Middletown Cogeneration Facility Emission Calculations

Emission Point:	**P001**
Operating Scenario	**MWERF1-MSS-2**
Description:	**Gas Turbine/HRSG Stop/Start Cycle Emissions**

Physical Characteristics:	Height of Stack above grade =	125	ft
	Diameter of Stack =	16.5	ft
Inputs shaded in Green	Stack Gas Exit Temperature =	317	F
	Cold Stop/Start Cycle Duration =	5.6	hours (25 mins to Stop and 310 mins to Start)
	Cold Stop/Start Cycles per year =	2	APCI and GE
	Warm Stop/Start Cycle Duration =	3.1	hours (25 mins to Stop and 160 mins to Start)
	Warm Stop/Start Cycles per year =	15	APCI and GE (Blast Furnace is off-line a minumum of 8 times a year)
Emission data:	Switching Point to Nat Gas =	40%	Capacity (GE recommendation)
	Switching Point for SCR =	40%	Capacity (APCI Design)
Inputs shaded in Green	BFG/NG NOx Emission Factor =	3	ppmvd @ 15% O2 with SCR operating
	NG NOx Emission Factor below 40% Load =	110	ppmvd @ 15% O2 (GE) - Assumes the SCR is shutdown.
	BFG/NG CO Emission Factor =	25	ppmvd at exhaust conditions (GE)
	NG CO Emission Factor below 40% Load =	100	ppmvd at exhaust conditions (GE)
	Cold Cycle NOx Emission =	1208	Lbs NOx (APCI and GE)
	Warm Cycle NOx Emission =	648	Lbs NOx (APCI and GE)
	Cold Cycle CO Emission =	845	Lbs CO (APCI and GE)
	Warm Cycle CO Emission =	453	Lbs CO (APCI and GE)

When does Shutdown/Startup Cycle begin/end? To shutdown the Gas Turbine from normal operation, the BFG firing rate is reduced to 40% load (~400 MMBtu/hr HHV dry) and then firing is switched to Natural Gas. Since the SCR will be operating and the emission factors for BFG and Natural Gas to this de-load point are the same as during normal operation, this is the point of departure from normal emission performance. Dropping below 40% Load increases the NOx and CO emissions (see factors above).

Shut-Down Sequences: (1) Switch to Nat Gas Firing at 40% Load (2) Reduce Load from 40% to Full Speed No Load (3) Reduce to No Load (shutdown)

Start-up Sequences: Reverse of Shut-Down sequence

Cold/Warm Difference: The time needed to go from Full Speed No Load to 40% Nat Gas firing is twice as long during a Cold Cycle. This is to protect a cold HRSG from excessive thermal stresses.

Emission Rate Calculations:

NOx Emissions:

NOx (tpy) =	2417	Cold Cycles +	9,718	Warm Cycles/2000 =	**6.1**	**tpy - NOx**
Cold Cycle NOx (#/event) =	1208	lbs/start /	2	Cycles/yr =	**2,417**	**#/yr NOx**
Warm Cycle NOx (#/event) =	648	lbs/start /	15	Cycles/yr =	**9,718**	**#/yr NOx**

CO Emissions:

CO (tpy) =	1689	Cold Cycles +	6,793	Warm Cycles/2000 =	**4.2**	**tpy - CO**
Cold Cycle CO (#/event) =	845	lbs/start /	2	Cycles/yr =	**1,689**	**#/yr CO**
Warm Cycle CO (#/event) =	453	lbs/start /	15	Cycles/yr =	**6,793**	**#/yr CO**

START TYPE		DURATION MINUTES	FUEL	CONSUMPTION, lhv MMBTU NG	BFG	NOx lbs	CO lbs	
COLD HRSG eg, after GT inspection								ADA-suggested changes - 9July2010
EVENTS PER YEAR	2							Suspect there may be more than one cold start per year.
DELOAD TO 40%		60	BFG		776	48	46	Max 100F/hr heat up rate of HRSG. May require tripping GT to control heat up
TRANSFER TO NG		5	NG	47		25	17	
DELOAD TO FSNL		10	NG	57		37	26	
FSNL TO OFF		10	NG	9		12	9	
LIGHT-OFF TO FSNL ON NG		10	NG	9		12	9	
FSNL TO ~40% LOAD		300	NG	1695		1121	784	
TRANSFER TO BFG AND HOLD		30	NG-BFG	141	141	14	13	
INCREASE TO 100%		60	BFG		776	48	46	Will have to control BFGC / HRSG / Aux Boilers etc. May reduce in time.
TOTAL PER EVENT		485		1959	1692	1318	949	
TOTAL STARTS PER YEAR		970		3917	3385	2637	1898	
		16.2 HRS						
WARM-HOT HRSG eg after BF downturn								
EVENTS PER YEAR	15							
DELOAD TO 40%		60	BFG		776	48	46	Hot will not be more than say 50 psig in drum. Will still have to limit heat up rate.
TRANSFER TO NG		5	NG	47		25	17	
DELOAD TO FSNL		10	NG	57		37	26	
FSNL TO OFF		10	NG	9		12	9	
LIGHT-OFF TO FSNL ON NG		10	NG	9		12	9	
FSNL TO ~40% LOAD		150	NG	848		561	392	
TRANSFER TO BFG AND HOLD		10	NG-BFG	47	47	5	4	
INCREASE TO 100%		60	BFG		776	48	46	Will have to control BFGC / HRSG / Aux Boilers etc. May reduce in time.
TOTAL PER EVENT		315		1017	1598	748	548	
TOTAL STARTS PER YEAR		4725		15255	23971	11227	8226	
		78.8 HRS						
TOTAL ALL STARTS-STOPS		94.9 HRS		19172	27356	13864	10124	

Above derived from these assumptions:		lhvMMBTUH	GT MW	FGC MW	NG NOx PPH	NG CO PPH	BFG NOx PPH	BFG CO PPH
FSNL		113	0		150	105		
40% LOAD **		565	50	26	299	209	27.5	26.1
100% LOAD - BFG *		986	102	33			68.6	65.2
100% LOAD - NG		1147.4	94		748	523		
					w/o stm inj	w/o stm inj		

** Assume SCR operates to 40% Load - A. Anderson

* SCR Operating