 Steam supply to ActiLAB

The annual steam supply from the boiler drum to the ActiLAB for purposes of reactivating unspent lime was calculated as follows:
Steam from boiler drum = Steam flow to ActiLAB (tonnes/hour) x Lines x Operating time (hours)

= 0.125 (tonnes/hour per line) x 2 lines x 8,000 (hours)
= 2,000 tonnes

4.9 Superheated Steam at Boiler Outlet

The annual superheated steam at the boiler outlet for the facility was calculated as follows:
Superheated steam from boilers = Main steam flow rate (tonnes/hour) x Lines x Operating time (hours)

= 133.5 (tonnes/hour per line) x 2 lines x 8,000 (hours)
= 2,136,000 tonnes

4.10 Boiler Feedwater

The annual boiler feedwater used by the facility was calculated as follows:
Boiler feedwater = Boiler feedwater flow rate (tonnes/hour) x Lines x Operating time (hours)

= 133.7 (tonnes/hour per line) x 2 (lines) x 8,000 (hours)
= 2,139,200 tonnes

	A	B	C	D	E	F	G	H	I
1	**PROFORMA FOR DETERMINING ENERGY EFFICIENCY USING R1**								
2	**Site name, address and grid reference**	K3 CHP Limited, Energy Recovery Facility, Barge Way, Sittingbourne, Kent, ME10 2FP	**EPR Permit reference (if known)**						
3	**Operator name**	Wheelabrator	**Application fee (£)**						
4	**Details of who to contact if we have any queries regarding this form**								
5	**What data has been used in the application? →**		Design data						
6	Indicative R1 factor (subject to confirmation)	0.93	Quantity in reporting year	Units	U_c	Properties (Average over reporting year)	Units	Note which parameters that have been estimated	Reference to Supporting information
7	Climate change correction factor (optional)								
8	R1 after CCF adjustment								
9	1. Gross electricity meter (Electricity produced at turbine)		399200	MWh					See PFD: AAK-04-0202
10	2. Electricity exported - Net input/output meter		348000	MWh					
11	3. Electricity imported - Net input/output meter		1459.2	MWh				Contractual guaranteed	
12	4. Other fuel inputs								
13		4.1 Light fuel oil	918780	litres		0.82	kg/l		
14						42800	kJ/kg	The calculation includes	Fue Fuel density see Fu
15		4.2 Natural gas		Nm^3		34200	kJ/Nm^3		
16									
17		4.3 LPG		Nm^3			kg/Nm^3		
18							kJ/kg		
19		4.4 Other fuels similar to light fuel oil		litres			kg/l		
20							kJ/kg		
21	5. Primary combustion air (as supplied to furnace)		1381392000	m^3		0.79	kg/Nm^3		
22						175	°C		
23						151.5	kJ/kg		See PFD AAK-04-0202
24	6. Secondary combustion air (as supplied to furnace)		919248000	m^3		0.79	kg/Nm^3		
25						175	°C		
26						151.5	kJ/kg	Secondary and tertiary a	See PFD AAK-04-0202
27	7. Recycled flue gas (as supplied to furnace)			m^3			kg/Nm^3		
28							°C		
29						0	kJ/kg		
30	8. Heat exported outside R1 boundary								
31		8.1 steam exported	560000	tonnes		220	°C		
32						1130	kPa		
33						2866	kJ/kg	Contractual minimum su	
34		condensate returned	560000	tonnes		50	°C		
35							kPa		
36							kJ/kg	Note: Condensate Enth	
37		8.2 hot water exported		tonnes			°C		
38							kPa		
39							kJ/kg		
40		hot water returned		tonnes			°C		
41							kPa		
42							kJ/kg		
43									
44	9. Internal steam use								
45		9.1 for soot blowing (no backflow)	18880	tonnes		430	°C		
46						3000	kPa		
47						3298	kJ/kg		AAK-04-14580102_FFG
48		9.2 for steam driven devices		tonnes			°C		
49							kPa		
50							kJ/kg		
51		backflow as steam		tonnes			°C		
52							kPa		
53							kJ/kg		
54		9.3 for trace heating		tonnes			°C		
55							kPa		
56							kJ/kg		
57		backflow as condensate		tonnes			°C		
58							kPa		
59							kJ/kg		
60		9.4 for re-heating flue gas		tonnes			°C		
61							kPa		
62							kJ/kg		
63		backflow as condensate		tonnes			°C		
64							kPa		
65							kJ/kg		
66		9.5 for concentration processes		tonnes			°C		
67							kPa		
68							kJ/kg		
69		backflow as condensate		tonnes			°C		
70							kPa		
71							kJ/kg		
72		9.6 for building, equipment, tank heating		tonnes			°C		
73							kPa		
74							kJ/kg		
75		backflow as condensate		tonnes			°C		
76							kPa		
77							kJ/kg		
78		9.7 for deaeration and demineralisation		tonnes			°C		
79							kPa		
80							kJ/kg		

	A	B	C	D	E	F	G	H	I
81		backflow as condensate		tonnes			°C		
82							kPa		
83							kJ/kg		
84		9.8 other internal applications, in line with commission guidance, to be specified	2000	tonnes		297	°C		
85							kPa		
86						2752.65	kJ/kg	Steam supplied from bo	See PFD: AAK-04-0202
87		backflow as condensate		tonnes			°C		
88							kPa		
89							kJ/kg		
90		9.9 other internal applications, in line with commission guidance, to be specified		tonnes			°C		
91							kPa		
92							kJ/kg		
93		backflow as condensate		tonnes			°C		
94							kPa		
95							kJ/kg		
96	10. Use of condensing energy from steam in flue gas			GJ					
97	11. Superheated steam at boiler outlet		2136000	tonnes		430	°C		
98						7500	kPa		
99						3227.12	kJ/kg		See PFD: AAK-04-0202
100	12. Boiler feedwater		2139200	tonnes		141	°C		
101						8770	kPa		
102						585.76	kJ/kg		See PFD: AAK-04-0202
103	13. Boiler Efficiency (Design)		88%	±	1.5%			Contractual guaranteed value of 88.3%	

Instructions for completing this spreadsheet

1. Ensure that you have completed the first three rows of the application form
2. This form should be accompanied by supporting information for the figures quoted. Where this information is in the permit application, reference to the relevant sections of the application can be made.

   A Sankey diagram (or equivalent) reflecting the boundaries of the installation used as well as any references to physical properties is the absolute minimum that should be provided for an application based on design information
3. We have colour coded the cells in this spreadsheet to assist you in completing this form, an explanation of the colour codes is provided below. The colour will disappear when data has been entered.

   Blue cells require data that is essential for the R1 calculation, where information on uncertainty of the data is available it would be useful (but not mandatory) for this to be included for these parameters.

   Beige Cells indicate that any data entered will be used in the R1 calculation. They have been used where there is a choice of inputs but not all plants will have data for all the input options.

   Where you are entering data into beige cells you need to make sure that you enter data into all the beige cells associated with the input as they are all needed for carrying out the calculation.

   Yellow cells have been used to provide flexibility to include fuels or energy uses not identified elsewhere. Supporting information to explain why the standard fields were not appropriate or adequate will need to be provided where these cells are used.

   Data entered in uncoloured cells are not used when calculating the R1 energy efficiency factor but can be completed to provide a more complete data set.

   Data in the purple cell for the CCF factor is optional. If used the way it was calculated must be explained in supporting information
4. Ensure the temperatures entered into cells F19 and F22 (and F25) are the actual temperatures of the heated air in °C.

   The spreadsheet uses these values to calculate the specific enthalpy associated with heating the air from ambient 25 °C in cells F20 and F23 (and F26).
5. Densities used in cells F18 and F21 (and F24) should be at the temperatures at which the flows quoted in C18 and C21 (and C24) are reported.

   The spreadsheet multiplies these pairs of entries to generate a mass of air.
6. If you believe that any of the information that you have submitted in this application form is commercially confidential please identify the confidential information and the grounds on which you believe it to be confidential in your covering letter