첨부 – 성능 관련 Tool 및 Calculation Sheet

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as per ISO 6976, ASTM D3588, AGA 8

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Draft 개발 완료. 지속 Development 예정.

첨부 – 성능 관련 Tool 및 Calculation Sheet

01. Calculator - Fuel Gas Heating Value, Density and Compressibility (ISO 6976, ASTM 3588, AGA 8)_20221015.xlsm	2022-10-31 오후 3:08	Microsoft Excel ...	12,109KB
02,03. Calculator - Flow_Orifice for Calibrated with Offset by ISO 5167-2.xls	2022-07-18 오후 4:55	Microsoft Excel 9...	918KB
02. Calculator - Flow_Nozzle, Orifice, Venturi for Cx or Uncalibrated by PTC 19.5_20220428.xls	2022-07-05 오전 7:30	Microsoft Excel 9...	572KB
04. Calculator - Flow_Turbine Meter.xlsm	2022-07-05 오후 1:38	Microsoft Excel ...	648KB
05. Calculator - Sensitivity & System Uncertainty & Overall Uncertainty Calculation.xlsm	2022-07-11 오전 11:15	Microsoft Excel ...	127KB
06. Format - Data Logging Sheet - CCPP_DCS (MMCC).xlsx	2022-07-07 오후 3:39	Microsoft Excel ...	5,840KB
06. Format - Data Logging Sheet - CCPP_DCS (MMCC)_Full.xlsx	2022-06-07 오전 10:26	Microsoft Excel ...	30,564KB
06. Format - Data Logging Sheet - Controller Source (TT2 CFPP Full-Scale).xlsx	2022-07-07 오후 3:51	Microsoft Excel ...	2,483KB
06. Format - Data Logging Sheet - Data Type (MD1 CFPP Full-Scale).xlsx	2022-07-07 오후 3:50	Microsoft Excel ...	4,308KB
07. P-Test Correction Tool - General Format.xlsm	2022-07-08 오전 10:57	Microsoft Excel ...	50KB
08. P-Test Correction Tool - CCPP-NP&HR-Base Load (MMCC).xlsm	2022-07-12 오전 8:52	Microsoft Excel ...	136KB
09. P-Test Correction Tool - CCPP-HR-Part Load (MMCC).xlsm	2022-07-12 오전 9:16	Microsoft Excel ...	233KB
11. Equipment - ST_Section Efficiency & Power.xlsx	2022-06-08 오전 11:21	Microsoft Excel ...	41KB
12. Equipment - HRSG Blowdown Rate by CBD VV Position (MMCC).xlsm	2022-06-09 오전 10:25	Microsoft Excel ...	101KB
13. Equipment - Unaccountable Leakage Calculation.xlsx	2022-06-14 오후 4:05	Microsoft Excel ...	848KB
14. Equipment - Cooler_Performance Check (MMCC).xls	2022-06-15 오후 3:23	Microsoft Excel 9...	110KB
20. Equipment - Condenser_CW Flow and Heat Duty by Pump Curve (MMCC).xlsm	2022-10-31 오후 3:30	Microsoft Excel ...	783KB
20. Equipment - Condenser_Heat Duty and CW Flow by Energy Balance (MMCC).xlsm	2022-10-31 오후 3:25	Microsoft Excel ...	712KB
20. Equipment - Condenser_Performance by ASME PTC 12.2 (MMCC).xlsm	2022-06-22 오전 9:41	Microsoft Excel ...	757KB
20. Equipment - Condenser_Performance by ASME PTC 12.2_Advanced (MMCC).xlsm	2022-06-22 오전 9:42	Microsoft Excel ...	758KB
20. Equipment - Condenser_Performance by NTU.xls	2022-10-31 오후 3:27	Microsoft Excel 9...	129KB
20. Equipment - Condenser_Performance by Performance Table (MD1).xls	2022-06-08 오후 3:04	Microsoft Excel 9...	70KB
20. Equipment - Q=CMdT (Uncertainty).xlsm	2022-10-31 오후 3:24	Microsoft Excel ...	64KB

1 P-Test Calculator - Fuel Gas Heating Value (ISO 6976, ASTM 3588)

- Natural Gas 발열량 계산의 International Standard인 ISO 6976:2016 에 따라 천연가스의 Heating Value를 계산함.

- 참고 : 과거 ISO 6976(e.g 1995) 의 경우 발열량에 대해 Gross와 Net에 대해 각 각의 몰당 발열량, 체적당 발열량, 질량당 발열량의 물성치를 제공함에 따라 각 기준변환시 일치가 되지 않고, 각각의 결과가 상이함.
  ISO 6976의 경우 몰당 발열량과 Summation Factor만을 제공함으로써, 일관성 있는 계산 결과가 도출됨.

ISO 6976:2016 Calculations of Gas Properties at 15.55 ℃ 101.325 kPa

	Formula	% mole	C	H	S	Molecular Weight, kg/kmol		Summation Factor		Ideal Gross Heating Value, kJ / mol		Ideal Net Heating Value, kJ / mol	
Compound		xj	αj	βj	γj	Mj	xi Mj	sj	xj sj	HcG0	xj HcG0	xj βj/2 L0	xj HcN0
Methane	CH4	92.923189	1	4	0	16.042460	14.907166	0.0444	0.04123002	891.46	828.37	82.53	745.84
Ethane	C2H6	3.014775	2	6	0	30.069040	0.906514	0.0916	0.00276153	1,562.06	47.09	4.02	43.08
Propane	C3H8	0.616761	3	8	0	44.095620	0.271965	0.1340	0.00082646	2,220.99	13.70	1.10	12.60
i-Butane	iC4H10	0.163284	4	10	0	56.106320	0.091613	0.1770	0.00028901	2,718.60	4.44	0.36	4.08
n-Butane	nC4H10	0.134874	4	10	0	58.122200	0.078392	0.1834	0.00024736	2,879.63	3.88	0.30	3.58
i-Pentane	iC5H12	0.044166	5	12	0	70.132900	0.030975	0.2287	0.00010101	3,377.63	1.49	0.12	1.37
n-Pentane	nC5H12	0.027274	5	12	0	72.148780	0.019678	0.2354	0.00006420	3,538.45	0.97	0.07	0.89
Hexane	nC6H14	0.022472	6	14	0	86.175360	0.019365	0.2990	0.00006719	4,198.06	0.94	0.07	0.87
Heptane	nC7H16	0.000000	7	16	0	100.201940	0.000000	0.3654	0.00000000	4,856.98	0.00	0.00	0.00
Octane	nC8H18	0.000000	8	16	0	114.228520	0.000000	0.4329	0.00000000	5,515.78	0.00	0.00	0.00
Hydrogen	H2	0.000000	0	2	0	2.015880	0.000000	-0.0100	0.00000000	286.13	0.00	0.00	0.00
Water	H2O	0.000000	0	2	0	18.015280	0.000000	0.2546	0.00000000	44.41	0.00	0.00	0.00
Hydrogen sulfide	H2S	0.000000	0	2	1	34.080880	0.000000	0.0920	0.00000000	562.36	0.00	0.00	0.00
Helium	He	0.000000	0	0	0	4.002602	0.000000	-0.0100	0.00000000	0.00	0.00	0.00	0.00
Nitrogen	N2	0.914023	0	0	0	28.013400	0.256049	0.0169	0.00015447	0.00	0.00	0.00	0.00
Carbondioxide	CO2	2.139181	0	0	0	44.009500	0.941443	0.0749	0.00160225	0.00	0.00	0.00	0.00
Summation		99.999999	H/C Ratio :		3.8919	...	17.523158	...	0.04734350	...	900.8870	88.5649	812.3221

Property at 15.55 & 101.325 kPa	Symbol		Unit	HHV	LHV
Z_Compression Factor	Z	-		0.997759	
Ideal Relative Density	G0		-	17.523158	
Real Relative Density	G		-	17.555516	
Ideal Density	D0		kg/m3	0.739673	
Real Density	D		kg/m3	0.741335	
Ideal Heating Value	HcG0	HcN0	kJ/mol	900.89	812.32
Ideal Heating Value	HmG0	HmN0	kJ/kg	51,411.22	46,357.06
Ideal Heating Value	HvG0	HvN0	kJ/m3	38,027.49	34,289.06
Real Heating Value	HvG	HvN	kJ/m3	38,042.67	34,302.75
Ideal Wobbe Index	WG0	WN0	kJ/kg	9,084.30	8,191.24
Real Wobbe Index	WG	WN	kJ/kg	9,087.93	8,191.24

1 P-Test Calculator - Fuel Gas Heating Value (ISO 6976, ASTM 3588)

- 일부 ASME PTC Code (e.g PTC 22:2005) 등에서 ASTM D3588을 참조토록 하고 있음에 따라 ASTM 3588의 경우 Table 1 & 2에 따른 계산서를 추가함.

- 참고 : ASTM D3588에서는 습분 함유에 따른 발열량 보정 계산이 포함되어 있음. 습분에 대한 고려를 하지 않는다면, 좀 더 International하게 인정되는 ISO 6976에 따른 발열량을 참조하는 것을 권장함.

Calculations of Gas Properties at 60°F and 14.696 psia (Gas Analysis on Dry Basis) according to ASTM D3588 Table 2

	Formula	% mole	% wt	C	H	S	Summation Factor		Molar Mass, Ratio		Ideal Gross Heating Value, Btu / ft3		Ideal Gross Heating Value, Btu / lbm		Ideal Net Heating Value, Btu / ft3		Ideal Net Heating Value, Btu / lbm		Molar Mass, lb / lbmol	
Compound		xi	gi	αi	βi	γi	bi	xibi	Giid	xiGiid	Hviid	xiHviid	Hmid	gi Hmid	hviid	xihviid	hmid	gi hmid		
Methane	CH4	92.923189	85.051021	1	4	0	0.0116	0.01077909	0.55392	0.51472	1,010.0	938.52	23,891	20,319.54	909.4	845.04	21,511	18,295.33	16.04300	14.90767
Ethane	C2H6	3.014775	5.171831	2	6	0	0.0239	0.00072053	1.03820	0.03130	1,769.7	53.35	22,333	1,155.02	1,618.7	48.80	20,429	1,056.55	30.07000	0.90654
Propane	C3H8	0.616761	1.551712	3	8	0	0.0344	0.00021217	1.52260	0.00939	2,516.1	15.52	21,653	335.99	2,314.9	14.28	19,922	309.13	44.09700	0.27197
i-Butane	iC4H10	0.163284	0.541447	4	10	0	0.0458	0.00007478	2.00680	0.00328	3,251.9	5.31	21,232	114.96	3,000.4	4.90	19,590	106.07	58.12300	0.09491
n-Butane	nC4H10	0.134874	0.447240	4	10	0	0.0478	0.00006447	2.00680	0.00271	3,262.3	4.40	21,300	95.26	3,010.8	4.06	19,658	87.92	58.12300	0.07839
i-Pentane	iC5H12	0.044166	0.181805	5	12	0	0.0581	0.00002566	2.49120	0.00110	4,000.9	1.77	21,043	38.26	3,699.0	1.63	19,456	35.37	72.15000	0.03187
n-Pentane	nC5H12	0.027274	0.112271	5	12	0	0.0631	0.00001721	2.49120	0.00068	4,008.9	1.09	21,085	23.67	3,703.9	1.01	19,481	21.87	72.15000	0.01968
Hexane	nC6H14	0.022472	0.110487	6	14	0	0.0802	0.00001802	2.97550	0.00067	4,755.9	1.07	20,943	23.14	4,403.9	0.99	19,393	21.43	86.17700	0.01937
Heptane	nC7H16	0.000000	0.000000	7	16	0	0.0944	0.00000000	3.45980	0.00000	5,502.5	0.00	20,839	0.00	5,100.3	0.00	19,315	0.00	100.20400	0.00000
Octane	nC8H18	0.000000	0.000000	8	16	0	0.1137	0.00000000	3.94410	0.00000	6,248.9	0.00	20,759	0.00	5,796.2	0.00	19,256	0.00	114.23100	0.00000
Hydrogen	H2	0.000000	0.000000	0	2	0	0.0000	0.00000000	0.06960	0.00000	324.2	0.00	61,022	0.00	273.9	0.00	51,566	0.00	2.01590	0.00000
Water	H2O	0.000000	0.000000	0	2	0	0.0623	0.00000000	0.62202	0.00000	50.3	0.00	1,060	0.00	0.0	0.00	0	0.00	18.01530	0.00000
Hydrogen sulfide	H2S	0.000000	0.000000	0	2	1	0.0253	0.00000000	1.17670	0.00000	637.1	0.00	7,094	0.00	586.8	0.00	6,534	0.00	34.08000	0.00000
Helium	He	0.000000	0.000000	0	0	0	0.0000	0.00000000	0.13820	0.00000	0.0	0.00	0	0.00	0.0	0.00	0	0.00	4.00260	0.00000
Nitrogen	N2	0.914023	1.460815	0	0	0	0.0044	0.00004022	0.96723	0.00884	0.0	0.00	0	0.00	0.0	0.00	0	0.00	28.01340	0.25605
Carbondioxide	CO2	2.139181	5.371372	0	0	0	0.0197	0.00042142	1.51960	0.03251	0.0	0.00	0	0.00	0.0	0.00	0	0.00	44.01000	0.94145
Summation		99.999999	100.000000	H/C Ratio :		3.8919	...	0.01237357	...	0.605190	...	1,021.0340	...	22,105.8475	...	920.7146	...	19,933.6686	...	17.527894

	Unit	HHV	LHV
Ideal Heating Value @ 60F, 14.696 psia	kJ/kg	51,418.20	46,365.71
Ideal Heating Value @ 60F, 14.696 psia	kJ/m3	38,042.71	34,304.91
Real Heating Value @ 60F, 14.696 psia	kJ/m3	38,128.50	34,382.27
Ideal Density @ 60F, 14.696 psia	kg/m3	0.739869	
Real Density @ 60F, 14.696 psia	kg/m3	0.741537	
Z_Compression Factor @ 60F, 14.696 psia	Z	0.997750	

xw	=	[vapor pressure of water : 0.25636] / 14.696	0.0174	
Hvid (dry gas, dry air)	=	[Sum of xiHviid]	1,021.0340	Btu / ft3
Gid (dry gas)	=	[Sum of xiGiid]	0.6052	
Z (dry gas)	=	1 – [Sum of xibi]^2 x (14.696)	0.99774997	
Z (dry air)	=	1 – [bi of Air : 0.0050]^2 x (14.696)	0.9996	
G (dry gas, dry air)	=	Gid (dry gas) x Z (dry air) / Z (dry gas)	0.6063	
G (dry gas, sat air)	=	Gid (dry gas) x Z (sat air) / Z (dry gas)	0.6062	
{Hvid /Z}(dry gas, dry air)	=	Hvid (dry gas, dry air) / Z (dry gas)	1,023.3366	Btu / ft3
1 – xw	=		0.9826	
Hvid (sat gas, dry air)	=	Hvid (dry gas, dry air) x (1- xw)	1,003.2229	Btu / ft3
Gid (sat gas)	=	Gid (dry gas) x (1- xw) + xw x [Gid of Water : 0.62202]	0.6055	
Z (sat gas)	=	1 – [(1- xw) x [Sum of xibi] + xw x [bi of Water : 0.0623]]^2 x (14.696)	0.9974	
Z (sat air)	=	1 – [(1- xw) x [bi of Air : 0.0050] + xw x [bi of Water : 0.0623]]^2 x (14.696)	0.9995	
G (sat gas, dry air)	=	Gid (sat gas) x Z (dry air) / Z (sat gas)	0.6068	
G (sat gas, sat air)	=	Gid (sat gas) x Z (sat air) / Z (sat gas)	0.6067	
{Hvid/Z } (sat gas, dry air)	=	Hvid (sat gas, dry air) / Z (sat gas)	1,005.8158	Btu / ft3

1 P-Test Calculator - Fuel Gas Density and Compressibility (AGA 8)

- Density and Compressibility에 대해서는 AGA 8이 International하게 공신력이 있음.
- 발열량 계산의 근거가 되는 ISO 6976 및 ASTM D3588의 경우 Standard Condition에 대한 발열량만 하므로, 다양한 운전조건에 대해서는 사용이 제한됨.
- AGA 8의 계산의 경우 계산 방법이 DETAIL, GROSS, GERG 으로 다양하고, 복잡한 계산이 필요함.
- NIST에서 제공하는 계산식 및 물성치를 토대로 계산서를 마련하였음.

60°F and 14.696 psia	Unit	Detail	GERG	Gross Method 0
Real Density @ 60F, 14.696 psia	kg/m3	0.741519	0.741493	0.741520
Z_Compression Factor @ 60F, 14.696 psia	Z	0.997778	0.997786	0.997775

Operating Condition	
Temp.	Pressure
C	Barg
22	45
F	psia
71.6	667.366

Property at 22℃ & 45 Barg	Unit	Detail	GERG
Real Density	kg/m3	36.160552	36.149980
Z_Compression Factor	Z	0.908864	0.909102

2 P-Test Calculator - Flow Calculation - Nozzle, Orifice, Venturi by PTC 19.5

- ASME PTC 19.5에 따라 Long Radius Nozzle, Orifice, Venturi 에 대한 유량을 계산함. Cx or C를 도출하여 계산에 활용함.
- 석탄화력 성능시험에서는 낮은 시험 불확도 달성을 위해 ASME PTC 6 Flow Section(Low Betta Ratio Throat-tap Nozzle)을 Deaerator Inlet에 사용해야하며, PTC 6 / 19.5에 따라 계산되어야 함.
- PTC 19.5따른 Un-calibrated된 경우에도 Betta Ratio와 Reynolds에 따른 Discharge Coefficient를 통해 유량 계산이 가능하며, 이에 따른 불확도를 반영하는 것으로 진행함.

Flow_Calc | Flow_UC

Flow Rate Calculation

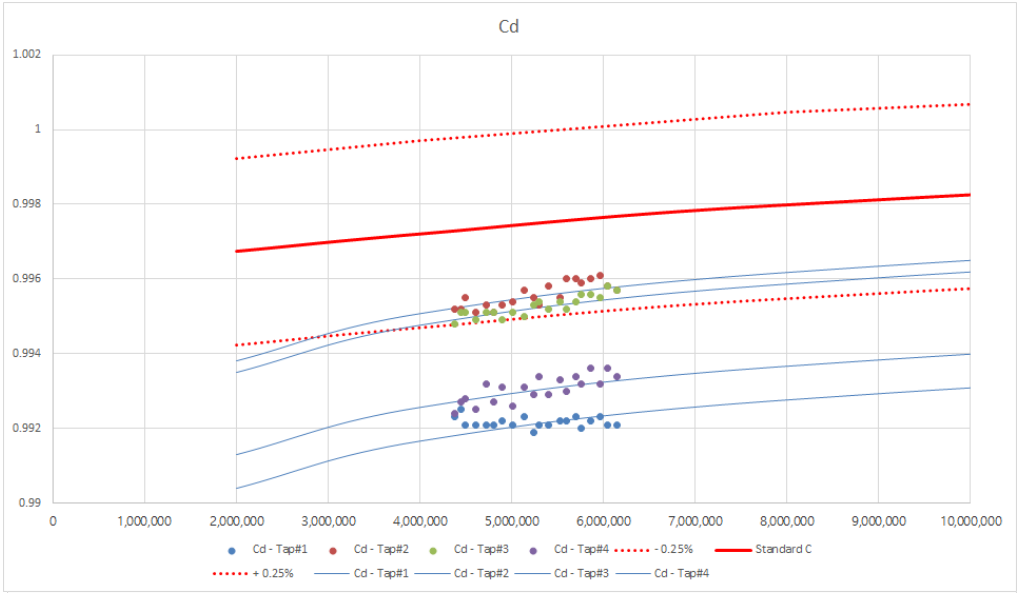
FLOWCAL

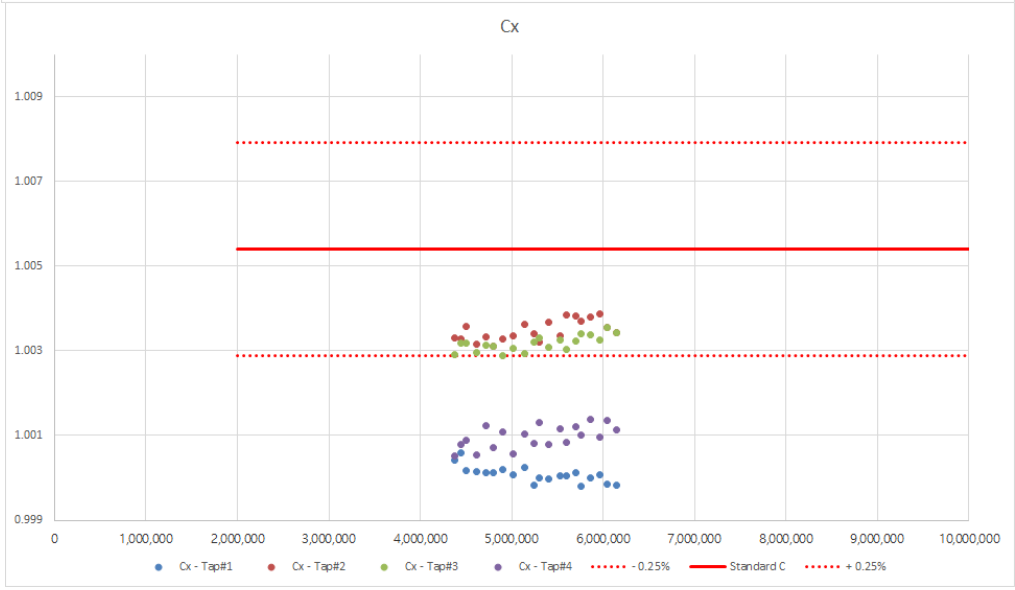
Measuring Point				21LAF10CF101	22LAF10CF101	23MAM10CF001	23MAM11CF001	23MAW40CF006	23MAW50CF001
Description		Deaerator Inlet Condensate Flow	Deaerator Inlet Condensate Flow	Boiler A RH Spray Flow	Boiler B RH Spray Flow	1) Control Valve Leak-off #1 to HRH	2) Control Valve Leak-off #2 to SSH	3) N1 Packing HP Leak-off to DTR	4) N1 Packing LP Leak-off to SSH
Flow Meter		Long Radius Nozzle	Long Radius Nozzle	Long Radius Nozzle	Long Radius Nozzle	Orifice Plate	Orifice Plate	Orifice Plate	Orifice Plate
Tap / Venturi Convergent Type						Flange	Flange	Flange	Flange
Fluid Condition		Liquid	Liquid	Liquid	Liquid	Steam	Steam	Steam	Steam
Flow Meter Material		Austenitic SS	Austenitic SS	Austenitic SS	Austenitic SS	Austenitic SS	Austenitic SS	Austenitic SS	Austenitic SS
Pipe Material		Carbon Steel	Carbon Steel	Carbon Steel	Carbon Steel	Alloy Steel	Alloy Steel	Carbon Steel	Carbon Steel
Calibrated or Uncalibrated		Calibrated	Calibrated	Uncalibrated	Uncalibrated	Uncalibrated	Uncalibrated	Uncalibrated	Uncalibrated
Corrected Beta ratio	-	0.4940	0.4940	0.6381	0.6381	0.7316	0.7312	0.7150	-
Pipe Diameter(D)	mm	387.250	387.250	73.660	73.660	102.260	102.260	154.080	202.740
Flow Throat Diameter(d)	mm	191.160	191.160	46.980	46.980	74.630	74.630	110.010	
Reference Temperature(T_{ref})	℃	20.000	20.000	20.000	20.000	20.000	20.000	20.000	20.000
Correction Factor for Pipe Material	-	1.1964E-05	1.1964E-05	1.1666E-05	1.1622E-05	1.2670E-05	1.2225E-05	1.3151E-05	1.3074E-05
Correction Factor for Throat Materal	-	1.7083E-05	1.7083E-05	1.6892E-05	1.6863E-05	1.8229E-05	1.7886E-05	1.7778E-05	1.7734E-05
Corrected Pipe Diameter(D_{corr})	mm	387.8866	387.8866	73.7443	73.7391	102.8353	102.6833	154.7031	203.5232
Corrected Throat Diameter(d_{corr})	mm	191.6087	191.6087	47.0578	47.0532	75.2341	75.0820	110.6114	-
Velocity of Approach Factor (E)	-	1.0312	1.0312	1.0949	1.0949	1.1838	1.1833	1.1635	1.0000
Fluid Chracteristics									
Pressure(P)	Bar.a	22.496	22.496	114.347	114.674	42.011	1.117	10.751	1.285
Temperature(T)	℃	157.401	157.401	118.099	112.397	464.025	358.612	327.491	315.497
Differential Pressure(ΔP)	mbar	839.677	840.368	-	-	4.080	10.358	54.161	10.462
density(ρ)	kg/m^3	910.959	910.959	950.122	954.527	12.857	0.384	3.966	0.474
Isentropic Exponent(κ)	-	8.561.E+02	8.561.E+02	1.993.E+02	2.015.E+02	1.280.E+00	1.293.E+00	1.295.E+00	1.298.E+00
Pressure Ratio(τ)	-	0.963	0.963	1.000	1.000	1.000	0.991	0.995	0.992
Dynamic viscosuty of the fluid(μ)	Pa.s	1.739.E-04	1.739.E-04	2.390.E-04	2.518.E-04	2.716.E-05	2.274.E-05	2.137.E-05	2.095.E-05
L2' Correction for tap location downst	-	N/A	N/A	N/A	N/A	0.247	0.247	0.164	
L1 Correction for tap location upstrea	-	N/A	N/A	N/A	N/A	0.247	0.247	0.164	
Pressure Loss(Δw)	mbar	502.941	503.439	-	-	1.810	4.553	25.532	10.462
Expansibility Factor(ε)	-	1.000.E+00	1.000.E+00	1.000.E+00	1.000.E+00	1.000.E+00	9.963.E-01	9.980.E-01	9.974.E-01
Average Coefficient of Discharge(Cx)	-	1.00349	1.00318						
Specified Coefficient of Discharge(C)	-	0.9967	0.9964	1.0054	1.0054	0.6082	0.6153	0.6040	0.7600
Reynolds Number (Re_D)	-	14,010,315	14,011,723	-	-	150,290	49,590	540,151	232,872
Flow(qm)	kg/s	366.570	366.607	-	-	0.328	0.091	1.397	0.777
Flow(qm)	kg/hr	1,319,652	1,319,785	-	-	1,180	326	5,029	2,797
Goal Seek	-	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000

: Input Data from Measurement
: Calculated Data
: Iterating Calculation
BLUE : Enthalpy from Steam Table / Material Property from Code
RED : Calculated Value

2 P-Test Calculator - Flow Calculation - Nozzle, Orifice, Venturi by PTC 19.5

➢ ASME PTC 6 Flow Section(Low Betta Ratio Throat-tap Nozzle) 교정성적서에 대한 Cx값 산출 및 Acceptance Check도 계산서에 포함함.





	Re	Cd - Tap#1	Cd - Tap#2	Cd - Tap#3	Cd - Tap#4	- 0.25%	Standard C	+ 0.25%	Cx - Tap#1	Cx - Tap#2	Cx - Tap#3	Cx - Tap#4
		Tap#1	Tap#2	Tap#3	Tap#4				Tap#1	Tap#2	Tap#3	Tap#4
1	6,148,300	0.9921	0.9957	0.9957	0.9934	0.9951722	0.9976664	1.0001605	0.999833625	1.003433625	1.003433625	1.001133625
2	5,969,000	0.9923	0.9961	0.9955	0.9932	0.9951381	0.9976321	1.0001262	1.000067866	1.003867866	1.003267866	1.000967866
3	5,761,500	0.992	0.9959	0.9956	0.9932	0.9950975	0.9975915	1.0000855	0.999808506	1.003708506	1.003408506	1.001008506
4	5,602,600	0.9922	0.996	0.9952	0.993	0.9950657	0.9975596	1.0000535	1.000040385	1.003840385	1.003040385	1.000840385
5	5,405,500	0.9921	0.9958	0.9952	0.9929	0.9950253	0.9975191	1.0000129	0.999980865	1.003680865	1.003080865	1.000780865
6	5,240,600	0.9919	0.9955	0.9953	0.9929	0.9949907	0.9974845	0.9999782	0.99981555	1.00341555	1.00321555	1.00081555
7	5,010,800	0.9921	0.9954	0.9951	0.9926	0.9949413	0.9974348	0.9999284	1.000065155	1.003365155	1.003065155	1.000565155
8	4,802,000	0.9921	0.9951	0.9951	0.9927	0.994895	0.9973885	0.9998819	1.000111531	1.003111531	1.003111531	1.000711531
9	4,615,800	0.9921	0.9951	0.9949	0.9925	0.9948527	0.9973461	0.9998394	1.000153943	1.003153943	1.002953943	1.000553943
10	4,447,600	0.9925	0.9952	0.9951	0.9927	0.9948136	0.9973069	0.9998002	1.000593109	1.003293109	1.003193109	1.000793109
11	4,380,200	0.9923	0.9952	0.9948	0.9924	0.9947977	0.997291	0.9997842	1.000409028	1.003309028	1.002909028	1.000509028
12	4,497,100	0.9921	0.9955	0.9951	0.9928	0.9948252	0.9973185	0.9998118	1.000181499	1.003581499	1.003181499	1.000881499
13	4,724,900	0.9921	0.9953	0.9951	0.9932	0.9948776	0.997371	0.9998645	1.000128971	1.003328971	1.003128971	1.001228971
14	4,903,100	0.9922	0.9953	0.9949	0.9931	0.9949176	0.9974111	0.9999046	1.00018892	1.00328892	1.00288892	1.00108892
15	5,138,700	0.9923	0.9957	0.995	0.9931	0.994969	0.9974626	0.9999563	1.000237362	1.003637362	1.002937362	1.001037362
16	5,305,100	0.9921	0.9953	0.9954	0.9934	0.9950044	0.9974981	0.9999919	1.000001893	1.003201893	1.003301893	1.001301893
17	5,528,100	0.9922	0.9955	0.9954	0.9933	0.9950506	0.9975444	1.0000383	1.000055562	1.003555562	1.003255562	1.001155562
18	5,703,500	0.9923	0.996	0.9954	0.9934	0.995086	0.9975799	1.0000739	1.000120065	1.003820065	1.003220065	1.001220065
19	5,865,900	0.9922	0.996	0.9956	0.9936	0.995118	0.9976121	1.0001061	0.999987921	1.003787921	1.003387921	1.001387921
20	6,049,300	0.9921	0.9958	0.9958	0.9936	0.9951534	0.9976476	1.0001417	0.999852433	1.003552433	1.003552433	1.001352433

Check for Average Value of the Leading Constant Cx												
	Acceptance for Cx			Average Cx					1.000081709	1.003486709	1.003176709	1.000966709
				Acceptance					Not Acceptable	Acceptable	Acceptable	Not Acceptable
				Standard C0					1.0054			
				Acceptable Range					± 0.25%	1.0028865	< Cx <	1.0079135
Check for Reynolds Number Independence												
	Cx = a + bRd			b					-2.53604E-10	2.65708E-10	2.29713E-10	2.86392E-10
									Acceptable	Acceptable	Acceptable	Not Acceptable
				Acceptable Range						-2.70E-10	< b <	2.70E-10
Check for Scatter of Calibration Data												
	Cx data for 95% confidence level								9.05954E-05	1.12643E-04	8.63992E-05	1.25842E-04
									Acceptable	Acceptable	Acceptable	Acceptable
				Acceptable Range							<	0.0003

2 P-Test Calculator - Flow Calculation - Nozzle, Orifice, Venturi by PTC 19.5

➢ 각 유량측정값에 대한 신뢰도 95% 수준의 시험 불확도를 계산도 함께 포함함.

Test Uncertainty Calculation of Flow Rate

PARAMETER	Units	Test Value (Average)	Standard Deviation	Number of Istruments	Number of Readings	Degree of Freedom	ti - Distribution	Sensitivity (%/unit)	Measuring(Random) Error		Instrument(Systematic) Error		Total
									Test Uncert'y	Error	Standard Uncert'y	Error	
DA Inlet Condensate Flow													
Discharge Coefficient		0.997		2				100.34%			0.0023	0.1632%	0.1632%
Pressure	bara	22.496	0.3769	1	1440	1439	1.962	0.00322%	0.0195	0.0001%	0.022	0.0001%	0.0001%
Temperature	℃	157.401	0.1995	1	1440	1439	1.962	-0.04985%	0.0103	-0.0005%	0.400	-0.0199%	0.0199%
Differential Pressure(A)	mbar	840	21.7947	1	1440	1439	1.962	0.02970%	1.1266	0.0335%	0.840	0.0249%	0.0417%
Differential Pressure(B)	mbar	840	21.7550	1	1440	1439	1.962	0.02967%	1.1246	0.0334%	0.840	0.0249%	0.0417%
Σ													0.1747%
Boiler A R/H Desuperheating Flow Rate													
Discharge Coefficient		1.005		1				99.46%			0.006	0.6347%	0.6347%
Pressure	bara	114.347	0.3726	1	1440	1439	1.962	0.00000%	0.0193	0.0000%	0.114	0.0000%	0.0000%
Temperature	℃	118.099	7.2945	1	1440	1439	1.962	0.00000%	0.3771	0.0000%	0.408	0.0000%	0.0000%
Differential Pressure	mbar	0.000	0.0518	1	1440	1439	1.962	0.00000%	0.0027	0.0000%	0.000	0.0000%	0.0000%
Σ													0.6347%
Boiler B R/H Desuperheating Flow Rate													
Discharge Coefficient		1.005		1				99.46%			0.006	0.6347%	0.6347%
Pressure	bara	114.674	0.3725	1	1440	1439	1.962	0.00%	0.0193	0.0000%	0.115	0.0000%	0.0000%
Temperature	℃	112.397	7.2622	1	1440	1439	1.962	0.00%	0.3754	0.0000%	0.427	0.0000%	0.0000%
Differential Pressure	mbar	0.000	0.0712	1	1440	1439	1.962	0.00%	0.0037	0.0000%	0.000	0.0000%	0.0000%
Σ													0.6347%
Control Valve Leak-off #1 to HRH													
Discharge Coefficient		0.608		1				164.43%			0.007	1.2030%	1.2030%
Pressure	bara	42.011	0.1249	1	1440	1439	1.962	1.23826%	0.0065	0.0080%	0.042	0.0520%	0.0526%
Temperature	℃	464.025	0.1817	1	1440	1439	1.962	-0.07443%	0.0094	-0.0007%	0.400	-0.0298%	0.0298%
Differential Pressure	mbar	4.080	0.0272	1	1440	1439	1.962	12.22344%	0.0014	0.0172%	0.004	0.0499%	0.0528%
Σ													1.2057%
Control Valve Leak-off #2 to SSH													
Discharge Coefficient		0.615		1				162.52%			0.007	1.1884%	1.1884%
Pressure	bara	1.117	0.0004	1	1351	1350	1.962	45.06212%	0.0000	0.0009%	0.001	0.0466%	0.0466%
Temperature	℃	358.612	0.4279	1	1440	1439	1.962	-0.07523%	0.0221	-0.0017%	0.400	-0.0301%	0.0301%
Differential Pressure	mbar	10.358	0.1220	1	1440	1439	1.962	4.77949%	0.0063	0.0301%	0.010	0.0495%	0.0580%
Σ													1.1911%
N1 Packing HP Leak-off to DTR													
Discharge Coefficient		0.604		1				165.58%			0.007	1.1839%	1.1839%
Pressure	bara	10.751	0.0072	1	1440	1439	1.962	4.76558%	0.0004	0.0018%	0.011	0.0512%	0.0513%
Temperature	℃	327.491	0.4511	1	1440	1439	1.962	-0.08628%	0.0233	-0.0020%	0.400	-0.0345%	0.0346%
Differential Pressure	mbar	54.161	0.8971	1	1440	1439	1.962	0.91726%	0.0464	0.0425%	0.054	0.0497%	0.0654%
Σ													1.1873%
N1 Packing LP Leak-off to SSH													
Discharge Coefficient		0.760		1				131.58%			0.008	1.0000%	1.0000%
Pressure	bara	1.285	0.0072	1	1351	1350	1.962	39.12327%	0.0004	0.0150%	0.001	0.0405%	0.0432%
Temperature	℃	315.497	0.4279	1	1440	1439	1.962	-0.08254%	0.0221	-0.0018%	0.400	-0.0330%	0.0331%
Differential Pressure	mbar	10.462	6.9837	1	1351	1350	1.962	4.74272%	0.3727	1.7678%	1.034	4.9050%	5.2138%
Σ													5.3091%

3 P-Test Calculator - Flow Calculation - Calibrated Orifice with Offset by ISO 5167-2

- Orifice 교정 성적서를 ISO 5167-2의 Re 와 Discharge Coefficient 식 추세를 Offset 적용하여 유량을 계산함.
- 검교정이 이루어진 낮은 Reynold 영역에서는 ISO 5167-2의 식을 따르는 듯하나, Test Reynold영역에서는 오차가 커질 우려가 있음.

5.3.2.1 Discharge coefficient, C

The discharge coefficient, C, is given by the Reader-Harris/Gallagher (1998) equation[5]:

$$C = 0{,}596\,1 + 0{,}026\,1\beta^2 - 0{,}216\beta^8 + 0{,}000\,521\left(\frac{10^6\beta}{Re_D}\right)^{0{,}7} + (0{,}018\,8 + 0{,}006\,3A)\beta^{3{,}5}\left(\frac{10^6}{Re_D}\right)^{0{,}3}$$

$$+ (0{,}043 + 0{,}080e^{-10L_1} - 0{,}123e^{-7L_1})(1 - 0{,}11A)\frac{\beta^4}{1-\beta^4} - 0{,}031(M'_2 - 0{,}8M'^{1{,}1}_2)\beta^{1{,}3}$$

Where $D < 71{,}12$ mm (2,8 in), the following term shall be added to Equation (4):

$$+ 0{,}011(0{,}75 - \beta)\left(2{,}8 - \frac{D}{25{,}4}\right)$$

W_{FG} = Gas fuel flow rate (Per ISO 5167-2, Eqn 1), kg/h

$$W_{FG} = 3600 \times \frac{C}{\sqrt{1-\beta^4}}\varepsilon\frac{\pi}{4}d^2\sqrt{2\Delta p\rho_1}$$

where:

3600	=	Units conversion, 3600 sec/hr
C	=	Coefficient of discharge from calibration report (See Appendix K: Station Instruments Calibration Data)
β	=	Diameter ratio, (= d/D) (Per ISO 5167-2, Sect 5.3.2.1)
d	=	Orifice Plate Bore Diameter in mm (Per ISO 5167-2, Figure 1)
D	=	Pipe Diameter in mm (Per ISO 5167-2, Figure 1)
ε	=	Expansion factor (Per ISO 5167-2, Sect 5.3.2.2)
Δp	=	Differential pressure, Pa
ρ	=	Density of flowing fluid in the pipe (Per AGA Rpt 8, Eqn. 6), kg/m³

5.3.2.2 Expansibility [expansion] factor, ε

For the three types of tapping arrangement, the empirical formula[6] for computing the expansibility [expansion] factor, ε, is as follows:

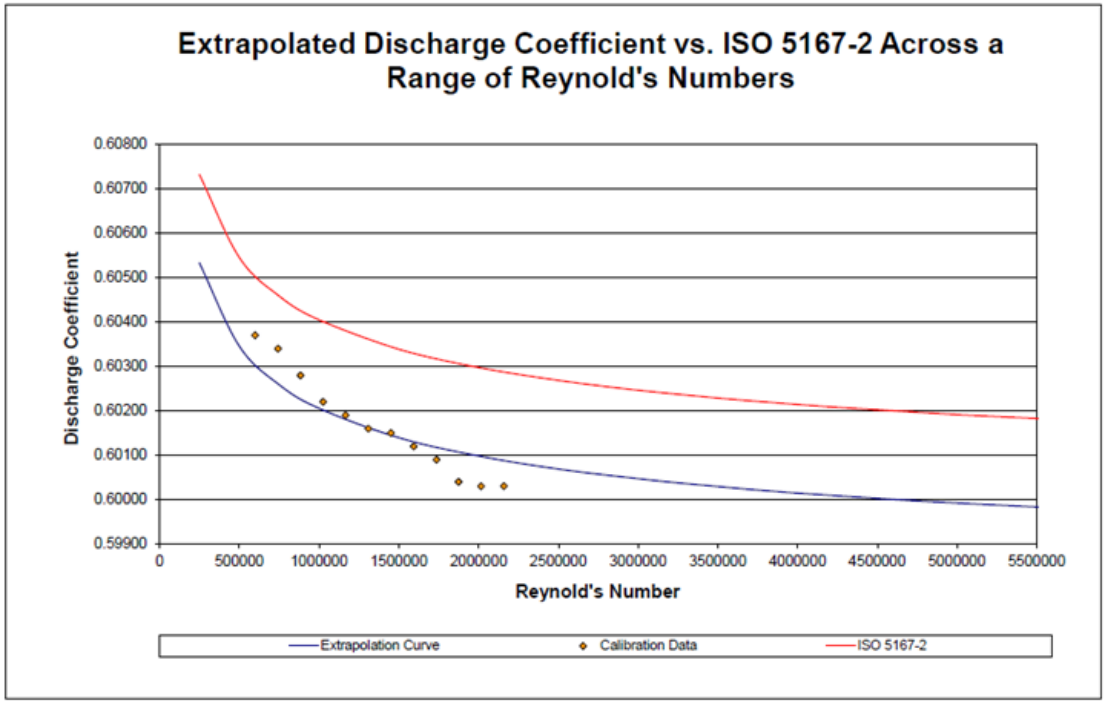
$$\varepsilon = 1 - \left(0{,}351 + 0{,}256\beta^4 + 0{,}93\beta^8\right)\left[1 - \left(\frac{p_2}{p_1}\right)^{1/\kappa}\right] \quad (5)$$

Equation (5) is applicable only within the range of the limits of use specified in 5.3.1.

Test results for the determination of ε are only known for air, steam and natural gas. However, there is no known objection to using Equation (5) for other gases and vapours of which the isentropic exponent is known.

Nonetheless, Equation (5) is applicable only if $p_2/p_1 \geqslant 0{,}75$.

Values of the expansibility [expansion] factor as a function of the isentropic exponent, the pressure ratio and the diameter ratio are given for convenience in Table A.12. These values are not intended for precise interpolation. Extrapolation is not permitted.



3 P-Test Calculator - Flow Calculation - Calibrated Orifice with Offset by ISO 5167-2

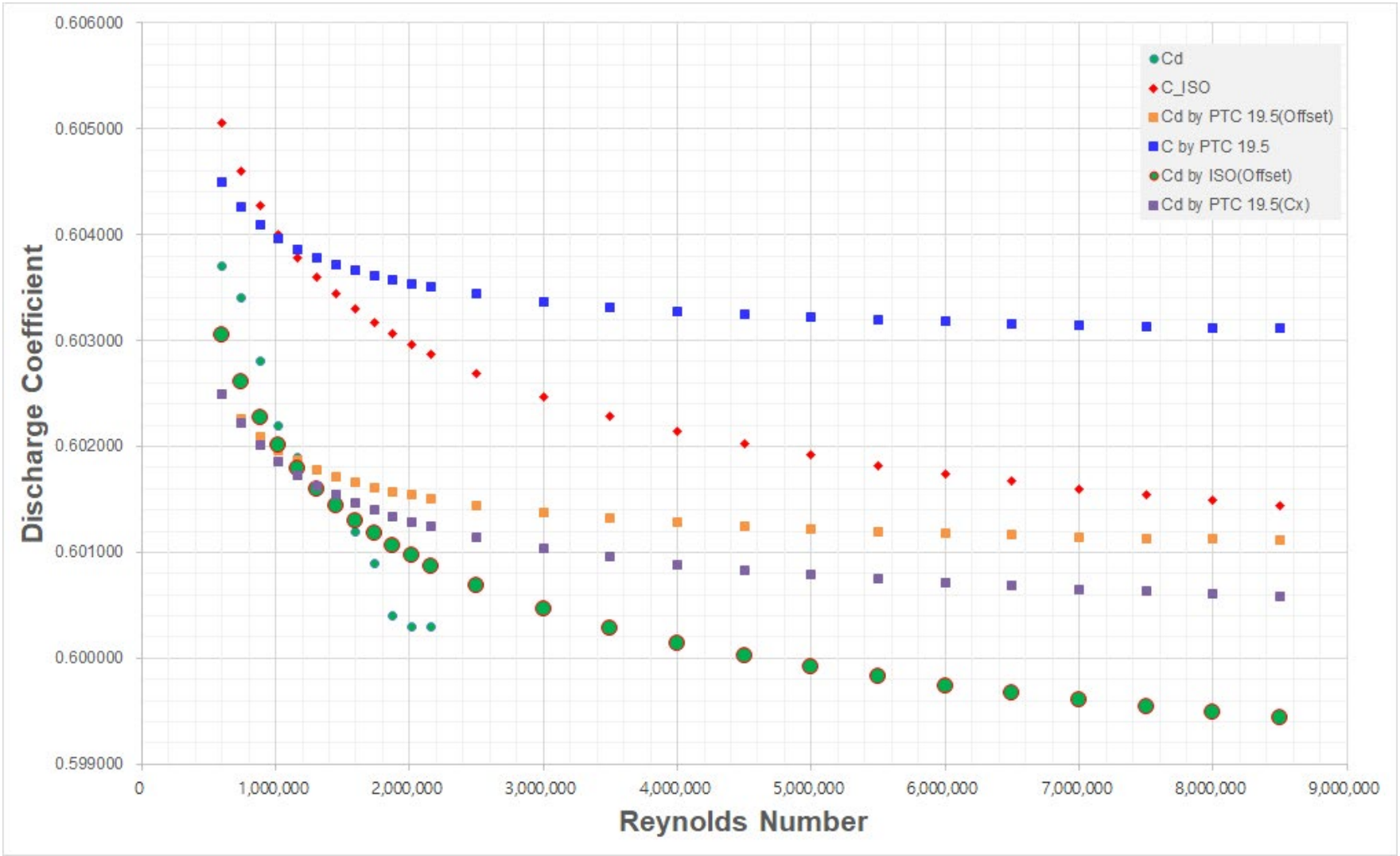
Fuel Flow Calculation

Flow_Cal_ISO

	Test	DESIGN	Unit #11	CC BL PRE T2	
	Date/Time	Simple Cycle	2021-05.25 PT2	2021-05.25 PT3	
	Fuel	NG	NG	NG	
DATA					
No	Description	Unit	Design	Value	Value	Remark
Formula						
Calculation						
1	Calibration Data					
	Discharge coefficient, C_ISO			0.601613	0.601615	
	Flange	L1		0.0993	0.0993	
		L'2		0.0993	0.0993	
	Offset from ISO Curve			-0.0020	-0.0020	
1-1	Coefficient of disharge (C)	-		0.599613	0.599615	
1-2	Diameter ratio (β)	-		0.6764	0.6764	
1-3	Orifice Plate Bore Diameter (d)	mm		173.1	173.1	
1-4	Pipe Diameter (D)	mm		255.9	255.9	
1-5	Expansion factor (ε)	-		0.9979	0.9979	
1-6	Isentropic Exponent (κ)	-		1.1826	1.1823	
1-7	Throat Diameter (for Orifice Tubes)	mm		173.2	173.2	
2	Measured Data					
2-1	Inlet Pressure (p1)	bara		33.750	33.729	
2-2	Outlet Pressure (p2)	bara		33.559	33.539	
	Pressure ratio (>=0.75)			0.9943	0.9944	
2-3	Differential Pressure (△p)	bar		0.191	0.190	
2-4	Density of flowing fluid in the pipe (ρ1)	kg/m3		23.3895	23.3627	
2-5	Dynamic Viscosity	Pa s		1.0764E-05	1.0757E-05	
2-6	Velocity	m/s		12.4550	12.4296	
2-7	Reynolds Number (RE)	-		6,925,358	6,907,649	
3	Gas Fuel Flow Rate	kg/h		53,933	53,761	
	Velocity Check			12.45	12.43	
	Velocity Error			-3.E-10	-3.E-10	
	Interation by Reynolds Number			-2.E-04	-2.E-04	

3 P-Test Calculator - Flow Calculation 비교 - Cx by PTC 19.5 vs Offset by ISO 5167-2

- 검교정 결과의 추세 방법에 따라 높은 Reynold의 Test 환경에서의 결과는 차이가 크게 벌어질 가능성이 존재함.
- 지젤 SC P-Test시의 측정 Data상으로는 Offset(-0.002) by ISO 5167-2 < Cx by PTC 19.5 < Offset(-0.002) by PTC 19.5 유량차가 있음.
  53,933 kg/h (Base)< +86 kg/h (+0.16%) < +135 kg/h (+0.25%)



4 P-Test Calculator - Flow Calculation - Turbine Meter

➢ Turbine Meter에서 발생되는 Pulse(Hz)로 Volume Flow를 산출함.

Gas Turbine No.				
Meter Under Test :				SGT5-4000F
Type		Turbine meter		
Manufacture		Elster		
Serial number		10520492		
Nominal Size		250		
Year of manufacture				
R/N	Deviation	Utot		
-	%	%		
510,000	0.030	0.13		
980,000	0.120	0.13		
2,500,000	0.070	0.13		
4,020,000	0.040	0.13		
6,920,000	-0.020	0.14		
9,270,000	-0.080	0.15		
			Design	Test 1
Design k-factor		pulses/m3	1126.63	1126.63
Measured pulse		Hz	727	758.0677
Volume Flow	Qi	m3/h	2323.0	2422.3
Nominal Diamter		m	0.250	0.250
Density		kg/m3	20.3	22.35637
Volume Flow		m3/s	0.645	0.673
Dynamic Viscosity		pa.s	1.18E-05	1.18E-05
Velocity		m/s	13.146	13.707
Reynolds Number			5,653,758	6,492,561
Deviation		%	0.006	-0.011
Volume Flow	Qi,corr	m3/h	2322.9	2422.6
Density		kg/m3	20.3	22.356367
Mass Flow		kg/h	47,155	54,160

5 P-Test Calculator - Uncertainty Calculation - Sensitivity Calculation

➢ 계산서의 Input 및 Output의 Cell Address를 연동하여 Input을 증분함으로써 변화하는 Output의 민감도를 매크로로 자동으로 계산함.

계산의 Output이 도출되는 Cell Address를 Refer함.

Sensitivity Calculation for Net Output and Net Heat Rate

NAME OF PLANT :	Melaka 2,242MW CCGT Power Plant								UNIT NO. :	Unit x					
TEST NO. :	Official Thermal P-Test			DATE :	20xx-xx-xx				LOAD :	Base Load					
TIME START :	xx:xx			END :	xx:xx				SHEET :	1 0f 1					
	Corrected Net Power Output	kW	#REF!	#REF!	#REF!	#REF!	SensCal				Corrected Net Power Output		Corrected Net Heat Rate		
	Corrected Net Heat Rate	kJ/kWh	#REF!	#REF!	#REF!	#REF!									
No.	PARAMETER	Units	Address	Test Value (Average)	Original	Increasement	Test Value	Power Output	Heat Rate	Error	Sensitivity (ΔP/P) / Unit	Relative Sensitivity (ΔP/P) /(ΔX/X)	Sensitivity (ΔP/P) / Unit	Relative Sensitivity (ΔHR/HR) /(ΔX/X)	
ambT	Ambient Temperature (dbT)	degC	#REF!	#REF!	25.37	0.0254	25.4	752325.4	5861.1	0.0000E+00	#REF!	#REF!	#REF!	#REF!	
ambP	Ambient Pressure	mbara	#REF!	#REF!	1,006	1.0063	1007.3	751515.2	5861.3	0.0000E+00	#REF!	#REF!	#REF!	#REF!	
ambH	Ambient Humidity (RH)	%	#REF!	#REF!	85.65	0.0856	85.7	752280.6	5861.1	0.0000E+00	#REF!	#REF!	#REF!	#REF!	
gLHV	Fuel LHV	kJ/kg	#REF!	#REF!	46,224	46.2243	46270.6	752319.5	5866.9	0.0000E+00	#REF!	#REF!	#REF!	#REF!	
gHC	Fuel H/C Ratio	-	#REF!	#REF!	3.80	0.0038	3.8	752250.6	5861.2	0.0000E+00	#REF!	#REF!	#REF!	#REF!	
Hz	Frequency	Hz	#REF!	#REF!	50.05	0.0501	50.1	751465.5	5860.7	0.0000E+00	#REF!	#REF!	#REF!	#REF!	
PF	Power Factor	-	#REF!	#REF!	0.9938	0.0010	0.9947770	752271.7	5861.2	0.0000E+00	#REF!	#REF!	#REF!	#REF!	
cwT	CW Temperature	degC	#REF!	#REF!	29.72	0.0297	29.7	752304.0	5861.0	0.0000E+00	#REF!	#REF!	#REF!	#REF!	
fgT	FG Temperature	degC	#REF!	#REF!	29.48	0.0295	29.5	752287.7	5861.1	0.0000E+00	#REF!	#REF!	#REF!	#REF!	
fgP	FG Pressure	Barg	#REF!	#REF!	38.72	0.0387	38.8	752287.5	5861.1	0.0000E+00	#REF!	#REF!	#REF!	#REF!	
TFT	Total Fired Time	Hours	#REF!	#REF!	1,204	1.2038	1205.0	752287.5	5861.1	0.0000E+00	#REF!	#REF!	#REF!	#REF!	
fgFlow	Fuel Flow	kg/h	#REF!	#REF!	97,005	97.0048	97101.8	752287.5	5867.0	0.0000E+00	#REF!	#REF!	#REF!	#REF!	
NetP	Net Power Output	kW	#REF!	#REF!	771,564	771.5643	772335.8931	753046.7	5855.2	0.0000E+00	#REF!	#REF!	#REF!	#REF!	

계산의 Input이 되는 인자의 Cell Address를 Refer함.

Input의 변화에 따른 Output의 민감도 결과가 자동으로 계산됨.

5 P-Test Calculator - Uncertainty Calculation - Overall Uncertainty Calculation

➢ 계산서의 Input 및 Output의 Cell Address를 연동하여 Input을 증분함으로써 변화하는 Output의 민감도를 매크로로 자동으로 계산함.

Test Logging Data가 입력되며, Test간 발생되는 Random Uncertainty 계산에 활용됨

Test간 측정된 Data의 표준편차를 일정 신뢰도를 갖는 정규분포의 불확도로 환산에 활용됨. 통상 95% 신뢰도 수준이 활용됨.

계기 수량 및 측정 횟수가 많을 수록 불확도는 낮아짐.

계기 혹은 측정시스템이 갖는 오차를 의미하며, 계기가 정확할 수록 불확도는 낮아짐.

Overall Test Uncertainty of Net Power Output

NAME OF PLANT :	Melaka 2,242MW CCGT Power Plant									UNIT NO. :	Unit x		
OFFICIAL TEST DATE :	20xx-xx-xx									TEST NO. :	Official Thermal P-Test		
OVERALL TEST TIME :	xx:xx	~	xx:xx							LOAD :	Base Load		
LOGGING TIME :	START :	xx:xx	END :	xx:xx						SHEET :	1 of 1		

PARAMETER	Units	Test Value (Average)	Standard Deviation	Number of Istruments	Number of Readings	Degree of Freedom	ti - Distribution	Sensitivity (%/unit)	Measuring (Random) Error		Instrument (Systematic) Error		Total
									Test Uncert'y	Error	Standard Uncertainty	Error	
Net Power Output - Power													
Net Power Output - WH Meter(Digital), kW	kW	#REF!	#REF!	1	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!
Σ													#REF!
Net Power Output - Correction Factors													
Ambient Temperature (dbT)	degC	#REF!	#REF!	8	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	0.1100	#REF!	#REF!
Ambient Pressure	mbara	#REF!	#REF!	2	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!
Ambient Humidity (RH)	%	#REF!	#REF!	2	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!
Fuel LHV	kJ/kg	#REF!	0.0000	1	3	2	4.303	#REF!	0.0000	#REF!	#REF!	#REF!	#REF!
Fuel H/C Ratio	-	#REF!	0.0000	1	3	2	4.303	#REF!	0.0000	#REF!	#REF!	#REF!	#REF!
Frequency	Hz	#REF!	#REF!	1	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!
Power Factor	-	#REF!	#REF!	1	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!
CW Temperature	degC	#REF!	#REF!	2	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	0.1100	#REF!	#REF!
FG Temperature	degC	#REF!	#REF!	1	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	0.8000	#REF!	#REF!
FG Pressure	Barg	#REF!	#REF!	3	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!
Total Fired Time	Hours	#REF!	#REF!	1	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!
Σ													#REF!
Overall Uncertainty	%												#REF!

개별 Input인자의 Random Uncertainty와 Measuring Uncertainty의 합성 불확도를 산출함.

모든 인자들의 Overall Uncertainty를 산출함.

5 P-Test Calculator - Uncertainty Calculation - Sample Calculation (Q=cp m dT)

Symbol	Description	Value	Unit	Remark
M+	Flow Rate	49,207,555	kg/hr	
T1+	Cooling Water Inlet Temperature	30.79	°C	
T2+	Cooling Water Outlet Temperature	37.75	°C	
Cp+	Specific Heat of Seawater	4.0194	J/g K	
Q+	Condenser Heat Load $Q^{\square} = w^{\square} \times c_p^{\square} \times (T_2^{\square} - T_1^{\square})$	1,377,123,313	kJ/hr	

Sensitivity Calculation

NAME OF PLANT :
TEST NO. :
TIME START :
DATE :
END :

A	Condenser Heat Load	kJ/hr	1,377,123,312.72274	1,377,123,312.72274	SensCala			Condenser Heat Load	
No.	PARAMETER	Units	Test Value (Average)	Original	Increasement	Test Value	A	Sensitivity (ΔA/A) / Unit	Relative Sensitivity (ΔA/A) /(ΔX/X)
M+	Flow Rate	kg/hr	49,207,554.58	49,207,554.58	492,075.55	49,699,630.12	1,390,894,545.84997	0.0000%	100.0000%
T1+	Cooling Water Inlet Temperature	°C	30.79	30.79	0.31	31.10	1,316,265,260.33488	-14.3530%	-441.9216%
T2+	Cooling Water Outlet Temperature	°C	37.75	37.75	0.38	38.13	1,451,791,761.81330	14.3622%	542.2060%

Overall Test Uncertainty of Condenser Heat Load

NAME OF PLANT :
OFFICIAL TEST DATE :
OVERALL TEST TIME : ~
LOGGING TIME : START : END :
UNIT NO. :
TEST NO. :
LOAD :
SHEET : 1 of 1

PARAMETER	Units	Test Value (Average)	Standard Deviation	Number of Istruments	Number of Readings	Degree of Freedom	ti - Distribution	Sensitivity (%/unit)	Measuring (Random) Error		Instrument (Systematic) Error		Total
									Test Uncert'y	Error	Standard Uncertainty	Error	
Flow Rate	kg/hr	49,207,554.58	492075.5458	1	121	120	1.980	0.00000%	88570.4850	0.1800%	59049.07	0.1200%	0.2163%
Cooling Water Inlet Temperature	°C	30.79	0.3079	2	121	240	1.970	-14.35298%	0.0390	-0.5596%	0.10	-1.0149%	1.1590%
Cooling Water Outlet Temperature	°C	37.75	0.3775	2	121	240	1.970	14.36222%	0.0478	0.6866%	0.10	1.0156%	1.2259%
Σ													1.7008%
Overall Uncertainty	%												**1.70%**

1) Test measured value average is calculated using test raw readings value.
2) Standard deviation is calculated using test raw readings value and average value.
3) Degree of freedom = Number of instruments×(Number of readings - 1)
4) ti-distribution for degrees of freedom : ASME PTC 6 Report - 1985, Table 5.1
5) Sensitivity is calculated using test average value and correction curves.
6) Test uncert'y = ti-distribution × standard deviation ÷ SQRT(number of instruments × number of readings)
7) Error for measurement = Test uncertainty × Sensitivity
8) Error for instrument = Standard uncertainty × Sensitivity / SQRT(No. of Inst.)
9) Total error = SQRT(Corr. error for measurement^2 + Corr. error for instrument^2)

6 P-Test Format - Data Logging Sheet

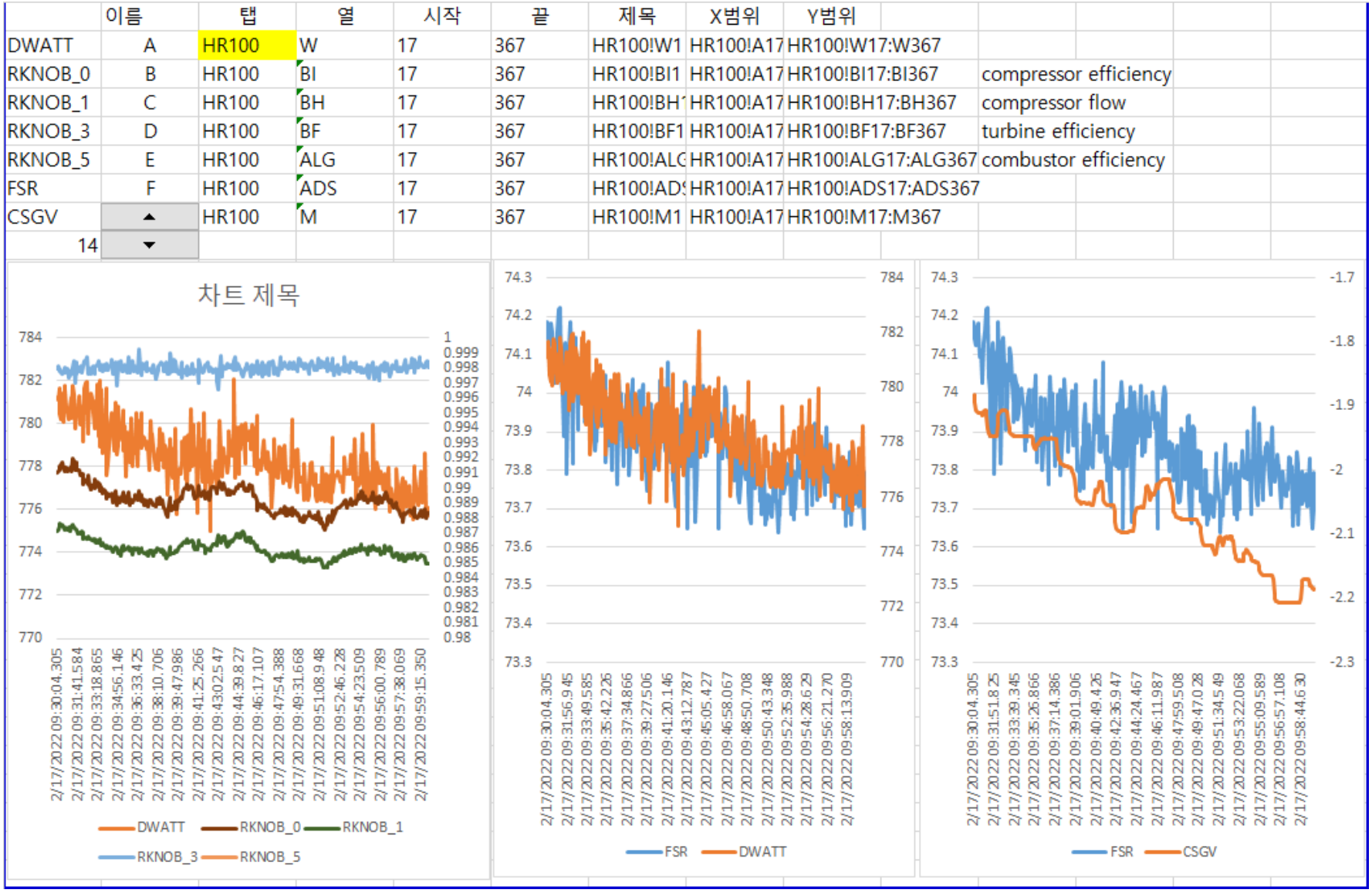
➢ 프로젝트 / DCS / DAS 마다 혹은 Data 취득시 마다 제 각각인 Data Log에 대해 성능 계산에 필요한 Min/Max/Average/Standard Deviation/No of Data를 계산서의 Input 으로 일관되게 연계되도록 엑셀 HLOOKUP을 이용 Format 을 마련함.

	Time	#!Min	#!Max	#!Units	#!Description	#!AltDescription	MAX	MIN	Average	stdv	Number of Data				
1	DWATT	0	800	MW	Selected Generator Watts	P	782.0900	774.9872	778.4174	1.4689	351		kW	778,417	778,417
2	EX2K_FLD_V	0	256	V	EX2K Generator Field Voltage	P	427.6501	401.4884	416.1965	5.7556	351		V	416	1,710
3	EX2K_FLD_A	0	6000	A	EX2K Generator Field Current	P	4127.9536	4094.7600	4109.6141	6.9214	351		A	4,110	
4	ATID	-103	149	°F	Air Temperature Inlet Filter	P	82.4734	80.2332	81.4630	0.5629	351		°C	27.48	27.48
5	AFPAP	0	59.0615	inHga	Ambient Pressure	P	29.6652	29.6565	29.6624	0.0021	351		mbara	1,004	1,004
6	RHUM	0	128	%	Humidity Relative to CTIM	P	75.3868	70.2786	72.9923	1.2404	351		%	72.99	72.99
7	DF	0	72	Hz	Generator Frequency	P	50.0698	49.9784	50.0379	0.0158	351		Hz	50.04	50.04
8	DPF	-1	1		Calculated Power Factor	P	0.9894	0.9883	0.9889	0.0003	351		-	0.9889	0.9889
9	FQG	0	80	lb/s	Gas fuel flow	P	57.8111	56.1433	56.9655	0.2882	351		kg/h	93,021	93,021
10	FUEL_FLOW	0	308.647	lb/s	LF Liquid Fuel Measured Flow (a_96lffm_q)	P	0.0068	-0.0116	-0.0032	0.0051	351		kg/h	-5	-5
11	TFT_T	0	262800	h	Total fired time	P	1379.2000	1378.7000	1378.9800	0.1470	351		H	1,379	1,379
12	CA_IGV_CRT	-100	100	°	IGV Position for min CRT protection	R	-7.0980	-7.4828	-7.2833	0.0899	351		°	-7.2833	-7.2833
13	CA_IGV_TCD	-100	100	°	IGV Position to Maintain TCD	R	-6.2198	-7.1807	-6.6696	0.2388	351		°	-6.6696	-6.6696
14	csrgv	-100	100	°	IGV Reference	R	-1.8856	-2.2107	-2.0588	0.0887	351		°	-2.0588	-2.0588
15	CSGV	-100	100	°	IGV Position - Corrected	R	-1.8831	-2.2077	-2.0562	0.0882	351		°	-2.0562	-2.0562
16	CSVSV	-100	100	°	VSV Position Feedback	R	-0.5642	-0.6609	-0.6160	0.0264	351		°	-0.6160	-0.6160
17	FSRT	0	128	%	Temperature Control Fuel Stroke Reference	R	74.2240	73.6378	73.8733	0.1238	351		%	73.87	73.87
18	FSR	0	128	%	Fuel Stroke Reference	R	74.2240	73.6378	73.8733	0.1238	351		%	73.87	73.87
19	CTDLAGD	-328	2552	°F	Performance CTD First Order Lag Model Delta	R	8.0959	5.4226	6.7983	0.5774	351		°C	3.78	3.78
20	CTDCORRCA	-328	2552	°F	CTD CORRECTED WITH BIAS	R	943.9833	938.8933	941.5549	1.2678	351		°C	523.09	523.09
21	CTD	-4	932	°F	Compressor Discharge Temperature	R	951.8318	946.6663	949.3780	1.2852	351		°C	509.65	509.65
22	CA_TX_TM	-328	2552	°F	Temperature Matching Reference	R	1231.6074	1229.4457	1230.5926	0.3674	351		°C	665.88	665.88
23	TTXM	32	1292	°F	Exhaust Temp Median Corrected By Average	R	1231.6123	1229.4138	1230.5929	0.3697	351		°C	665.88	665.88
24	AFQD	0	308.647	lb/s	Compressor Inlet Dry Air Mass Flow	R	1739.8337	1733.7881	1736.3272	1.2087	351		kg/h	2,835,306	2,835,306
25	WEXH	0	308.647	lb/s	Turbine Exhaust Mass Flow	R	2176.7065	2167.2744	2171.0059	2.0532	351		kg/h	3,545,107	3,545,107
26	CA_BCPF_GTMW	0	600	MW	BCP based GT MW	R	523.9684	518.2484	520.5878	1.1469	351		kW	520,588	520,588
27	CA_BCP_G	0	1000	kW	Bottoming Cycle Performance (kW) - Generator	R	252770.1094	251540.2813	252131.8780	285.5390	351		kW	252,132	252,132
28	RKNOB_0	0	100		ARES Output	R	0.9920	0.9872	0.9893	0.0009	351		-	0.9893	0.9893
29	RKNOB_1	0	100		ARES Output	R	0.9876	0.9847	0.9860	0.0006	351		-	0.9860	0.9860
30	RKNOB_5	0	100		ARES Output	R	1.0436	1.0372	1.0397	0.0011	351		-	1.0397	1.0397
31	RKNOB_3	0	100		ARES Output	R	0.9993	0.9966	0.9980	0.0003	351		-	0.9980	0.9980
32	TPR2	0	100	RAT	Turbine Pressure Ratio	R	22.9946	22.8541	22.9180	0.0240	351		-	22.92	22.92
33	CPR	0	100	RAT	Compressor Pressure Ratio	R	23.9723	23.8593	23.9044	0.0239	351		-	23.90	23.90
34	CPDABS_F	0	1015.26	psig	Filtered CPDABS signal	R	347.1511	345.5992	346.2427	0.3281	351		barg	23.87	23.87
35	EV_P	0	100		Steam Condenser Pressure (LP Exhaust Pressure)	R	2.4509	2.3901	2.4277	0.0131	351		Bara	0.0820	0.0820
36	CA_CRT	0	128		Combustion Reference Index	R	107.1159	106.8406	106.9796	0.0381	351		%	106.98	106.98
37	O2_Concentration	0	100	%		E	12.0357	11.9869	12.0106	0.0091	351		%	12.01	12.01
38	NOx_Concentration	0	5000	ppm		E	21.9042	21.3131	21.6596	0.1086	351		ppm	21.66	21.66
39	CO_Concentration	0	5000	ppm		E	6.2016	0.7687	2.9212	1.0063	351		ppm	2.92	2.92

6 P-Test Format - Data Logging Sheet

- Test Data는 Logging간의 기술적 문제 혹은 실제 추세 변화 등을 확인하여 Data 의 적절성을 확인해야 함. 또한, 주요 인자간의 경향성 혹은 추세를 확인할 필요가 있음. 이를 용이하게 확인 가능하도록 Format 을 마련함.

	이름	탭	열	시작	끝	제목	X범위	Y범위				
DWATT	A	HR100	W	17	367	HR100!W1	HR100!A17	HR100!W17:W367				
RKNOB_0	B	HR100	BI	17	367	HR100!BI1	HR100!A17	HR100!BI17:BI367	compressor efficiency			
RKNOB_1	C	HR100	BH	17	367	HR100!BH	HR100!A17	HR100!BH17:BH367	compressor flow			
RKNOB_3	D	HR100	BF	17	367	HR100!BF1	HR100!A17	HR100!BF17:BF367	turbine efficiency			
RKNOB_5	E	HR100	ALG	17	367	HR100!ALC	HR100!A17	HR100!ALG17:ALG367	combustor efficiency			
FSR	F	HR100	ADS	17	367	HR100!AD	HR100!A17	HR100!ADS17:ADS367				
CSGV	▲	HR100	M	17	367	HR100!M1	HR100!A17	HR100!M17:M367				
14	▼											



6 P-Test Format - Data Logging Sheet

- 석탄화력의 경우 최대 400여개에 달하는 Data를 취득하는 경우가 있으며, 이러한 경우 방대한 양의 Input Data 연계가 용이하도록 Data Type 혹은 Controller Source 별로 구분하도록 Sample Format도 수록함.

No.	Tag	Description	Unit
219		21LAB33CF103XQ01.U	U1 BLR-A FW FLOW-C	T/H
220		22LAB33CF101XQ01.U	U1 BLR-B FW FLOW-A	T/H
221		22LAB33CF102XQ01.U	U1 BLR-B FW FLOW-B	T/H
222		22LAB33CF103XQ01.U	U1 BLR-B FW FLOW-C	T/H
225	TCS	S2.I_FIELD	Excitation Current	A
226	TCS	S2.V_FIELD	Excitation Voltage	V
227	TCS	S2.cv1_pos	CV1 Position	%
228	TCS	S2.cv1_pos1	CV1 Position 1	%
229	TCS	S2.cv1_pos2	CV1 Position 2	%
230	TCS	S2.cv1_pos3	CV1 Position 3	%

PERFORMANCE INSTRUMENT LIST FOR GROSS POWER OUT AND GROSS HEAT RATE
[PRESSURE]

NAME OF PLANT :											#REF!					UNIT NO. :	#REF!		
OFFICIAL TEST DATE :											#REF!					TEST NO. :	#REF!		
OVERALL TEST TIME :										#REF!	~	#REF!				LOAD :	#REF!		
LOGGING TIME								START :	#REF!	END :	#REF!					SHEET :	1 of 1		
No.	Input to Where	Description	Tag #	Measuring Range	Unit	Systematic Uncertainty	Remark	Symbol	Unit	Max	Min	Average	Stdev	Unit Conversion	Unit	Average	STD Dev.	Number of Sample	Systematic Uncertainty
P1		Barometric Pressure	N/A	1040	mbar	0.10% of Reading	Used for Vendor Test Only	P_BARO	mbar	1015.5	1013.0	1014.6	0.7579	0.001	bara	1.0146	7.58E-04	1440	0.0010
P2		Main Steam Pressure-Left	PP-23LBA10CP401	210	bar	0.10% of Reading		P_MS_L	barg	170.7255	168.6042	169.8560	0.4818	1	bara	170.871	4.82E-01	1440	0.1709
P3		Main Steam Pressure-Right	PP-23LBA20CP401	210	bar	0.10% of Reading		P_MS_R	barg	170.7912	168.6656	169.9181	0.4824	1	bara	170.933	4.82E-01	1440	0.1709
	IDS108P	Main Steam Pressure (Average)													bara	170.902	4.82E-01	1440	0.1709
P4		HP Turbine 1st Stage Shell Steam Pressure	PT-23MAA10CP102	210	bar	0.10% of Reading	Used for Vendor Test Only	P_1STG	barg	138.4437	136.8266	137.7551	0.3788	1	bara	138.7697	3.79E-01	1440	0.1388
P5		HP Turbine Exhaust Steam Pressure-Left	PP-23LBC10CP401	210	bar	0.10% of Reading		P_CRH_L	barg	44.6976	43.7096	44.1810	0.2278	1	bara	45.196	2.28E-01	1440	0.0452
P6		HP Turbine Exhaust Steam Pressure-Right	PP-23LBC20CP401	210	bar	0.10% of Reading		P_CRH_R	barg	44.1209	43.1170	43.5977	0.2313	1	bara	44.612	2.31E-01	1440	0.0446
	IDS109P	HP Turbine Exhaust Steam Pressure (Average)													bara	44.904	2.30E-01	1440	0.0449
P7		Hot Reheat Steam Pressure-Left	PP-23LBB10CP401	210	bar	0.10% of Reading		P_HRH_L	barg	41.3173	40.7271	41.0665	0.1238	1	bara	42.081	1.24E-01	1440	0.0421
P8		Hot Reheat Steam Pressure-Right	PP-23LBB20CP401	210	bar	0.10% of Reading		P_HRH_R	barg	41.2447	40.6566	40.9929	0.1238	1	bara	42.007	1.24E-01	1440	0.0420
	IDS110P	Hot Reheat Steam Pressure (Average)													bara	42.044	1.24E-01	1440	0.0420
P9		Heater 8 Extraction Steam Pressure @tbn	PP-23LBQ30CP401	210	bar	0.10% of Reading	Used for Vendor Test Only	P_H8EXT	barg	80.9448	79.8126	80.4237	0.2423	1	bara	81.4383	2.42E-01	1440	0.0814
P10	IDS103cP	Heater 8 Extraction Steam Pressure @htr	PP-23LBQ30CP402	210	bar	0.10% of Reading		P_H8STM	barg	79.5529	78.2990	78.9676	0.2435	1	bara	79.982	2.43E-01	1440	0.0800

244	TCS	S2.dwatt	GEN WATT	MW
245	TCS	S2.dvar	GEN VAR	
248	TCS	S2.DT_GCCG1	GEN Common Gas Cold Temp 1	° C
249	TCS	S2.DT_GCCG2	GEN Common Gas Cold Temp 2	° C
250	TCS	S2.DT_GCCG3	GEN Common Gas Cold Temp 3	° C

Tag | SKODA | B&W | DCS_Calc | Elect | Wet Bulb | Sampling | STG_DAS | Boiler_DAS | STG_DCS | Boiler_DCS

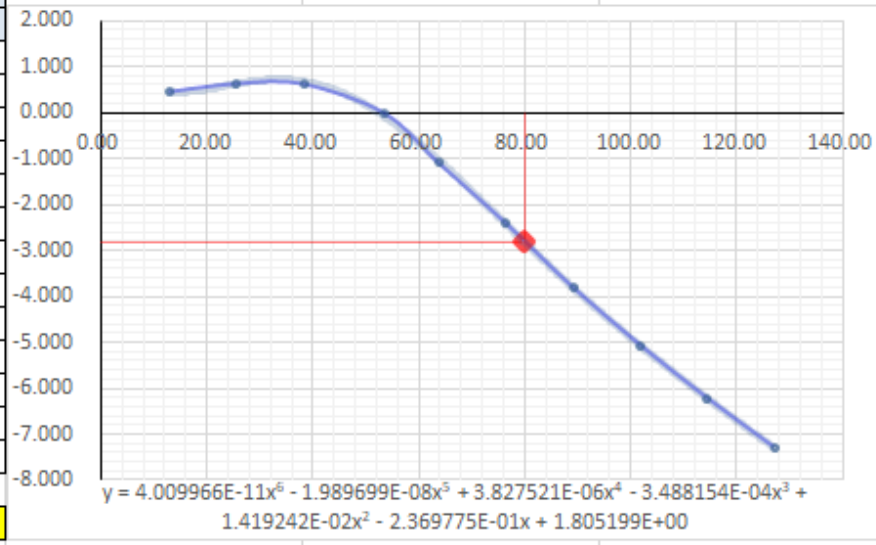
Tag | DAS | DCS | TCS | Pressure | Temperature | Differential Pressure | Level | Electrical | SS

7 P-Test Format – General Correction Format

- Correction Table의 X와 Y Data로부터 6차 다항식의 상수와 계수를 자동(Curve Pitting 방식 생략)으로 추출하도록 엑셀 Function(Index & Linest)을 구현함.
- 6차 다항식의 상수와 계수를 용이하게 계산하도록 엑셀(Seriessum)을 구현함.
- 필요에 따라 단순 보간법으로 보정할 경우를 고려하여 매크로 Function(Table2Search) 도 마련함.

	LPT Exhaust Pressure (mmHgA)	VS
LPT Exhaust Pressure (mmHgA)	Gross Output	
0.071	53.33	0	540,000
X	x	y	Y
Bara	mmHgA	%	Value
0.017	12.70	0.460	542,484
0.034	25.40	0.640	543,456
0.051	38.10	0.630	543,402
0.071	53.34	0.000	540,000
0.085	63.50	-1.070	534,222
0.102	76.20	-2.390	527,094
0.119	88.90	-3.790	519,534
0.135	101.60	-5.050	512,730
0.152	114.30	-6.210	506,466
0.169	127.00	-7.290	500,634
0.000			540,000
0.107	80.000	-2.826	524,738

Gross Output



Coefficient						
C6	C5	C4	C3	C2	C1	C0
1	2	3	4	5	6	7
4.009966E-11	-1.989699E-08	3.827521E-06	-3.488154E-04	1.419242E-02	-2.369775E-01	1.805199E+00

8 P-Test Format – CCPP NP & HR for Base Load (MMCC Sample)

➢ Input Sheet를 별도 분리하여, 성능체크에 대한 Input/Output 히스토리를 Log할 수 있게 구성 되었으며, 재 계산 및 Update가 가능함.

				0	1	2	3	4	5	6	7	8	9	10
			Design HBD	02/07 Test2 20:30~21:30	12/17A 13:00~14:00	01/26A 19:20~20:20	01/26B 22:30~23:30	02/01 00:40~01:30	02/02 07:40~08:50	02/02 12:00~13:00	02/07 Test1 19:30~20:30	02/07 Test2 20:30~21:30	Unit 3 P-Test Average	
			Guarantee	Isol / Precision	Isol / DCS	Isol / DCS	Isol / DCS	Isol / DCS	Isol / DCS	Isol / DCS	Isol / Precision	Isol / Precision		
	Summation of Correction	-												
ambT	Ambient Temperature (dbT)	degC	34.00	25.37	28.18	29.34	27.96	27.63	26.31	31.38	25.40	25.37		
ambP	Ambient Pressure	mbara	1,013.00	1,006.29	1,004.51	1,004.19	1,006.27	1,006.10	1,007.02	1,007.16	1,005.32	1,006.29		
ambH	Ambient Humidity (RH)	%	80.00	85.65	74.35	76.65	79.66	70.95	73.62	56.75	84.18	85.65		
gLHV	Fuel LHV	kJ/kg	45,135	46,224	47,672	46,814	46,794	46,810	46,973	47,347	46,233	46,224		
gHC	Fuel H/C Ratio	-	3.7849	3.8010	3.9537	3.9010	3.9032	3.8897	3.8929	3.9088	3.8052	3.8010		
Hz	Frequency	Hz	50.0000	50.0527	50.0350	49.9670	50.0149	50.0123	50.0378	50.0311	50.0427	50.0527		
PF	Power Factor	-	0.8500	0.9938	0.9922	0.9998	1.0000	0.9934	0.9961	0.9936	0.9934	0.9938		
cwT	CW Temperature	degC	32.00	29.7161	29.60	28.91	28.90	30.12	29.42	29.30	29.82	29.72		
fgT	FG Temperature	degC	15.00	29.48	29.42	28.61	27.31	29.55	29.92	31.06	29.45	29.48		
fgP	FG Pressure	Barg	26.00	38.72	43.13	38.58	37.85	42.99	49.75	52.28	38.78	38.72		
TFT	Total Fired Time	Hours	1,479	1,204	723	1,018	1,021	1,077	1,095	1,099	1,203	1,204		
	Fuel		Natural gas	Natural gas	Natural gas	Natural gas	Natural gas	Natural gas	Natural gas	Natural gas	Natural gas	Natural gas		
CH4	Methane, CH4	% molar	87.6300	91.8074	95.4491	93.6716	93.6948	92.6785	92.9028	93.8547	91.9574	91.8074		
C2H6	Ethane, C2H6	% molar	5.6300	3.6037	1.5303	2.7459	2.7510	3.8990	3.8757	3.3967	3.5066	3.6037		
C3H8	Propane, C3H8	% molar	1.5000	0.9744	0.2122	0.5922	0.5689	0.4826	0.4401	0.3584	0.9585	0.9744		
IC4H10	Isobutane, C4H10	% molar	0.4100	0.2402	0.0582	0.1540	0.1457	0.1086	0.0991	0.0766	0.2324	0.2402		
NC4H10	N-butane, C4H10	% molar	0.4200	0.1683	0.0419	0.1192	0.1116	0.0872	0.0757	0.0588	0.1607	0.1683		
IC5H12	Iso-Pentane, C5H12	% molar	0.0700	0.9585	0.0021	0.0398	0.0361	0.0278	0.0278	0.0186	0.9585	0.9585		
NC5H12	N-Pentane, C5H12	% molar	0.0200	0.0249	0.0001	0.0223	0.0211	0.0140	0.0144	0.0072	0.0110	0.0249		
C6H14	Hexane, C6H14+	% molar	0.0100	0.0186	0.0088	0.0141	0.0122	0.0118	0.0131	0.0103	0.0143	0.0186		
Heptane	Heptane	% molar		0.0080	0.0038	0.0054	0.0048	0.0051	0.0062	0.0051	0.0051	0.0080		
CO2	Carbon Dioxide, CO2	% molar	2.7300	2.2439	1.3726	1.7995	1.8223	1.6996	1.5831	1.3727	2.2391	2.2439		
N2	Nitrogen, N2	% molar	1.5800	0.8546	0.4832	0.8341	0.8278	0.9823	0.9588	0.8368	0.8557	0.8546		
fgFlow	Fuel Flow	kg/h	96,480	97,004.792	91,998	93,462	95,072	95,104	95,274	93,554	96,853	97,005		
NetP	Net Power Output	kW	747,377	771,564	755,962	753,924	768,906	768,342	772,114	766,360	770,003	771,564		
comAuxP	Common Aux Power	kW		3,008	2,991	2,991	2,991	3,025	3,013	3,015	3,010	3,012		
CSGV	IGV Position - Corrected	°		-1.3731	-0.4080	-0.5775	-2.2038	-2.1304	-1.6950	-2.4960	-1.3794	-1.3731		
CTDLAGD	P-CTD First Order Lag Delta	K	< 2.8 °C	0.5619	1.6824	0.3111	1.1224	0.7363	1.3150	1.5252	0.7486	0.5619		
CTD	Compressor Discharge Temp	°C		505	507.92	508.57	510.07	509.73	507.60	517.00	505.59	505.40		
TTXM	Exhaust Temp	°C		664	665.45	669.26	666.56	664.92	664.50	673.38	664.32	664.35		
AFQD	Compressor Dry Air Mass Flow	kg/h		2,866,982	2,833,423	2,810,732	2,842,693	2,852,144	2,863,418	2,834,768	2,864,463	2,866,982		
CA_BCPF_(	BCP based GT MW	kW		529,240	518,415	511,174	522,411	524,066	527,144	517,589	528,223	529,240		
RKNOB_0	Compressor Efficiency	-		0.9922	0.9896	0.9872	0.9896	0.9912	0.9914	0.9870	0.9917	0.9922		
RKNOB_1	Compressor Flow	-		0.9892	0.9889	0.9866	0.9888	0.9893	0.9893	0.9864	0.9890	0.9892		
RKNOB_5	Combustor Efficiency	-		1.0209	1.0295	1.0212	1.0218	1.0241	1.0252	1.0279	1.0203	1.0209		
RKNOB_3	Turbine Efficiency	-		0.9987	1.0006	0.9968	0.9983	0.9988	0.9983	1.0000	0.9986	0.9987		
GrossP	Gross Output - HBD	kW	770,287	789,678	772,971	770,933	785,915	785,317	789,100	783,345	788,154	789,678		
	Gross Output - GE Guarantee	kW	766,017											
AuxP	Auxiliary Power - HBD	kW	22,910	21,122	20,000	20,000	20,000	20,000	20,000	20,000	21,161	21,126		
	Auxiliary Power - HEC Guarantee	kW	18,640											
	Power - Margin	kW	4,270											
HeatQ	Heat Consumption	kJ/h	4,354,605,504	4,483,982,530	4,385,746,512	4,375,302,873	4,448,766,828	4,451,860,368	4,475,354,891	4,429,493,956	4,477,809,463	4,483,982,530		
NetHR	Net Heat Rate	kJ/kWh	5,827.00	5,811.55	5,801.55	5,803.37	5,785.84	5,794.12	5,796.24	5,779.91	5,815.31	5,811.55		
	Correction-NP	kW			-12,510	-9,120	-15,122	-13,795	-17,745	-6,287	-18,150	-19,281	-18,715	
	Correction-HR	kJ/kWh			53.75	57.19	56.85	51.55	53.58	56.72	49.17	49.58	49.38	
crNetP	Correted Net power output	kW	747,377		743,452	744,805	753,784	754,547	754,369	760,073	751,853	752,284	752,068	
crNetHR	Correted Net Heat Rate	kJ/kWh	5,827.00		5,855.30	5,860.57	5,842.69	5,845.67	5,849.82	5,836.64	5,864.48	5,861.13	5,862.81	

8 P-Test Format – CCPP NP & HR for Base Load (MMCC Sample)

➢ 성능시험 계산 Sheet 이며, Input Index를 변경함으로써, Vlookup함수를 통해 용이하게 반복 계산 및 히스토리 Log를 가능하게 구현함.

0	1	2	3	4	5	6	7	8	9	10
02/07 Test2 20:30~21:30	12/17A 13:00~14:00	01/26A 19:20~20:20	01/26B 22:30~23:30	02/01 00:40~01:30	02/02 07:40~08:50	02/02 12:00~13:00	02/07 Test1 19:30~20:30	02/07 Test2 20:30~21:30	Unit 3 P-Test Average	
Isol / Precision	Isol / DCS	Isol / DCS	Isol / DCS	Isol / DCS	Isol / DCS	Isol / DCS	Isol / Precision	Isol / Precision		

			Design HBD	0 02/07 Test2 20:30~21:30	Correction-P	Correction-P	Correction-H	Correction-H	
			Guarantee	Isol / Precision	CF	kW	CF	kJ/kWh	
	Summation of Correction	-			1.021578	-19,21	1.000590	5	
ambT	Ambient Temperature (dbT)	degC	34.00	25.37	1.02228824	-16,670	1.00004802	0	
ambP	Ambient Pressure	mbara	1,013.00	1,006.29	0.99319851	5,236	1.00026974	-2	
ambH	Ambient Humidity (RH)	%	80.00	85.65	1.00060748	-464	1.00006025	0	
gLHV	Fuel LHV	kJ/kg	45,135	46,224.34	0.99924583	577	1.00015425	-1	
gHC	Fuel H/C Ratio	-	3.78	3.80					
Hz	Frequency	Hz	50.00	50.05	1.00114966	-878	1.00005831	0	
PF	Power Factor	-	0.8500	0.9938	2,345	-2,345		18	
cwT	CW Temperature	degC	32.00	29.72	1,656	-1,656		13	
fgT	FG Temperature	degC	15.00	29.48	-60	60			
fgP	FG Pressure	Barg	26.00	38.72	27	-27			
TFT	Total Fired Time	Hours	1,479	1,204	*1.000000*	*0*	*1.00000000*	*0*	
	Fuel		Natural gas	Natural gas	C	H	Total MW	C (Atom)	H (Atom)
CH4	Methane, CH4	% molar	87.63	91.81	1	4	16.00	0.0625	0.25
C2H6	Ethane, C2H6	% molar	5.63	3.60	2	6	30.00	0.066666667	0.2
C3H8	Propane, C3H8	% molar	1.50	0.97	3	8	44.00	0.068181818	0.181818182
IC4H10	Isobutane, C4H10	% molar	0.41	0.24	4	10	58.00	0.068965517	0.172413793
NC4H10	N-butane, C4H10	% molar	0.42	0.17	4	10	58.00	0.068965517	0.172413793
IC5H12	Iso-Pentane, C5H12	% molar	0.07	0.96	5	12	72.00	0.069444444	0.166666667
NC5H12	N-Pentane, C5H12	% molar	0.02	0.02	5	12	72.00	0.069444444	0.166666667
C6H14	Hexane, C6H14+	% molar	0.01	0.02	6	14	86.00	0.069767442	0.162790698
Heptane	Heptane	% molar		0.01					
CO2	Carbon Dioxide, CO2	% molar	2.73	2.24			44	0	0
N2	Nitrogen, N2	% molar	1.58	0.85			28		
fgFlow	Fuel Flow	kg/h	96,488	97,005					
NetP	Net Power Output	kW	747,377	771,564					
comAuxP	Common Aux Power	kW		3,008	3,008	-3,008		23	
CSGV	IGV Position - Corrected	°		-1.3731					
CTDLAGD	P-CTD First Order Lag Delta	K		0.5619					
CTD	Compressor Discharge Temp	°C		505.40					
TTXM	Exhaust Temp	°C		664.35					
AFQD	Compressor Dry Air Mass Flow	kg/h		2,866,982					
CA_BCPF_	BCP based GT MW	kW		529,240					
RKNOB_0	Compressor Efficiency	-		0.9922					
RKNOB_1	Compressor Flow	-		0.9892					
RKNOB_5	Combustor Efficiency	-		1.0209					
RKNOB_3	Turbine Efficiency	-		0.9987					
GrossP	Gross Output - HBD	kW	770,287	789,678	773,069	-16,609			
	Gross Output - GE Guarantee	kW	766,017			7,052			
AuxP	Auxiliary Power - HBD	kW	22,910	21,122					
	Auxiliary Power - HEC Guarantee	kW	18,640						
	Power - Margin	kW	4,270						
HeatQ	Heat Consumption	kJ/h	4,354,605,504	4,483,982,530					
NetHR	Net Heat Rate	kJ/kWh	5,827.00	5,811.55					

8 P-Test Format – CCPP NP & HR for Base Load (MMCC Sample)

➢ 보정인자에 대한 보정 계산도 구현함. (기본적으로 6차 다항식에 대한 상수/계수 Table 형태가 활용에 용이함)

		X Axis Value	Interpolate Z Curves?	Value of Z Variable	Y Value
Drawing No. 1GP027779_1	Estimated CC Net Plant Output vs. Ambient Temperature	25.37	N		1.022288241
Drawing No. 1GP027779_2	Estimated CC Net Plant heat rate vs. Ambient Temperature	25.37	N		1.000048019
Drawing No. 1GP027779_3	Estimated CC Net Plant Output vs. Ambient Pressure	1,006	N		0.993198512
Drawing No. 1GP027779_4	Estimated CC Net Plant heat rate vs. Ambient Pressure	1,006	N		1.000269735
Drawing No. 1GP027779_5	Estimated CC Net Plant Output vs. Ambient Relative Humidity (15°C < Tamb < 27.5°C)	85.65	Y	25.37	1.000607483
Drawing No. 1GP027779_6	Estimated CC Net Plant Output vs. Ambient Relative Humidity (27.5°C < Tamb < 40°C)	85.65	Y	25.37	
Drawing No. 1GP027779_7	Estimated CC Net Plant heat rate vs. Ambient Relative Humidity (15°C < Tamb < 27.5°C)	85.65	Y	25.37	1.000060248
Drawing No. 1GP027779_8	Estimated CC Net Plant heat rate vs. Ambient Relative Humidity (27.5°C < Tamb < 40°C)	85.65	Y	25.37	
Drawing No. 1GP027779_9	Estimated CC Net Plant Output vs. Grid Frequency	50.05274	Y	25.37	1.00114966
Drawing No. 1GP027779_10	Estimated CC Net Plant heat rate vs. Grid Frequency	50.05274	Y	25.37	1.000058314
Drawing No. 1GP027779_11	Estimated CC Net Plant Output vs. Circulating Water Temperature	29.72	Y	25.37	1655.884738
Drawing No. 1GP027779_12	Estimated CC Net Plant Output vs. LHV	46,224	Y	3.8010	0.999245834
Drawing No. 1GP027779_13	Estimated CC Net Plant heat rate vs. LHV	46,224	Y	3.8010	1.000154251
Drawing No. 1GP027779_15	Estimated CC Net Plant Output vs. Gas Fuel Temperature at Terminal Point	29.48	N		-60.3366333
Drawing No. 1GP027779_16	Estimated CC Net Plant Output vs. Gas Fuel Pressure at Terminal Point	38.72	N		26.81196252

Estimated CC Net Plant Output vs. Ambient Temperature

Drawing No. 1GP027779_1 Revision C Feb 13, 2021

Curve Number	x^6	x^5	x^4	x^3	x^2	x	constant	Lower Bound	Upper Bound	Z value	Y value
1 (15 <= x < 20 °C)	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00	1.1652306E-05	-1.7704210E-03	1.0651449E+00	15	20	FALSE	FALSE
2 (20 <= x < 28 °C)	0.0000000E+00	0.0000000E+00	0.0000000E+00	-6.1633281E-07	5.5893112E-05	-3.8366701E-03	1.0937111E+00	20	28	TRUE	1.022288241
3 (28 <= x < 34 °C)	0.0000000E+00	0.0000000E+00	0.0000000E+00	-2.8414189E-06	2.7466488E-04	-1.1572822E-02	1.1876360E+00	28	34	FALSE	FALSE
4 (34 <= x < 38 °C)	0.0000000E+00	0.0000000E+00	0.0000000E+00	-2.8466748E-05	3.0182194E-03	-1.1181230E-01	2.4314135E+00	34	38	FALSE	FALSE
5 (38 <= x < 40 °C)	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00	1.5077618E-04	-1.8770148E-02	1.4743725E+00	38	40	FALSE	FALSE

8 P-Test Format – CCPP NP & HR for Base Load (MMCC Sample)

➢ Double Correction에 대한 계산 형식이 제공됨. (e.g. Correction for NP vs RH for Ambient T)

Estimated CC Net Plant Output vs. Ambient Relative Humidity (15°C < Tamb < 27.5°C)

Drawing No. 1GP027779_5 Revision C Feb 13, 2021

Curve Number	x^6	x^5	x^4	x^3	x^2	x	constant	Lower Bound	Upper Bound	Z value	Y value
1 (15 °C, 0 <= x < 100 %)	0.0000000E+00	0.0000000E+00	0.0000000E+00	-6.152900634E-10	6.399746842E-09	8.534651139E-05	9.934609421E-01	0	100	FALSE	FALSE
2 (17.5 °C, 0 <= x < 100 %)	0.0000000E+00	0.0000000E+00	0.0000000E+00	-1.571691266E-10	6.054015514E-09	8.763330202E-05	9.930300625E-01	0	100	FALSE	FALSE
3 (20 °C, 0 <= x < 100 %)	0.0000000E+00	0.0000000E+00	0.0000000E+00	-2.377883722E-09	2.431012450E-07	9.656471118E-05	9.918698941E-01	0	100	FALSE	FALSE
4 (22.5 °C, 0 <= x < 100 %)	0.0000000E+00	0.0000000E+00	0.0000000E+00	-6.468140274E-10	4.195575709E-08	9.579708420E-05	9.923947726E-01	0	100	FALSE	FALSE
5 (25 °C, 0 <= x < 100 %)	0.0000000E+00	0.0000000E+00	0.0000000E+00	-9.035988766E-11	-4.540756873E-08	1.148676404E-04	9.911382843E-01	0	100	25	1.000586733
6 (27.5 °C, 0 <= x < 25 %)	0.0000000E+00	0.0000000E+00	0.0000000E+00	1.076596336E-08	-6.246402624E-07	4.290831899E-04	9.825804032E-01	0	25	FALSE	FALSE
7 (27.5 °C, 25 <= x < 100 %)	0.0000000E+00	0.0000000E+00	0.0000000E+00	6.401086096E-10	-1.970883741E-07	1.413855401E-04	9.896614691E-01	25	100	27.5	1.000727413

Estimated CC Net Plant Output vs. Ambient Relative Humidity (27.5°C < Tamb < 40°C)

Drawing No. 1GP027779_6 Revision C Feb 13, 2021

Curve Number	x^6	x^5	x^4	x^3	x^2	x	constant	Lower Bound	Upper Bound	Z value	Y value
1 (27.5 °C, 0 <= x < 25 %)	0.0000000E+00	0.0000000E+00	0.0000000E+00	1.076596336E-08	-6.246402624E-07	4.290831899E-04	9.825804032E-01	0	25	FALSE	FALSE
2 (27.5 °C, 25 <= x < 100 %)	0.0000000E+00	0.0000000E+00	0.0000000E+00	6.401086096E-10	-1.970883741E-07	1.413855401E-04	9.896614691E-01	25	100	27.5	1.000727413
3 (30 °C, 0 <= x < 47 %)	0.0000000E+00	0.0000000E+00	0.0000000E+00	-1.512822267E-08	-3.630813354E-08	4.912638501E-04	9.748264817E-01	0	47	FALSE	FALSE
4 (30 °C, 47 <= x < 100 %)	0.0000000E+00	0.0000000E+00	0.0000000E+00	-1.313382114E-09	2.391580318E-07	9.956985603E-05	9.911942929E-01	47	100	FALSE	FALSE
5 (32 °C, 0 <= x < 55 %)	0.0000000E+00	0.0000000E+00	0.0000000E+00	-1.571896260E-08	8.566427933E-07	4.736343264E-04	9.706156089E-01	0	55	FALSE	FALSE
6 (32 °C, 55 <= x < 100 %)	0.0000000E+00	0.0000000E+00	0.0000000E+00	6.257729019E-09	-1.794034288E-06	2.905276632E-04	9.850334767E-01	55	100	FALSE	FALSE
7 (34 °C, 0 <= x < 64 %)	0.0000000E+00	0.0000000E+00	0.0000000E+00	-1.407635729E-08	4.648039917E-07	5.308540081E-04	9.655325033E-01	0	64	FALSE	FALSE
8 (34 °C, 64 <= x < 100 %)	0.0000000E+00	0.0000000E+00	0.0000000E+00	4.098913708E-09	-1.218253131E-06	2.533950763E-04	9.854239460E-01	64	100	FALSE	FALSE
9 (37 °C, 0 <= x < 80 %)	0.0000000E+00	0.0000000E+00	-5.037917206E-10	5.136594019E-08	-1.619771340E-06	6.338097177E-04	9.540008598E-01	0	80	FALSE	FALSE
10 (37 °C, 80 <= x < 100 %)	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00	-9.414091953E-08	1.840278536E-04	9.858802736E-01	80	100	FALSE	FALSE
11 (40 °C, 0 <= x < 91 %)	0.0000000E+00	0.0000000E+00	-3.402422172E-10	4.740746148E-08	-1.918502028E-06	7.401071281E-04	9.426924882E-01	0	91	FALSE	FALSE
12 (40 °C, 91 <= x < 100 %)	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00	-7.408641812E-06	1.196202483E-03	9.590297005E-01	91	100	FALSE	FALSE

85.65	25.37	1.000607483
25	1.000586733	E
27.5	1.000727413	G
15	17.5	A
17.5	20	B
20	22.5	C
22.5	25	D
25	27.5	E
27.5	30	F
27.5	30	G
27.5	30	F
27.5	30	G
30	32	H
30	32	I
32	34	J
32	34	K
34	37	L
34	37	M
37	40	N
37	40	O
40	45	P
40	45	Q

8 P-Test Format – CCPP NP & HR for Base Load (MMCC Sample)

➢ Generator Loss Correction 계산 형식도 제공함.

Generator Loss Table

PF	A6	A5	A4	A3	A2	A1	A0	Lower Bound	Upper Bound
0.70	0	0	0	0	1.10E-08	1.58E-03	2.74E+03	0	634,000
0.80	0	0	0	0	8.43E-09	9.54E-04	2.75E+03	0	845,000
0.85	0	0	0	0	7.82E-09	3.46E-04	2.79E+03	0	1,050,000
0.90	0	0	0	0	6.19E-09	6.37E-04	2.75E+03	0	1,050,000
1.00	0	0	0	0	4.42E-09	1.27E-05	2.73E+03	0	1,050,000

Generator Loss Table

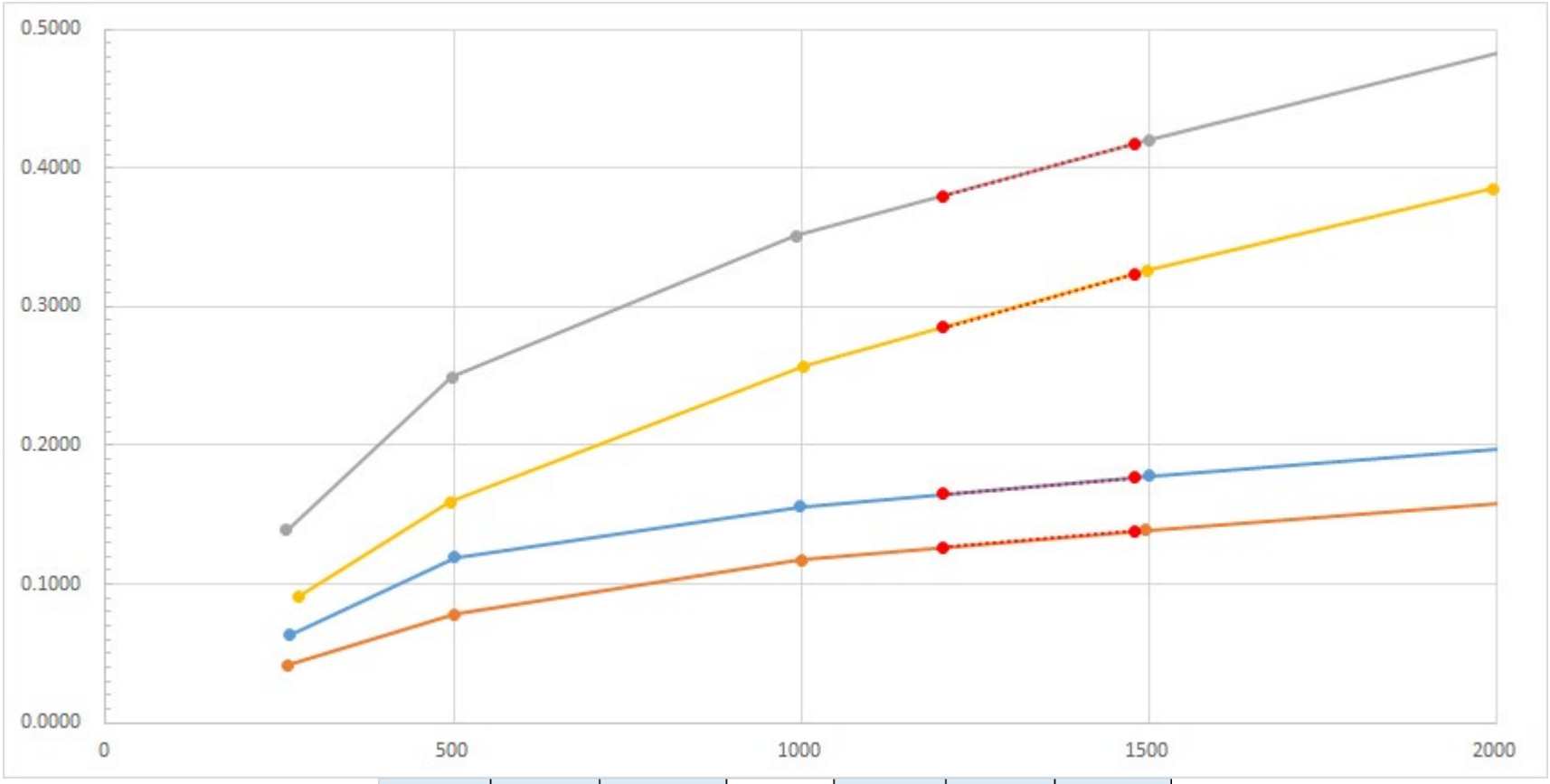
Generator Loss (Including Field I2R Loss)			Power Factor			Remark
			0.85	0.90	1.00	
Load Factor	0	0.0000	0	0	0	
	253,725	0.3000	3378	3309	3017	
	338,300	0.4000	3799	3673	3240	
	422,875	0.5000	4332	4126	3526	
	507,450	0.6000	4976	4667	3875	
	592,025	0.7000	5733	5297	4287	
	676,600	0.8000	6602	6016	4763	
	761,175	0.9000	7582	6823	5302	
	845,750	1.0000	8674	7718	5904	
	930,325	1.1000	9879	8703	6570	
	1,014,900	1.2000	11195	9776	7299	

Generator Loss Correction

No.		Description		Unit	Value	Remark
1		Generator Rating		kW	845,750	From Vendor Data
2		Measured Power		kW	789,678	Measured
3		Test Load Factor (LF)		-	0.9337	[2] / [1]
4		GL(PF=1.00)		kW	5,505	Interpolation by PF(1.0) & LF([3])
5		GL(PF=0.85)		kW	7,950	Interpolation by PF(0.85) & LF([3])
6		Test Power Factor (PF)		-	0.9938	Measured
7		GL(Design PF)		kW	7,950	Interpolation by PF(0.85) & LF([3])
8		GL(Test PF)		kW	5,606	Interpolation by PF([6]) & LF([3]) or [5]+([6]-0.85)/(1-0.85) x ([4]-[5])
9		Correction		kW	2,345	[7] - [8]

8 P-Test Format – CCPP NP & HR for Base Load (MMCC Sample)

➢ 제작사가 제공한 Potential Degradation Curve가 있다면, 체크 시점과 시험 시점간의 Degradation도 체크에 고려될 수 있음.



Owner	HR	H-Deg_O
1,204	0.1649	0.99835101
1,479	0.1768	0.99823198
-275.23191	-0.0119	1.00011903

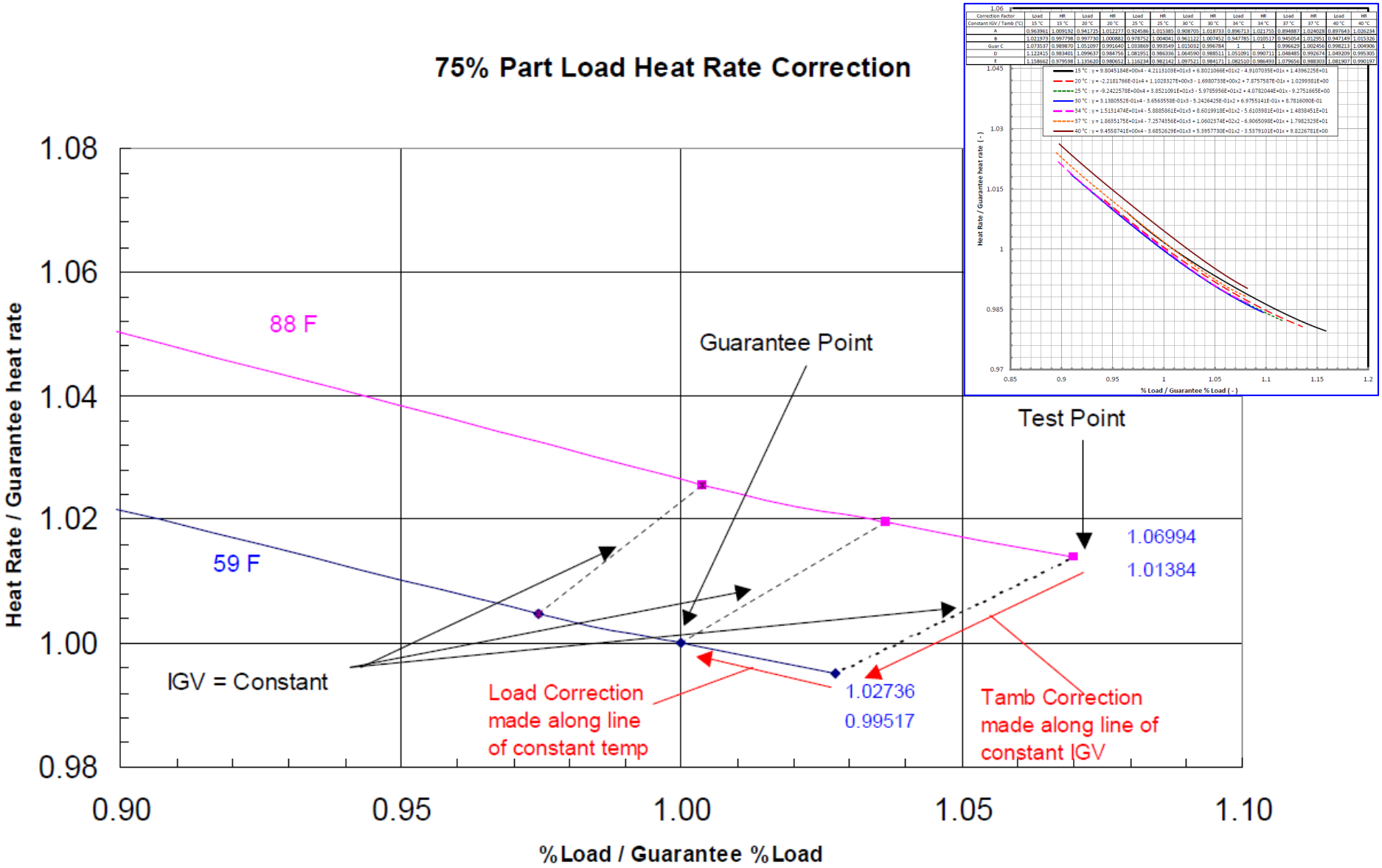
Owner	NP	P-Deg_O
1203.76809	0.3799	1.00379949
1479	0.4176	1.00417560
-275.23191	-0.0376	0.99962389

GE	HR	H-Deg_G
1203.76809	0.1262	0.99873841
1479	0.1382	0.99861848
-275.23191	-0.0120	1.00011993

GE	NP	P-Deg_G
1203.76809	0.2850	1.00285019
1479	0.3237	1.00323683
-275.23191	-0.0387	0.99961336

9 P-Test Format – CCPP HR for Part Load (MMCC Sample)

➢ **ASME PTC 46 Appendix H (GEK 111095로부터 유래)에 따른 Part Load Correction 계산서를 마련함.**



9 P-Test Format – CCPP HR for Part Load (MMCC Sample)

Symbol	Formula	Description	Unit	Data	Correction-P [α / Δ]	Correction-H [f]	Reference Condition
0. Test Target Load (As Reference Condition)		Capacity of CAC x Target Part Load Frac	kW	530,972			
1. Input Data for Plant Performance (As Tested)			-				
ambT	(Measured Average)	Ambient Temperature (dbT)	degC	31.98			
ambP	(Measured Average)	Ambient Pressure	mbara	1,004.28			
ambH	(Measured Average)	Ambient Humidity (RH)	%	54.00			
cwT	(Measured Average)	CW Temperature	degC	29.8			
HHV_V	(Measured Average)	HV Sup	MJ/m3	38.81			
DEN	(Measured Average)	Gas Density	kg/m3	0.7368			
HHV	HHV_V / DEN x 1000	Fuel HHV	kJ/kg	52,674			
WGT	(Measured Average)	Fuel Flow	kg/h	67,977			
PCCPL-meas	(Measured Average)	Net Power Output	kW	533,535			
Q	WGT x HHV	Measured heat consumption	kJ/hr	3,580,620,856			
HR	Q / P	Net Heat Rate (As Tested)	kJ/kWh	6,711			
2. Corrected Performance							
PCorr	(Result of CAC Test)	Correted Net Output at Base Load	kW	758,532			
α1	(Pitting from Curve)	CF_BS_ambT(Ref to Test ambT)	-	31.98	0.999952		32
PCC-Base	PCorr / α1	Base Net Output at ambT	kW	758,568			
ΔA	(Measured & Calculated)	Auxiliary Power Consumption	kW	6,540.34	6,540		
Δ1PL	(Pitting from Curve)	CF_PL_P-cwT	kW	29.82	2,026		32
α2PL	(Pitting from Curve)	CF_PL_P-ambP	-	1,004.28	1.009240		1,013
α3PL	(Pitting from Curve)	CF_PL_P-ambH	-	54.00	1.000980		80
PCC-Part	PCCPL-meas – ΔA – Δ1PL) x α2PL x α3PL	Corrected partload CC at ambT	kW	530,338			
X	(Target Part Load Fraction)	Target Part Load Fraction	%	70.00			
PPLfrac	100 x PCC-part / PCC-Base	test part-load fraction	%	69.91			
PPLfrac-ratio	PPLfrac / X	part-load fraction ratio	-	0.998758			
Q	WGT x HHV	Measured heat consumption	kJ/hr	3,580,620,856			
PPL-INT	PCC-Part	Inter-Corrected Net Output	kW	530,338			
f2PL	(Pitting from Curve)	CF_PL_Ambient Pressure	-	1,004.28		0.999532	1,013
f3PL	(Pitting from Curve)	CF_PL_Ambient Humidity	-	54.00		1.000677	80
HRPL-INT	(Q / PPL-INT) x f2PL x f3PL	Inter-Corrected Net Heat Rate	kJ/kWh	6,752.99			
f1PL	(Pitting from Curve)	CF_PL_Ambient Temperature	-	31.98		1.000002	32
HRcorr-PL	HRPL-INT x f1-PL	Correted Net Heat Rate	kJ/kWh	6,753.00			

BLUE : Input Data from Measurement
PURPPLE : Calculated Data from Correction Curve
RED : Calculated Data

9 P-Test Format – CCPP HR for Part Load (MMCC Sample)

PERFORMANCE TEST CALCULATION SHEET FOR HEAT RATE FOR PART LOAD (DTAILED CALCULATION)							
NAME OF PLANT :	Melaka 2,242MW CCGT Power Plant			GB NO. :	GB 2	GB 2	GB 2	GB 2
OFFICIAL TEST DATE :	2022-02-17			TEST NO. :	PPA-HR-90%	PPA-HR-70%	PPA-HR-60%	PPA-HR-Minload
LOGGING TIME :	09:30 AM	~	05:00 PM	LOAD :	90% Load	70% Load	60% Load	Min Load(374MW)
FUEL :	Natural Gas from Petronas			SHEET :	11:00~11:30	12:30~13:00	14:00~14:30	16:30~17:00

Part 1: **Determine the test combined cycle part-load fraction**

Step 1:	Calculate baseload combined cycle power output at part-load test ambient temperature						
	$P_{CC\text{-}Base}$	= Baseload CC Power Output at part load test ambient temperature = PCorr / α1	763,910.43439924	758,568.38234607	759,168.06643871	759,857.98931057	kW
	Where:						
	P_{Corr}	= Corrected CC power output from Section 5.1	758,532.00000000	758,532.00000000	758,532.00000000	758,532.00000000	kW
	α_1	= Baseload Correction Factor to correct from reference ambient temperature to part-load test ambient temperature	0.99295934	0.99995204	0.99916215	0.99825495	
Step 2:	Calculate part-load combined cycle power output at part-load test ambient temperature using relevant part load correction curves						
	$P_{CC\text{-}Part}$	= Corrected partload combined cycle Power Output at part-load test ambient temperature, kW = (PCCPL-meas – Δ1PL) * α2PL * α3PL, kW	686,662.19259094	530,338.19447656	452,929.75013644	371,159.82462818	kW
	Where:						
	$P_{CCPL\text{-}meas}$	= Measured CC Power Output during the part load CC test	689,646.53935000	533,535.01156667	455,765.46790000	373,676.88361667	kW
	Δ_A	= Calculated Auxiliary Load feeding from Common (Refer to Appendix D)	6,558.30582000	6,540.33559000	6,509.17443000	6,495.51620000	kW
	Δ_{1PL}	= Correction Factor to correct from PL test to reference cooling water temperature	1,944.74334704	2,026.33796070	1,719.53504291	1,517.51214709	kW
	α_{2PL}	= Correction Factor to correct from PL test to reference ambient pressure	1.00870599	1.00924019	1.01066365	1.01253537	
	α_{3PL}	= Correction Factor to correct from PL test to reference ambient humidity	0.99940134	1.00097968	1.00137211	1.00246386	
	Note: The α_{iPL} and Δ_{PL} correction factors will be determined in a similar fashion as outlined in Section 5.2.2						
Step 3:	Calculate test part-load fraction and the part-load fraction ratio at the part-load test ambient temperature:						
	P_{PLfrac}	= 100 * PCC-part / PCC-Base	89.88778811	69.91303709	59.66132799	48.84594620	%
	$P_{PLfrac\text{-}ratio}$	= PPLfrac / X	0.99875320	0.99875767	0.99435547	0.99067415	
	Where,						
	X	= Target Part Load Fraction (90%, 70%, 60%, Ratio of Min Load(374MW)), %	90.00000000	70.00000000	60.00000000	49.30576429	%
Step 4:	Determine the combined ambient temperature and heat rate correction factor for combined cycle:						
	f1-PL						
	Use the $P_{PLfrac\text{-}ratio}$, measured ambient temperature, along with curves						
	to determine the combined ambient temperature and heat rate correction factor for the combined cycle						
	This factor is depicted by "f1-PL".						

9 P-Test Format – CCPP HR for Part Load (MMCC Sample)

PERFORMANCE TEST CALCULATION SHEET FOR HEAT RATE FOR PART LOAD (DTAILED CALCULATION)						
NAME OF PLANT :	Melaka 2,242MW CCGT Power Plant		GB NO. :	GB 2	GB 2	GB 2	GB 2
OFFICIAL TEST DATE :	2022-02-17		TEST NO. :	PPA-HR-90%	PPA-HR-70%	PPA-HR-60%	PPA-HR-Minload
LOGGING TIME :	09:30 AM ~ 05:00 PM		LOAD :	90% Load	70% Load	60% Load	Min Load(374MW)
FUEL :	Natural Gas from Petronas		SHEET :	11:00~11:30	12:30~13:00	14:00~14:30	16:30~17:00

Part 2: **Determine corrected combined cycle heat rate at 90% 70% 60% or 49% CC load. Two steps, as follows, are involved:**

Measured heat consumption

Q	=	WGT * HHV, kJ/hr	4,480,810,343.37333000	3,580,620,856.18953000	3,156,188,128.52614000	2,697,164,164.26572000	kJ/hr
WGT	=	Gas Turbine fuel flow rate, kg/hr	85,067.27804683	67,977.36271168	59,919.59322592	51,205.11611005	kg/hr
HHV	=	HHB_V / DEN, kJ/kg	52,673.72421281	52,673.72421281	52,673.72421281	52,673.72421281	kJ/kg
HHV_V	=	Fuel Gas HHV per Volume, MJ/m3	38.81000000	38.81000000	38.81000000	38.81000000	MJ/m3
DEN	=	Gas Density, kg/m3	0.73680000	0.73680000	0.73680000	0.73680000	kg/m3

Step 1: Calculate an intermediate heat rate at the test ambient temperature with all other boundary conditions at reference.

P_{PL-INT}	= Intermediate Corrected combined cycle Equipment Net Output = (P – ΔA – Δ1PL) * α2PL * α3PL, kW	686,662.19259094	530,338.19447656	452,929.75013644	371,159.82462818	kW
$H_{RPL-INT}$	= Intermediate Corrected combined cycle Power Net Heat Rate = (Q / PPL-INT)*f2PL*f3PL	6,526.03935056	6,752.99253849	6,966.42440504	7,260.15197920	kJ/kWh

Where:

f_{2PL}	= Correction Factor to correct from PL test to reference ambient pressure	0.99965630	0.99953207	0.99939732	0.99908072	
f_{3PL}	= Correction Factor to correct from PL test to reference ambient humidity	1.00042735	1.00067743	1.00032176	0.99999704	

Step 2: Calculate the final corrected combined cycle heat rate
by applying the combined ambient temperature and heat rate correction factor for load as follows:

$H_{Rcorr-PL}$	= HRPL-INT * F1-PL	6,527.83382384	6,753.00410154	6,966.51600214	7,260.32481698	kJ/kWh

Where:

f_{1PL}	= Correction Factor to correct from PL test to reference ambient temperature	1.00027497	1.00000171	1.00001315	1.00002381	

BLUE : Input Data from Measurement
PURPPLE : Calculated Data from Correction Curve
RED : Calculated Data