MAN TURBO AG

Doc. No.:	100005 64544	Rev. 1	ATP&R-THM
Code Word:	VILLARPIPE 3		Appendix RVT
Order No.:	H.0200017		Page 1 of 43

Acceptance Test Procedure and Report for the THM Gas Turbine

Appendix RVT
Results of Thermodynamic and Mechanical Verification Test

Contract Engine	Gas Turbine Type: THM 1304 – 12 DLN Serial No. GG: 2156 / PT: 2156
Location of Test	MAN Turbo AG, Oberhausen, Germany
Date of Test	10.11.09
Test Engineer	B.Zimprich, M.Nern
Customer's Representatives	Mr. Rafel Moreno (Enagas) Mr. Eduardo Garcia (Enagas)

Contents

The Revision was marked with <1>.

Date:	19/01/10	prepared by:	Nern / PP53
Date:	22.01.10	checked by:	Krüger / PG 1
Date:	27/01/2010	released by:	Thomas / PP53

1 General

This document is an Appendix to the document "Acceptance Test Procedure an Report for the THM Gas Turbine, Cover Sheet ", No. 100005 64540.

The verification test was performed on 10.11.09 as described in Appendix DVT.

2 Comments on the Verification Test

The handwritten log sheets of the test and the signed printouts of the measured data were given to the customer's representative at the end of the test run.

3 Results

The thermodynamic performance test and the mechanical running test were conducted on the test stand of MAN Turbo AG, to furnish proof of compliance with designed data of the gas turbine.

Guarantee values

The expected shaft power output of 12.3 MW according to Document 100001 65361 (Annex LGD) was reached at a measured PT inlet temperature T4 of 787 °C. This temperature is below the max. allowable temperature of 802 °C .

The emission measurement values related to 15 % O2 are below the guarantee values NOx (50 mg/m³_n) and CO (30 mg/m³_n) according ATP Appendix LGD. <1>

Operating Point A

Measured Values	**MP. 40**
Ambient pressure [kPa]	100.39
Ambient temperature [°C]	7.2
Inlet pressure loss [kPa]	2.32
Outlet pressure loss [kPa]	0
Power turbine speed [rpm]	7253
Torque [Nm]	5637
Fuel gas volume flow [m³_n/h]	2246
Calorific value [MJ/m³_n]*	32.596
Correction factor of inlet loss	
ε_1 Power	0.9546
ε_1 Heat rate	0.9784
Calculated Values (real)	
Power [kW]	4281

* Calorific value according the taken gas sample

	MP.40		Operating point A (ISO Cond.)
Calculated Values (ISO Cond.)			
Power turbine speed [rpm]	7353		7354
Power [kW]	4588		4577
Heat Rate [kJ/kWh]	16729		17690

The heat rate guarantee for operating point A has been met.

Therefore all guarantees have been met.

The vibratory condition of the gas turbine "VILLARPIPE 3" is good and according to the above mentioned specifications.

4 Graphical Analysis

Conversion of Measured Data to Guarantee Conditions CMG Rev. 2

Order:	*VILLARPIPE 3*	*Date of Test:*	*10.11.2009*		
Order No.:	*H.0200017*	*Prepared:*	*M.Nem*	*Date:*	*13.11.2009*
Mach-No.:	*2156*	*Checked:*	*D.Krüger*	*Date:*	*16.11.2009*

Measured Data during Acceptance Test Fuel Lower Heating Value : 32,5960 MJ/m^3_N

		Measuring Point -	Time -	GG Speed rpm	PT Speed rpm	TORQUE Nm	Fuel Volume Flow m^3_N/h	Ambient Pressure kPa	Inlet Press. Loss kPa	Average Inlet Temperature °C	Average PT Inlet Temperature °C	Exh. Press. Loss kPa	Degradation Factor -
GG Speed 1	*1*	41	11:15:02	10649	6121	7347	2334	100,39	2,515	7,2	577,4	0,000	1,000
	2	42	11:18:15	10649	6908	6562	2355	100,39	2,555	7,1	580,4	0,000	1,000
	3	43	11:22:00	10649	7696	5814	2367	100,38	2,560	7,2	583,0	0,000	1,000
	4												
	5												
	6												
GG Speed 2	*1*	44	11:43:01	11044	6903	8967	2866	100,38	3,280	6,8	629,4	0,000	1,000
	2	45	11:46:12	11043	7687	8136	2886	100,38	3,265	6,7	631,9	0,000	1,000
	3	46	11:49:01	11044	8481	7306	2895	100,37	3,420	6,8	635,4	0,000	1,000
	4												
	5												
	6												
GG Speed 3	*1*	47	12:04:52	11248	7298	10034	3209	100,36	3,610	6,6	671,8	0,000	1,000
	2	48	12:07:19	11248	7688	9586	3214	100,36	3,565	6,7	673,6	0,000	1,000
	3	49	12:10:21	11250	8081	9148	3219	100,36	3,565	6,6	675,7	0,000	1,000
	4	50	12:13:54	11248	8479	8694	3219	100,36	3,560	6,7	677,2	0,000	1,000
	5	51	12:17:13	11249	9038	8026	3230	100,35	3,625	6,6	679,1	0,000	1,000
	6												
GG Speed 4	*1*	52	12:32:59	11437	7290	11465	3566	100,34	3,975	6,4	715,2	0,000	1,000
	2	53	12:36:08	11438	7680	11032	3573	100,34	4,050	6,4	716,7	0,000	1,000
	3	54	12:38:42	11437	8077	10574	3571	100,34	4,020	6,4	716,8	0,000	1,000
	4	55	12:46:05	11437	8474	10140	3582	100,34	3,990	6,4	718,3	0,000	1,000
	5	56	12:48:40	11437	9038	9430	3588	100,34	4,005	6,5	719,4	0,000	1,000
	6												
GG Speed 5	*1*	57	13:03:24	11637	7291	13005	3969	100,33	4,685	6,8	759,4	0,000	1,000
	2	58	13:06:52	11640	7687	12567	3976	100,32	4,530	6,5	761,3	0,000	1,000
	3	59	13:11:08	11635	8087	12102	3979	100,31	4,455	6,5	762,4	0,000	1,000
	4	60	13:13:22	11641	8479	11649	3981	100,31	4,465	6,5	763,4	0,000	1,000
	5	61	13:17:19	11633	9037	10969	3990	100,31	4,415	6,8	764,3	0,000	1,000
	6												
GG Speed 6	*1*	62	13:32:52	11769	7698	13567	4269	100,30	4,855	6,8	790,7	0,000	1,000
	2	63	13:34:54	11766	8087	13087	4270	100,29	4,865	6,8	791,3	0,000	1,000
	3	64	13:37:49	11770	8484	12640	4277	100,29	4,890	6,8	792,1	0,000	1,000
	4	65	13:39:27	11768	9040	11968	4288	100,29	4,860	6,8	793,4	0,000	1,000
	5												
	6												

Degradation Factors acc. to Document 10000010153

Conversion of Measured Data to Guarantee Conditions CMG Rev. 2

Order: VILLARPIPE 3 *Date of Test: 10.11.2009*
Order No.: H.0200017 *Prepared: M.Nem* *Date: 13.11.2009*
Mach No.: 2156 *Checked: D.Krüger* *Date: 16.11.2009*

Correction of Measured Data
Reference Inlet Temperature [°C] : 6,7

Data corrected to :
Sea Level, No Losses, 6,7°C Inlet Temperature

		Measuring Point -	Time -	Measured Shaft Power kW	Power Corr. Factor Inlet Press. Loss $\varepsilon_{P,in}$ -	Power Corr. Factor Exh. Press. Loss $\varepsilon_{P,ex}$ -	Efficiency Corr. Factor Inlet Press. Loss $\varepsilon_{\eta,in}$ -	Efficiency Corr. Factor Exh. Press. Loss $\varepsilon_{\eta,ex}$ -	Corr. Factor Ambient Press. δ -	Corr. Factor Average Inlet Temp. θ -	PT Speed rpm	GG Speed rpm	Shaft Power Output kW	Efficiency [%]	PT Inlet Temperature °C	*Reference Inlet Temp. °C*	*Average GG Speed rpm*
GG Speed 1	*1*	41	11:15:02	4709	0,9508	1,0000	0,9766	1,0000	0,9906	1,0017	6116	10640	4995	22,82	576		
	2	42	11:18:15	4747	0,9500	1,0000	0,9762	1,0000	0,9908	1,0015	6903	10641	5039	22,80	579		
	3	43	11:22:00	4686	0,9499	1,0000	0,9762	1,0000	0,9907	1,0016	7690	10640	4976	22,40	582		
	4																
	5															7,2	10640
	6																
GG Speed 2	*1*	44	11:43:01	6462	0,9358	1,0000	0,9695	1,0000	0,9907	1,0004	6902	11042	6991	25,76	629		
	2	45	11:46:12	6549	0,9361	1,0000	0,9696	1,0000	0,9907	1,0000	7687	11043	7083	25,85	632		
	3	46	11:49:01	6489	0,9331	1,0000	0,9682	1,0000	0,9906	1,0002	8480	11043	7020	25,57	635		
	4																
	5															6,8	11042
	6																
GG Speed 3	*1*	47	12:04:52	7668	0,9293	1,0000	0,9664	1,0000	0,9905	0,9995	7300	11251	8333	27,31	672		
	2	48	12:07:19	7718	0,9302	1,0000	0,9668	1,0000	0,9905	0,9999	7688	11248	8377	27,43	674		
	3	49	12:10:21	7742	0,9302	1,0000	0,9668	1,0000	0,9905	0,9997	8082	11252	8404	27,47	676		
	4	50	12:13:54	7720	0,9303	1,0000	0,9669	1,0000	0,9905	0,9999	8479	11248	8378	27,39	677		
	5	51	12:17:13	7596	0,9290	1,0000	0,9663	1,0000	0,9904	0,9996	9040	11251	8257	26,88	679		
	6															6,6	11250
GG Speed 4	*1*	52	12:32:59	8752	0,9222	1,0000	0,9630	1,0000	0,9903	0,9990	7294	11443	9589	28,15	716		
	2	53	12:36:08	8873	0,9207	1,0000	0,9623	1,0000	0,9903	0,9989	7684	11444	9736	28,50	718		
	3	54	12:38:42	8944	0,9213	1,0000	0,9626	1,0000	0,9903	0,9990	8081	11442	9808	28,74	718		
	4	55	12:46:05	8998	0,9219	1,0000	0,9629	1,0000	0,9903	0,9990	8478	11443	9861	28,81	719		
	5	56	12:48:40	8925	0,9216	1,0000	0,9628	1,0000	0,9903	0,9992	9042	11442	9783	28,54	720		
	6															6,4	11443
GG Speed 5	*1*	57	13:03:24	9929	0,9083	1,0000	0,9564	1,0000	0,9902	0,9995	7293	11640	11043	28,89	760		
	2	58	13:06:52	10116	0,9113	1,0000	0,9579	1,0000	0,9901	0,9993	7690	11644	11215	29,33	762		
	3	59	13:11:08	10249	0,9128	1,0000	0,9586	1,0000	0,9900	0,9992	8090	11640	11346	29,68	763		
	4	60	13:13:22	10343	0,9126	1,0000	0,9585	1,0000	0,9900	0,9994	8482	11644	11452	29,94	764		
	5	61	13:17:19	10380	0,9136	1,0000	0,9589	1,0000	0,9900	0,9996	9039	11635	11479	29,96	765		
	6															6,5	11641
GG Speed 6	*1*	62	13:32:52	10937	0,9050	1,0000	0,9548	1,0000	0,9899	1,0003	7697	11767	12207	29,63	790		
	2	63	13:34:54	11083	0,9048	1,0000	0,9548	1,0000	0,9898	1,0003	8086	11766	12374	30,03	791		
	3	64	13:37:49	11229	0,9043	1,0000	0,9545	1,0000	0,9898	1,0003	8483	11766	12544	30,38	792		
	4	65	13:39:27	11329	0,9049	1,0000	0,9548	1,0000	0,9898	1,0002	9039	11767	12648	30,56	793		
	5															6,8	11767
	6																

6,7

Correction Factors for Pressure Losses acc. to Document 10000086928

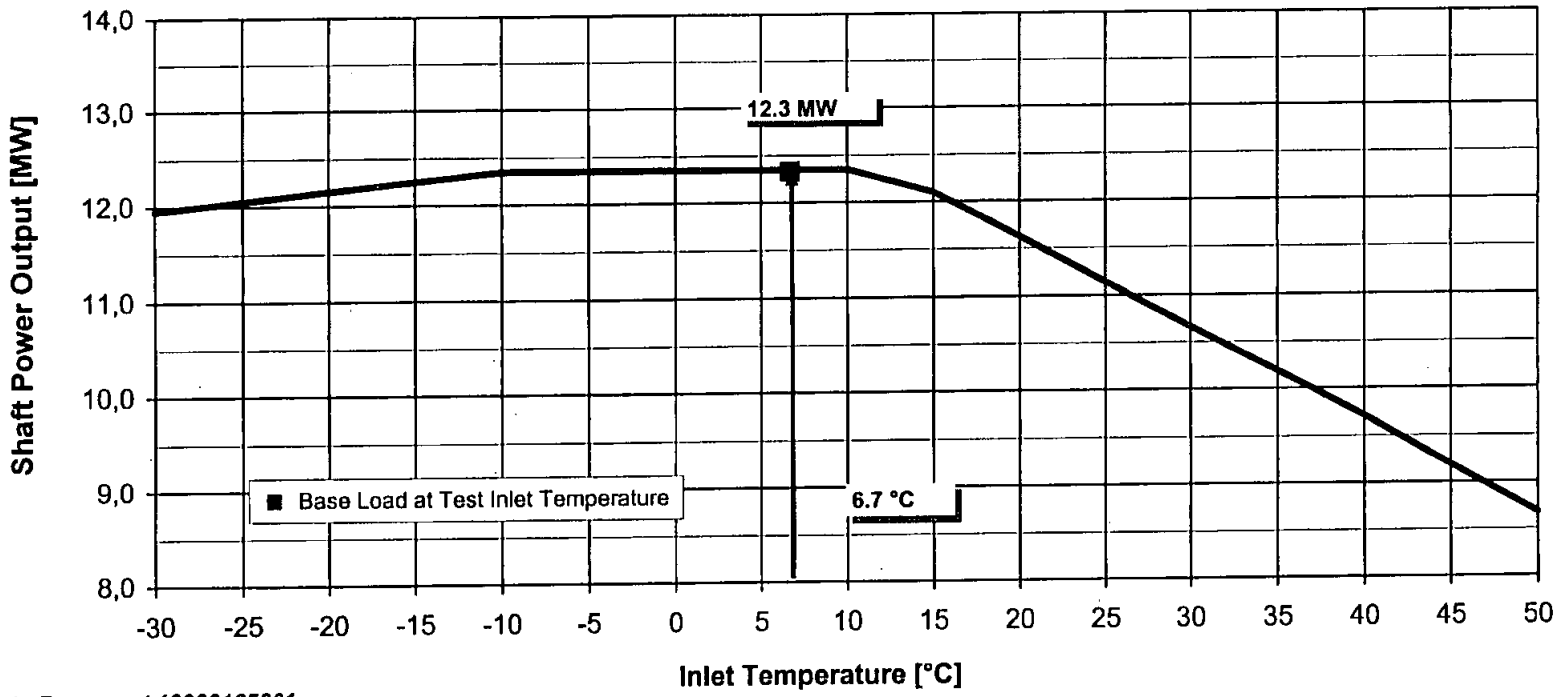
Conversion of Measured Data to Guarantee Conditions CMG Rev. 2

Order:	***VILLARPIPE 3***	*Date of Test:*	*10.11.2009*		
Order No.:	***H.0200017***	*Prepared:*	*M.Nern*	*Date:*	*13.11.2009*
Mach No.:	***2156***	*Checked:*	*D.Krüger*	*Date:*	*16.11.2009*

Sea Level, No Losses

Shaft Power Output vs. Inlet Temperature

Power Turbine Speed 8600 rpm
No Water Injection

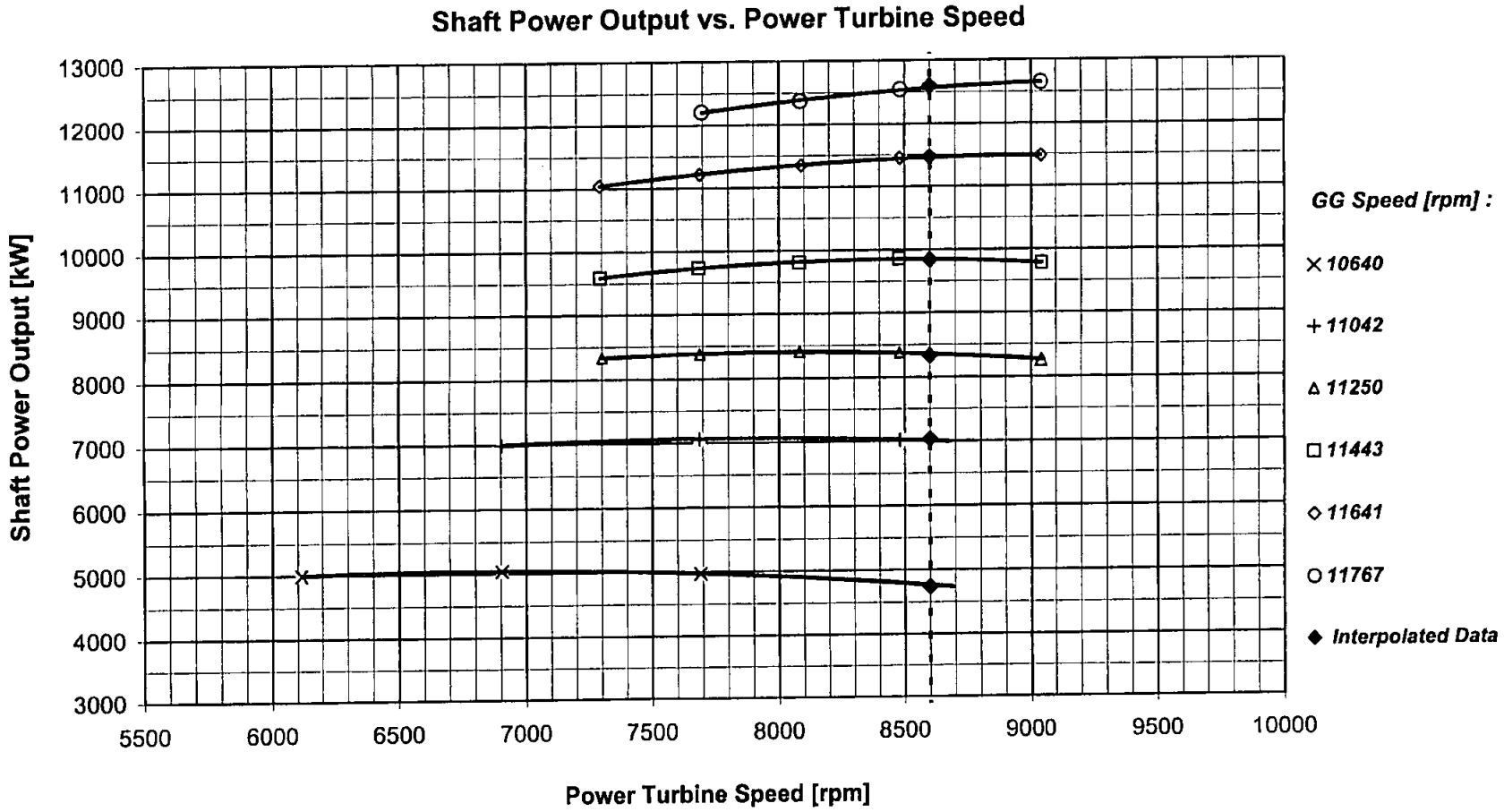


Refer to Document 10000165361

Conversion of Measured Data to Guarantee Conditions CMG Rev. 2

Order:	***VILLARPIPE 3***	*Date of Test:*	*10.11.2009*
Order No.:	***H.0200017***	*Prepared:*	*M.Nern* *Date: 13.11.2009*
Mach No.:	***2156***	*Checked:*	*D.Krüger* *Date: 16.11.2009*

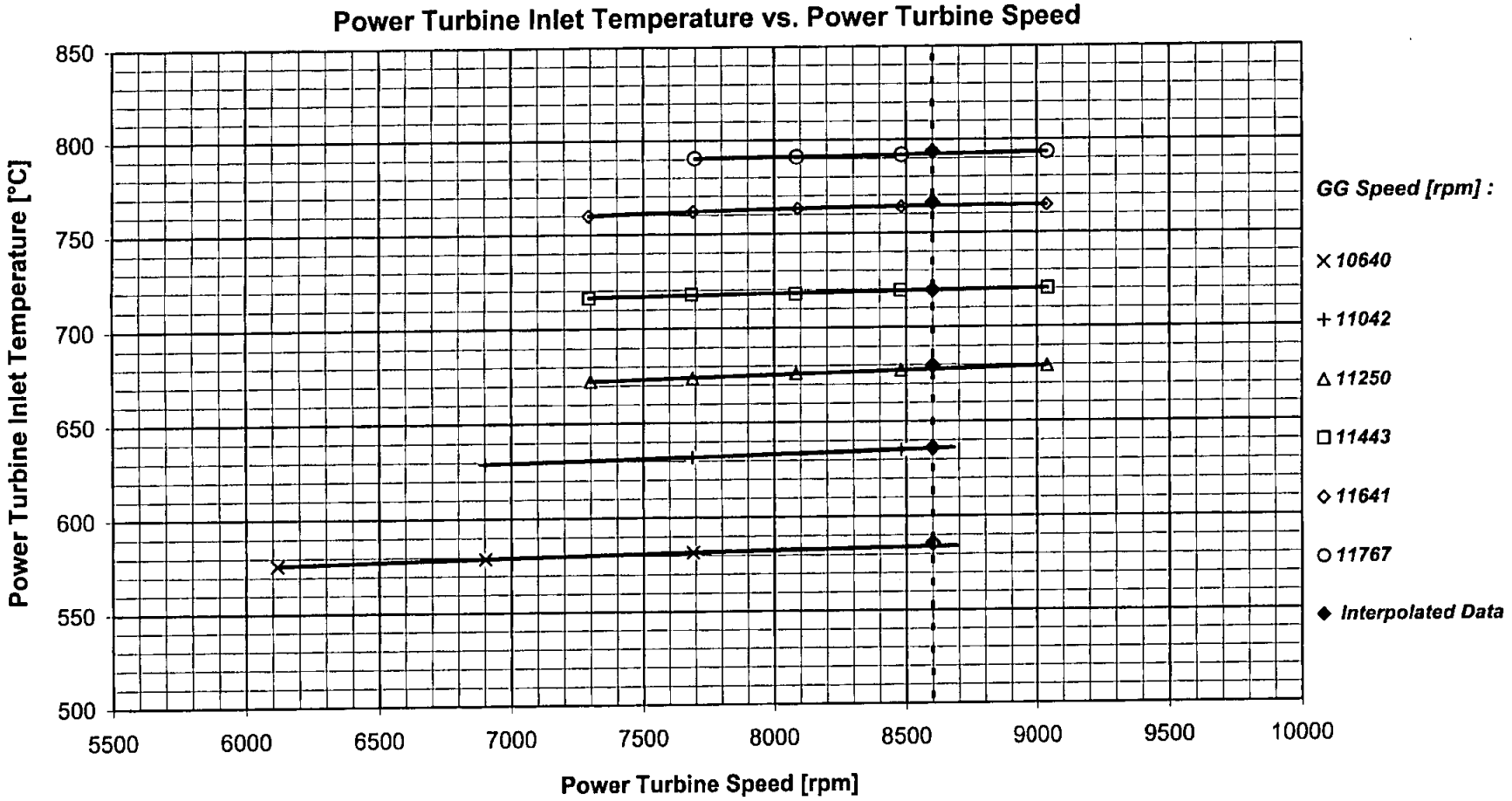
Sea Level, No Losses, 6,7°C Inlet Temperature



Conversion of Measured Data to Guarantee Conditions CMG Rev. 2

Order: VILLARPIPE 3	*Date of Test:*	*10.11.2009*	
Order No.: H.0200017	*Prepared:*	*M.Nern*	*Date: 13.11.2009*
Mach No.: 2156	*Checked:*	*D.Krüger*	*Date: 16.11.2009*

Sea Level, No Losses, 6,7°C Inlet Temperature



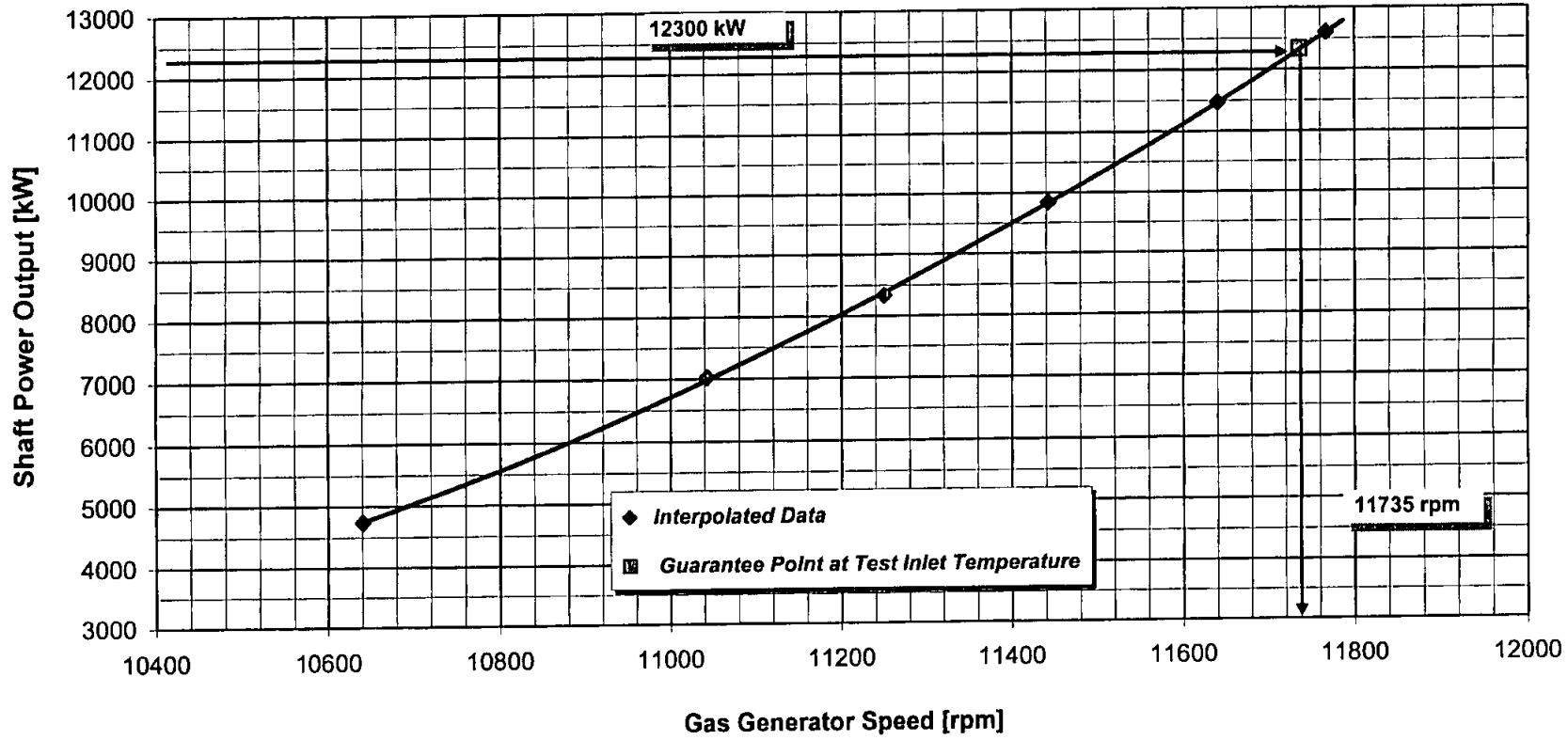
Conversion of Measured Data to Guarantee Conditions CMG Rev. 2

Order:	***VILLARPIPE 3***	*Date of Test:*	*10.11.2009*
Order No.:	***H.0200017***	*Prepared:*	*M.Nern*
Mach No.:	***2156***	*Checked:*	*D.Krüger*

Date: 13.11.2009
Date: 16.11.2009

Sea Level, No Losses, 6,7°C Inlet Temperature, 8600 rpm Power Turbine Speed

Shaft Power Output vs. Gas Generator Speed



Conversion of Measured Data to Guarantee Conditions CMG Rev. 2

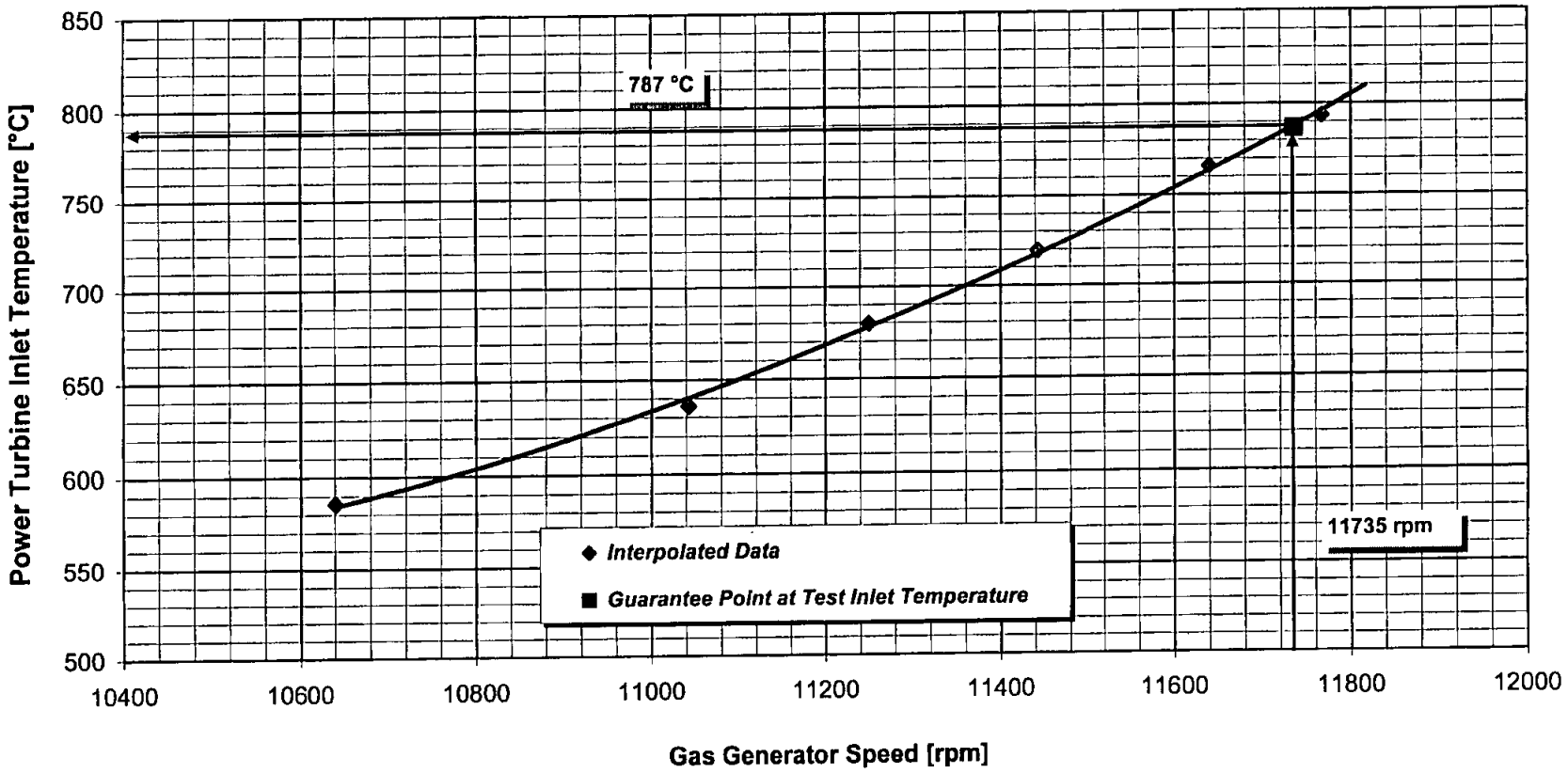
Order:	***VILLARPIPE 3***	*Date of Test:*	*10.11.2009*
Order No.:	***H.0200017***	*Prepared:*	*M.Nern*
Mach No.:	***2156***	*Checked:*	*D.Krüger*

Date: 13.11.2009

Date: 16.11.2009

Sea Level, No Losses, 6,7°C Inlet Temperature, 8600 rpm Power Turbine Speed

Power Turbine Inlet Temperature vs. Gas Generator Speed



Conversion of Measured Data to Guarantee Conditions CMG Rev. 2

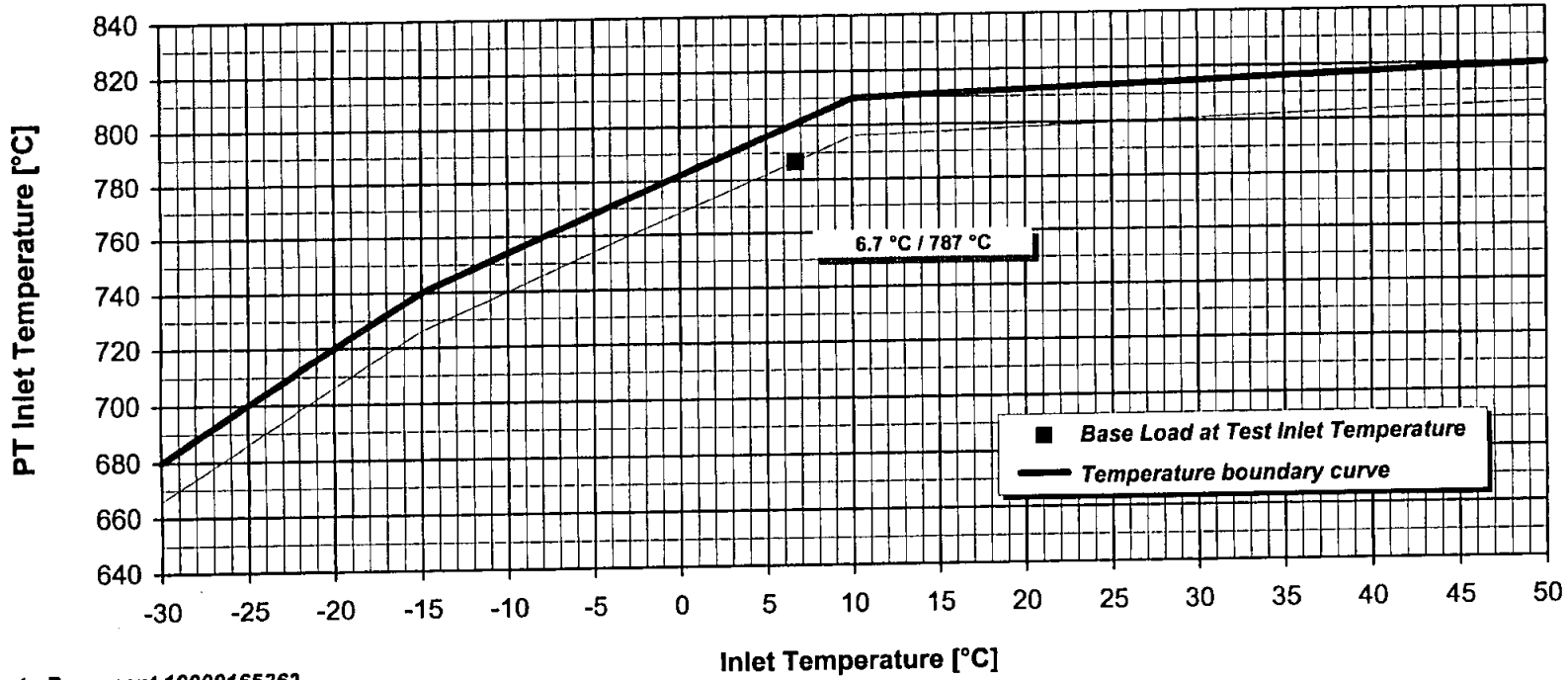
Order:	***VILLARPIPE 3***	*Date of Test:*	*10.11.2009*
Order No.:	***H.0200017***	*Prepared:*	*M.Nern*
Mach No.:	***2156***	*Checked:*	*D.Krüger*

Date: 13.11.2009
Date: 16.11.2009

Sea Level, No Losses

Power Turbine (PT) Inlet Temperature vs. Inlet Temperature

Power Turbine Speed 8600 rpm
Standard Combustion System, No Water Injection



Refer to Document 10000165362

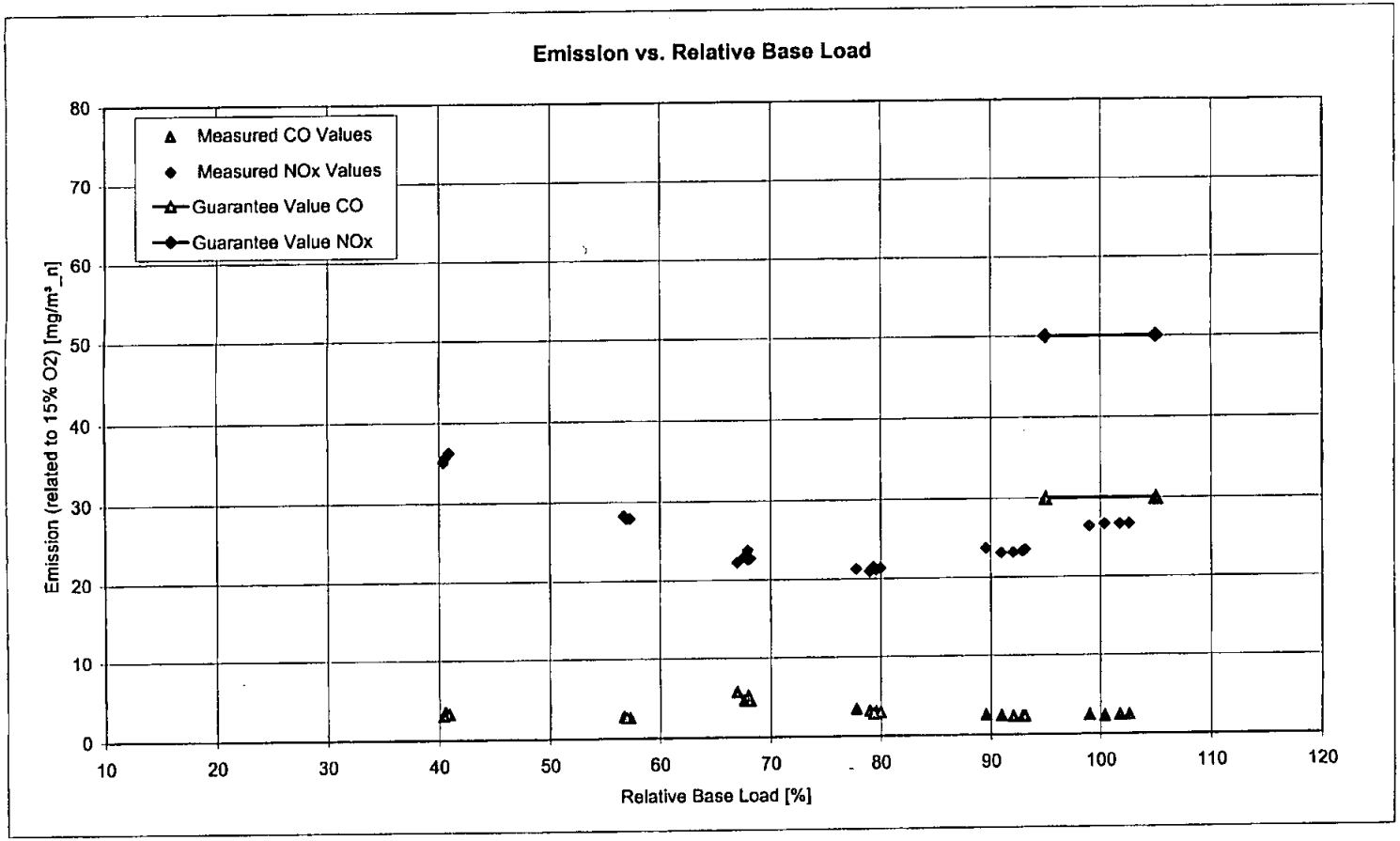
Temperature curve points

Inlet Temperature [°C]	50	10	-15	-30			
PT Inlet Temperature [°C]	806	796	726	666			

Conversion of Measured Data to Guarantee Conditions CMG Rev. 2

Order: VILLARPIPE 3 *Date of Test: 10.11.2009*
Order No.: H.0200017 *Prepared: M.Nem* *Date: 09.03.09*
Mach No.: 2156 *Checked: D.Krüger* *Date: 11.03.09*

Measuring Point		GG Speed 1			GG Speed 2			GG Speed 3					GG Speed 4					GG Speed 5					GG Speed 6			
		41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65
O2 measured	Vol %	16,9	16,9	16,9	16,4	16,4	16,4	16,1	16,1	16,1	16,1	16,1	15,8	15,7	15,7	15,7	15,7	15,4	15,3	15,3	15,3	15,3	15,1	15,0	15,0	15,0
CO Measured	mg/m³_n	2,4	2,2	2,1	2,1	2,0	2,0	3,8	3,8	3,8	4,3	4,7	3,0	2,8	2,7	2,6	2,5	2,4	2,3	2,2	2,2	2,2	2,4	2,3	2,4	2,4
NO measured	mg/m³_n	12,6	12,8	12,3	10,2	10,0	10,1	8,2	8,6	8,2	8,0	7,9	8,0	7,9	8,0	8,2	8,2	10,2	9,9	9,9	10,2	10,5	12,7	12,9	13	13,1
NO2 measured	mg/m³_n	5,0	5,2	5,3	5,8	6,0	5,9	6,1	6,3	6,0	6,2	6,1	6,2	6,2	6,2	6,2	6,3	6,7	6,7	6,7	6,5	6,3	6,8	6,8	6,7	6,6
NOx measured	mg/m³_n	24,3	24,8	24,2	21,4	21,3	21,4	18,7	19,5	18,6	18,5	18,2	18,5	18,3	18,5	18,8	18,9	22,3	21,9	21,9	22,1	22,4	26,3	26,6	26,6	26,7
CO (related to 15% O2)	mg/m³_n	3,5	3,2	3,1	2,8	2,6	2,6	4,7	4,6	4,6	5,2	5,7	3,4	3,2	3,1	3,0	2,8	2,6	2,4	2,3	2,3	2,3	2,4	2,3	2,4	2,4
NOx (related to 15% O2)	mg/m³_n	35,6	36,3	35,1	28,3	28,0	28,0	22,9	23,8	22,7	22,5	22,2	21,2	20,9	21,1	21,3	21,5	23,7	23,1	23,2	23,3	23,5	26,5	26,8	26,8	26,8
CO (related to 15% O2)	ppm	2,8	2,6	2,4	2,2	2,1	2,1	3,7	3,7	3,7	4,2	4,6	2,8	2,6	2,5	2,4	2,3	2,0	1,9	1,9	1,9	1,8	1,9	1,9	1,9	1,9
NOx (related to 15% O2)	ppm	17,4	17,7	17,1	13,8	13,6	13,6	11,2	11,6	11,1	11,0	10,8	10,3	10,2	10,3	10,4	10,5	11,6	11,3	11,3	11,4	11,5	12,9	13,0	13,0	13,0



5 Test Run Log Sheets

TEST READINGS

Official Mechanical Running and Shop Performance Test

Dept.	Code Word	Job No.	Machine No.	
PP53	VILLARPIPE 3	H.0200017	GG 2156 / PT 2156	
	Name: Zimprich		Date: 10.11.09	Sheet: 1/2

MP-No.	Time	Speed GG actual	Speed PT actual		
/	hh:mm	rpm	rpm		
				Gas Turbine	
				Type: THM 1304-12	
				Machine No. 2156	
	10:10			Start of the gas turbine	
	10:15			Warming up speed reached	
40	11:05	10526	7253	Measurement	for Operating point A*
41	11:15	10649	6121	Measurement	for $n_{GG\,150}$ = 10900 rpm
42	11:18	10649	6907	"	
43	11:22	10649	7696	"	
44	11:43	11044	6903	Measurement	for $n_{GG\,150}$ = 11100 rpm
45	11:46	11043	7687	"	
46	11:49	11044	8481	"	
47	12:04	11248	7298	Measurement	for $n_{GG\,150}$ = 11400 rpm
48	12:07	11249	7680	"	
49	12:10	11250	8074	"	
50	12:13	11248	8473	"	
51	12:21	11249	9038	"	
52	12:32	11432	7290	Measurement	for $n_{GG\,150}$ = 11600 rpm
53	12:36	11438	7690	"	
54	12:38	11437	8077	"	
55	12:46	11437	8474	"	
56	12:48	11437	9038	"	

MAN
MAN Turbo AG
Test Department
Oberhausen

SGS Tecnos, S.A.
Fdo.:

TEST READINGS

Official Mechanical Running and Shop Performance Test

Dept.	Code Word	Job No.	Machine No.
PP53	VILLARPIPE 3	H.0200017	GG 2156 / PT 2156

Name	Date	Sheet
Bingerich	10.11.05	2/2

MP-No.	Time	Speed GG actual	Speed PT actual										
/	hh:mm	rpm	rpm										
57	13:03	11637	7294	Measurement									
58	13:06	11640	7697	"									
59	13:11	11635	8097	"		}	for	$n_{GG,tst}$ =	11800	rpm			
60	13:13	11641	8479	"									
61	13:17	11633	9037	"									
62	13:32	11769	7698	Measurement									
63	13:34	11769	8087	"									
64	13:37	11770	8484	"		}	for	$n_{GG,test\ max}$ =					
65	13:39	11768	9040	"									
66	13:40	11727	9037	Measurement									
67	13:55	11736	9038	"		}	mechanical test run						
68	14:10	11736	9037	"									
	14:11			Speed of power turbine increased near trip speed									
69	14:13	11736	9307	Measurement									
	14:15			Speed decreased									
				Cool down phase									
	14:27			Normal Stop ; End of Test Run									

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6 Measurement Readings

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Inicial

MACHINE NO. : 2156 Shop Performance Test
ORDER-NO. : H.0200017
CODEWORD : VILLARPIPE 3
TYPE : THM 1304-12 DLN
DATE OF TEST: 10.11.2009

MEASURINGPOINT		040
SAMPLETIME		11:05
Gas Generator (GG) speed	1/min	10526
Power turbine (PT) speed	1/min	7253
Torque at PT	Nm	5637.2
Guide vane position	GRAD	-18.0
Ambient pressure	bar	1.0039
Relative humidity	%	78.1
Reference temperature	GrdC	8.7
Pressure loss filter	bar	-0.0016
Pressure loss venturi A	bar	0.0945
Pressure loss venturi B	bar	0.0944
Pressure loss venturi C	bar	0.0968
Inlet press. compressor A	bar_g	-0.0241
Inlet press. compressor B	bar_g	-0.0222
Inlet temp. compr. Tt_11	GrdC	7.7
Inlet temp. compr. Tt_12	GrdC	7.3
Inlet temp. compr. Tt_13	GrdC	6.8
Inlet temp. compr. Tt_14	GrdC	7.2
Inlet temp. compr. Tt_15	GrdC	6.9
Inlet temp. compr. Tt_16	GrdC	7.1
Outlet press.compressor A	bar_g	5.8325
Outlet press.compressor B	bar_g	5.8263
Outlet temp. compr. Tt_21	GrdC	265.3
Outlet temp. compr. Tt_22	GrdC	266.7
Inlet press. PT	bar_g	1.0525
Inlet temp. PT Tt_41	GrdC	627.5
Inlet temp. PT Tt_42	GrdC	507.2
Inlet temp. PT Tt_43	GrdC	508.0
Inlet temp. PT Tt_44	GrdC	603.6
Inlet temp. PT Tt_45	GrdC	589.4
Inlet temp. PT Tt_46	GrdC	650.2
Inlet temp. PT Tt_47	GrdC	550.0
Inlet temp. PT Tt_48	GrdC	548.7
Outlet press. PT A	bar_g	-0.0013
Outlet press. PT B	bar_g	-0.0032
Outlet temp. PT Tt_51	GrdC	422.6
Outlet temp. PT Tt_52	GrdC	431.5
Outlet temp. PT Tt_53	GrdC	431.5
Outlet temp. PT Tt_54	GrdC	426.3
Fuel gas temp.	GrdC	16.4
Fuel gas pressure	bar	9.7531
Fuel gas volume flow	m3n/h	2246.3
Oil press.GG f. bearing	bar_g	2.4

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MACHINE NO. : 2156 Shop Performance Test
ORDER-NO. : H.0200017
CODEWORD : VILLARPIPE 3
TYPE : THM 1304-12 DLN
DATE OF TEST: 10.11.2009

MEASURINGPOINT		040
SAMPLETIME		11:05
Oil press.GG r. bearing	bar_g	1.9
Oil press.PT	bar_g	2.1
Oil inlet temp.	GrdC	45.8
Oil vol.flow GG f.bearing	l/min	132.7
Oil vol.flow GG r.bearing	l/min	53.5
Oil vol.flow PT	l/min	121.6
Oil outl.temp.GG f.bear.	GrdC	51.4
Oil outl.temp.GG r.bear.	GrdC	65.6
Oil outl.temp.PT	GrdC	61.7
Shaft vib. GG f.1 unfilt.	my_pp	34
Shaft vib. GG f.2 unfilt.	my_pp	17
Shaft vib. PT r.1 unfilt.	my_pp	24
Shaft vib. PT r.2 unfilt.	my_pp	24
Shaft position GG axial	mm	0.12
Shaft position PT axial	mm	0.15
Temp.journal bear. GG f.1	GrdC	75.4
Temp.journal bear. GG f.2	GrdC	56.7
Temp.thrust bear.GG act.1	GrdC	55.6
Temp.thrust bear.GG act.2	GrdC	56.7
Temp.journal bear. GG r.1	GrdC	78.7
Temp.journal bear. GG r.2	GrdC	56.8
Temp.journal bear. PT f.1	GrdC	58.8
Temp.journal bear. PT f.2	GrdC	79.4
Temp.journal bear. PT r.1	GrdC	60.8
Temp.journal bear. PT r.2	GrdC	58.1
Temp.thrust bear.PT act.1	GrdC	60.9
Temp.thrust bear.PT act.2	GrdC	72.8
Measured O2	%	16.93
Measured CO	mg/m3	2.6
Measured NO	mg/m3	12.6
Measured NO2	mg/m3	4.7

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MACHINE NO. : 2156 Shop Performance Test
ORDER-NO. : H.0200017
CODEWORD : VILLARPIPE 3
TYPE : THM 1304-12 DLN
DATE OF TEST: 10.11.2009

MEASURINGPOINT		041	042	043
SAMPLETIME		11:15	11:18	11:22
Gas Generator (GG) speed	1/min	10649	10649	10649
Power turbine (PT) speed	1/min	6121	6908	7696
Torque at PT	Nm	7346.9	6561.5	5814.3
Guide vane position	GRAD	-17.1	-17.1	-17.1
Ambient pressure	bar	1.0039	1.0039	1.0038
Relative humidity	%	77.2	76.8	77.5
Reference temperature	GrdC	8.6	8.7	8.7
Pressure loss filter	bar	-0.0018	-0.0017	-0.0017
Pressure loss venturi A	bar	0.1023	0.1025	0.1022
Pressure loss venturi B	bar	0.1023	0.1022	0.1019
Pressure loss venturi C	bar	0.1048	0.1046	0.1043
Inlet press. compressor A	bar_g	-0.0262	-0.0266	-0.0267
Inlet press. compressor B	bar_g	-0.0241	-0.0245	-0.0245
Inlet temp. compr. Tt_11	GrdC	7.8	7.7	7.7
Inlet temp. compr. Tt_12	GrdC	7.3	7.2	7.2
Inlet temp. compr. Tt_13	GrdC	6.8	6.8	6.8
Inlet temp. compr. Tt_14	GrdC	7.2	7.2	7.2
Inlet temp. compr. Tt_15	GrdC	6.8	6.9	6.9
Inlet temp. compr. Tt_16	GrdC	7.1	7.0	7.1
Outlet press.compressor A	bar_g	6.1123	6.1186	6.1214
Outlet press.compressor B	bar_g	6.1045	6.1112	6.1142
Outlet temp. compr. Tt_21	GrdC	269.8	270.0	270.3
Outlet temp. compr. Tt_22	GrdC	271.0	271.4	271.7
Inlet press. PT	bar_g	1.1121	1.1173	1.1186
Inlet temp. PT Tt_41	GrdC	633.5	636.7	642.9
Inlet temp. PT Tt_42	GrdC	513.7	519.8	526.6
Inlet temp. PT Tt_43	GrdC	512.8	518.3	522.3
Inlet temp. PT Tt_44	GrdC	602.7	598.9	592.5
Inlet temp. PT Tt_45	GrdC	594.9	596.1	593.1
Inlet temp. PT Tt_46	GrdC	655.3	658.9	660.6
Inlet temp. PT Tt_47	GrdC	552.4	557.8	567.3
Inlet temp. PT Tt_48	GrdC	553.6	556.3	558.5
Outlet press. PT A	bar_g	-0.0014	-0.0003	-0.0010
Outlet press. PT B	bar_g	-0.0016	-0.0029	-0.0031
Outlet temp. PT Tt_51	GrdC	412.3	419.4	426.9
Outlet temp. PT Tt_52	GrdC	419.2	428.9	437.6
Outlet temp. PT Tt_53	GrdC	434.3	426.7	438.5
Outlet temp. PT Tt_54	GrdC	420.4	427.1	429.6
Fuel gas temp.	GrdC	21.0	22.3	23.7
Fuel gas pressure	bar	9.7345	9.7464	9.7140
Fuel gas volume flow	m3n/h	2334.2	2355.4	2366.9
Oil press.GG f. bearing	bar_g	2.4	2.4	2.4

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MACHINE NO. : 2156 Shop Performance Test
ORDER-NO. : H.0200017
CODEWORD : VILLARPIPE 3
TYPE : THM 1304-12 DLN
DATE OF TEST: 10.11.2009

MEASURINGPOINT		041	042	043
SAMPLETIME		11:15	11:18	11:22
Oil press.GG r. bearing	bar_g	1.9	1.9	1.9
Oil press.PT	bar_g	2.2	2.1	2.1
Oil inlet temp.	GrdC	46.0	46.0	46.1
Oil vol.flow GG f.bearing	l/min	133.3	133.4	133.4
Oil vol.flow GG r.bearing	l/min	53.7	53.7	53.7
Oil vol.flow PT	l/min	121.9	122.3	122.6
Oil outl.temp.GG f.bear.	GrdC	51.7	51.7	51.7
Oil outl.temp.GG r.bear.	GrdC	66.3	66.4	66.5
Oil outl.temp.PT	GrdC	59.5	60.9	63.2
Shaft vib. GG f.1 unfilt.	my_pp	34	35	34
Shaft vib. GG f.2 unfilt.	my_pp	18	19	19
Shaft vib. PT r.1 unfilt.	my_pp	24	20	28
Shaft vib. PT r.2 unfilt.	my_pp	26	21	28
Shaft position GG axial	mm	0.11	0.12	0.12
Shaft position PT axial	mm	0.14	0.14	0.14
Temp.journal bear. GG f.1	GrdC	75.7	75.7	75.6
Temp.journal bear. GG f.2	GrdC	57.0	57.0	56.9
Temp.thrust bear.GG act.1	GrdC	56.2	56.1	56.0
Temp.thrust bear.GG act.2	GrdC	57.4	57.3	57.1
Temp.journal bear. GG r.1	GrdC	79.3	79.4	79.4
Temp.journal bear. GG r.2	GrdC	57.2	57.2	57.2
Temp.journal bear. PT f.1	GrdC	57.1	58.5	60.0
Temp.journal bear. PT f.2	GrdC	75.8	78.4	80.8
Temp.journal bear. PT r.1	GrdC	60.8	61.0	61.2
Temp.journal bear. PT r.2	GrdC	56.4	57.6	58.6
Temp.thrust bear.PT act.1	GrdC	58.8	60.7	62.4
Temp.thrust bear.PT act.2	GrdC	68.7	72.2	75.2
Measured O2	%	16.89	16.88	16.86
Measured CO	mg/m3	2.4	2.2	2.1
Measured NO	mg/m3	12.6	12.8	12.3
Measured NO2	mg/m3	5.0	5.2	5.3

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MACHINE NO. : 2156 Shop Performance Test
ORDER-NO. : H.0200017
CODEWORD : VILLARPIPE 3
TYPE : THM 1304-12 DLN
DATE OF TEST: 10.11.2009

MEASURINGPOINT			044	045	046
SAMPLETIME			11:43	11:46	11:49
Gas Generator (GG) speed		1/min	11044	11043	11044
Power turbine (PT) speed		1/min	6903	7687	8481
Torque at PT		Nm	8967.1	8136.2	7306.0
Guide vane position		GRAD	-10.3	-10.4	-10.3
Ambient pressure		bar	1.0038	1.0038	1.0037
Relative humidity		%	77.2	77.1	76.7
Reference temperature		GrdC	8.9	9.0	8.9
Pressure loss filter		bar	-0.0021	-0.0021	-0.0021
Pressure loss venturi A		bar	0.1298	0.1298	0.1298
Pressure loss venturi B		bar	0.1294	0.1293	0.1293
Pressure loss venturi C		bar	0.1330	0.1329	0.1327
Inlet press. compressor A		bar_g	-0.0352	-0.0348	-0.0378
Inlet press. compressor B		bar_g	-0.0304	-0.0305	-0.0306
Inlet temp. compr.	Tt_11	GrdC	7.6	7.4	7.5
Inlet temp. compr.	Tt_12	GrdC	6.9	6.7	6.8
Inlet temp. compr.	Tt_13	GrdC	6.5	6.4	6.4
Inlet temp. compr.	Tt_14	GrdC	6.8	6.7	6.8
Inlet temp. compr.	Tt_15	GrdC	6.4	6.4	6.4
Inlet temp. compr.	Tt_16	GrdC	6.7	6.6	6.7
Outlet press.compressor A		bar_g	7.1688	7.1803	7.1885
Outlet press.compressor B		bar_g	7.1622	7.1727	7.1817
Outlet temp. compr.	Tt_21	GrdC	289.6	289.7	290.0
Outlet temp. compr.	Tt_22	GrdC	290.5	290.6	291.0
Inlet press. PT		bar_g	1.3715	1.3779	1.3851
Inlet temp. PT	Tt_41	GrdC	728.0	728.1	727.8
Inlet temp. PT	Tt_42	GrdC	594.7	598.7	603.8
Inlet temp. PT	Tt_43	GrdC	524.2	527.5	532.9
Inlet temp. PT	Tt_44	GrdC	621.9	622.4	622.9
Inlet temp. PT	Tt_45	GrdC	560.0	558.9	559.3
Inlet temp. PT	Tt_46	GrdC	690.2	689.8	692.2
Inlet temp. PT	Tt_47	GrdC	682.2	687.4	692.3
Inlet temp. PT	Tt_48	GrdC	633.8	642.1	651.7
Outlet press. PT A		bar_g	-0.0000	-0.0001	-0.0001
Outlet press. PT B		bar_g	-0.0011	-0.0036	-0.0027
Outlet temp. PT	Tt_51	GrdC	433.6	455.6	454.4
Outlet temp. PT	Tt_52	GrdC	466.7	462.0	456.8
Outlet temp. PT	Tt_53	GrdC	452.4	444.3	459.9
Outlet temp. PT	Tt_54	GrdC	444.9	458.5	461.8
Fuel gas temp.		GrdC	28.7	29.0	29.3
Fuel gas pressure		bar	9.6636	9.6622	9.6315
Fuel gas volume flow		m3n/h	2866.4	2885.6	2895.2
Oil press.GG f. bearing		bar_g	2.5	2.5	2.5

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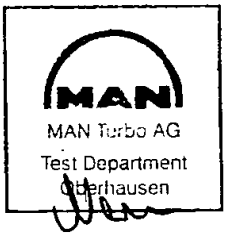
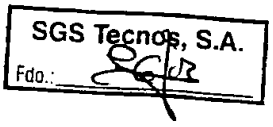
MACHINE NO. : 2156 Shop Performance Test
ORDER-NO. : H.0200017
CODEWORD : VILLARPIPE 3
TYPE : THM 1304-12 DLN
DATE OF TEST: 10.11.2009

MEASURINGPOINT		044	045	046
SAMPLETIME		11:43	11:46	11:49
Oil press.GG r. bearing	bar_g	1.9	1.9	1.9
Oil press.PT	bar_g	2.2	2.2	2.2
Oil inlet temp.	GrdC	45.7	45.6	45.5
Oil vol.flow GG f.bearing	l/min	134.1	134.0	133.9
Oil vol.flow GG r.bearing	l/min	54.2	54.2	54.2
Oil vol.flow PT	l/min	122.9	123.1	123.0
Oil outl.temp.GG f.bear.	GrdC	52.0	51.9	51.7
Oil outl.temp.GG r.bear.	GrdC	68.8	68.7	68.6
Oil outl.temp.PT	GrdC	62.1	64.0	66.5
Shaft vib. GG f.1 unfilt.	my_pp	36	36	36
Shaft vib. GG f.2 unfilt.	my_pp	23	22	22
Shaft vib. PT r.1 unfilt.	my_pp	24	27	29
Shaft vib. PT r.2 unfilt.	my_pp	21	27	24
Shaft position GG axial	mm	0.11	0.11	0.11
Shaft position PT axial	mm	0.12	0.13	0.13
Temp.journal bear. GG f.1	GrdC	76.2	76.0	76.0
Temp.journal bear. GG f.2	GrdC	57.0	56.7	56.5
Temp.thrust bear.GG act.1	GrdC	57.1	56.8	56.6
Temp.thrust bear.GG act.2	GrdC	57.9	57.6	57.5
Temp.journal bear. GG r.1	GrdC	81.6	81.4	81.3
Temp.journal bear. GG r.2	GrdC	57.9	57.6	57.7
Temp.journal bear. PT f.1	GrdC	60.6	62.4	64.1
Temp.journal bear. PT f.2	GrdC	77.8	79.1	80.7
Temp.journal bear. PT r.1	GrdC	62.2	62.5	63.4
Temp.journal bear. PT r.2	GrdC	56.8	57.4	58.6
Temp.thrust bear.PT act.1	GrdC	62.4	64.1	66.0
Temp.thrust bear.PT act.2	GrdC	74.9	78.1	81.4
Measured O2	%	16.44	16.41	16.40
Measured CO	mg/m3	2.1	2.0	2.0
Measured NO	mg/m3	10.2	10.0	10.1
Measured NO2	mg/m3	5.8	6.0	5.9





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MACHINE NO. : 2156
ORDER-NO. : H.0200017
CODEWORD : VILLARPIPE 3
TYPE : THM 1304-12 DLN
DATE OF TEST: 10.11.2009

Shop Performance Test

MEASURINGPOINT			047	048	049	050	051
SAMPLETIME			12:04	12:07	12:10	12:13	12:17
Gas Generator (GG) speed		1/min	11248	11248	11250	11248	11249
Power turbine (PT) speed		1/min	7298	7688	8081	8479	9038
Torque at PT		Nm	10034.0	9586.1	9148.2	8694.3	8026.0
Guide vane position		GRAD	-5.4	-5.3	-5.4	-5.5	-5.5
Ambient pressure		bar	1.0036	1.0036	1.0036	1.0036	1.0035
Relative humidity		%	75.6	75.9	75.8	74.9	74.6
Reference temperature		GrdC	9.1	9.1	9.1	9.2	9.2
Pressure loss filter		bar	-0.0022	-0.0022	-0.0022	-0.0022	-0.0022
Pressure loss venturi A		bar	0.1465	0.1461	0.1462	0.1463	0.1461
Pressure loss venturi B		bar	0.1459	0.1457	0.1458	0.1457	0.1456
Pressure loss venturi C		bar	0.1498	0.1496	0.1498	0.1496	0.1495
Inlet press. compressor A		bar_g	-0.0376	-0.0371	-0.0371	-0.0370	-0.0377
Inlet press. compressor B		bar_g	-0.0346	-0.0342	-0.0342	-0.0342	-0.0348
Inlet temp. compr.	Tt_11	GrdC	7.2	7.4	7.4	7.5	7.4
Inlet temp. compr.	Tt_12	GrdC	6.5	6.7	6.6	6.6	6.6
Inlet temp. compr.	Tt_13	GrdC	6.2	6.3	6.3	6.3	6.2
Inlet temp. compr.	Tt_14	GrdC	6.7	6.7	6.6	6.7	6.7
Inlet temp. compr.	Tt_15	GrdC	6.3	6.4	6.3	6.4	6.2
Inlet temp. compr.	Tt_16	GrdC	6.4	6.6	6.5	6.6	6.5
Outlet press.compressor A		bar_g	7.8258	7.8282	7.8377	7.8408	7.8421
Outlet press.compressor B		bar_g	7.8103	7.8150	7.8237	7.8272	7.8291
Outlet temp. compr.	Tt_21	GrdC	302.3	302.6	302.8	302.9	303.1
Outlet temp. compr.	Tt_22	GrdC	305.0	305.1	305.3	305.5	305.5
Inlet press. PT		bar_g	1.5451	1.5476	1.5525	1.5554	1.5580
Inlet temp. PT	Tt_41	GrdC	688.5	692.0	694.8	697.3	699.0
Inlet temp. PT	Tt_42	GrdC	624.1	625.5	626.8	627.9	629.4
Inlet temp. PT	Tt_43	GrdC	622.7	628.2	634.0	637.3	641.4
Inlet temp. PT	Tt_44	GrdC	706.2	708.3	710.9	712.0	712.8
Inlet temp. PT	Tt_45	GrdC	624.4	625.2	626.1	631.6	640.3
Inlet temp. PT	Tt_46	GrdC	692.7	694.6	694.4	693.2	693.1
Inlet temp. PT	Tt_47	GrdC	718.5	718.2	719.5	719.1	718.2
Inlet temp. PT	Tt_48	GrdC	697.2	696.8	698.8	699.3	698.4
Outlet press. PT A		bar_g	0.0006	0.0016	0.0007	-0.0000	0.0002
Outlet press. PT B		bar_g	0.0009	0.0004	-0.0033	-0.0040	-0.0026
Outlet temp. PT	Tt_51	GrdC	465.7	464.9	466.2	471.8	473.9
Outlet temp. PT	Tt_52	GrdC	474.4	473.9	464.9	468.9	468.4
Outlet temp. PT	Tt_53	GrdC	465.3	456.6	459.3	465.3	471.7
Outlet temp. PT	Tt_54	GrdC	466.5	466.7	474.5	477.5	475.2
Fuel gas temp.		GrdC	30.0	30.0	30.0	30.0	29.8
Fuel gas pressure		bar	9.6164	9.5916	9.6226	9.6130	9.5984
Fuel gas volume flow		m3n/h	3208.5	3213.6	3219.2	3218.9	3230.4
Oil press.GG f. bearing		bar_g	2.5	2.5	2.5	2.5	2.5

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MACHINE NO. : 2156
ORDER-NO. : H.0200017
CODEWORD : VILLARPIPE 3
TYPE : THM 1304-12 DLN
DATE OF TEST: 10.11.2009

Shop Performance Test

MEASURINGPOINT		047	048	049	050	051
SAMPLETIME		12:04	12:07	12:10	12:13	12:17
Oil press.GG r. bearing	bar_g	1.9	1.9	1.9	1.9	1.9
Oil press.PT	bar_g	2.2	2.2	2.2	2.2	2.2
Oil inlet temp.	GrdC	45.4	45.4	45.3	45.4	45.5
Oil vol.flow GG f.bearing	l/min	134.4	134.4	134.3	134.5	134.6
Oil vol.flow GG r.bearing	l/min	54.4	54.5	54.4	54.5	54.5
Oil vol.flow PT	l/min	123.3	123.5	123.3	123.5	123.1
Oil outl.temp.GG f.bear.	GrdC	52.1	52.1	51.9	52.0	52.1
Oil outl.temp.GG r.bear.	GrdC	69.4	69.5	69.4	69.4	69.4
Oil outl.temp.PT	GrdC	63.9	64.9	66.0	67.7	70.1
Shaft vib. GG f.1 unfilt.	my_pp	33	34	34	33	32
Shaft vib. GG f.2 unfilt.	my_pp	25	25	25	24	24
Shaft vib. PT r.1 unfilt.	my_pp	19	23	23	25	28
Shaft vib. PT r.2 unfilt.	my_pp	20	23	20	20	26
Shaft position GG axial	mm	0.11	0.10	0.10	0.10	0.10
Shaft position PT axial	mm	0.12	0.12	0.12	0.13	0.14
Temp.journal bear. GG f.1	GrdC	76.4	76.2	76.3	76.3	76.3
Temp.journal bear. GG f.2	GrdC	57.2	57.1	57.1	57.0	57.1
Temp.thrust bear.GG act.1	GrdC	57.3	57.2	57.2	57.2	57.2
Temp.thrust bear.GG act.2	GrdC	57.6	57.6	57.7	57.7	57.8
Temp.journal bear. GG r.1	GrdC	81.6	81.4	81.5	81.4	81.3
Temp.journal bear. GG r.2	GrdC	57.6	57.6	57.6	57.6	57.6
Temp.journal bear. PT f.1	GrdC	61.1	61.7	62.6	63.3	63.8
Temp.journal bear. PT f.2	GrdC	76.3	76.9	77.8	78.5	79.5
Temp.journal bear. PT r.1	GrdC	64.5	64.8	65.4	65.5	66.5
Temp.journal bear. PT r.2	GrdC	57.0	57.6	58.2	58.9	60.8
Temp.thrust bear.PT act.1	GrdC	64.2	65.2	66.2	67.3	65.8
Temp.thrust bear.PT act.2	GrdC	77.4	79.3	81.3	83.1	77.5
Measured O2	%	16.10	16.07	16.08	16.07	16.07
Measured CO	mg/m3	3.8	3.8	3.8	4.3	4.7
Measured NO	mg/m3	8.2	8.6	8.2	8.0	7.9
Measured NO2	mg/m3	6.1	6.3	6.0	6.2	6.1

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MACHINE NO. : 2156
ORDER-NO. : H.0200017
CODEWORD : VILLARPIPE 3
TYPE : THM 1304-12 DLN
DATE OF TEST: 10.11.2009

Shop Performance Test

MEASURINGPOINT			052	053	054	055	056
SAMPLETIME			12:32	12:36	12:38	12:46	12:48
Gas Generator (GG) speed		1/min	11437	11438	11437	11437	11437
Power turbine (PT) speed		1/min	7290	7680	8077	8474	9038
Torque at PT		Nm	11464.9	11032.1	10573.9	10139.8	9429.9
Guide vane position		GRAD	-0.9	-0.9	-0.9	-0.9	-0.9
Ambient pressure		bar	1.0034	1.0034	1.0034	1.0034	1.0034
Relative humidity		%	77.2	75.9	76.5	76.4	76.3
Reference temperature		GrdC	8.7	8.9	8.9	9.0	8.9
Pressure loss filter		bar	-0.0024	-0.0024	-0.0024	-0.0024	-0.0024
Pressure loss venturi A		bar	0.1630	0.1636	0.1630	0.1632	0.1630
Pressure loss venturi B		bar	0.1626	0.1630	0.1626	0.1627	0.1625
Pressure loss venturi C		bar	0.1671	0.1671	0.1666	0.1670	0.1667
Inlet press. compressor A		bar_g	-0.0413	-0.0421	-0.0418	-0.0415	-0.0417
Inlet press. compressor B		bar_g	-0.0382	-0.0389	-0.0386	-0.0383	-0.0384
Inlet temp. compr.	Tt_11	GrdC	7.3	7.2	7.2	7.2	7.3
Inlet temp. compr.	Tt_12	GrdC	6.4	6.4	6.4	6.4	6.4
Inlet temp. compr.	Tt_13	GrdC	6.1	6.1	6.1	6.1	6.2
Inlet temp. compr.	Tt_14	GrdC	6.4	6.4	6.5	6.5	6.5
Inlet temp. compr.	Tt_15	GrdC	6.0	6.1	6.1	6.0	6.1
Inlet temp. compr.	Tt_16	GrdC	6.3	6.2	6.3	6.3	6.3
Outlet press.compressor A		bar_g	8.4343	8.4387	8.4309	8.4427	8.4383
Outlet press.compressor B		bar_g	8.4245	8.4265	8.4215	8.4330	8.4294
Outlet temp. compr.	Tt_21	GrdC	315.1	315.3	315.1	315.3	315.3
Outlet temp. compr.	Tt_22	GrdC	317.9	318.1	317.8	318.1	318.1
Inlet press. PT		bar_g	1.6968	1.7006	1.7005	1.7063	1.7084
Inlet temp. PT	Tt_41	GrdC	729.1	730.4	730.4	731.9	733.0
Inlet temp. PT	Tt_42	GrdC	661.2	662.9	662.8	664.3	665.5
Inlet temp. PT	Tt_43	GrdC	687.9	689.3	689.1	690.4	691.4
Inlet temp. PT	Tt_44	GrdC	739.2	740.8	740.7	741.9	743.1
Inlet temp. PT	Tt_45	GrdC	714.0	715.7	715.6	717.6	718.6
Inlet temp. PT	Tt_46	GrdC	739.8	740.9	741.1	742.8	743.5
Inlet temp. PT	Tt_47	GrdC	737.7	739.3	740.0	741.4	742.6
Inlet temp. PT	Tt_48	GrdC	712.3	714.0	714.3	716.0	717.1
Outlet press. PT A		bar_g	-0.0003	0.0002	0.0001	0.0012	0.0009
Outlet press. PT B		bar_g	0.0016	0.0021	0.0013	0.0003	-0.0036
Outlet temp. PT	Tt_51	GrdC	492.8	493.3	490.0	486.4	490.9
Outlet temp. PT	Tt_52	GrdC	486.5	486.7	488.1	488.2	488.2
Outlet temp. PT	Tt_53	GrdC	497.3	496.9	490.8	483.4	480.8
Outlet temp. PT	Tt_54	GrdC	498.2	495.2	489.7	487.8	495.4
Fuel gas temp.		GrdC	29.7	29.7	29.7	29.6	29.6
Fuel gas pressure		bar	9.5553	9.5610	9.5905	9.5743	9.5859
Fuel gas volume flow		m3n/h	3565.7	3573.1	3570.7	3582.4	3587.9
Oil press.GG f. bearing		bar_g	2.5	2.5	2.5	2.5	2.5

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MACHINE NO. : 2156
ORDER-NO. : H.0200017
CODEWORD : VILLARPIPE 3
TYPE : THM 1304-12 DLN
DATE OF TEST: 10.11.2009

Shop Performance Test

MEASURINGPOINT		052	053	054	055	056
SAMPLETIME		12:32	12:36	12:38	12:46	12:48
Oil press.GG r. bearing	bar_g	1.9	1.9	1.9	1.9	1.9
Oil press.PT	bar_g	2.2	2.2	2.2	2.2	2.2
Oil inlet temp.	GrdC	45.4	45.4	45.4	45.4	45.5
Oil vol.flow GG f.bearing	l/min	134.7	134.8	134.6	134.8	134.9
Oil vol.flow GG r.bearing	l/min	54.7	54.8	54.7	54.8	54.8
Oil vol.flow PT	l/min	123.9	124.0	124.0	124.1	123.7
Oil outl.temp.GG f.bear.	GrdC	52.2	52.2	52.2	52.2	52.2
Oil outl.temp.GG r.bear.	GrdC	70.6	70.6	70.6	70.7	70.8
Oil outl.temp.PT	GrdC	64.7	65.6	66.8	68.7	70.8
Shaft vib. GG f.1 unfilt.	my_pp	32	31	31	31	31
Shaft vib. GG f.2 unfilt.	my_pp	25	25	26	25	25
Shaft vib. PT r.1 unfilt.	my_pp	18	22	20	23	27
Shaft vib. PT r.2 unfilt.	my_pp	19	22	18	19	25
Shaft position GG axial	mm	0.10	0.10	0.10	0.10	0.10
Shaft position PT axial	mm	0.11	0.11	0.12	0.12	0.13
Temp.journal bear. GG f.1	GrdC	76.8	76.9	76.9	76.8	76.9
Temp.journal bear. GG f.2	GrdC	57.5	57.5	57.6	57.6	57.7
Temp.thrust bear.GG act.1	GrdC	57.6	57.5	57.5	57.4	57.5
Temp.thrust bear.GG act.2	GrdC	57.8	57.8	57.8	57.8	57.8
Temp.journal bear. GG r.1	GrdC	82.7	82.8	82.8	82.8	82.9
Temp.journal bear. GG r.2	GrdC	57.8	57.9	57.9	57.9	57.9
Temp.journal bear. PT f.1	GrdC	60.7	61.3	62.2	63.1	64.2
Temp.journal bear. PT f.2	GrdC	76.5	77.4	78.2	79.2	80.0
Temp.journal bear. PT r.1	GrdC	65.1	65.4	66.0	66.1	67.0
Temp.journal bear. PT r.2	GrdC	56.7	57.4	58.0	58.9	60.6
Temp.thrust bear.PT act.1	GrdC	65.1	66.2	67.4	68.4	67.1
Temp.thrust bear.PT act.2	GrdC	78.0	80.3	82.6	84.7	79.4
Measured O2	%	15.77	15.74	15.74	15.71	15.72
Measured CO	mg/m3	3.0	2.8	2.7	2.6	2.5
Measured NO	mg/m3	8.0	7.9	8.0	8.2	8.2
Measured NO2	mg/m3	6.2	6.2	6.2	6.2	6.3

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MACHINE NO. : 2156 Shop Performance Test
ORDER-NO. : H.0200017
CODEWORD : VILLARPIPE 3
TYPE : THM 1304-12 DLN
DATE OF TEST: 10.11.2009

MEASURINGPOINT		057	058	059	060	061
SAMPLETIME		13:03	13:06	13:11	13:13	13:17
Gas Generator (GG) speed	1/min	11637	11640	11635	11641	11633
Power turbine (PT) speed	1/min	7291	7687	8087	8479	9037
Torque at PT	Nm	13004.9	12566.7	12102.3	11648.5	10968.6
Guide vane position	GRAD	3.6	3.6	3.6	3.6	3.6
Ambient pressure	bar	1.0033	1.0032	1.0031	1.0031	1.0031
Relative humidity	%	76.1	76.2	75.5	76.5	75.0
Reference temperature	GrdC	8.9	8.9	8.9	8.9	9.1
Pressure loss filter	bar	-0.0026	-0.0026	-0.0026	-0.0026	-0.0026
Pressure loss venturi A	bar	0.1812	0.1818	0.1819	0.1818	0.1813
Pressure loss venturi B	bar	0.1807	0.1811	0.1812	0.1812	0.1808
Pressure loss venturi C	bar	0.1852	0.1857	0.1858	0.1855	0.1856
Inlet press. compressor A	bar_g	-0.0506	-0.0478	-0.0464	-0.0465	-0.0458
Inlet press. compressor B	bar_g	-0.0431	-0.0428	-0.0427	-0.0428	-0.0425
Inlet temp. compr. Tt_11	GrdC	7.4	7.4	7.4	7.4	7.4
Inlet temp. compr. Tt_12	GrdC	6.4	6.4	6.4	6.4	6.5
Inlet temp. compr. Tt_13	GrdC	6.3	6.2	6.2	6.2	6.4
Inlet temp. compr. Tt_14	GrdC	6.5	6.5	6.5	6.6	6.5
Inlet temp. compr. Tt_15	GrdC	6.3	6.2	6.1	6.2	6.3
Inlet temp. compr. Tt_16	GrdC	6.5	6.4	6.3	6.4	6.5
Outlet press.compressor A	bar_g	9.0195	9.0397	9.0456	9.0471	9.0446
Outlet press.compressor B	bar_g	9.0116	9.0315	9.0382	9.0395	9.0374
Outlet temp. compr. Tt_21	GrdC	328.4	328.7	328.8	328.9	329.0
Outlet temp. compr. Tt_22	GrdC	331.1	331.5	331.7	331.8	331.8
Inlet press. PT	bar_g	1.8594	1.8664	1.8707	1.8738	1.8756
Inlet temp. PT Tt_41	GrdC	770.0	771.7	772.7	773.8	774.8
Inlet temp. PT Tt_42	GrdC	700.2	702.4	703.3	704.2	704.9
Inlet temp. PT Tt_43	GrdC	731.9	733.4	734.8	735.3	736.4
Inlet temp. PT Tt_44	GrdC	782.9	784.3	785.3	786.4	787.1
Inlet temp. PT Tt_45	GrdC	759.0	762.1	763.9	764.4	766.2
Inlet temp. PT Tt_46	GrdC	785.2	787.8	789.4	790.4	791.1
Inlet temp. PT Tt_47	GrdC	788.4	789.8	790.5	791.6	792.4
Inlet temp. PT Tt_48	GrdC	757.3	758.9	759.4	760.8	761.6
Outlet press. PT A	bar_g	-0.0012	-0.0004	0.0000	-0.0004	0.0007
Outlet press. PT B	bar_g	0.0019	0.0019	0.0031	0.0018	-0.0000
Outlet temp. PT Tt_51	GrdC	518.3	516.3	516.0	515.3	509.2
Outlet temp. PT Tt_52	GrdC	513.9	511.7	510.7	512.4	514.4
Outlet temp. PT Tt_53	GrdC	523.5	523.3	522.9	521.2	510.9
Outlet temp. PT Tt_54	GrdC	526.5	524.4	522.3	517.2	511.2
Fuel gas temp.	GrdC	29.4	29.4	29.4	29.3	29.2
Fuel gas pressure	bar	9.4909	9.5115	9.4691	9.4935	9.4978
Fuel gas volume flow	m3n/h	3968.7	3976.1	3978.9	3980.6	3989.7
Oil press.GG f. bearing	bar_g	2.5	2.5	2.5	2.5	2.5

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MACHINE NO. : 2156
ORDER-NO. : H.0200017
CODEWORD : VILLARPIPE 3
TYPE : THM 1304-12 DLN
DATE OF TEST: 10.11.2009

Shop Performance Test

MEASURINGPOINT		057	058	059	060	061
SAMPLETIME		13:03	13:06	13:11	13:13	13:17
Oil press.GG r. bearing	bar_g	1.9	1.9	1.9	1.9	1.9
Oil press.PT	bar_g	2.2	2.2	2.2	2.2	2.2
Oil inlet temp.	GrdC	45.5	45.6	45.5	45.7	45.8
Oil vol.flow GG f.bearing	l/min	135.3	135.3	135.2	135.3	135.5
Oil vol.flow GG r.bearing	l/min	55.1	55.1	55.1	55.2	55.2
Oil vol.flow PT	l/min	124.8	124.9	124.9	125.0	124.6
Oil outl.temp.GG f.bear.	GrdC	52.4	52.5	52.5	52.6	52.7
Oil outl.temp.GG r.bear.	GrdC	72.0	72.1	72.1	72.2	72.4
Oil outl.temp.PT	GrdC	65.3	66.4	67.8	69.4	71.8
Shaft vib. GG f.1 unfilt.	my_pp	33	33	33	33	33
Shaft vib. GG f.2 unfilt.	my_pp	26	26	27	26	26
Shaft vib. PT r.1 unfilt.	my_pp	19	23	21	23	27
Shaft vib. PT r.2 unfilt.	my_pp	21	24	19	21	26
Shaft position GG axial	mm	0.10	0.10	0.10	0.10	0.10
Shaft position PT axial	mm	0.10	0.10	0.11	0.12	0.12
Temp.journal bear. GG f.1	GrdC	77.4	77.5	77.5	77.6	77.6
Temp.journal bear. GG f.2	GrdC	57.9	57.9	57.9	58.0	58.1
Temp.thrust bear.GG act.1	GrdC	57.8	57.9	57.9	58.0	57.9
Temp.thrust bear.GG act.2	GrdC	58.1	58.2	58.2	58.2	58.3
Temp.journal bear. GG r.1	GrdC	84.1	84.1	84.2	84.3	84.1
Temp.journal bear. GG r.2	GrdC	58.1	58.2	58.2	58.3	58.4
Temp.journal bear. PT f.1	GrdC	61.2	61.9	62.2	63.0	63.7
Temp.journal bear. PT f.2	GrdC	76.4	77.3	78.2	79.2	80.3
Temp.journal bear. PT r.1	GrdC	65.0	65.5	66.2	66.3	67.4
Temp.journal bear. PT r.2	GrdC	56.5	57.4	59.5	61.0	64.1
Temp.thrust bear.PT act.1	GrdC	66.1	67.5	68.7	70.0	68.5
Temp.thrust bear.PT act.2	GrdC	78.7	81.1	83.7	86.2	81.1
Measured O2	%	15.35	15.32	15.33	15.30	15.28
Measured CO	mg/m3	2.4	2.3	2.2	2.2	2.2
Measured NO	mg/m3	10.2	9.9	9.9	10.2	10.5
Measured NO2	mg/m3	6.7	6.7	6.7	6.5	6.3

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MACHINE NO. : 2156
ORDER-NO. : H.0200017
CODEWORD : VILLARPIPE 3
TYPE : THM 1304-12 DLN
DATE OF TEST: 10.11.2009

Shop Performance Test

MEASURINGPOINT			062	063	064	065
SAMPLETIME			13:32	13:34	13:37	13:39
Gas Generator (GG) speed		1/min	11769	11768	11770	11768
Power turbine (PT) speed		1/min	7698	8087	8484	9040
Torque at PT		Nm	13567.2	13087.2	12639.5	11967.5
Guide vane position		GRAD	6.9	6.9	6.9	6.9
Ambient pressure		bar	1.0030	1.0029	1.0029	1.0029
Relative humidity		%	74.5	75.5	76.6	76.6
Reference temperature		GrdC	9.0	8.9	9.0	9.1
Pressure loss filter		bar	-0.0027	-0.0027	-0.0027	-0.0027
Pressure loss venturi A		bar	0.1937	0.1938	0.1939	0.1936
Pressure loss venturi B		bar	0.1932	0.1931	0.1931	0.1932
Pressure loss venturi C		bar	0.1980	0.1976	0.1979	0.1981
Inlet press. compressor A		bar_g	-0.0492	-0.0493	-0.0496	-0.0493
Inlet press. compressor B		bar_g	-0.0479	-0.0480	-0.0482	-0.0479
Inlet temp. compr.	Tt_11	GrdC	7.3	7.3	7.3	7.3
Inlet temp. compr.	Tt_12	GrdC	6.9	6.8	6.9	6.9
Inlet temp. compr.	Tt_13	GrdC	6.7	6.7	6.6	6.6
Inlet temp. compr.	Tt_14	GrdC	6.4	6.4	6.4	6.4
Inlet temp. compr.	Tt_15	GrdC	6.6	6.7	6.7	6.6
Inlet temp. compr.	Tt_16	GrdC	6.8	6.8	6.8	6.8
Outlet press.compressor A		bar_g	9.4428	9.4368	9.4418	9.4458
Outlet press.compressor B		bar_g	9.4331	9.4270	9.4303	9.4362
Outlet temp. compr.	Tt_21	GrdC	338.4	338.3	338.4	338.5
Outlet temp. compr.	Tt_22	GrdC	341.3	341.3	341.4	341.4
Inlet press. PT		bar_g	1.9848	1.9848	1.9876	1.9931
Inlet temp. PT	Tt_41	GrdC	804.3	805.8	806.3	807.2
Inlet temp. PT	Tt_42	GrdC	732.3	732.5	733.2	735.2
Inlet temp. PT	Tt_43	GrdC	765.5	766.1	767.1	769.0
Inlet temp. PT	Tt_44	GrdC	819.0	819.1	820.5	822.4
Inlet temp. PT	Tt_45	GrdC	801.8	803.1	803.7	805.3
Inlet temp. PT	Tt_46	GrdC	817.1	817.6	818.2	818.9
Inlet temp. PT	Tt_47	GrdC	810.8	811.1	811.6	812.2
Inlet temp. PT	Tt_48	GrdC	774.8	775.0	776.2	777.3
Outlet press. PT A		bar_g	-0.0023	-0.0010	0.0003	-0.0011
Outlet press. PT B		bar_g	0.0022	0.0028	0.0029	0.0006
Outlet temp. PT	Tt_51	GrdC	537.1	534.0	532.8	532.5
Outlet temp. PT	Tt_52	GrdC	531.1	527.8	527.5	530.5
Outlet temp. PT	Tt_53	GrdC	541.1	540.4	540.2	538.2
Outlet temp. PT	Tt_54	GrdC	545.5	542.4	540.4	533.9
Fuel gas temp.		GrdC	28.9	28.9	28.8	28.7
Fuel gas pressure		bar	9.4569	9.4646	9.4331	9.4211
Fuel gas volume flow		m3n/h	4268.8	4269.5	4277.3	4287.7
Oil press.GG f. bearing		bar_g	2.5	2.5	2.5	2.5

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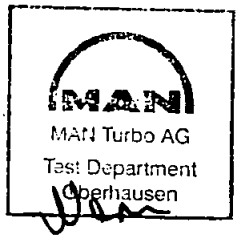
MACHINE NO. : 2156 Shop Performance Test
ORDER-NO. : H.0200017
CODEWORD : VILLARPIPE 3
TYPE : THM 1304-12 DLN
DATE OF TEST: 10.11.2009

MEASURINGPOINT		062	063	064	065
SAMPLETIME		13:32	13:34	13:37	13:39
Oil press.GG r. bearing	bar_g	1.9	1.9	1.9	1.9
Oil press.PT	bar_g	2.2	2.2	2.2	2.2
Oil inlet temp.	GrdC	46.0	46.0	45.9	45.9
Oil vol.flow GG f.bearing	l/min	136.0	135.9	135.8	135.9
Oil vol.flow GG r.bearing	l/min	55.5	55.5	55.5	55.5
Oil vol.flow PT	l/min	126.0	126.0	125.8	125.2
Oil outl.temp.GG f.bear.	GrdC	53.1	53.1	53.0	53.0
Oil outl.temp.GG r.bear.	GrdC	73.3	73.4	73.3	73.3
Oil outl.temp.PT	GrdC	67.4	68.4	70.1	72.0
Shaft vib. GG f.1 unfilt.	my_pp	35	35	34	36
Shaft vib. GG f.2 unfilt.	my_pp	28	28	27	27
Shaft vib. PT r.1 unfilt.	my_pp	27	25	25	28
Shaft vib. PT r.2 unfilt.	my_pp	27	21	22	26
Shaft position GG axial	mm	0.10	0.10	0.10	0.10
Shaft position PT axial	mm	0.10	0.10	0.11	0.11
Temp.journal bear. GG f.1	GrdC	78.0	78.1	77.9	78.1
Temp.journal bear. GG f.2	GrdC	58.4	58.4	58.2	58.4
Temp.thrust bear.GG act.1	GrdC	58.5	58.4	58.2	58.4
Temp.thrust bear.GG act.2	GrdC	58.7	58.7	58.5	58.6
Temp.journal bear. GG r.1	GrdC	85.0	85.0	84.9	85.0
Temp.journal bear. GG r.2	GrdC	58.7	58.7	58.5	58.6
Temp.journal bear. PT f.1	GrdC	61.7	62.3	63.2	64.3
Temp.journal bear. PT f.2	GrdC	77.7	78.3	78.9	79.7
Temp.journal bear. PT r.1	GrdC	65.2	65.6	65.6	66.6
Temp.journal bear. PT r.2	GrdC	59.0	58.9	58.6	60.4
Temp.thrust bear.PT act.1	GrdC	68.3	69.5	70.7	69.4
Temp.thrust bear.PT act.2	GrdC	81.8	84.2	87.0	82.7
Measured O2	%	15.05	15.04	15.03	15.02
Measured CO	mg/m3	2.4	2.3	2.4	2.4
Measured NO	mg/m3	12.7	12.9	13.0	13.1
Measured NO2	mg/m3	6.8	6.8	6.7	6.6



MAN Turbo AG

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Pub Final

MACHINE NO. : 2156
ORDER-NO. : H.0200017
CODEWORD : VILLARPIPE 3
TYPE : THM 1304-12 DLN
DATE OF TEST: 10.11.2009

Shop Performance Test

MEASURINGPOINT			066	067	068	069
SAMPLETIME			13:40	13:55	14:10	14:17
Gas Generator (GG) speed		1/min	11727	11736	11736	11736
Power turbine (PT) speed		1/min	9037	9038	9037	9307
Torque at PT		Nm	11678.6	11730.9	11728.4	11441.7
Guide vane position		GRAD	6.3	6.2	6.2	6.2
Ambient pressure		bar	1.0028	1.0027	1.0026	1.0025
Relative humidity		%	75.5	77.4	77.7	77.9
Reference temperature		GrdC	9.0	8.9	9.0	8.8
Pressure loss filter		bar	-0.0027	-0.0027	-0.0026	-0.0027
Pressure loss venturi A		bar	0.1901	0.1907	0.1904	0.1913
Pressure loss venturi B		bar	0.1896	0.1900	0.1898	0.1901
Pressure loss venturi C		bar	0.1939	0.1949	0.1947	0.1949
Inlet press. compressor A		bar_g	-0.0488	-0.0491	-0.0528	-0.0572
Inlet press. compressor B		bar_g	-0.0475	-0.0474	-0.0469	-0.0472
Inlet temp. compr.	Tt_11	GrdC	7.2	7.4	7.3	7.2
Inlet temp. compr.	Tt_12	GrdC	6.8	6.9	6.9	6.8
Inlet temp. compr.	Tt_13	GrdC	6.6	6.7	6.6	6.6
Inlet temp. compr.	Tt_14	GrdC	6.4	6.4	6.4	6.3
Inlet temp. compr.	Tt_15	GrdC	6.6	6.6	6.5	6.6
Inlet temp. compr.	Tt_16	GrdC	6.7	6.9	6.7	6.7
Outlet press.compressor A		bar_g	9.3268	9.3400	9.3380	9.3465
Outlet press.compressor B		bar_g	9.3159	9.3323	9.3269	9.3391
Outlet temp. compr.	Tt_21	GrdC	336.0	336.1	336.0	336.1
Outlet temp. compr.	Tt_22	GrdC	339.0	339.2	339.2	339.0
Inlet press. PT		bar_g	1.9572	1.9606	1.9591	1.9635
Inlet temp. PT	Tt_41	GrdC	797.9	798.6	798.5	799.5
Inlet temp. PT	Tt_42	GrdC	726.2	728.0	727.8	729.5
Inlet temp. PT	Tt_43	GrdC	759.5	761.9	761.7	762.7
Inlet temp. PT	Tt_44	GrdC	811.8	813.1	813.3	814.1
Inlet temp. PT	Tt_45	GrdC	792.6	794.3	793.6	795.5
Inlet temp. PT	Tt_46	GrdC	811.5	812.1	811.9	810.8
Inlet temp. PT	Tt_47	GrdC	805.8	807.3	807.2	806.1
Inlet temp. PT	Tt_48	GrdC	771.5	772.0	772.1	771.1
Outlet press. PT A		bar_g	-0.0002	-0.0001	0.0000	-0.0002
Outlet press. PT B		bar_g	0.0006	0.0008	0.0006	-0.0015
Outlet temp. PT	Tt_51	GrdC	527.5	527.7	527.6	525.1
Outlet temp. PT	Tt_52	GrdC	526.9	526.3	526.6	527.8
Outlet temp. PT	Tt_53	GrdC	532.4	532.3	531.9	527.4
Outlet temp. PT	Tt_54	GrdC	527.5	526.8	527.1	524.8
Fuel gas temp.		GrdC	28.7	28.3	28.1	28.0
Fuel gas pressure		bar	9.4654	9.4861	9.4541	9.4410
Fuel gas volume flow		m3n/h	4193.1	4213.6	4221.8	4212.2
Oil press.GG f. bearing		bar_g	2.5	2.5	2.5	2.5

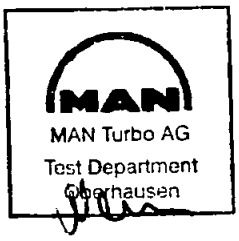
SGS Tecnos, S.A.
Fdo.:

MAN Turbo AG
Test Department
Oberhausen

MAN Turbo AG

MACHINE NO. : 2156 Shop Performance Test
ORDER-NO. : H.0200017
CODEWORD : VILLARPIPE 3
TYPE : THM 1304-12 DLN
DATE OF TEST: 10.11.2009

MEASURINGPOINT		066	067	068	069
SAMPLETIME		13:40	13:55	14:10	14:17
Oil press.GG r. bearing	bar_g	1.9	1.9	1.9	1.9
Oil press.PT	bar_g	2.2	2.2	2.2	2.2
Oil inlet temp.	GrdC	46.0	46.6	46.9	46.8
Oil vol.flow GG f.bearing	l/min	135.7	136.3	136.4	136.4
Oil vol.flow GG r.bearing	l/min	55.5	55.6	55.6	55.6
Oil vol.flow PT	l/min	125.0	126.0	126.3	126.3
Oil outl.temp.GG f.bear.	GrdC	53.0	53.6	53.8	53.7
Oil outl.temp.GG r.bear.	GrdC	73.3	73.7	73.8	73.7
Oil outl.temp.PT	GrdC	72.3	73.3	73.4	74.6
Shaft vib. GG f.1 unfilt.	my_pp	34	35	35	36
Shaft vib. GG f.2 unfilt.	my_pp	26	27	27	27
Shaft vib. PT r.1 unfilt.	my_pp	28	29	29	29
Shaft vib. PT r.2 unfilt.	my_pp	26	27	27	28
Shaft position GG axial	mm	0.10	0.10	0.10	0.10
Shaft position PT axial	mm	0.12	0.12	0.12	0.13
Temp.journal bear. GG f.1	GrdC	78.6	78.1	78.4	78.0
Temp.journal bear. GG f.2	GrdC	58.6	58.7	59.0	58.8
Temp.thrust bear.GG act.1	GrdC	58.6	58.7	59.1	58.7
Temp.thrust bear.GG act.2	GrdC	58.6	59.0	59.2	59.3
Temp.journal bear. GG r.1	GrdC	85.1	84.6	84.9	84.6
Temp.journal bear. GG r.2	GrdC	58.7	59.2	59.4	59.4
Temp.journal bear. PT f.1	GrdC	64.6	64.1	64.2	64.1
Temp.journal bear. PT f.2	GrdC	80.1	81.7	81.7	82.9
Temp.journal bear. PT r.1	GrdC	67.0	65.9	66.7	65.2
Temp.journal bear. PT r.2	GrdC	60.7	61.0	61.5	62.9
Temp.thrust bear.PT act.1	GrdC	69.5	70.7	70.0	70.3
Temp.thrust bear.PT act.2	GrdC	82.2	85.7	82.4	84.4
Measured O2	%	15.09	15.08	15.08	15.10
Measured CO	mg/m3	2.4	2.3	2.3	2.4
Measured NO	mg/m3	12.9	12.5	12.1	12.5
Measured NO2	mg/m3	6.4	6.2	6.4	6.2



7 Fuel Gas Analysis

DEPARTMENT : **PP53**
VILLARPIPE 3

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Fuel Gas Data Analysis

Instrument : Gaschromatograph Foxboro Typ 931C-1C1A1B3
Ser.No. 94F21196-01-701

Sampling time : 10.11.2009 13:40:00 hours

Readings :

Components	Equation	Vol.-%
Helium	He	0,060
Nitrogen	N2	11,667
Methane	CH4	82,942
Carbon Dioxide	CO2	1,433
Ethane	C2H6	3,141
Propane	C3H8	0,483
i-Butane	i-C4H10	0,077
Butane	n-C4H10	0,087
i-Pentane	i-C5H12	0,023
Pentane	n-C5H12	0,023
Summary C6+	C6+	0,067
Summary		100,000

Determination of Fuel Gas Data according to DIN 51857 :

Calorific Value	(MJ/m3-n)	32,5960
Specific Density Ratio	(-)	0,6417

Date 10.11.09 Signature

8 Vibration Report SMB 1769

MAN Turbo AG

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Abt/*Dept.*	MAN Turbo Kennwort/*Code Word* :	VILLARPIPE 3	Seite/*Page* 1/5
PP53	MAN Turbo Auftrag-Nr./*Job No.*:	H.0200017	SMB 1769

Date: 12.11.09

SMB 1769

Vibration Measurements during the Mechanical Shop Running Test

Code Word	"VILLARPIPE 3"
Job Number	H.0200017
Date of Test	10.NOV.2009

1. Machines, Serial Numbers, Manufactures, ...

Air Multi-shaft Compressor	-----
Air Axial Compressor	-----
Screw Compressor	-----
Expander	-----
Steam Turbine	-----
Gas Turbine	THM 1304 – 12 / No. 2156 / 2156 / MAN Turbo AG
Gear	-----
Electric Motor	-----
Generator	-----

2. Operation Speeds [rpm].

	Machine	N_{min}	N_{norm}	N_{max}	N_{trip}
1	Gas Generator (GG)	9400	11900	12100	12200
2	Power Turbine (PT)	3870	8600	9030	9480
3	-----	--	--	--	--
4	-----	--	--	--	--
5	-----	--	--	--	--
6	-----	--	--	--	--

MAN Turbo AG

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Abt/*Dept.*	MAN Turbo Kennwort/*Code Word* :	VILLARPIPE 3	Seite/*Page* 2/5
PP53	MAN Turbo Auftrag-Nr./*Job No.*:	H.0200017	SMB 1769

3. Lateral Critical Speeds [rpm].		Calculated		
Machine		N_{c1}	N_{c2}	N_{c3}
1	Gas Generator (GG)	~20000	--	--
2	Power Turbine (PT)	~21000	--	--
3	-----	--	--	--
4	-----	--	--	--
5	-----	--	--	--
		Measured		
Machine		N_{c1}	N_{c2}	N_{c3}
1	Gas Generator (GG)	--	--	--
2	Power Turbine (PT)	--	--	--
3	-----	--	--	--
4	-----	--	--	--
5	-----	--	--	--

4. Applicable Specifications.

4.1. Vibrations measured on the shafts.**)

Specification:	Limits [µm]	GG	60*		PT	60*	
ATP & R –THM Rev.1	Speeds [rpm]	GG	11900		PT	8600	

Measurement Quantity:

*) Peak to Peak Value S_{p-p}

4.2. Vibrations measured on the Bearing Housings.

Specification: ISO 10816-4 not applicable.	Limits [mm/s]	GG	4.5*	PT	4.5*

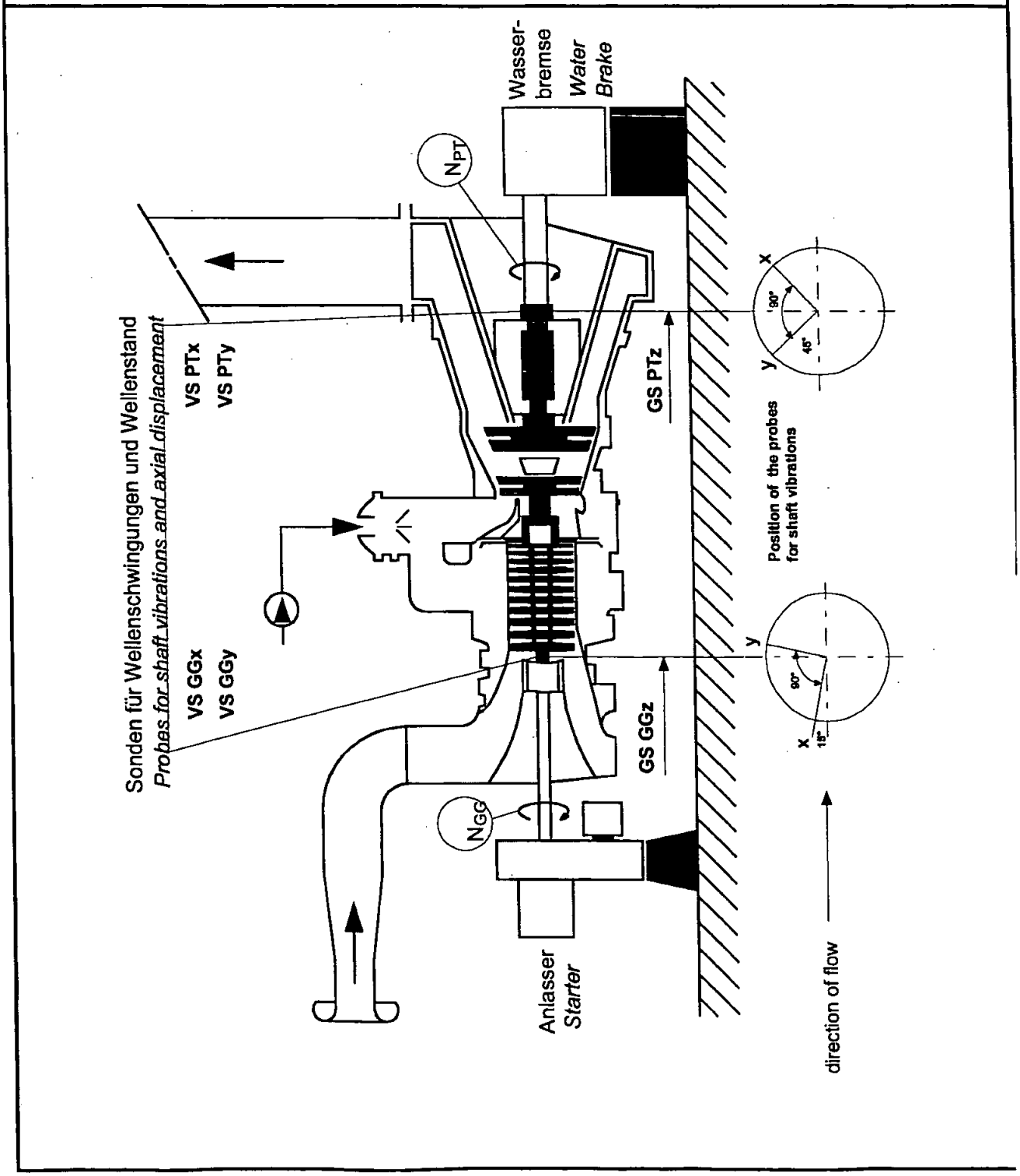
Measurement Quantity:

*) RMS Value

Remarks: **) Filtered values (rotational frequency, only).

Abt/*Dept.*	MAN Turbo Kennwort/*Code Word* :	VILLARPIPE 3	Seite/*Page* 3/5
PP53	MAN Turbo Auftrag-Nr./*Job No.*:	H.0200017	SMB 1769

5. Schematic Test Arrangement with Measurement Points.



6. Instrumentation.

6.1 Vibration Measurements on the Shafts.

Transducers, Proximitors S 3300 (Bently Nevada),
Monitors S 3500 (Bently Nevada),
Data Acquisition Interface Unit 208 DAIU (Bently Nevada),
ADRE for Windows Version 5.1 (Bently Nevada).

6.2 Vibration Measurements on the Bearing Housings.

Not applicable.

7. Other.

See appendix to this report on plot 1 – 2.

8. Commentary of Results.

The vibratory conditions of the Gas Turbine set „VILLARPIPE 3" are good and according to the specifications.

The survey of the vibration spectrum during the mechanical shop running test gave no indication of a vibration problem.

MAN Turbo AG

Abt./*Dept.*	MAN Turbo Kennwort/*Code Word* :	VILLARPIPE 3	Seite/*Page* 5/5
PP53	MAN Turbo Auftrag-Nr./*Job No.*:	H.0200017	SMB 1769

9. Enclosures: Plots 1 – 2.

Plot	Commentary
1	Spectra at high speed (GG and PT),
2	Bode diagrams of shutdown (GG and PT).
-	---
-	---
-	---

10. Tester:	Friedhoff / PP53	Checked:	Nern / PP53
12.11.2009	R. Friedhoff	12.11.2009	M. Nern