

WASTE HEAT RECOVERY UNIT DATA SHEET

BROACH JOB NO: 20071233

DATE: June 11, 2008

REV: 7

PURCHASER/OWNER: BP		ITEM NO.: H-Z6002			
SERVICE: WASTE HEAT RECOVERY TEG HEAT MEDIUM		LOCATION: NORTH SLOPE, AK			
1	UNIT:	NUMBER REQUIRED: One			REV
2	MANUFACTURER: The G. C. Broach Company	REFERENCE: PO: 107410-0006			
3	TYPE OF HEATER: Waste Heat Recovery Unit, TEG Heat Medium	Final Data Sheet Issued for Job Books			2
4	TOTAL HEATER ABSORBED DUTY, MM BTU/Hr: 100 MM BTU per hour				
5	PROCESS DESIGN CONDITIONS				
6	OPERATING CASE	-40 ° Ambient	-40 ° Ambient	+80 Ambient	+ 80 ° Ambient
7	HEATER SECTION	Tube Side	Flue Gas Side	Tube Side	Flue Gas Side
8	SERVICE	Heat Medium	GT Exhaust	Heat Medium	GT Exhaust
9	HEAT ABSORPTION, MM BTU/Hr	100.0 MM	N/A	100.0 MM	N/A
10	FLUID	TEG	Vapor	TEG	Vapor
11	FLOW RATE, Lb/Hr	1,204,004	891,360	1,204,004	572,000
12	FLOW RATE, B.P.D.	N/A	-	N/A	See note 1.0
13	PRESSURE DROP, ALLOWABLE, PSI/Inches H ₂ O	40.0	11.7" H ₂ O (See note 4.0)	40.0	7.3" H ₂ O (See note 4.0)
14	PRESSURE DROP, CALCULATED (Clean), PSI/Inches H ₂ O	39.5	10.5	39.5	6.0
15	AVG. RAD. SECT. FLUX DENSITY, ALLOW., BTU/Hr-Ft ²	N/A	N/A	N/A	N/A
16	AVG. RAD. SECT. FLUX DENSITY, CALC., BTU/Hr-Ft ²	N/A	N/A	N/A	N/A
17	MAX. RAD. SECT. FLUX DENSITY, BTU/Hr-Ft ²	N/A	N/A	N/A	N/A
18	AVG. CONV. SECT. FLUX DENSITY (Bare Tube), BTU/Hr-Ft ²	12,834	N/A	12,834	N/A
19	VELOCITY LIMITATION, F/VS	N/A	N/A	N/A	N/A
20	PROCESS FLUID MASS VELOCITY, Lbs./Sec	8.95	N/A	8.95	N/A
21	MAXIMUM ALLOW./CALC. INSIDE FILM TEMPERATURE, °F	400/373	N/A	400/385	N/A
22	FOULING FACTOR, Hr-Ft ² - °F/BTU, * = See note 3.0	0.0011 *	0.0	0.0011 *	0.0
23	COKING ALLOWANCE, In.	N/A	N/A	N/A	N/A
24	INLET CONDITIONS				
25	TEMPERATURE, °F	240	Flue Gas = 734	Same as -40 °	Flue Gas = 944
26	PRESSURE, (PSIA) / (Inches H ₂ O)	470	11.7" H ₂ O	"	7.3" H ₂ O
27	LIQUID FLOW, Lb/Hr	1,204,004	0.0	"	0.0
28	VAPOR FLOW, Lb/Hr	0.0	891,360	"	572,000
29	LIQUID GRAVITY, (Deg API) (SP.GR. @ Temp.)	1.02	N/A	"	N/A
30	VAPOR MOLECULAR WEIGHT	N/A	28.74	"	28.49
31	VISCOSITY, (Liquid/Vapor), cP	0.828	N/A	"	N/A
32	SPECIFIC HEAT, (Liquid/Vapor), BTU/Lb-°F	0.841	N/A	"	N/A
33	THERMAL CONDUCTIVITY, (Liquid/Vapor), BTU/Hr-Ft °F	0.190	N/A	"	N/A
34	OUTLET CONDITIONS				
35	TEMPERATURE, °F	340	Flue gas = 291	Same as -40 °	Flue gas = 271
36	PRESSURE, (PSIA)	430.5	Atmos.	"	Atmos.
37	LIQUID FLOW, Lb/Hr	1,204,004	0.0	"	0.0
38	VAPOR FLOW, Lb/Hr	0.0	891,360	"	572,000
39	LIQUID GRAVITY, (SP.GR. @ Temp.)	0.965	N/A	"	N/A
40	VAPOR MOLECULAR WEIGHT	N/A	28.74	"	28.49
41	VISCOSITY, (Liquid), cP	0.265	N/A	"	N/A
42	SPECIFIC HEAT, (Liquid/), BTU/Lb-°F	0.906	N/A	"	N/A
43	THERMAL CONDUCTIVITY, (Liquid/), BTU/Hr-Ft °F	0.181	N/A	"	N/A
44	REMARKS AND SPECIAL REQUIREMENTS				
45	DISTILLATION DATA OR FEED COMPOSITION:	N/A			
46	SHORT TERM OPERATING CONDITIONS:	N/A			
47					
48	NOTES:				
49	1.0 On 80° ambient days 18. 4 Wt. % of gas turbine exhaust must be diverted to the by-pass stack to maintain a 340°F TEG outlet temperature.				
50	2.0 See separate Excel spread sheets for Process Conditions at various ambient temperatures.				
51	3.0 All thermal runs done clean. (No fouling)				
52	4.0 Flue gas loss from turbine flange to outlet of main stack based on elbow turn.				

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COMBUSTION DESIGN CONDITIONS – Not applicable to WHRU						REV	
1	OPERATING CASE					-	
2	TYPE OF FUEL					-	
3	EXCESS AIR, Percent					-	
4	CALCULATED HEAT RELEASE (LHV), MM BTU/Hr					-	
5	FUEL EFFICIENCY CALCULATED, Percent (LHV)					-	
6	FUEL EFFICIENCY GUARANTEED, Percent (LHV)					-	
7	RADIATION LOSS, PERCENT OF HEAT RELEASE (LHV)					-	
8	FLUE GAS TEMPERATURE LEAVING: RADIANT SECTION, °F					-	
9	CONVECTION SECTION, °F					-	
10	AIR PREHEATER, °F					-	
11	FLUE GAS QUANTITY, Lb/Hr					-	
12	FLUE GAS MASS VELOCITY THROUGH CONVECTION SECTION, Lb/Sec-Ft ²					-	
13	DRAFT: AT ARCH, In. H ₂ O					-	
14	AT BURNERS, In. H ₂ O					-	
15	AMBIENT AIR TEMPERATURE, EFFICIENCY CALCULATION, °F					-	
16	AMBIENT AIR TEMPERATURE, STACK DESIGN, °F					-	
17	ALTITUDE ABOVE SEA LEVEL, Ft					-	
18	VOLUMETRIC HEAT RELEASE, (LHV), BTU/Hr-Ft ³					-	
19	FUEL CHARACTERISTICS; Not applicable to WHRU						
20	GAS TYPE		LIQUID TYPE		OTHER TYPE		
21	LHV: BTU/(Lb) (SCF)		LHV: BTU/Lb		LHV: BTU/(Lb) (SCF)		
22	HHV: BTU/(Lb) (SCF)		HHV: BTU/Lb		HHV: BTU/(Lb) (SCF)		
23	PRESSURE @ BURNER: PSIG		PRESSURE @ BURNER: PSIG		PRESSURE @ BURNER: PSIG		
24	TEMPERATURE @ BURNER: °F		TEMPERATURE @ BURNER: °F		TEMPERATURE @ BURNER: °F		
25	MOLECULAR WEIGHT:		VISCOSITY @ °F SSU		MOLECULAR WEIGHT:		
26			ATOMIZING STEAM TEMP: °F				
27	COMPOSITION	MOLE %	ATOMIZING STEAM PRESSURE: PSIG		COMPOSITION	MOLE %	
28							
29			COMPOSITION	WT %			
30							
31							
32							
33							
34			VANADIUM (PPM)				
35			SODIUM (PPM)				
36			SULFUR				
37			ASH				
38	BURNER DATA: Not applicable to WHRU						
39	MANUFACTURER:		SIZE/MODEL NO:		NUMBER:		
40	TYPE:		LOCATION:		ORIENTATION:		
41	HEAT RELEASE PER BURNER, MM BTU/Hr		DESIGN: NORMAL:		MINIMUM:		
42	PRESSURE DROP ACROSS BURNER @ DESIGN HEAT RELEASE, In. H ₂ O:						
43	DISTANCE BURNER CENTER LINE TO TUBE CENTER LINE, Ft:			HORIZONTAL:		VERTICAL:	
44	DISTANCE BURNER CENTER LINE TO UNSHIELDED REFRACTORY, Ft:			HORIZONTAL:		VERTICAL:	
45	PILOT, Type:		CAPACITY, BTU/Hr:		FUEL:		
46	IGNITION METHOD:						
47	FLAME SCANNERS, LOCATION:			NUMBER:			
48	REQUIRED EMISSIONS: PPMV (d) (Corrected to 3% O ₂)		NOx:		CO: SOx:		
51	Lb/MM BTU, (LHV) (HHV)		UHC:		PARTICULATES:		
52	NOTES:						
53							
54							
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MECHANICAL DESIGN CONDITIONS				
1	PLOT LIMITATIONS: Module Base	STACK LIMITATIONS:	Minimum of 80.0 ft.	REV
2	TUBE LIMITATIONS: None	NOISE LIMITATIONS:	85 dBA at 3.0 ft.	
3	STRUCTURAL DESIGN DATA: WIND VELOCITY: 110 MPH	WIND OCCURRENCE:	Exposure "C"	6
4	SNOW LOAD: 50 PSF	SEISMIC ZONE:	.38g Site Class B	6
5	MINIMUM / NORMAL / MAXIMUM AMBIENT AIR TEMPERATURE, °F: Per spec.	RELATIVE HUMIDITY, %:	50%	
6	HEATER SECTION	Convection	Flue Gas Casing	
7	SERVICE	Heat Medium	WHRU	
8	COIL DESIGN			
9	DESIGN BASIS: TUBE WALL THICKNESS (Code or Spec)	ASME VIII	None	
10	RUPTURE STRENGTH (Minimum or Average)	N/A	N/A	
11	DESIGN LIFE, Hr	N/A	N/A	
12	DESIGN PRESSURE, Elastic / Rupture, PSIG	600	20" H ₂ O	3
13	DESIGN FLUID TEMPERATURE, °F	400	N/A	
14	TEMPERATURE ALLOWANCE, °F	50	N/A	
15	CORROSION ALLOWANCE, Tubes / Fittings, In.	0.0625	N/A	6
16	HYDROSTATIC TEST PRESSURE, PSIG	No	N/A	
17	POST WELD HEAT TREATMENT (Yes or No)	No	N/A	
18	PERCENT OF WELDS FULLY RADIOGRAPHED	100 %	N/A	
19	MAXIMUM (CLEAN) TUBE METAL TEMPERATURE, °F	400° @ 80° Amb.	N/A	
20	DESIGN TUBE METAL TEMPERATURE, °F	480	N/A	5
21	INSIDE FILM COEFFICIENT, BTU/Hr-Ft ² -°F	1214	N/A	
22	COIL ARRANGEMENT			
23	TUBE ORIENTATION: Vertical or Horizontal	Horizontal		
24	TUBE MATERIAL (ASTM Specification and Grade)	SA-333, Gr. 6		
25	TUBE OUTSIDE DIAMETER, In.	4.50		
26	TUBE WALL THICKNESS, (Average), In.	0.237		
27	NUMBER OF FLOW PASSES	7		
28	NUMBER OF TUBES / NUMBER OF TUBE ROWS	252/18		
29	NUMBER OF TUBES PER ROW (Convection Section)	14		
30	OVERALL TUBE LENGTH, Ft	28'-0"		
31	EFFECTIVE TUBE LENGTH, Ft	26.25'		
32	BARE TUBES: NUMBER	0		
33	TOTAL EXPOSED SURFACE, Ft ²	0		
34	EXTENDED SURFACE TUBES: NUMBER	252		
35	TOTAL EXPOSED SURFACE, Ft ²	104,081		
36	TUBE LAYOUT (Inline or Staggered)	Staggered		
37	TUBE SPACING, CENT. TO CENT: HORIZONTAL, In.	8"		
38	DIAGONAL, In.	8"		
39	VERTICAL, In.	6.9375"		
40	SPACING TUBE CENT. TO FURNACE WALL, In.	4"		
41	CORBELS (Yes or No)	Yes		
42	CORBEL WIDTH, In.	4"		
43	DESCRIPTION OF EXTENDED SURFACE			
44	TYPE: (Studs) (Serrated Fins) (Solid Fins)	Solid		
45	MATERIAL	CS		
46	DIMENSIONS: HEIGHT, In.	1.0"		
47	THICKNESS, In.	0.06"		
48	SPACING (No. / In.)	5 / inch		
49	MAXIMUM TIP TEMPERATURE, (Calculated), °F	696		
50	EXTENSION RATIO (Total Area)	13.356 : 1		
51	PLUG TYPE HEADERS: Not applicable			
52	TYPE	-		
53	MATERIAL (ASTM Specification and Grade)	-		
54	NOMINAL RATING	-		
55	LOCATION (One or Both Ends)	-		
56	WELDED OR ROLLED JOINT	-		
57	NOTES:			
58				

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MECHANICAL DESIGN CONDITIONS (Continued)					
1	HEATER SECTION	Convection			REV
2	SERVICE	Heat Medium			
3	RETURN BENDS				
4	TYPE	Wrought			
5	MATERIAL (ASTM Specification and Grade)	SA-420, WPL6			
6	NOMINAL RATING OR SCHEDULE	Sch. 40			
7	LOCATION (F. B. = Firebox, H. B. = Header Box)	Header Boxes			
8	TERMINALS AND / OR MANIFOLDS				
9	TYPE (BEV. = Beveled, MANIF. = Manifold, FLG. = Flanged)	Flanged			
10	INLET: MATERIAL (ASTM Specification and Grade)	SA-333, Gr. 6			
11	SIZE	12"			
12	SCHEDULE OR THICKNESS	Sch. 40			
13	NUMBER OF TERMINALS	1			
14	FLANGE MATERIAL (ASTM Specification and Grade)	SA-350, LF2			
15	FLANGE (Size / Rating)	300#			
16	OUTLET: MATERIAL (ASTM Specification and Grade)	SA-333, Gr. 6			
17	SIZE	12"			
18	SCHEDULE OR THICKNESS	Sch. 40			
19	NUMBER OF TERMINALS	1			
20	FLANGE MATERIAL (ASTM Specification and Grade)	SA-350, LF2			
21	FLANGE (Size / Rating)	300#			
22	MANIFOLD TO TUBE CONNECTION (Welded, Extruded, Etc.)	Extruded			
23	MANIFOLD LOCATION (Inside or Outside Header Box)	Outside			
24	CROSSOVERS: Not applicable				
25	WELDED OR FLANGED	-			
26	PIPE MATERIAL (ASTM Specification and Grade)	-			
27	PIPE SIZE	-			
28	PIPE SCHEDULE OR THICKNESS	-			
29	FLANGE MATERIAL	-			
30	FLANGE (Size / Rating)	-			
31	LOCATION (Internal / External)	-			
32	FLUID TEMPERATURE, °F	-			
33	TUBE SUPPORTS				
34	LOCATION (Ends, Top, Bottom)	Ends			
35	MATERIAL (ASTM Specification and Grade)	A-516, Gr. 70			
36	DESIGN METAL TEMPERATURE, °F	200			
37	THICKNESS, In.	0.50"			
38	INSULATION: THICKNESS, In.	4"			
39	MATERIAL	Cast Refractory			
40	ANCHOR (Material and Type)	SS			
41	INTERMEDIATE TUBE SUPPORTS				
42	MATERIAL (ASTM Specification and Grade)	Lower 304 SS	Mid A 516, Gr.70	Top A-516, Gr.70	
43	DESIGN METAL TEMPERATURE, °F	1000	700	700	
44	THICKNESS, In.	0.75	0.50	0.50	
45	SPACING, Ft				
46	TUBE GUIDES: Not applicable				
47	LOCATION	-			
48	MATERIAL	-			
49	TYPE / SPACING	-			
50	HEADER BOXES				
51	LOCATION:	Convection Ends	HINGED DOOR / BOLTED PANEL:		Welded
52	CASING MATERIAL:	CS	THICKNESS, In:	0.25	
53	LINING MATERIAL:	CF	THICKNESS, In:	1.0	
54	ANCHOR (Material and Type)	CS pins			
55	NOTES:				
56					
57					
58					

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MECHANICAL DESIGN CONDITIONS (Continued)				REV
1	REFRACTORY DESIGN BASIS			
2	AMBIENT, °F: 70	WIND VELOCITY, MPH: 0	CASING TEMPERATURE, °F: 150	
3	EXPOSED VERTICAL WALLS: Not applicable			
4	LINING THICKNESS, In:	HOT FACE TEMPERATURE, SERVICE, °F:	CALCULATED, °F:	
5	WALL CONSTRUCTION:			
6				
7	ANCHOR (Material and Type)			
8	CASING MATERIAL:	THICKNESS, In:	TEMPERATURE, °F:	
9	SHIELDED VERTICAL WALLS: Not applicable			
10	LINING THICKNESS, In:	HOT FACE TEMPERATURE, SERVICE, °F:	CALCULATED, °F:	
11	WALL CONSTRUCTION:			
12				
13	ANCHOR (Material and Type)			
14	CASING MATERIAL:	THICKNESS, In:	TEMPERATURE, °F:	
15	ARCH: Not applicable			
16	LINING THICKNESS, In:	HOT FACE TEMPERATURE, SERVICE, °F:	CALCULATED, °F:	
17	WALL CONSTRUCTION:			
18				
19	ANCHOR (Material and Type)			
20	CASING MATERIAL:	THICKNESS, In:	TEMPERATURE, °F:	
21	FLOOR: Not applicable			
22	LINING THICKNESS, In:	HOT FACE TEMPERATURE, SERVICE, °F:	CALCULATED, °F:	
23	FLOOR CONSTRUCTION:			
24				
25	CASING MATERIAL:	THICKNESS, In:	TEMPERATURE, °F:	
26	MINIMUM FLOOR ELEVATION, Ft:	FREE SPACE BELOW PLENUM, Ft:		
27	CONVECTION SECTION			
28	LINING THICKNESS, In: 3"	HOT FACE TEMPERATURE, SERVICE, °F: 2,000	CALCULATED, °F: 944	
29	WALL CONSTRUCTION: 0.0625" thick 304 SS inner liner over 1" 8# CF / 2" 6# CF / 0.125" High Temperature Mastic			
30				
31	ANCHOR (Material and Type) SS Pins, Washers, Clips			
32	CASING MATERIAL: CS	THICKNESS, In: 0.25	TEMPERATURE, °F: 138	
33	INTERNAL WALL: Not applicable			
34	TYPE:		MATERIAL:	
35	DIMENSION, Height / Width, Ft:			
36	DUCTS	TURBINE EXHAUST FLUE GAS		COMBUSTION AIR
37	LOCATION	DAMPER "T"	Plenum	
38	SIZE: Ft. or Net Free Area Ft ²	See Drawing	See Drawing	
39	CASING MATERIAL	CS	CS	
40	CASING THICKNESS, In.	0.25	0.25	
41	LINING: Internal / External	Internal with SS Inner Liner		
42	THICKNESS, In.	3"	3"	
43	MATERIAL	CF	CF	
44	ANCHOR (Material and Type)	SS Pins/Clips	SS Pins/Clips	
45	CASING TEMPERATURE, °F	146	146	
46	PLENUM CHAMBER (AIR): Not applicable			
47	TYPE OF PLENUM (Common or Integral):			
48	CASING MATERIAL:	THICKNESS, In:	SIZE, Ft:	
49	LINING MATERIAL:	THICKNESS, In:		
50	ANCHOR (Material and Type):			
51	NOTES:			
52				
53				
54				
55				

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MECHANICAL DESIGN CONDITIONS (Continued)

1	STACKS: MAIN EXHAUST & BYPASS – See drawing					REV
2	NUMBER: Two	SELF-SUPPORTED OR GUYED: Self	LOCATION: See Drawing			
3	CASING MATERIAL: CS	MINIMUM THICKNESS, In: 0.25	MINIMUM THICKNESS, In: 0.25			
4	INSIDE METAL DIAMETER, Ft: See Drawing	HEIGHT ABOVE steel base, Ft: 80'-0"	STACK LENGTH, Ft: See Drawing			
5	LINING MATERIAL: Bypass = None, Main Exhaust = External			THICKNESS, In: TBD		
6	ANCHOR (Material and Type): N/A					
7	EXTENT OF LINING: N/A		INTERNAL OR EXTERNAL: N/A			
8	DESIGN FLUE GAS VELOCITY, Ft/S: N/A		FLUE GAS TEMP., °F: See Data Sheets			
9	DAMPERS					
10	LOCATION; In damper "T" duct	Main	Bypass			
11	TYPE (Control, Tight Shut-Off, Etc.)	Control	Control			
12	MATERIAL: BLADE	SS	SS			
13	SHAFT	SS	SS			
14	SINGLE LEAFS	Single blades	Single blades			
15	PROVISION FOR OPERATION (Manual or Automatic)	Auto	Auto			
16	TYPE OF OPERATOR (Cable or Pneumatic)	Pneumatic	Pneumatic			
17	PLATFORMS					
18	LOCATION	NUMBER	WIDTH	LENGTH/ARC	STAIRS/LADDER	ACCESS FROM
19	To EPA Connections & Damper controllers	See GA Dwg				
20						
21						
22						
23						
24	TYPE OF FLOORING:					
25	DOORS					
26	TYPE: Bolted	NUMBER	LOCATION	SIZE	BOLTED/HINGED	
27	ACCESS:	2	See Drawing	24" x 24"	Bolted	6
28		2	See Drawing	24" x 48"	Bolted	6
29	OBSERVATION	None				
30						
31	TUBE REMOVAL	None				
32						
33	MISCELLANEOUS					
34	INSTRUMENT CONNECTIONS			NUMBER	SIZE	TYPE
35	COMBUSTION AIR	TEMPERATURE		N/A		
36		PRESSURE		N/A		
37	FLUE GAS	TEMPERATURE		4	1 ½"	150# Flange 3
38		PRESSURE		6	1 ½"	3000# Coupling 7
39	FLUE GAS SAMPLE: EPA		Under Review	8	4"	MPT with Cap 7
40	SNUFFING STEAM / PURGE			N/A		
41	O ₂ ANALYZER			N/A		
42	FLOOR DRAINS			1	1 ½"	150# Flange 3
43	PROCESS FLUID TEMPERATURE			2	2"	300# Flange 3
44	TUBESKIN THERMOCOUPLES			7	1 ½"	3000# Coupling 3
45	HIGH POINT VENT			1	2"	300# RFWN 3
46	LOW POINT DRAIN			1	2"	300# RFWN 3
47	PAINTING REQUIREMENTS: See Notes on GA Drawings					
48						
49	INTERNAL COATING: 0.125" High Temperature Mastic					
50	GALVANIZING REQUIREMENTS: All Ladders & Platforms					
51	ARE PAINTER'S TROLLEY AND RAIL INCLUDED (Yes or No): No					
52	SPECIAL EQUIPMENT: SOOTBLOWERS: N/A					
53	AIR PREHEATER: N/A					
54	FAN (S): None. Deleted by Customer.					
55	OTHER: None. Deleted by Customer.					
56	NOTES: 1.0 See attached Excel spread sheet for back ratings of other performance data for other ambient days with constant flow and bypass.					
57	2.0 See attached Excel spread sheet for back ratings of other performance data for other ambient days with variable flows and no bypass.					
58						