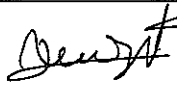

 DIVISION TECHNIQUES AVANCEES		PROCES-VERBAL D' ESSAI TEST REPORT CRYOGENIC TURBO EXPANDER			N° : C 4023 NT 12 (0) Folio : 1 / 11 Folio :	
AFFAIRE : KSTAR JOB :		N° : T05 N° :		Fiche Suiveuse n° : Inspection traveller n° :		
Identification du matériel : C4 Material identification :		N° : 555 FW1	Quantité / 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 :			Instruments de contrôles utilisés : Inspection instruments used :			
PROCEDURE : D4444-PO-2			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				
START/STOP		Passed				
DESCENTE EN FROID Cold down		Passed				
RENDEMENT / Efficiency		Passed				
DECISION : DECISION :		<input checked="" type="checkbox"/> <input type="checkbox"/>		OBSERVATIONS : COMMENTS :		
CONFORME / PASS		<input checked="" type="checkbox"/>				
NON CONFORME / FAIL		<input type="checkbox"/>				
	ESSAI / TEST	Responsable / Manager	A.Q. / Q.A.			
NOM / NAME	B Renzetti	F. Delcayre	JL. David			
DATE / DATE	30/11/06	30/11/06				
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 : C4 555 FW1

Bearing conditions required : NORMAL

CASE	EXTREME 1	EXTREME 2	
INPUTS			
Load	0	256	N
On	Brake	Turbine	Bearing
Equivalent pressure difference on the shaft	0	19	10 ⁵ Pa
OUTPUTS			
Inlet bearing pressure	13.37	13.41	10 ⁵ Pa
Outlet bearing pressure	1.49	1.52	10 ⁵ Pa
Turbine outlet pressure (1)	1.98	1.32	10 ⁵ Pa
Brake pressure (2)	2.06	16.80	10 ⁵ Pa
Pressure difference = (2) – (1)	0.08	15.48	10 ⁵ Pa
Speed	20	18	Hz
Passed/failed	passed	passed	

TEST REPORT

5.2 THRUST AND JOURNAL BEARINGS TEST, HIGH SPEED

(Items 6.2 of procedure)

Cartridge number : C4 555 FW1

Bearing conditions required : NORMAL

MODE	MINIMAL	NOMINAL	MAXIMAL	
INPUTS				
Turbine outlet design pressure (1)	1.6	1.3	1.0	10 ⁵ Pa
Brake design pressure (2)	7.0	8.7	10.5	10 ⁵ Pa
$\Delta = 2-1$	5.4	7.4	9.5	10 ⁵ Pa
OUTPUTS				
Inlet bearing pressure	13.38	13.38	13.39	10 ⁵ Pa
Outlet bearing pressure	1.57	1.54	1.53	10 ⁵ Pa
Turbine outlet test pressure (1)	1.45	1.46	1.50	10 ⁵ Pa
Brake test pressure (2)	6.86	8.82	11.07	10 ⁵ Pa
$\Delta = (2) - (1)$	5.41	8.36	9.57	10 ⁵ Pa
Speed	2345	2224	2008	Hz
Passed	passed	passed	passed	

TEST REPORT

5.3 THRUST AND JOURNAL BEARING TEST, HIGH SPEED

(Items 6.2 of procedure)

Cartridge number : C4 555 FW1

Bearing conditions required : ALARM AND STOP

BEARING CONDITIONS	ALARM	STOP	
Mode	Nominal	Nominal	
INPUTS			
Turbine design outlet pressure (1)	1.3	1.3	10 ⁵ Pa
Brake design pressure (2)	8.7	8.7	10 ⁵ Pa
$\Delta = 2-1$	7.4	7.4	10 ⁵ Pa
OUTPUTS			
Inlet bearing pressure		12.82	10 ⁵ Pa
Outlet bearing pressure		1.55	10 ⁵ Pa
Turbine outlet test pressure		1.52	10 ⁵ Pa
Brake inlet pressure		8.52	10 ⁵ Pa
$\Delta = 2-1$		8	10 ⁵ Pa
Speed		2421	Hz
Passed		passed	

TEST REPORT

5.4 CRITICAL SPEEDS AND SHAFT VIBRATIONS

(Items 6.3 of procedure)

Cartridge number : C4 555 FW1

Bearing conditions required : STOP

INPUTS					
	1 st RIGID MODE		2 nd RIGID MODE		
Calculated peak freq.	1000		1100		H _z
OUTPUTS					
Measured critical speeds	BEGIN.	END	BEGIN.	END	H _z
				1100	
Sound level estimation	A		B		
Time within the mode (> 3 ')			3		Min
Inlet bearing pressure	13.39		13.39		10 ⁵ Pa
Outlet bearing pressure	1.58		1.58		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 : C4 555 FW1

Bearing conditions required : NORMAL

INPUTS				
Nominal speed (Hz)		Maximum speed (Hz)		Over speed (Hz)
2428		2600		2745
OUPUTS				
BEARING TEST CONDITIONS				
BEARING GAS PRESSURE (10 ⁵ Pa)		BEARING GAS TEMPERATURE (°C)		BEARING GAS FLOW RATE (g/s)
SUPPLY	RETURN	SUPPLY	RETURN	
13.37	1.58	16.2	32.5	

TURBINE TEST CONDITIONS

TURBINE PRESSURE (10 ⁵ Pa)		TURBINE TEMPERATURE (K)		TURBINE FLOW RATE (g/s)
SUPPLY	RETURN	SUPPLY	RETURN	
16.26	1.53	157.2	113.7	40.9

BRAKE TEST CONDITIONS

INLET BRAKE PRESSURE 10 ⁵ Pa	OUTLET BRAKE TEMPERATURE °C
7.22	113.4

TEST RESULTS

ROTATION SPEED H _z	STEADY STATE	OVERSPEED STATE DURATION (mn)	COMMENTS	
			FAIL	PASS
2747	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 : C4 555 FW1

Bearing conditions required : normal

Nominal speed :

	AMBIENT	MEDIUM	+10 %	NOMINAL	-10 %	
Target outlet temperature	280	150	15	13	11	K
TURBINE :						
Inlet pressure	15.14	12.75	16.49	16.81	16.30	10 ⁵ Pa
Outlet pressure	1.53	1.45	1.60	1.62	1.62	10 ⁵ Pa
Inlet temperature	226.2	142.2	29.2	16.81	23.4	K
Outlet temperature	178.3	106.9	15	13	11.8	K
Flow	31.9	33.9		99;5	101.5	g/s
U _i / Co	0.22	0.27	0.59	0.61	0.63	
η_s	35	43	79	80	79	
BRAKE :						
Inlet pressure	8.08	6.86	7.08	7.14	7.24	10 ⁵ Pa
Outlet temperature	73.2	75.5	87.9	83.9	80.7	°C
BEARING :						
Inlet pressure	13.38	13.38	13.54	13.52	13.52	10 ⁵ Pa
Outlet pressure	1.56	1.57	1.60	1.60	1.63	10 ⁵ Pa
Inlet temperature	16.5	16.5	17.4	17.7	17.7	°C
Outlet temperature	24.2	28	24.8	22.3	21.6	°C
Inlet flow						g/s
SPEED :	2440	2345	2367	2308	2234	Hz
Number of start up/shut down	X	3	X	X	3	
Fail/pass	passed	passed	passed	passed	passed	



DIAGRAMME PIVOTERIE
GAS BEARING DIAGRAM

N° :C4023-NT-9 (0)

Folio : 10 / 11

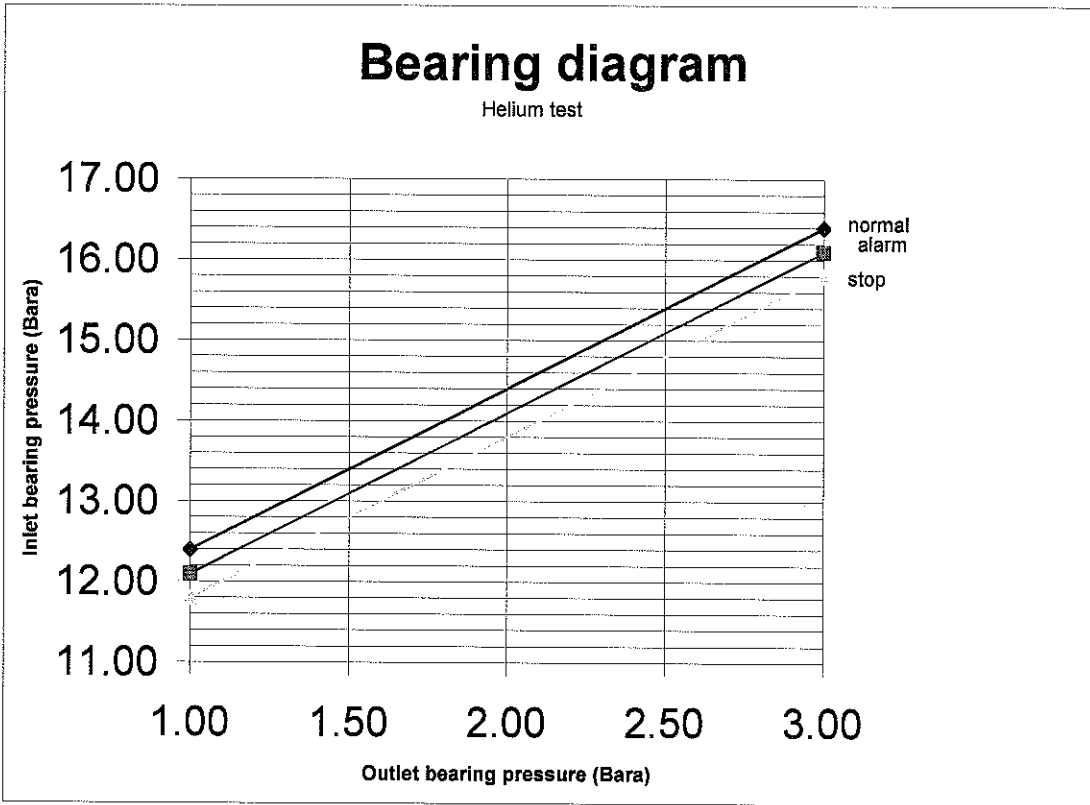
Folio :

AFFAIRE / JOB :KSTAR

N° :

Identification du matériel / *Material identification* : C4 555 FW1

APPLICATION : Site Client/*Customer* DTA Test



NOM / NAME	F. DELCAYRE				
DATE / DATE	02/10/06				
SIGNATURE / VISA					
VERSION / ISSUE					

TEST REPORT

5.7 EFFICIENCY VERSUS U1/CO

(Items 6.7 of procedure)

Cartridge number : C4 555 FW1

INPUTS

TURBINE PROCESS CONDITIONS

GAS	PRESSURE 10 ⁵ Pa		TEMPERATURES K		FLOW kg/s	ENTHALP. DROP kJ/kg		η^s Δ Hr/ Δ Hs	ROTATION SPEED Hz	REFRIG. POWER Watt	INLET WHEEL PRESS. 10 ⁵ Pa
	INLET	OUTLET	INLET	OUTLET		Δ Hs	Δ Hr				
He	20.53	1.3	25.93	13.05	121.5	88.7	63.9	0.72	2428	7763	8.0

OUTPUTS

TURBINE TEST CONDITIONS

GAS	PRESSURE 10 ⁵ Pa		TEMPERATURES K		FLOW kg/s	ENTHALP. DROP KJ/kg		η^s Δ Hr/ Δ Hs	ROTATION SPEED Hz	REFRIG. POWER Watt	INLET WHEEL PRESS. 10 ⁵ Pa
	INLET	OUTLET	INLET	OUTLET		Δ Hs	Δ Hr				
He	16.81	1.62	25.9	13.0	99.5	80.950	64.645	0.80	2308	5076	4.95

BEARING TEST CONDITIONS

GAS	PRESSURE 10 ⁵ Pa		TEMPERATURES °C
	SUPPLY	RETURN	
He	13.52	1.60	In : 17.7 Out : 22.3

BRAKE TEST CONDITIONS

GAS	PRESSURES 10 ⁵ Pa		TEMPERATURE °C
	INLET	OUTLET	
He	7.14		83.9

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
34	246.5	402.3	0.61	0.61	80 %		X

UTILITY FLOW RATE

GAS BEARING SUPPLY g/s	BRAKE SUPPLY g/s		SEAL GAS g/s	RETURN g/s
	INLET	OUTLET		