

Test Report GV 1699/12

VILLARPIPE 1-3

Performance Test of three Pipeline Compressor / Gas Turbine Units
at the ENAGAS Villar de Arnedo Compressor Station
in Spain

This report comprises 31 sheets (including attachments 1 through 4).

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1. Purpose of Test

Check of Pipeline Compressor / Gas Turbine performance under compressor transport or station recycle conditions according MAN Diesel & Turbo Field – Acceptance Test Procedure F-ATP/THM-Pipe VILLARPIPE 1-3.

2. Summary (short form)

After conversion of Pipeline Compressor performance from test to reference conditions according VDI 2045 and after conversion from test to reference conditions according ISO 2314 Gas Turbine units are fulfilling the contractual value with partial utilisation of a measurement result uncertainty (ca. $\pm 4\%$):

		Unit #1	Unit #2	Unit #3
Gros specific heat rate (guar.)	kJ/kW/h	17290	17290	17290
Gros specific heat rate (con.)	kJ/kW/h	17010	17395	17398
Difference	kJ/kW/h	-190	+105	+108
Difference	%	-1.10	+0.61	+0.63

3. Test Set-up

Original installed instruments for pipeline compressor, gas turbine and station control were used.

All values were read from Control Room Terminal.

4. Test Procedure

4.1 Condition of Pipeline Compressor / Gas Turbines Unit before and during Test

Mechanical completion and commissioning was finished some weeks before the test.

The number of starts and collected running hours for the units before testing were:

- <51 starts,
- <188 running hours.

Gas turbine compressors were washed with detergent directly before test.

4.2 Performance Test

After startup compressor was accelerated to guarantee speed of 7540 rpm.

Suction pressure was set to 44.4 bar-g.

At discharge pressures of approx. 70, 72 and 74 bar-g three test points (MP01 through MP03) were recorded for each unit on the same speed characteristic following the rules of thermodynamic similarity.

Gas composition was taken separately.

Attachments 1 through 3 show test readings and gas composition.

5. Evaluation

Suction and discharge conditions of the Pipeline Compressor are determined according VDI 2045 (Acceptance and Performance Tests on Turbo Compressors and Displacement Compressors; VDI-Compressor-Rules) and real gas equations according Benedict-Webb-Rubin-Starling (BWRS) using gas compositions based on operators analysis.

Gas compositions from 05.03.12-12:31h and 07.03.12-12:31h are used for evaluation.

Fuel gas mass flows are determined according ISO 5167 calculation procedure.

Fouling of compressor flow channels is not taken into account.

Gas turbine evaluation data is converted from test to reference conditions according ISO 2314 conversion formulae.

Recorded, evaluated, converted and corrected values for the relevant test points are summarised in the attachment 3 and 4.

6. Results

6.1 Pipeline Compressor

For guarantee comparison according VDI 2045, part 1, section 5.3.4.1 (fig. 7) and section 6.2.2.2 (formula -56-) first specific compressor performance parameters must be corrected in regard to suction conditions and speed. Then corrected coupling power must be converted for suction volume flow and polytropic head. This method is valid for operating points which fulfil the requirements of the thermodynamic similarity theory (see VDI 2045, part 1, section 5.3.1).

Following test point are chosen for this:

Parameter		Punto A Garantia	Unit #1 MP02	Unit #2 MP03	Unit #3 MP03
Internal power	[kW]	-	4155	4072	3786
Suction density	[kg/m ³]	37.87	35.67	36.37	35.93
Speed	[rpm]	7541	7542	7540	7540
Internal power (corrected)	[kW]	-	4410	4242	3992
Suction volume flow (corr.)	[m ³ /h]	5376	5445	4656	4397
Polytropic head (corrected)	[kJ/kg]	61.79	61.79	69.07	69.31
Internal power (converted)	[kW]	-	4354	4381	4351
Mechanical losses	[kW]	-	110	110	110
Coupling power (converted)	[kW]	4376	4464	4491	4461
Difference	[kW]	-	+88	+115	+85
Difference	[%]	-	+2.01	+2.63	+1.95

6.2 Gas Turbine

For guarantee comparison site condition guarantee point and actual test point must be corrected to ISO and zero loss conditions according ISO 2314.

Degradation for collected operation hours is not taken into account.

Results:

kJ/kW/h		Punto A Garantia	Unit #1 MP02	Unit #2 MP03	Unit #3 MP03
Reference/Test					
Ambient pressure	bar	0.9615	0.9860	0.9930	0.9920
GG inlet temperature	°C	30.0	18.1	8.9	10.0
Inlet pressure loss *1)	mbar	7.50	15.00	15.00	15.00
Exhaust pressure loss *1)	mbar	5.00	2.00	2.00	2.00
Speed power turbine	rpm	7541	7542	7540	7540
Power at coupling	kW	4376	4265	4182	4104
Thermal efficiency	%	0.2030	0.2085	0.2041	0.2015
Gros specific heat rate	kJ/kW/h	-	17264	17638	17866
Corrected (ISO, zero loss) *2)					
Gros specific heat rate	kJ/kW/h	17290	17100	17395	17398
Difference	kJ/kW/h		-190	105	108
Difference	%		-1.10	0.61	0.63

*1) estimated

*2) including correction for off reference operation of gas turbine, converted coupling power of pipeline compressor and +3.5% manufacturing tolerance.

Gas turbine units are fulfilling the contractual value with partial utilisation of manufacturing tolerance and measurement result uncertainty of > ±4%:

7. Conclusion

In regard to the plant layout, plant and unit operation and test conditions it was possible to record a significant part of a speed characteristic for the pipeline compressors which prove that the performance of all three units is good.