CGEN12

AIR LIQUIDE DIVISION TECHNIQUES AVANCEES	**PROCES-VERBAL D' ESSAI** ***TEST REPORT*** **CRYOGENIC TURBO EXPANDER**	**N° : C 4023 NT 10 (0)** Folio : 1 / 11 *Folio :*

AFFAIRE : KSTAR *JOB :*	N° : T03 *N° :*	Fiche Suiveuse n° : *Inspection traveller n° :*
Identification du matériel : C5 *Material identification :*	**N° : 605 FU1**	Quantité / *Quantity* : 1 Lot / *Batch* :

Fournisseur/Fabricant : *Supplier / Manufacturer :*	Organisme de Contrôle : *Inspected by :*	Lieu : *Location :*	Phase : *Phase :*
AIR LIQUIDE	D2TI	**Sassenage**	

Documents de référence :
Reference documents :

PROCEDURE : **D4444-PO-2**

Instruments de contrôles utilisés :
Inspection instruments used :

Type / *Type*	N° de Gestion/*Control n°*
Test bed	**504 9999 100**

MESURES	**RESULTATS**	**OBSERVATIONS**
PIVOTERIE / *BEARINGS*	Passed	
VITESSES CRITIQUES *Critical speeds*	Passed	
SURVITESSE / *Overspeeds*	Passed	
DESCENTE EN FROID *Cold down*	Passed	
RENDEMENT / *Efficiency*	Passed	

DECISION :
DECISION :

CONFORME / *PASS* ☑
NON CONFORME / *FAIL* ☐

OBSERVATIONS :
COMMENTS :

	ESSAI / ***TEST***	**Responsable** / ***Manager***	**A.Q.** / ***Q.A.***		
NOM / ***NAME***	B Renzetti	F. Delcayre	JL. David		
DATE / ***DATE***	31/05/06	31/05/06			
SIGNATURE / ***VISA***					

CONTENTS

1. SCOPE

This report is a summary of the tests of a Cryogenic turbo-expander cartridge, performed on DTA test bed according to the procedure D4444-PO-2.

2. PROCESS CONDITION

The data sheet in appendix gives the turbine process conditions specified by the customer.

3. GAS USED FOR THE TEST

☑Helium ☐Nitrogen

4. BEARING CONDITIONS

The diagrams in appendix give the gas bearing conditions :

- to be applied on site,

- to be applied during the test.

5. ANNEXES

TESTS REPORTS

TEST REPORT

5.1 THRUST BEARING TEST, LOW SPEED

(Items 6.1 of procedure)

Cartridge number : C5 605 FU1
Bearing conditions required : NORMAL

CASE	EXTREME 1	EXTREME 2	
INPUTS			
Load	0	589	N
On	Brake	Turbine	Bearing
Equivalent pressure difference on the shaft	0	29	10^5Pa
OUTPUTS			
Inlet bearing pressure	15 98	16.06	10^5Pa
Outlet bearing pressure	2.97	2.96	10^5Pa
Turbine outlet pressure (1)	2.86	2.85	10^5Pa
Brake pressure (2)	2.92	17.66	10^5Pa
Pressure difference = (2) – (1)	0.06	14.81	10^5Pa
Speed	18	15	H_Z
Passed/failed	passed	passed	

TEST REPORT

5.2 THRUST AND JOURNAL BEARINGS TEST, HIGH SPEED

(Items 6.2 of procedure)

Cartridge number : C5 605 FU1
Bearing conditions required : NORMAL

MODE	MINIMAL	NOMINAL	MAXIMAL	
INPUTS				
Turbine outlet design pressure (1)	6.1	5.2	4.2	10^5Pa
Brake design pressure (2)	8.8	11.0	13.2	10^5Pa
Δ = 2-1	2.7	5.8	9.0	10^5Pa
OUTPUTS				
Inlet bearing pressure	16.02	15.99	15.91	10^5Pa
Outlet bearing pressure	3.05	2.93	3.0	10^5Pa
Turbine outlet test pressure (1)	3.17	3.33	3.31	10^5Pa
Brake test pressure (2)	5.88	9.05	12.25	10^5Pa
Δ = (2) – (1)	2.71	5.72	8.94	10^5Pa
Speed	1955	1916	1537	Hz
Passed	passed	passed	passed	

TEST REPORT

5.3 THRUST AND JOURNAL BEARING TEST,HIGH SPEED

(Items 6.2 of procedure)

Cartridge number : C5 605 FU1
Bearing conditions required : ALARM AND STOP

BEARING CONDITIONS	**ALARM**	**STOP**	
Mode	Nominal	Nominal	
INPUTS			
Turbine design outlet pressure (1)	5.2	5.2	10^5Pa
Brake design pressure (2)	11.0	11.0	10^5Pa
Δ = 2-1	5.8	5.8	10^5Pa
OUTPUTS			
Inlet bearing pressure		15.04	10^5Pa
Outlet bearing pressure		2.94	10^5Pa
Turbine outlet test pressure		3.32	10^5Pa
Brake inlet pressure		9.09	10^5Pa
Δ = 2-1		5.77	10^5Pa
Speed		1950	Hz
Passed		passed	

TEST REPORT

5.4 CRITICAL SPEEDS AND SHAFT VIBRATIONS

(Items 6.3 of procedure)

Cartridge number : C5 605 FU1
Bearing conditions required : STOP

INPUTS					
	1st RIGID MODE		2nd RIGID MODE		
Calculated peak freq.	780		840		H_z
OUTPUTS					
Measured critical speeds	BEGIN.	END	BEGIN.	END	
			800	950	H_z
Sound level estimation	A		B		
Time within the mode (> 3 ')			3		Min
Inlet bearing pressure	16.02		16.02		10^5Pa
Outlet bearing pressure	2.98		2.98		10^5Pa
Fail/pass	passed		passed		

Sound level estimation :

A : Inaudible B : Perceptible C : Noisy D : Excessive

TEST REPORT

5.5 OVERSPEED TEST

(Items 6.4 of procedure)

Cartridge number : C5 605 FU1
Bearing conditions required : NORMAL

INPUTS		
Nominal speed (Hz)	Maximum speed (Hz)	Over speed (Hz)
1906	2050	2110
OUPUTS		

BEARING TEST CONDITIONS

BEARING GAS PRESSURE (10^5Pa)		BEARING GAS TEMPERATURE (°C)		BEARING GAS FLOW RATE (g/s)
SUPPLY	RETURN	SUPPLY	RETURN	
16.00	3.01	15.4	31.3	10.53

TURBINE TEST CONDITIONS

TURBINE PRESSURE (10^5Pa)		TURBINE TEMPERATURE (K)		TURBINE FLOW RATE (g/s)
SUPPLY	RETURN	SUPPLY	RETURN	
13.21	3.48	206.6	153.8	145.7

BRAKE TEST CONDITIONS

INLET BRAKE PRESSURE 10^5 Pa	OUTLET BRAKE TEMPERATURE °C
9.22	93.9

TEST RESULTS

ROTATION SPEED H_z	STEADY STATE	OVERSPEED STATE DURATION (mn)	COMMENTS	
			FAIL	PASS
2111	A	3		X

Steady state evaluation

A : Stable B : Noisy C : Unstable

TEST REPORT

5.6 COOL DOWN, START-UP AND SHUT-DOWN

(Items 6.5 and 6.6 of procedure)

Cartridge number : C5 605 FU1
Bearing conditions required : normal
Nominal speed :

	AMBIENT	MEDIUM	+10 %	NOMINAL	-10 %	
Target outlet temperature	280	150	56	51	46	K
TURBINE :						
Inlet pressure	11.5	10.39	12.15	12.28	12.32	10^5Pa
Outlet pressure	3.33	3.31	3.2	3.14	3.15	10^5Pa
Inlet temperature	251.5	153.5	81.6	75.7	69.4	K
Outlet temperature	195.9	121.9	56.0	50.7	46.0	K
Flow	116	132.2	207.8	215.7	223.8	g/s
BRAKE :						
Inlet pressure	9.05	12.25	8.39	8.34	8.39	10^5Pa
Outlet temperature	48.2	62.8	79.1	76.3	75.4	°C
BEARING :						
Inlet pressure	15.99	15.91	15.98	15.99	16.01	10^5Pa
Outlet pressure	2.93	3.0	3.01	2.96	2.97	10^5Pa
Inlet temperature	15.8	16.0	17.4	18.7	18.7	°C
Outlet temperature	20.3	29.6	27.3	23.0	22.5	°C
Inlet flow	10.56	9.57	9.79	9.78	9.74	g/s
SPEED :						Hz
Number of start up/shut down		3			3	
Fail/pass	passed	passed	passed	passed	passed	

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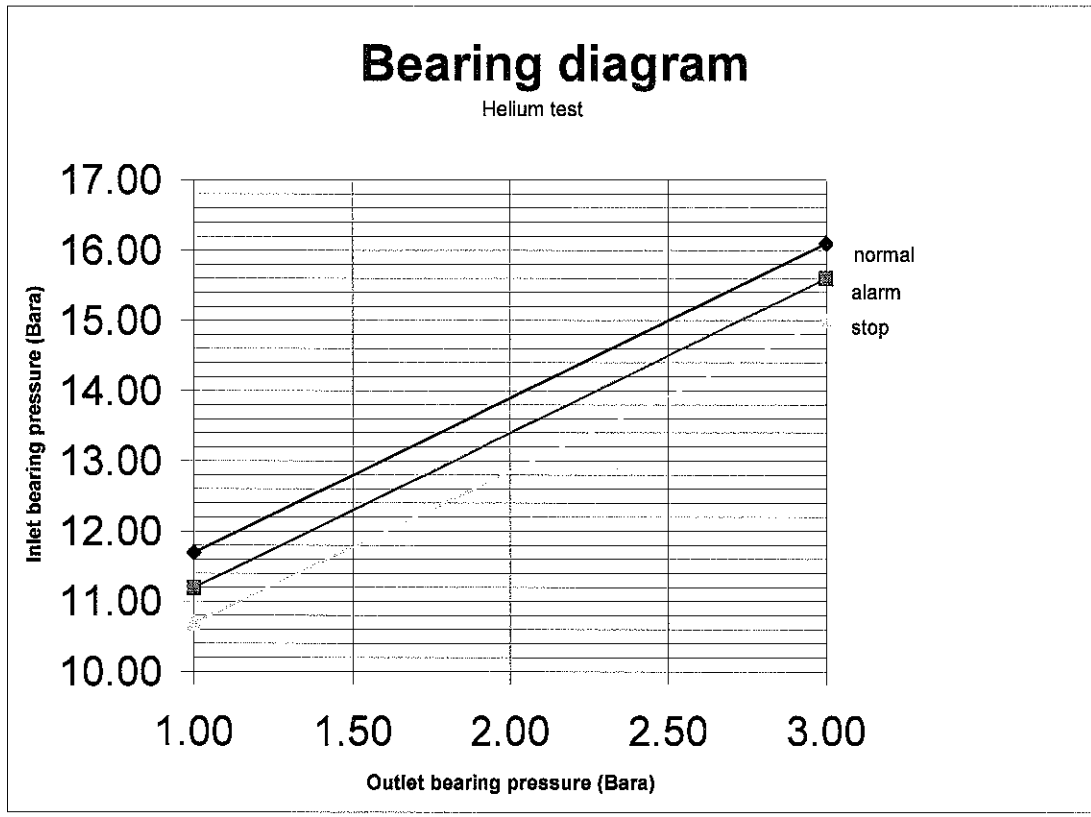
AIR LIQUIDE DIVISION TECHNIQUES AVANCEES	**DIAGRAMME PIVOTERIE** ***GAS BEARING DIAGRAM***	**N° :C4023-NT-9 (0)** Folio : 10 / 11 *Folio* :
AFFAIRE / *JOB* :KSTAR	N° :	
Identification du matériel / *Material identification* : C5 605 FU1		
APPLICATION : ☐ Site Client/*Customer* ☑ DTA Test		



NOM / *NAME*	F. DELCAYRE				
DATE / *DATE*	04/04/06				
SIGNATURE / *VISA*					
VERSION / *ISSUE*					

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TEST REPORT

5.7 EFFICIENCY VERSUS U1/CO

(Items 6.7 of procedure)

Cartridge number : C5 605 FU1

INPUTS **TURBINE PROCESS CONDITIONS**

GAS	PRESSURE 10^5Pa		TEMPERATURES K		FLOW kg/s	ENTHALP. DROP kJ/kg		η s	ROTATION SPEED Hz	REFRIG. POWER Watt	INLET WHEEL PRESS. 10^5Pa
	INLET	OUTLET	INLET	OUTLET		Δ Hs	Δ Hr	Δ Hr/ Δ Hs			
He	15.78	5.17	70.0	50.7	279.8	133.8	103.1	0.77	1906	28835	9.5

OUTPUTS **TURBINE TEST CONDITIONS**

GAS	PRESSURE 10^5Pa		TEMPERATURES K		FLOW kg/s	ENTHALP. DROP KJ/kg		η s	ROTATION SPEED Hz	REFRIG. POWER Watt	INLET WHEEL PRESS. 10^5Pa
	INLET	OUTLET	INLET	OUTLET		Δ Hs	Δ Hr	Δ Hr/ Δ Hs			
He	12.28	3.14	75.7	50.7	215.4	167.94	132.02	0.786	1897	284439	6.18

BEARING TEST CONDITIONS

GAS	PRESSURE 10^5Pa		TEMPERATURES °C
	SUPPLY	RETURN	
He	15.99	2.96	In : 18.7 Out : 23.0

BRAKE TEST CONDITIONS

GAS	PRESSURES 10^5Pa		TEMPERATURE °C	
	INLET	OUTLET	INLET	OUTLET
He	8.34			76.3

TEST RESULTS

DIAM. WHEEL mm	TIP VELOCITY U_1 m/s	SPOUTING VELOCITY C_O m/s	U_1/ Co	η s	COMMENTS	
		SUPPLY	RETURN		FAIL	PASS
55	327.7	577.5	0.57	78 %		X

UTILITY FLOW RATE

GAS BEARING SUPPLY g / s	BRAKE SUPPLY g / s	SEAL GAS g / s	RETURN g / s
	INLET	OUTLET	OUTLET
9.78	0.52	0.43	10.90