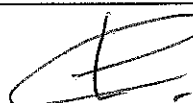
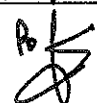
 DIVISION TECHNIQUES AVANCEES		PROCES-VERBAL D' ESSAI TEST REPORT CRYOGENIC TURBO EXPANDER		N° : C 4023 NT 8 (0) Folio : 1 / 11 Folio :	
AFFAIRE : KSTAR JOB :		N° : T01 N° :		Fiche Suiveuse n° : Inspection traveller n° :	
Identification du matériel : C5 Material identification :		N° : 603 FS1		Quantité / Quantity : 1 Lot / Batch :	
Fournisseur/Fabricant : Supplier / Manufacturer : AIR LIQUIDE		Organisme de Contrôle : Inspected by : D2TI		Lieu : Location : 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 <input checked="" type="checkbox"/> NON CONFORME / FAIL <input type="checkbox"/>		OBSERVATIONS : Limited by our test bench COMMENTS :			
	ESSAI / TEST	Responsable / Manager		A.Q. / Q.A.	
NOM / NAME	L. Pelosi	F. Delcayre		JL. David	
DATE / DATE	31/03/06	15/12/06			
SIGNATURE / VISA					

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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 603 FS1

Bearing conditions required : NORMAL

CASE	EXTREME 1	EXTREME 2	
INPUTS			
Load	44	605	N
On	Brake	Turbine	Bearing
Equivalent pressure difference on the shaft	3	30	10 ⁵ Pa
OUTPUTS			
Inlet bearing pressure	16.47	16.81	10 ⁵ Pa
Outlet bearing pressure	2.51	2.77	10 ⁵ Pa
Turbine outlet pressure (1)	5.62	2.28	10 ⁵ Pa
Brake pressure (2)	2.59	18.25	10 ⁵ Pa
Pressure difference = (2) – (1)	-3.03	15.97	10 ⁵ Pa
Speed	33	22	Hz
Passed/failed	passed	passed	

TEST REPORT

5.2 THRUST AND JOURNAL BEARINGS TEST, HIGH SPEED

(Items 6.2 of procedure)

Cartridge number : C5 603 FS1

Bearing conditions required : NORMAL

MODE	MINIMAL	NOMINAL	MAXIMAL	
INPUTS				
Turbine outlet design pressure (1)	15.7	13.4	4.8	10 ⁵ Pa
Brake design pressure (2)	8.3	10.4	12.5	10 ⁵ Pa
$\Delta = 2-1$	-7.4	-3.0	7.7	10 ⁵ Pa
OUTPUTS				
Inlet bearing pressure		16.4	16.42	10 ⁵ Pa
Outlet bearing pressure		3.13	3.09	10 ⁵ Pa
Turbine outlet test pressure (1)		2.8	2.81	10 ⁵ Pa
Brake test pressure (2)		3.39	10.53	10 ⁵ Pa
$\Delta = (2) - (1)$		0.59	7.72	10 ⁵ Pa
Speed		2103	1508	Hz
Passed		passed	passed	

TEST REPORT

5.3 THRUST AND JOURNAL BEARING TEST, HIGH SPEED

(Items 6.2 of procedure)

Cartridge number : C5 603 FS1

Bearing conditions required : ALARM AND STOP

BEARING CONDITIONS	ALARM	STOP	
Mode	Nominal	Nominal	
INPUTS			
Turbine design outlet pressure (1)	13.4	13.4	10 ⁵ Pa
Brake design pressure (2)	10.4	10.4	10 ⁵ Pa
$\Delta = 2-1$	-3.0	-3.0	10 ⁵ Pa
OUTPUTS			
Inlet bearing pressure		15.33	10 ⁵ Pa
Outlet bearing pressure		3.14	10 ⁵ Pa
Turbine outlet test pressure		2.87	10 ⁵ Pa
Brake inlet pressure		3.34	10 ⁵ Pa
$\Delta = 2-1$		0.47	10 ⁵ Pa
Speed		2096	Hz
Passed		passed	

TEST REPORT

5.4 CRITICAL SPEEDS AND SHAFT VIBRATIONS

(Items 6.3 of procedure)

Cartridge number : C5 603 FS1

Bearing conditions required : STOP

INPUTS					
	1 st RIGID MODE		2 nd RIGID MODE		
Calculated peak freq.	800				Hz
OUTPUTS					
Measured critical speeds	BEGIN.	END	BEGIN.	END	Hz
	800			1200	
Sound level estimation	A		A		
Time within the mode (> 3 ')					Min
Inlet bearing pressure	16.57		16.57		10 ⁵ Pa
Outlet bearing pressure	3.09		3.09		10 ⁵ Pa
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 603 FS1

Bearing conditions required : NORMAL

INPUTS				
Nominal speed (Hz)		Maximum speed (Hz)		Over speed (Hz)
2065		2200		2280
OUPUTS				
BEARING TEST CONDITIONS				
BEARING GAS PRESSURE (10 ⁵ Pa)		BEARING GAS TEMPERATURE (°C)		BEARING GAS FLOW RATE (g/s)
SUPPLY	RETURN	SUPPLY	RETURN	
16.51	3.18	16.3	32.0	12.09

TURBINE TEST CONDITIONS

TURBINE PRESSURE (10 ⁵ Pa)		TURBINE TEMPERATURE (K)		TURBINE FLOW RATE (g/s)
SUPPLY	RETURN	SUPPLY	RETURN	
6.63	2.8	290.3	235.4	52.4

BRAKE TEST CONDITIONS

INLET BRAKE PRESSURE 10 ⁵ Pa	OUTLET BRAKE TEMPERATURE °C
4.72	55.3

TEST RESULTS

ROTATION SPEED Hz	STEADY STATE	OVERSPEED STATE DURATION (mn)	COMMENTS	
			FAIL	PASS
2290	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 603 FS1
 Bearing conditions required : normal
 Nominal speed :

	AMBIENT	MEDIUM	+10 ° K	NOMINAL	-10 °K	
Target outlet temperature	280	250	200	180	160	K
TURBINE :						
Inlet pressure	3.9	6.05	8.06	9.48	10.76	10 ⁵ Pa
Outlet pressure	2.76	2.8	3.99	4.86	5.57	10 ⁵ Pa
Inlet temperature	293.3	293.0	239.3	215.4	193.3	K
Outlet temperature	274.9	245.3	200.0	180.3	160.0	K
Flow	32.6	46.9	69.5	82.5	98.3	g/s
BRAKE :						
Inlet pressure	4.64	4.65	5.89	6.7	6.36	10 ⁵ Pa
Outlet temperature	19.0	32.1	55.9	58.8	64.1	°C
BEARING :						
Inlet pressure	16.57	16.52	16.44	16.44	16.47	10 ⁵ Pa
Outlet pressure	3.09	3.13	3.18	3.1	3.13	10 ⁵ Pa
Inlet temperature	16.9	16.8	16.6	16.6	17.4	°C
Outlet temperature	20.6	23.7	34.6	34.0	35.4	°C
Inlet flow	10.31	11.56	11.34	11.29	11.41	g/s
SPEED :	1192	2089	2085	2085	2224	Hz
Number of start up/shut down	 	3	 	 	3	
Fail/pass	passed	passed	passed	passed	passed	



DIVISION TECHNIQUES AVANCEES

DIAGRAMME PIVOTERIE

GAS BEARING DIAGRAM

N° :C4023-NT-5 (0)

Folio : 10 / 11

Folio :

AFFAIRE / JOB :

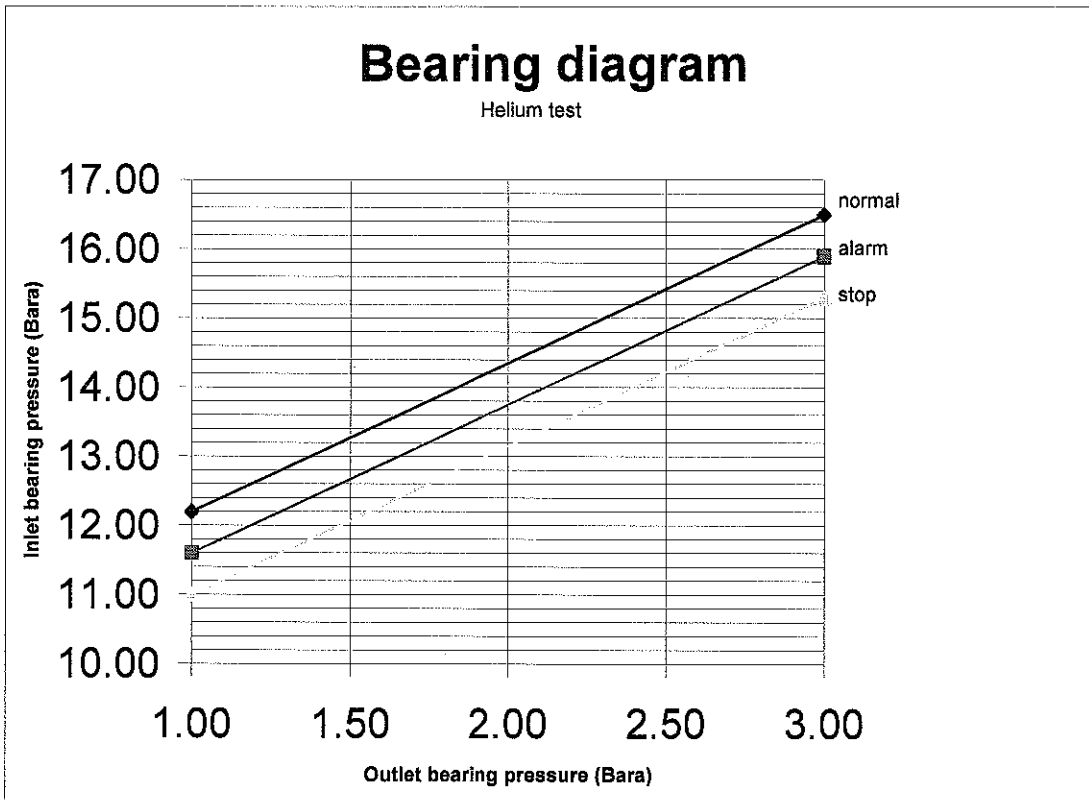
N° :

Identification du matériel / Material identification : C5 603 FS1

APPLICATION :

Site Client/Customer

DTA Test



NOM / NAME	F. DELCAYRE				
DATE / DATE	04/01/06				
SIGNATURE / VISA					
VERSION / ISSUE					

TEST REPORT

5.7 EFFICIENCY VERSUS U1/CO

(Items 6.7 of procedure)

Cartridge number : C5 603 FSI

INPUTS

GAS	PRESSURE 10 ⁵ Pa		TEMPERATURES K		FLOW kg/s	ENTHALP. DROP kJ/kg		η_s	ROTATION SPEED Hz	REFRIG. POWER Watt	INLET WHEEL PRESS. 10 ⁵ Pa
	INLET	OUTLET	INLET	OUTLET		ΔH_s	ΔH_r				
He	20.85	13.38	204.4	179.3	162.2	174.8	132.8	0.76	2066	21553	16.5

TURBINE PROCESS CONDITIONS

OUTPUTS

GAS	PRESSURE 10 ⁵ Pa		TEMPERATURES K		FLOW kg/s	ENTHALP. DROP KJ/kg		η_s	ROTATION SPEED Hz	REFRIG. POWER Watt	INLET WHEEL PRESS. 10 ⁵ Pa
	INLET	OUTLET	INLET	OUTLET		ΔH_s	ΔH_r				
He	10.73	5.49	199.2	163.7	95.1	244.83	186.08	0.76	2241	17697	7.41

TURBINE TEST CONDITIONS

BEARING TEST CONDITIONS

GAS	PRESSURE 10 ⁵ Pa		TEMPERATURES °C
	SUPPLY	RETURN	
He	16.46	3.15	In : 17.2 Out : 35.6

BRAKE TEST CONDITIONS

GAS	PRESSURES 10 ⁵ Pa		TEMPERATURE °C	
	INLET	OUTLET	INLET	OUTLET
He	6.31	6.23		65.5

TEST RESULTS

DIAM. WHEEL mm	TIP VELOCITY U ₁ m/s	SPOUTING VELOCITY C ₀ m/s		U ₁ /C ₀	η_s	COMMENTS	
		SUPPLY	RETURN			FAIL	PASS
55	387.02	699.75		0.55	76%		X

UTILITY FLOW RATE

GAS BEARING SUPPLY g/s	BRAKE SUPPLY g/s		SEAL GAS g/s		RETURN g/s	
	INLET	OUTLET	INLET	OUTLET	INLET	OUTLET
11.45	0.29	0.4				12.37