ONERA

CHARACTERIZATION OF A SWIVEL JOINT

ENGINEERING TEST REPORT

Rev	Description of modifications	Date	Written by	Checked by	Approved by
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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ACRONYMS & ABBREVIATIONS

ONERA	Office National d'Etudes et de Recherches Aérospatiales
$Rp_{0.2}$	0.2 Offset Yield Strength
Rm	Ultimate Strength
SDU	Safran Aerosystems Ducts

1. INTRODUCTION

1.1. SCOPE

This document provides the results of the engineering tests that SDU performed to characterize the performances of the swivel joint HT-DN080-Sched.40.

Figure 1: Swivel Joint HT-DN080-Sched.40

This swivel joint is intended to be mounted on a mobile piping system. Details are provided on the swivel joint operation in section 4.

2. APPLICABLE DOCUMENTS

2.1. ONERA DOCUMENTS

In the following list, document's issues are not specified. Please refer to the last valid issues.

- ***Documentation Swivel Joint Type: HT-DN80-SCHED.40***

2.2. SDU DOCUMENTS

In the following list, drawings' issues are not specified. Please refer to the last valid issues.

- ***2-3-20-0028:*** Proof Test Fixture
- ***0-1-20-0018:*** Stiffness Measurement Fixture
- ***ST 1045***: Hydraulic and pneumatic tests for rigid and articulated pipes
- ***DTE 001/2020***: Characterization of a swivel joint – Engineering Test Procedure

2.3. GENERAL DOCUMENTS

Documents issues are not specified in the following list, refer to the last valid issues:

- ***CS-E 640:*** Certification Specification for Engines – Pressure Loads
- ***MMPDS-08:*** Metallic Materials Properties Development and Standardization

3. TEST REQUIREMENTS

3.1. GENERAL REQUIREMENTS

Applicable standards for test requirements.

Table 1: Applicable Standards

Requirements	Applicable Standard
Proof test	ETP DTE 001/2020 / ST 1045
Leakage test	ETP DTE 001/2020 / ST 1045
Stiffness test	ETP DTE 001/2020

3.2. TEST LABORATORY AND SURVEILLANCE

All tests have been conducted by SDU at SDU lab (5, Rue des Ateliers, 60200 Compiègne, France).

3.3. TEST SURVEILLANCE

The engineering test program has been monitored by SDU.

4. SWIVEL JOINT OPERATION

4.1. WORKING CONDITIONS

The swivel joint is intended to be used under the following maximum conditions:

Table 2: Maximum Working conditions

Maximum Working Pressure (barg)	***Maximum Working Temperature (°C)***
50	377

4.2. PRELOAD SCREWS

This swivel joint has four preloaded screws located as follows:

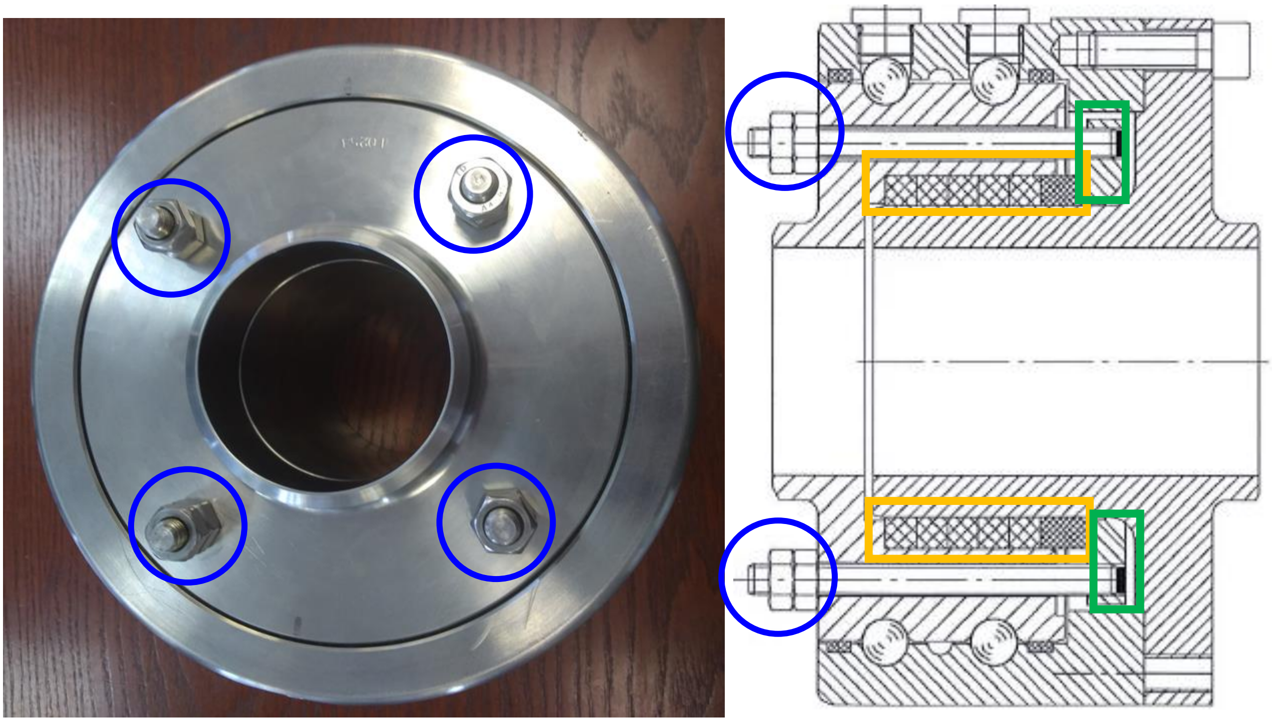


Figure 2: Screws for preload application

These screws (blue) are used to manage the compression of the graphite seals (orange) by pulling on the threaded rods anchored in the crown (green). The principle used to compress the graphite seals is the stuffing box.

5. TEST RESULTS

5.1. PROOF PRESSURE

5.1.1. Test Article Identification

- Swivel Joint HT-D 80-Sched.40

5.1.2. Test Equipment List

Table 3 here after sums-up the equipment list used for the proof test.

Table 3: Proof Test Items of Equipment

Items of Equipment	Measurements ranges	Measurement Accuracy (±)	Equipment reference	Calibration Validity
Pressure Test Bench (also used as pressure gauge)	0 to 5.5 bar	0.05 bar	812000	19/09/2020
	0 to 35 bar	0.3 bar		
	0 to 350 bar	1 bar		
Vernier calliper	0 to 300mm	0.01mm	11769	12/11/2020

Calibration certificates are available on Appendix II.

Note:

The three (3) manometers here before are respectively used during the pressure ramp-up by the test bench.

5.1.3. Test Setup

Figure 3 and Figure 4 here after present of the test setup used to perform proof test of the swivel joint.

Figure 3: Proof Test Bench

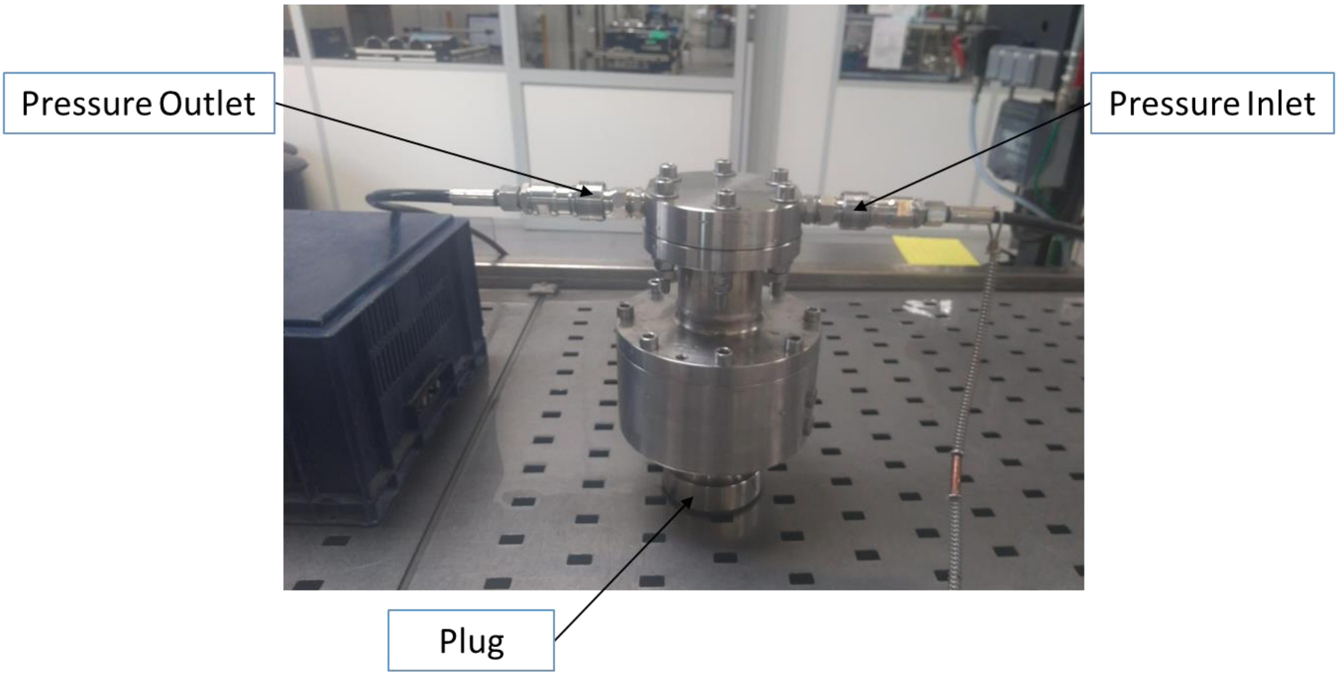


Figure 4: Proof Test Setup

5.1.4. Test Procedure and Parameters

- **Procedure from ETP DTE 001/2020**

Procedure for the proof pressure test is reminded here after:

- The swivel joint was installed into a set-up equivalent to the one shown here after in Figure 4, in unrestrained and undeflected conditions.
- The swivel joint was pressurized using water, at room temperature, in increments of 5 barg per minute, up to the nominal proof pressure test level.
- Upon stabilization of the proof pressure, the swivel joint withstood these conditions for 3-minute duration.
- After 3 minutes at the proof pressure conditions, the swivel joint was depressurized to ambient conditions.

Note / Deviations from the ETP DTE 001/2020:

The dimensions of the swivel joint (length and diameter at three locations) was recorded before the test:

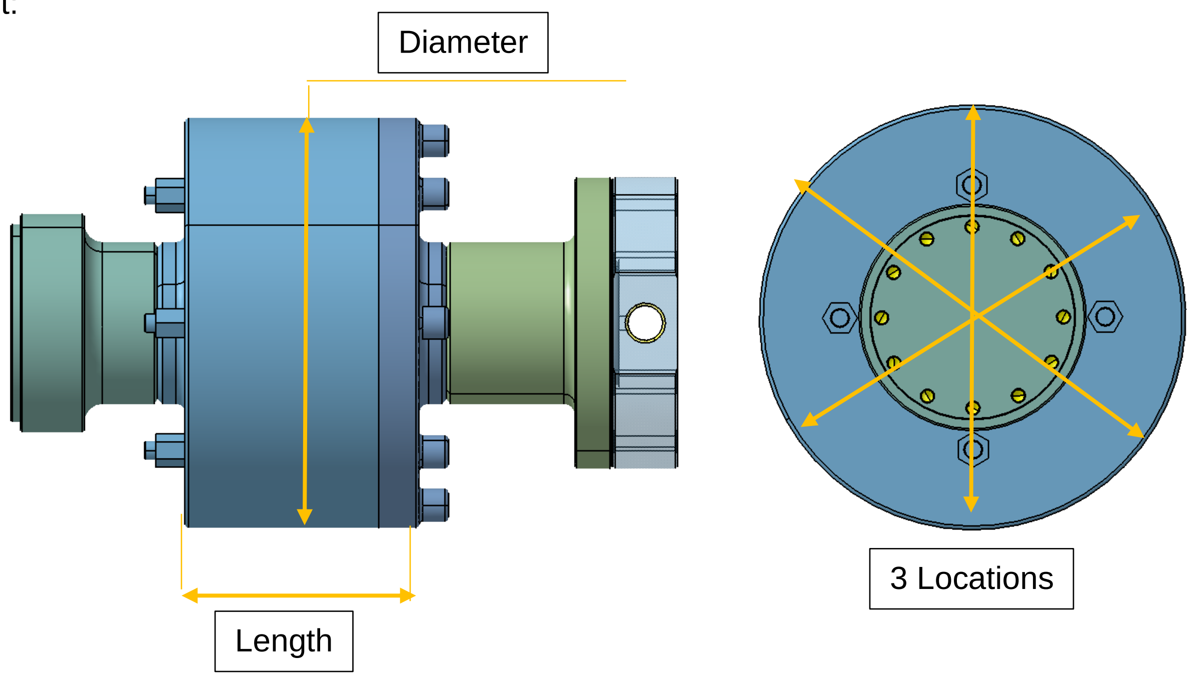


Figure 5: Locations for length and dimeter measurements

- **Parameters**

Table 4 below sums up the parameters used for the proof test.

Table 4: Proof Test Parameters

Proof Test Conditions	
Proof Pressure:	***109.2 barg Tolerance: 0/+5%***
Temperature:	***20°C ± 3°C***
Fluid:	***Water under air***
Time duration:	***3 minutes***

The proof test was performed at room temperature; therefore, a coefficient was applied to the proof pressure at high temperature and was calculated as follow:

$$Ktp = \frac{Rp_{0.2\ at\ 20°C}}{Rp_{0.2\ at\ 377°C}}$$

$$Ktp = \frac{151}{92} = 1.6413$$

(*) The proof pressure was determined per CS-E 640 methodology with MMPDS-08 material properties for AISI 316.

Proof pressure wis the greatest of the following pressures:

a. 1.1 times the maximum working pressure or,
b. 1.33 times the normal working pressure or,
c. 35 kPa above the normal working pressure.

Cases	***CS-E 640 Methodology***	***Proof Pressure (barg)***
a	P = 1.1 x 50 x Ktp	90.3
b	P = 1.33 x 50 x Ktp	109.2
c	P = (50 + 0.35) x Ktp	82.7

The greatest pressure value is **109.2 barg** at room temperature.

- **Screws Preload**

For the proof test, the preload torque used on the screw was 10 N.m (see section 4.2).

5.1.5. Pre-Test Measurements

The pre-test measurements results performed according to Figure 5 are presented here after:

Measured dimension	Location 1	Location 2	Location 2
External Diameter	217.3 mm	217.3 mm	217.3 mm
Length	124.8 mm	124.8 mm	124.8 mm

These lengths and diameters were checked after proof test.

5.1.6. Proof Test

Figure 6 here after shows the swivel joint during the proof pressure test.

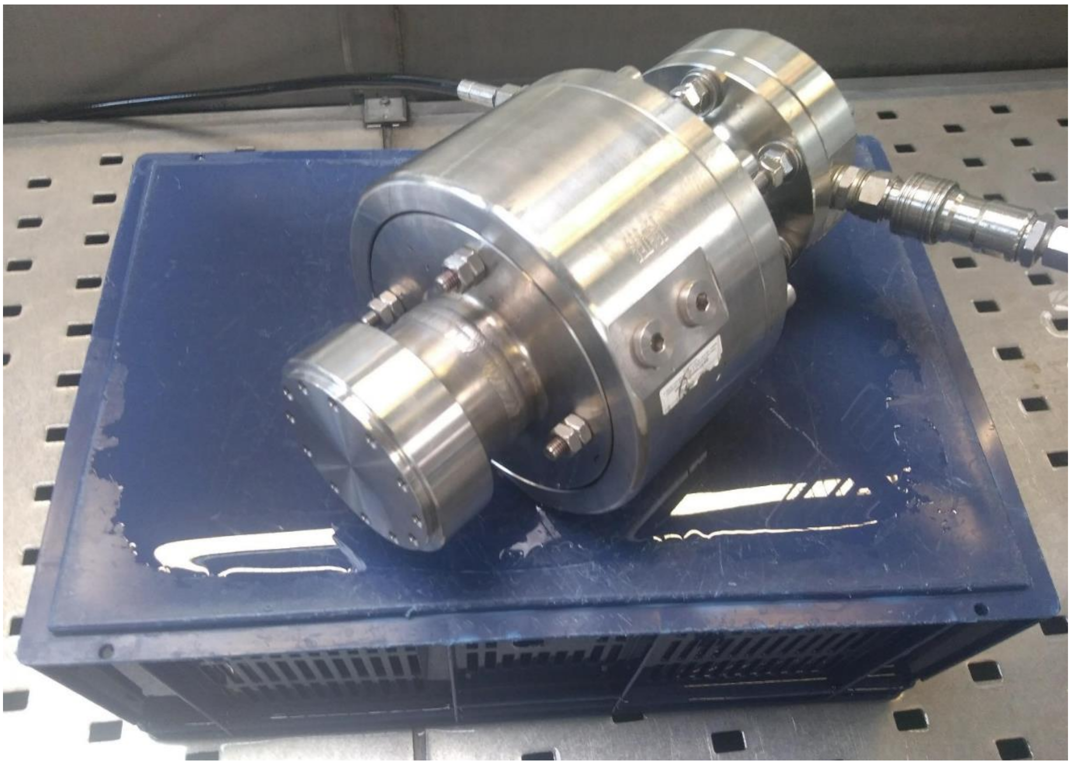


Figure 6: View of the Swivel Joint during Proof Pressure Test

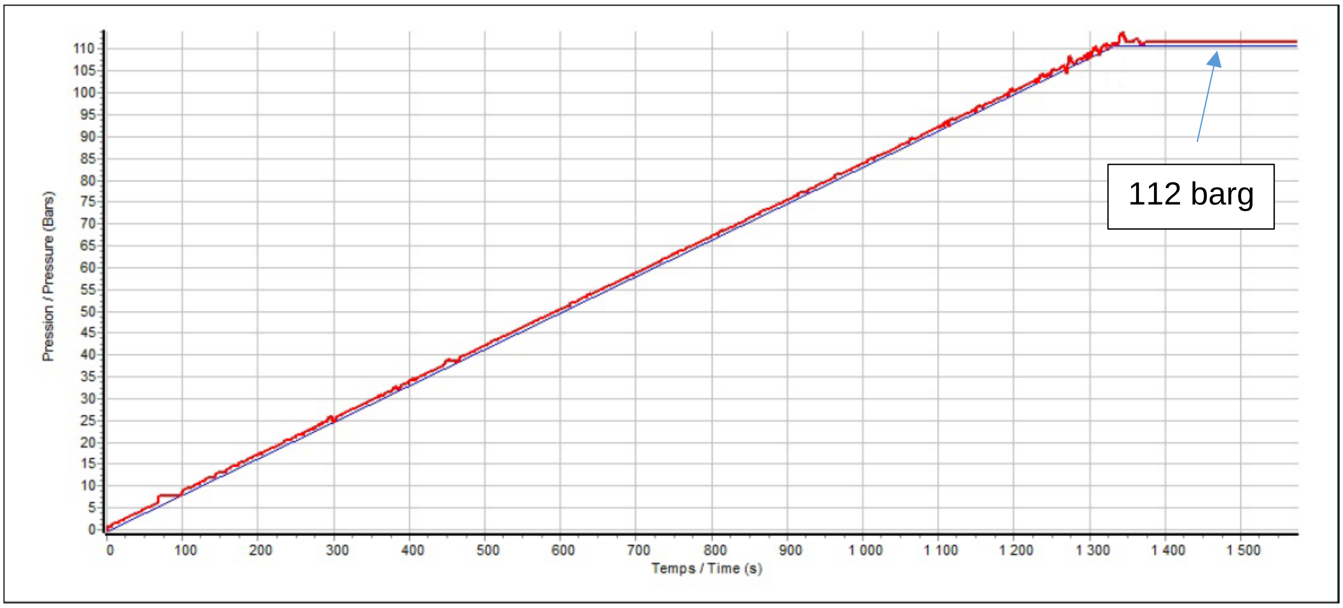


Figure 7: Swivel Joint Proof Test – Pressure VS Time

During the test, the swivel joint leaked slightly at different locations and for different pressures:

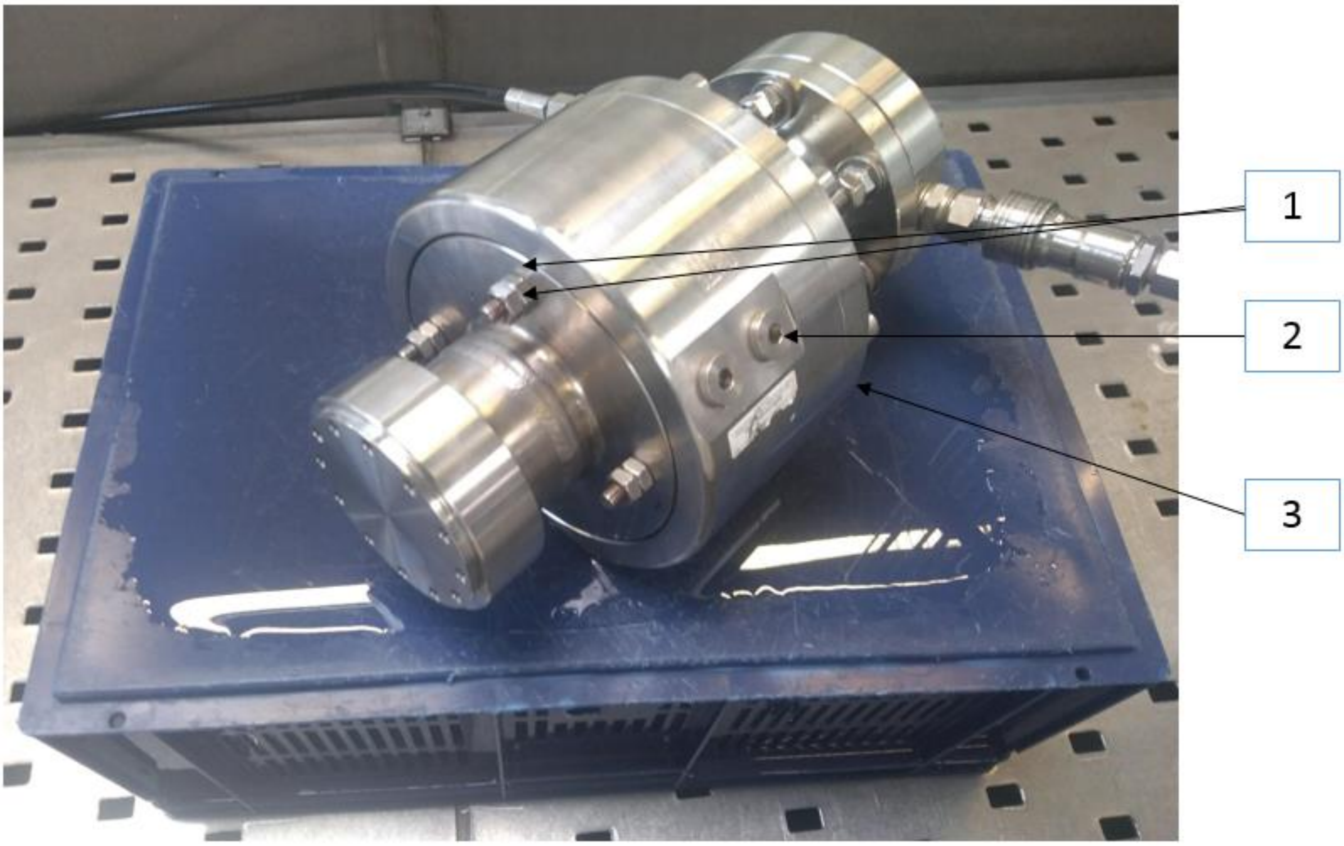


Figure 8: Location of the Leakages on the Swivel Joint

During the proof test, SDU noticed the following slight leakages. Locations are identified on Figure 8 and corresponding pressures noted in Table 5.

Table 5: Summary of the Leakage on the Swivel Joint

Pressure	Location of the leakage on Figure 8
30 bar	Location 1
40 bar	Location 2
70 bar	Location 3

5.1.7. Post-Test Measurements

After the test, lengths and diameters according to Figure 5 have been checked.

Table 6 here after shows the results of the dimensional inspection before and after the proof test.

Table 6: Comparison of Dimensional Inspection before and after the Proof Test

Measured dimension	Location	Measurement before proof test	Measurement after proof test	Compliance
External Diameter	Location 1	217.3 mm	217.3 mm	✓
	Location 2	217.3 mm	217.3 mm	
	Location 3	217.3 mm	217.3 mm	
Length	Location 1	124.8 mm	124.8 mm	✓
	Location 2	124.8 mm	124.8 mm	
	Location 3	124.8 mm	124.8 mm	

5.1.8. Conclusion

Section 5.1 demonstrates that the swivel joint successfully passed the proof test without plastic deformation.

5.2. LEAKAGE TEST

5.2.1. Test Article Identification

- Swivel Joint HT-D 80-Sched.40

5.2.2. Test Equipment List

The table here after sums-up the equipment list used for the leakage test.

Table 7: Leakage Measurement Equipment

Items of Equipment	Measurement range	Measurement accuracy	Model	Calibration
SDU Test bench	N/A	N/A	986219	N/A
Thermocouples	[-200 ; +1100] °C	± 2.9°C at 710°C	K-Type	12/10/2020
Pressure Gauge	[0 ; 160] bar	± 1%	81505	11/03/2022
Heating element	[20 ; 750] °C	N/A	Chromalox	N/A
Chronometer	0 – 60 min	± 0.01 sec	93738	29/10/2020

Calibration certificates are available on Appendix II.

5.2.3. Test Setup

Figure 9 here after presents the swivel joint installed on the test bench.

Figure 9: Leakage Test Bench

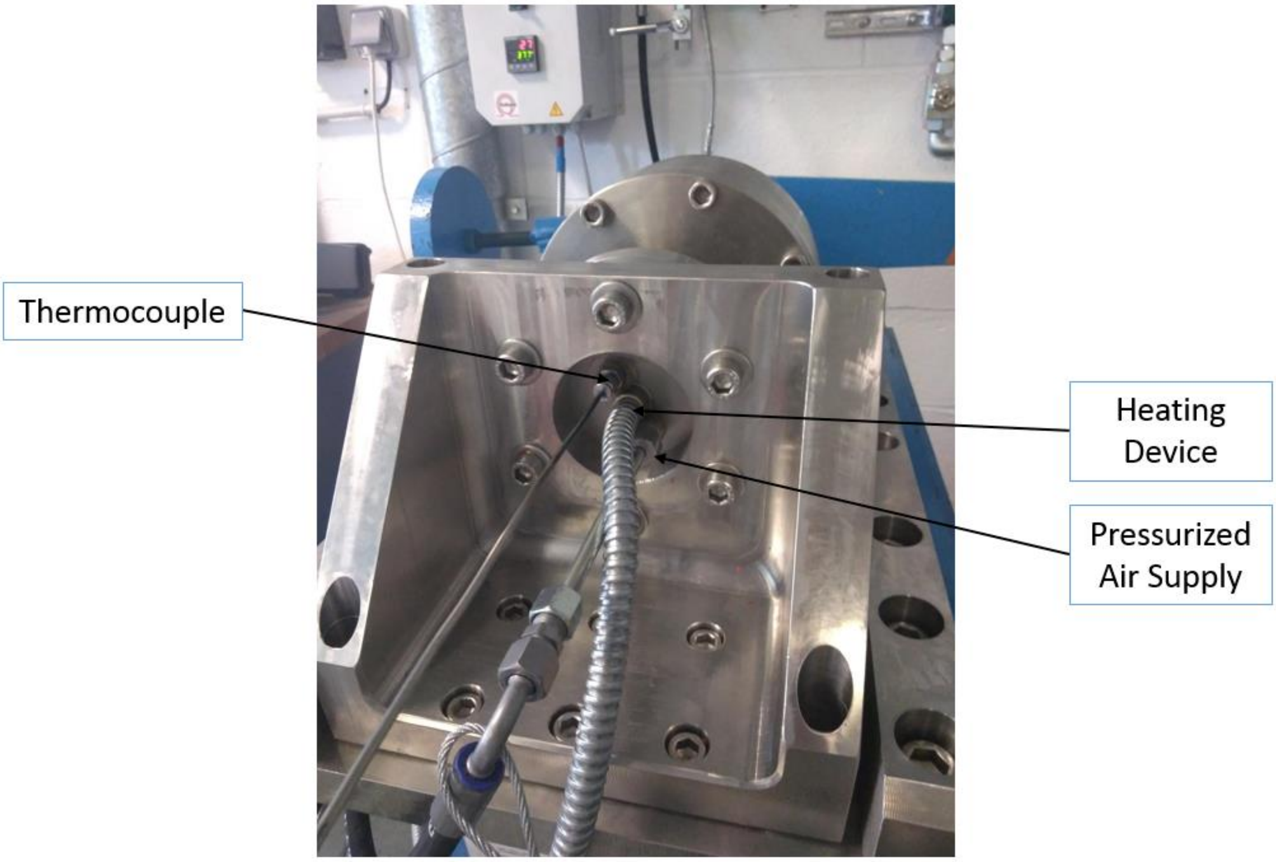


Figure 10: Front View of the Swivel Joint on the Leakage Test Bench

As a reminder, the heating device has a thermocouple inside only dedicated to control. To measure a second thermocouple is added as presented here after:

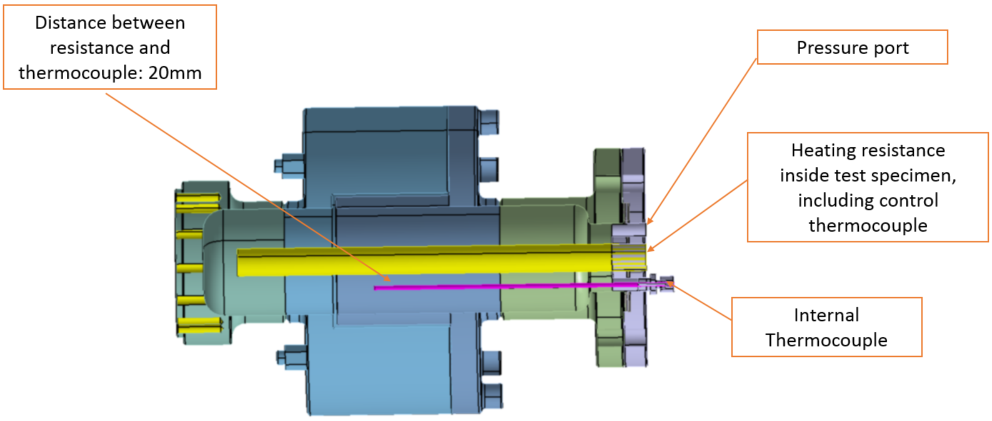


Figure 11: Leakage Test Internal Setup

5.2.4. Test Procedures and Parameters

Two leakage tests have been performed: a first leakage test at ambient temperature (20°C ± 3°C) and a second one at 377°C ± 20°C.

- **Procedure from ETP DTE 001/2020**

  ➢ ***Case 1: Test at 20°C***

a. The swivel joint was installed into a set-up equivalent to the one shown in Figure 9 and Figure 10, in unrestrained and undeflected conditions.

b. The preload torque for swivel joint nuts was set at 0 N.m for iteration 1.

c. The swivel joint was pressurized pneumatically up to the nominal pressure test level.

d. Upon stabilizing the pressure, the inlet valve was closed and the pressure maintained for 5 minutes, while looking out for any leak in the system through the pressure gauge.

e. In case of a leak, the leakage rate was determined by timing the decrease of the pressure indicated by the pressure gauge during 5 minutes.

f. The rotating joint was unpressurized.

g. Steps b. to f. were repeated increasing the preload torque according to iterations in Table 9 until reaching iteration 6 (torque = 25Nm) or leakage equal to 0.

<u>Note / Deviations from the ETP DTE 001/2020:</u>

- Before Step a. Before performing the leakage test at 20°C, the swivel joint was heated to 377°C ± 20°C and cool down to ambient temperature. Then, the preload torque according to Figure 2 has been checked.

- Step c. For the first iteration, the preload torque was set at 10 N.m due to the certainty of leakage at lower preload torque.

- Step g. The preload torque has been increased from 10 N.m to 30 N.m.

➢ ***Case 2: Test at 377°C***

a. The swivel joint was installed into a set-up equivalent to the one shown in Figure 9 and Figure 10, in unrestrained and undeflected conditions.

b. The preload of the swivel joint nuts was set at same value than for last iteration of Case 1.

c. The heating resistance was turned on and set to reach 377°C.

d. Upon reaching the required temperature, the test article was allowed to soak until steady state temperature has been achieved.

e. The swivel joint was pressurized pneumatically up to the nominal pressure test level.

f. Upon stabilizing the pressure, the inlet valve was closed and the pressure maintained for 5 minutes, while looking out for any leak in the system through the pressure gauge.

g. In case of a leak, the leakage rate was determined by timing the decrease of the pressure indicated by the pressure gauge during 5 minutes.

h. The rotating joint was unpressurized and cooled down to ambient temperature.

i. Steps b. to h. were repeated increasing the preload torque according to iterations in Table 9 until reaching iteration 6 (torque = 25Nm) or leakage equal to 0.

<u>Note / Deviations from the ETP DTE 001/2020:</u>

- Step b. Given the results of the leakage test at 20°C, the preload torque was set at 15 N.m. This preload torque was mutually agreed between SDU and ONERA.

- **Parameters**

Table 8 here after sums up the parameters used for the leakage tests

Table 8: Leakage Test Parameters

Case	*Pressure*	*Temperature*	*Fluid*	*Duration*
1	50 barg	20°C ± 3°C	Air	5 minutes
2	50 barg	377°C ± 20°C		

Table 9 here after presents the iterations applied in term of preload torque (test at 20°C).

Table 9: Preload Torque Iterations

Iteration	*1*	*2*	*3*	*4*	*5*
Preload Torque (N.m)	10	15	20	25	30

5.2.5. Leakage Tests Results at 20°C

- **Pressure Loss**

Table 10 here after presents the results of the leakage tests performed on the swivel joint at 20°C.

Table 10: Results of Leakage Tests at 20°C

Case	*Temperature (°C)*	*Preload Torque (N.m)*	*Time (s)*	*Measured Pressure (barg)*	*ΔP * (bar)*
1	20°C ± 3°C	10	0	50	0
			60	38	12
			120	37	13
			180	36	14
			240	35	15
			300	35	15
		15	0	50	0
			60	49	1
			120	49	1
			180	48	2
			240	48	2
			300	48	2
		20	0	50	0
			60	49	1
			120	49	1
			180	48	2
			240	48	2
			300	48	2
		25	0	50	0
			60	49	1
			120	49	1
			180	49	1
			240	48	2
			300	48	2
		30	0	50	0
			60	49	1
			120	49	1
			180	49	1
			240	48	2
			300	48	2

* ΔP is the difference between the initial pressure (50 barg) and the pressure read on the manometer at each interval of time.

- **Leakage Rate**

Based on the results provided in Table 10 and Table 12, SDU has calculated the leakage rate using the following formula (perfect gas rule as first hypothesis):

$$Leakage\ rate = \left(\frac{PVM}{RT}\right)\Big/_{\Delta}$$

With:

P = Pressure in the swivel joint (Pa) ➔ See Table 10 & Table 12
V = Volume inside the swivel joint and the air supply hose (m^3) ➔ V = 0.001601 m^3
M = Molar mass of the air (g/mol) ➔ M = 28.97 g/mol
R = Constant of the ideal gases (J/°K/mol) ➔ R = 8.31 J/°K/mol
T = Temperature of the air inside the swivel joint (°K) ➔ T = 293.15°K
Δ = Duration of the experience (s) ➔ Δ = 300s (5 minutes)

Table 11 here after presents the calculated leakage rates.

Table 11: Results of Leakage Tests (at 20°C)

Case	*Temperature (°C)*	*Preload Torque (N.m)*	*Leakage Rate (g/s)*
1	20°C ± 3°C	10	0.095
		15	0.013
		20	0.013
		25	0.013
		30	0.013

Note:

Considering that the leakage rate is the same when the preload torque is equal or higher than 15N.m, SDU used the preload torque of 15N.m for the next step of the tests. This methodology was mutually agreed between ONERA and SDU.

5.2.6. Leakage Test Result at 377°C

- **Pressure Loss**

Table 12 here after presents the results of the leakage tests performed on the swivel joint at 377°C.

Table 12: Results of Leakage Tests at 377°C

Case	Temperature (°C)	Preload Torque (N.m)	Time (s)	Measured Pressure (barg / Pa)	ΔP * (bar / Pa)
2	377°C ± 20°C	15	0	50	0
			60	50	0
			120	50	0
			180	50	0
			240	50	0
			300	50	0

* ΔP is the difference between the initial pressure (50 bar) and the pressure read on the manometer at each interval of time.

Based on the results provided in Table 10 and Table 12, SDU has calculated the leakage rate using the following (perfect gas rule):

$$Leakage\ rate = \left(\frac{PVM}{RT}\right) \Big/ \Delta$$

With:

P = Pressure in the swivel joint (Pa) ➔ See Table 10 & Table 12
V = Volume inside the swivel joint and the air supply hose (m^3) ➔ V = 0.001601 m^3
M = Molar mass of the air (g/mol) ➔ M = 28.97 g/mol
R = Constant of the ideal gases (J/°K/mol) ➔ R = 8.31 J/°K/mol
T = Temperature of the air inside the swivel joint (°K) ➔ T = 650.15°K
Δ = Duration of the experience (s) ➔ Δ = 300s (5 minutes)

Table 13 here after presents the calculated leakage rates.

Table 13: Results of Leakage Tests (at 377°C)

Case	Temperature (°C)	Preload Torque (N.m)	Leakage Rate (g/s)
2	377 ± 20°C	20	0

Conclusion

The leakage rate at 20°C reaches a limit when the preload torque used is 15N.m or higher (2bar lost during 5 minutes).

In addition, this preload torque gives no pressure losses at 377°C.

So on, SDU used the preload torque value of 15N.m for the angular stiffness tests. This methodology was mutually agreed between ONERA and SDU.

5.3. ANGULAR STIFFNESS TEST

5.3.1. Test Article Identification

- Swivel Joint HT-D 80-Sched.40

5.3.2. Test Equipment List

The table here after sums-up the equipment list used for the angular stiffness test.

Table 14: Angular Stiffness Measurement Equipment

Items of Equipment	Measurement range	Measurement accuracy	Model	Calibration
SDU Test bench	N/A	N/A	986219	N/A
Thermocouples	[-200 ; +1100] °C	± 2.9°C at 710°C	K-Type	12/10/2020
Pressure Gauge	[0 ; 160] bar	± 1%	81505	11/03/2022
Heating element	[20 ; 750] °C	N/A	Chromalox	N/A
Inclinometer	[-90° ; 90°]	0.05°	59703	18/11/2020
Weighting Scale	[0 - 60] Kg	± 0.05 Kg	KERN 99804	14/06/2020
Weights*	1kg	N/A	N/A	N/A
	2kg			
	5kg			
	10kg			

*Weights have been checked on calibrated weighting scale: 10kg masses are in the range ±1%, other masses are in the range ±2,5%. Support used for the weights has a mass of 1.8kg. Calibration certificates are available on Appendix II.

5.3.3. Test Setup

The test setup used is the same than for leakage tests (Figure 9 and Figure 10) except the elements added on the next figure :

Figure 12: Angular Stiffnesses Test Setup

5.3.4. Test Procedures and Parameters

- **Procedure from the ETP DTE 001/2020**

a. Test article was installed on the test bench as shown in Figure 12, while ensuring the arm is in equilibrium to keep the swivel joint in a neutral position.

b. For high temperature cases, the heating resistance was turned on and set to reach the required temperature.

c. Test article was allowed to soak for 20 minutes or until steady state temperature of the thermocouple has been achieved.

d. For pressurized cases, test article was pressurized to the required pressure until stabilization.

e. Upon achieving the required testing conditions for each case, testing was started.

f. Using weights, the arm was lowered in increments twisting the swivel joint until reaching 10° angulation.

g. The mass corresponding to the beginning of swivel joint rotation was recorded

h. Every 2° angulation, the mass was recorded in the table below and included in the test report.

Note / Deviations from the ETP DTE 001/2020:

- Step a. Equilibrium is reached without weight support. Its mass (1.8Kg) has to be added in the measurements.

- Step h. Given that as soon as the rotation of the joint has started it does not stop, recording the mass every 2° angulation is not possible. SDU has recorded the mass corresponding to the beginning of swiveling the joint for each case presented in Table 15.

- **Parameters**

Table 15 here after presents the different iterations performed to realize the angular stiffness test.

Table 15: Stiffness Test Conditions

Case	Pressure (barg)	Temperature (°C)	Fluid
1	Atmospheric	20°C ± 3°C	Air
2	50	20°C ± 3°C	
3	Atmospheric	377 ± 20°C	
4	50	125 ± 20°C	
5	50	250 ± 20°C	
6	50	377 ± 20°C	

5.3.5. Test Results

Table 16 here after presents the results of angular stiffness tests performed on the swivel joint.

Table 16: Stiffness Results

Cases	Pressure (barg)	Temperature (°C)	Angulation* (°)	Mass (kg)**	Torque (N.m)***
1	Atmospheric	20°C ± 3°C	Beginning of rotation	21.8 - 23.8	224
2	50	20°C ± 3°C	Beginning of rotation	9.8 - 10.8	106
3	Atmospheric	377 ± 20°C	Beginning of rotation	33.8 - 34.8	341
4	50	125 ± 20°C	Beginning of rotation	31.8 - 33.8	332
5	50	250 ± 20°C	Beginning of rotation	36.8 - 38.8	381
6	50	377 ± 20°C	Beginning of rotation	38.8 - 40.8	400

* As explained in § 5.3.4, recording the mass for different angulation is not possible. SDU has recorded the mass necessary to initiate the rotation of the joint.

** Several measurements have been performed (3 or 4 tests). Maximum and minimum results are given in the table.

*** Torque is deduced with: T = Mass x Level Arm x g (considering maximum mass).

6. CONCLUSION

6.1. Synthesis

At 20°C, the measured angular stiffness is higher without pressure than with pressure which is opposite to expectations (see §6.3.3 for explanation hypothesis).

At 377°C, the measured angular stiffness is higher with pressure than without pressure. The angular stiffness is also higher at 377°C than at 20°C (see §6.3.4 for explanation hypothesis).

6.2. System Mounting

SDU had to perform several mounting iterations of the system. These iterations were due to slight leakage noticed on SDU side:

Figure 13: Location of the leakage on SDU side

Here after are presented the mounting steps:

- On the first Installation of the swivel joint only a Mica® seal was installed at the following location:

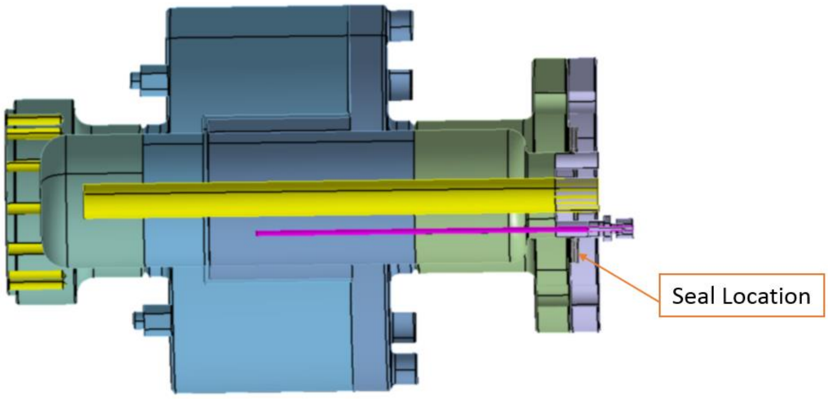


Figure 14: Seal Location

- After first pressurization, a leakage was noticed. The Mica® seal was removed and replaced by a graphite seal. In addition, CAF 1® (silicone past for high temperature applications) was added.
- After new pressurization, the leakage was undetectable at this location.

Note:

First Pre-tests at ambient temperature were conducted in these conditions (Graphite Seal and CAF 1®) without leakage detection.

Before first tests at high temperature a disassembly and a new assembly of the system was performed. After this handling, the leakage rate of the system at ambient temperature was lower than before. All the results presented in this report have been obtained after this measurement.

This leakage was mainly due to the difficulty to realize the airtightness on the contact flat surface on flat surface. This difficulty was increased due the weight of the swivel joint assembly (approximatively 45kg).

6.3. Feedback and good practices

6.3.1. Preload Torque Application

For preload torque application, the following methodology must be used:

- Torque the first screw to the nominal torque (for example 15N.m)
- Torque the other screws using the order according to Figure 13:

Figure 15: Preload Torque Application

- Repeat the tightening of the 4 screws until the nominal torque is reach on the four screws.

Note:

Due to the system linked to the screws (see Figure 2), the tightening of the screws must be done very carefully. For example when screw n°3 is torqued, it may move the seals inside the swivel joint and reduce the torque on screw n°1.

6.3.2. Preload Torque Application after first heating and pressurization

Note:

Before first heating and pressurization of the swivel joint, the preload torque was set at 15N.m. When returned to ambient pressure and temperature, the preload torque slightly decreased. It may due to a small plastic deformation of the threaded rods.

The preload screws must be tight after first heating and pressurization of the swivel joint.

After the second heating and pressurization, no deviation of the preload torque was noticed.

6.3.3. Comparison of angular stiffness at ambient temperature

Note:

According to results in Table 16, the swivel joint is stiffer unpressurized than pressurized (224N.m compared to 106N.m). This difference may be due to the pressure thrust:

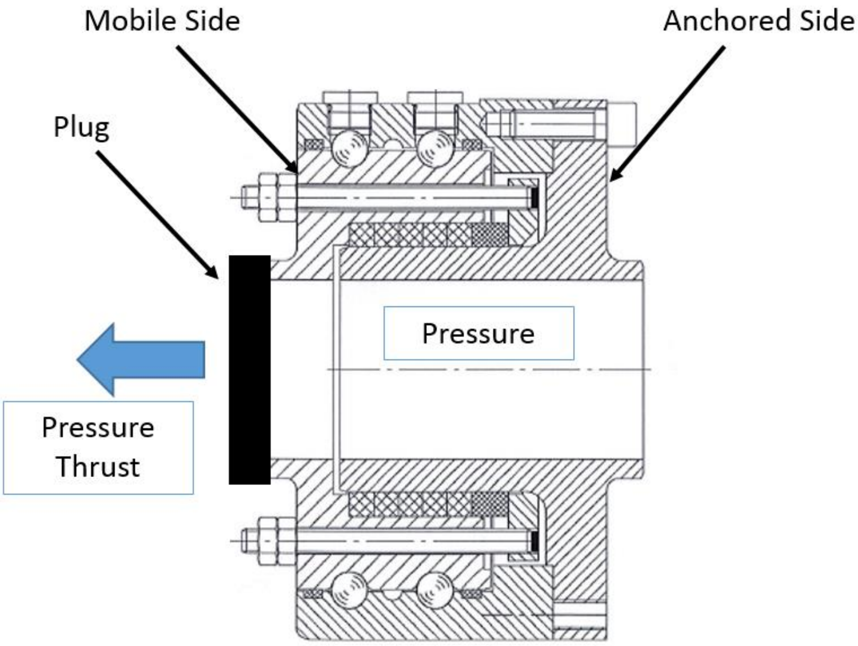


Figure 16: Pressure Thrust Effect

According to Figure 16, the pressure inside the swivel joint generates a pressure thrust. This load may allow a better alignment between mobile and anchored sides in particular on bearing side. This better alignment may decrease the angular stiffness.

6.3.4. Comparison of angular stiffness working pressure

Note:

According to results in Table 16, the swivel joint is stiffer when heated at high temperature. This difference may be due to differential thermal expansion:

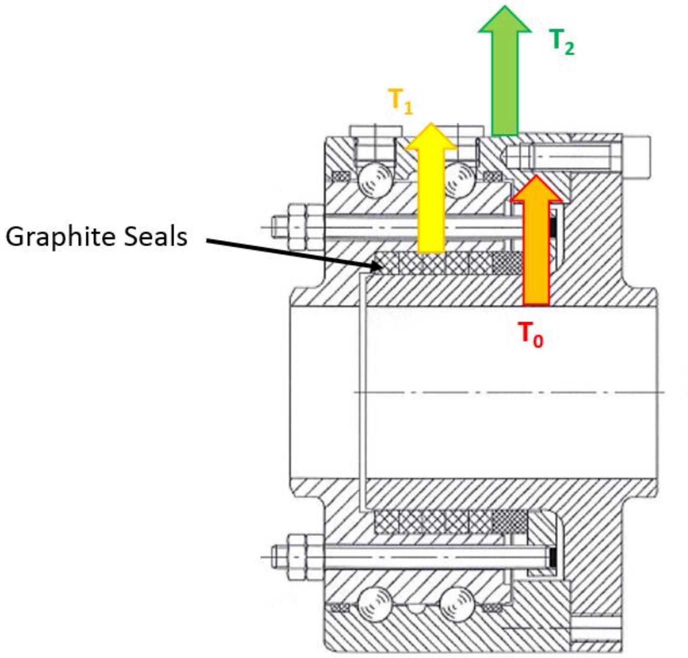


Figure 17: Thermal Expansion Effect

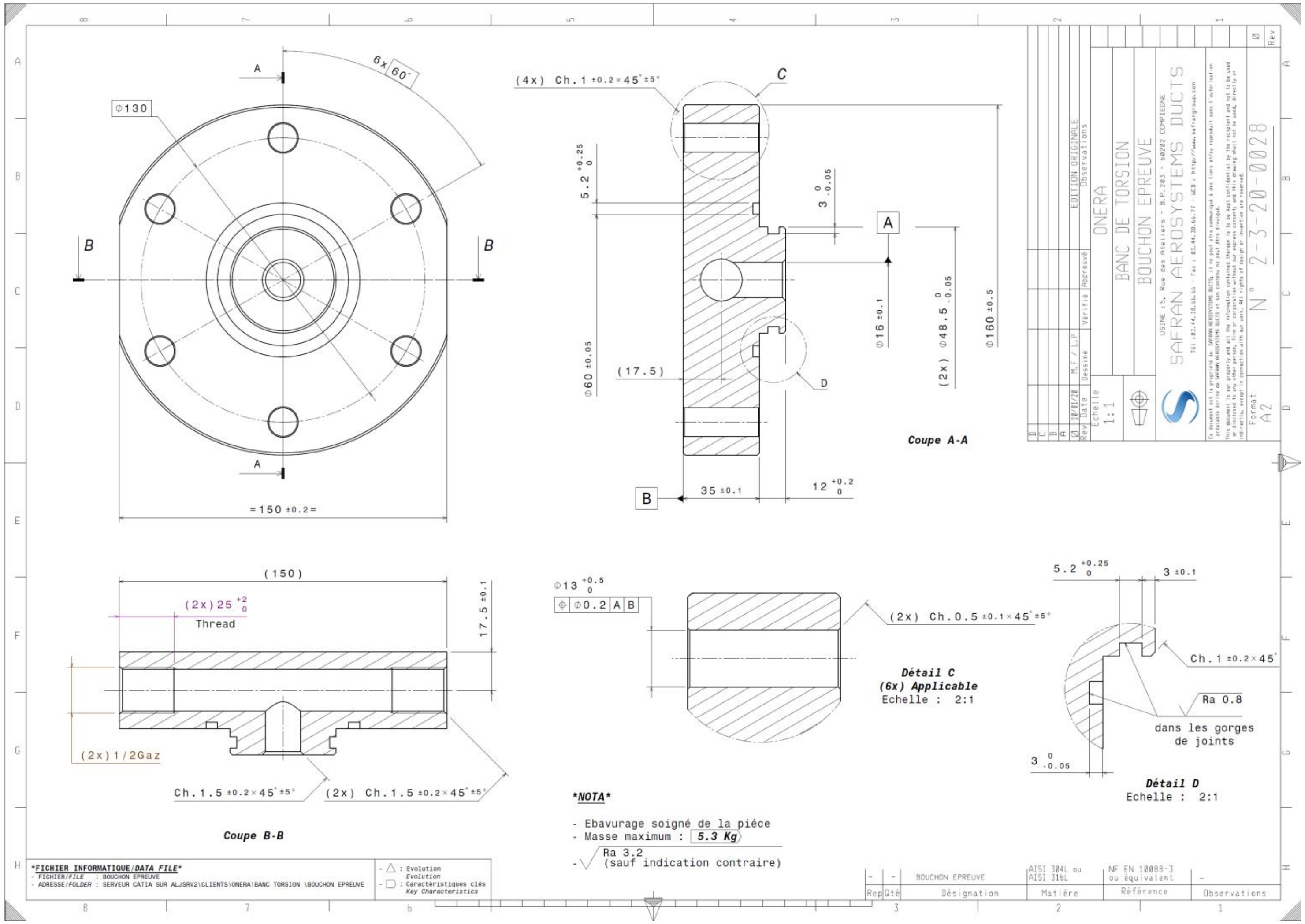
During the tests at temperature, the internal temperature of the swivel joint is controlled. The external temperature of the swivel joint is lower than the temperature inside: T2<T1<T0 (External face exposed to ambient conditions).

The temperature difference between the internal and external parts may induce a normal effort on the graphite seals, which tends to improve the air tightness of the swivel joint and increases its angular stiffness.

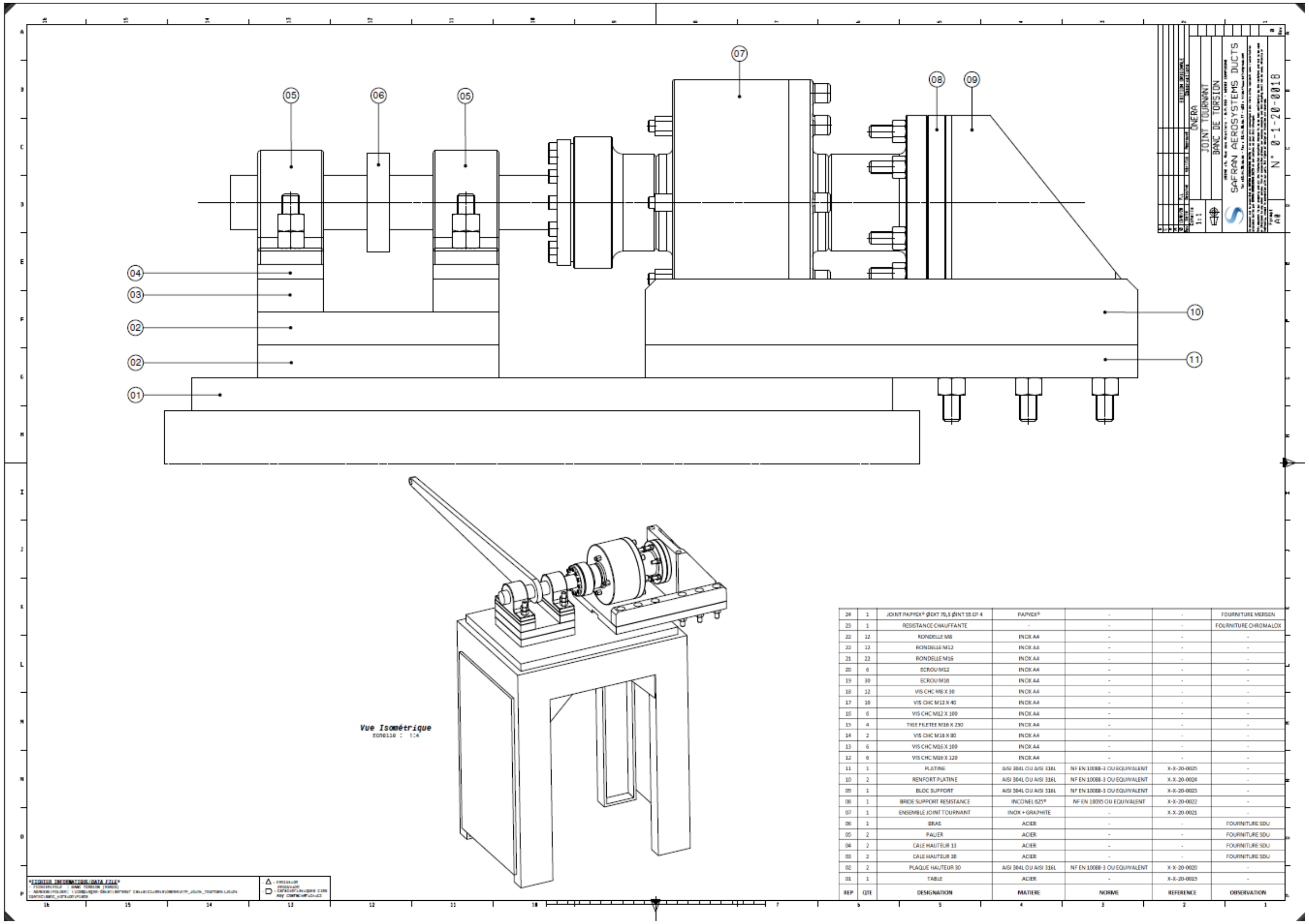
APPENDIX I

Setup Drawings
(For Reference Only)

Proof Test Setup



Stiffness Test Setup



APPENDIX II

Calibration Certificates

Proof Pressure Test Bench

ZODIAC AEROSPACE ZODIAC AERO DUCT SYSTEMS	Compte rendu Relevé de mesure	PV ME 19-0119-1 Rév.A

De/*From* : **P.SAWEZYN** **Date : 21/09/2019**

Objet/*Subject* : Vérification métrologique du banc de test hydraulique et pneumatique n° **812000** de l'atelier titane.

1. **Matériel utilisé :**

- Manomètre étalon n° 81705 (validité 15/11/2019) : range 0-400 bar
- Manomètre étalon n° 81704 (validité 07/10/2022) : range 0-40 bar
- Manomètre étalon n° 81717 (validité 22/08/2021) : range 0-6 bar
- Chronomètre étalon n°93783 (validité 03/07/2020) : range 0-60 min

2. **Mode opératoire et critères d'acceptation :**

Les essais réalisés suivant procédure ST 1032/G § 6.2.

La partie essai hydrauliques a été vérifiée à l'aide des manomètres n°**81704** et **81705** et la partie pneumatique à l'aide du mano n° **81717** sur 3 cycles d'essai.

Critères d'acceptation : **+/- 1%** de l'echelle maxi (voir ST 1032) pour l'essai de pression et **+/-10%** de la valeur étalon du chronomètre

Vr : valeur lue sur l'étalon de mesure

Vl : valeur lue sur l'écran du banc de test

La partie temps est vérifiée à l'aide d'un chronomètre étalon sur 3 points : 5 / 10 et 20 minutes (Tr : valeur lue étalon / Tl : valeur lue sur l'écran du banc de test)

3. **Essai hydraulique de 0 à 35 bar (étalon n° 81704)**

Vr (bar)	Vl(1er cycle) (bar)	Vl(2ème cycle) (bar)	Vl(3ème cycle) (bar)	Vr – Vl (bar)	conformité
0	0	0	0	0	conforme
10.0	10.3	10.2	10.3	0.3	conforme
15.0	15.0	15.0	15.0	0	conforme
20.0	20.0	20.1	20.1	0.1	conforme
22.0	22.0	22.2	22.1	0.2	conforme
25.0	25.0	25.0	25.2	0.2	conforme
35.0	35.0	35.1	35.0	0.1	conforme

ZODIAC AEROSPACE
ZODIAC AERO DUCT SYSTEMS

Compte rendu
Relevé de mesure

PV ME 19-0119-1
Rév.A

4. Essai hydraulique de 0 à 350 bar (étalon n° 81705)

Vr (bar)	VI(1er cycle) (bar)	VI(2ème cycle) (bar)	VI(3ème cycle) (bar)	Vr – VI (bar)	conformité
0	0	0	0	0	conforme
40	40.6	40.6	40.6	0.6	conforme
50	50.5	50.6	50.5	0.6	conforme
60	60.7	60.7	60.7	0.7	conforme
70	70.3	70.3	70.3	0.3	conforme
80	80.6	80.5	80.5	0.6	conforme
90	90.3	90.3	90.6	0.6	conforme
100	100.4	100.4	100.4	0.4	conforme
150	150.5	150.5	150.7	0.7	conforme
200	200.2	200.2	200.8	0.8	conforme
250	250.5	250.5	250.5	0.5	conforme
300	301.0	301.0	301.0	1.0	conforme
350	351.0	351.0	351.0	1.0	conforme

5. Essai pneumatique de 0 à 5.5 bar (étalon n° 81717)

Vr (bar)	VI(1er cycle) (bar)	VI(2ème cycle) (bar)	VI(3ème cycle) (bar)	Vr – VI (bar)	conformité
0	0	0	0	0	conforme
0.50	0.50	0.50	0.50	0	conforme
1.00	1.00	1.04	0.96	-0.04	conforme
1.50	1.50	1.54	1.51	0.04	conforme
2.00	2.05	2.03	1.95	-0.05	conforme
2.50	2.55	2.52	2.53	0.05	conforme
3.00	3.00	3.00	2.99	-0.01	conforme
4.00	3.95	3.97	3.95	-0.05	conforme
4.50	4.50	4.48	4.51	-0.02	conforme
5.00	4.95	5.00	5.04	-0.05	conforme
5.50	5.45	5.50	5.51	-0.05	conforme

6. Vérification du temps

Tr (min.)	TI (min.)	Tr-TI	conformité
5’	5’	0	conforme
10’	10’	0	conforme
20’	20’	0	conforme

Vernier Calliper

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80534 FRIVILLE CEDEX
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Fax : 03-22-60-20-21
Mail : c2tpm@orange.fr

Chaîne d'étalonnage
National calibration system
DIMENSIONNEL
Accréditation n° 2-1273
Accreditation number
Portée disponible sur www.cofrac.fr
Scope available on www.cofrac.fr

cofrac ETALONNAGE

CERTIFICAT D'ÉTALONNAGE
CALIBRATION CERTIFICATE
N° 1809-JG/6758-C

DÉLIVRÉ À : *ISSUED TO* — **ZODIAC AERO DUCT SYSTEMS**
5,Rue Ateliers
60202 COMPIEGNE

INSTRUMENT ÉTALONNÉ
CALIBRATED INSTRUMENT

Désignation : *Designation* — **Pied à coulisse 0 / 300 mm**

Constructeur : *Manufacturer* — Tesa (00530223)

Type : *Type* — Universel A affichage numérique

N° de série : *Serial number* — 5Z0597 01

N° d'identification : *Identification number* — **11769**

Ce document comprend 3 pages
This document includes 3 pages

Date d'émission : *Date of issue* — 20/09/2018

LE DIRECTEUR

Dominique CATTEAU

N° d'identification :	**11769**		
Désignation :	**Pied à coulisse Universel A affichage numérique 0 / 300 mm**		
Résolution :	**0,01 mm**		
Constructeur :	**Tesa (00530223)**	Procédure interne :	IM 02-300/1
N° de série :	**5Z0597 01**		

Mesures effectuées le 18/09/2018 à FRIVILLE-ESCARBOTIN par Julien GOSSET

Ce certificat d'étalonnage garantit le raccordement des résultats d'étalonnage au Système international d'unités (SI).

1- Conditions d'environnement

Température : (20 ± 1) °C
Température de référence : 20 °C

2- Mode(s) opératoire(s) utilisé(s)

Erreur de contact - Pleine touche J (MO 02-300/1)

Instruction d'étalonnage : IM 02

Norme de référence : NF E 11-091 (20 Mars 2013)

Les mesures pour déterminer l'erreur d'indication de contact pleine touche sont effectuées à l'aide de cales étalons, placées en contact avec les becs, suivant la longueur de leurs faces mesurantes (35 mm), le plus proche de la règle.
Les mesures sont effectuées en six positions du coulisseau, incluant le zéro, réparties sur l'étendue de mesure, utilisant 5 valeurs de référence. La mesure est répétée 2 fois en chaque position.

L'erreur d'indication est déterminée à partir de la valeur lue, Vi sur le pied à coulisse et la valeur conventionnelle de l'étalon utilisé Vc, comme suit :

$$Ei = Vi - Vc$$

L'erreur d'indication de contact pleine touche J est égale à la valeur maximale des valeurs absolues des Ei.

Erreur de contact - Sur surface limitée E (MO 02/1)

L'erreur d'indication de contact sur surface limitée est effectuée à la position du coulisseau où a été constatée la plus grande erreur d'indication pleine touche.
Les mesures sont effectuées à l'aide de cales étalons en contact suivant la largeur de leurs faces mesurantes en trois positions : la plus proche (mesures 1 et 2), au milieu (mesures 3 et 4) et le plus loin de la règle (mesures 5 et 6).

L'erreur d'indication de contact sur surface limitée est déterminée à partir de la valeur lue, Vi sur le pied à coulisse et la valeur conventionnelle de l'étalon utilisé Vc, comme suit :

$$Ei = Vi - Vc$$

L'erreur d'indication de contact sur surface limitée E est égale à la valeur maximale des valeurs absolues des Ei

La répétabilité de l'erreur d'indication de contact sur surface limitée (Erreur de fidélité) , R est l'écart-type des erreurs d'indication Ei liés au contact partiel, en tenant compte du facteur de sécurité t en fonction du nombre de mesures (t=1,3 pour 6 mesures).

Erreur de décalage d'échelle - Intérieur (MO02/3)

L'erreur de décalage d'échelle, S est déterminée, pour des mesures avec les becs d'intérieur, en mesurant le diamètre d'une bague lisse étalon (mesure 1) et la longueur d'une cale étalon (mesure 2) ayant des valeurs proches l'une de l'autre à la largeur combinée près des becs, comme suit :

$$S = (Vibague - Vicale) - (Vcbague - 2Lc - Vccale)$$

où :
Vi = valeur lue
Vc = valeur conventionnelle de l'étalon utilisé
Lc = largeur des becs d'intérieur (dans le cas de becs couteaux, Lc =0)

3- Moyen(s) de mesure utilisé(s)

Bague lisse étalon 40 mm identifié(e) : BLT033
Date d'étalonnage : 31/10/2017, N° de document : 1710-VB/6750-C, Prestataire : C.2.T

Jeu de cales étalons 0,5 mm à 100 mm identifié(e) : CEA004
Date d'étalonnage : 09/07/2018, N° de document : 1807-JG/5229-C, Prestataire : C.2.T

Jeu de cales étalons 125 mm à 500 mm identifié(e) : CEA007
Date d'étalonnage : 09/06/2017, N° de document : P169429/8, Prestataire : Laboratoire National d'Essais

4- Commentaires

Les incertitudes élargies mentionnées sont celles correspondant à deux fois l'incertitude-type composée.

CERTIFICAT D'ÉTALONNAGE N° 1809-JG/6758-C Page 3 / 3

5- Résultats

Erreur de contact - Pleine touche J

Valeur nominale (mm)	Vc (mm)	Vi (mm)	Ei (µm)	N° de série des étalons
0,00	0,000	0,00	0	N/A
		0,00	0	
51,38	51,380	51,37	-10	70605+165616
		51,37	-10	
126,46	126,460	126,44	-20	70634+14120(125)
		126,44	-20	
176,26	176,259	176,24	-19	880415+890694(175)
		176,24	-19	
251,42	251,419	251,40	-19	880400+890694(250)
		251,40	-19	
300,00	300,000	299,98	-20	890694(300)
		299,98	-20	

Erreur d'indication : 20 µm Incertitude de mesure : 18 µm + 4 .10-6.L

Erreur de contact - Sur surface limitée E

Valeur nominale (mm)	Vc (mm)	Vi (mm)	Ei (µm)	N° de série des étalons
300,00	300,000	299,98	-20	890694(300)
		299,98	-20	
		299,97	-30	
		299,97	-30	
		299,96	-40	
		299,96	-40	

Erreur d'indication : 40 µm Incertitude de mesure : 18 µm + 4 .10-6.L
Erreur de fidélité : 11,6 µm

Erreur de décalage d'échelle - Intérieur

Lc (largeur bec) : 5 ; Unité : mm

Valeur nominale (mm)	Vc (mm)	Vi (mm)	Identification des étalons
40,001	40,001	30,00	BLT033
30,000	30,000	29,99	CEA004

Erreur de décalage d'échelle : 9 µm Incertitude de mesure : 18 µm + 4 .10-6.L

Les incertitudes élargies mentionnées sont celles correspondant à deux fois l'incertitude-type composée.

CENTRE DE TRANSFERT DE TECHNOLOGIE DE PICARDIE MARITIME

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Mail : c2tpm@orange.fr

CONSTAT DE VÉRIFICATION

VERIFICATION CERTIFICATE

N° 1809-JG/6758-CV

DÉLIVRÉ À : *ISSUED TO* — **ZODIAC AERO DUCT SYSTEMS**
5,Rue Ateliers
60202 COMPIEGNE

IDENTIFICATION DE L'INSTRUMENT
CALIBRATED INSTRUMENT

Désignation : *Designation*	**Pied à coulisse 0 / 300 mm**
Constructeur : *Manufacturer*	Tesa (00530223)
Type : *Type*	Universel A affichage numérique
N° de série : *Serial number*	5Z0597 01
N° d'identification : *Identification number*	**11769**

CONDITIONS DE VÉRIFICATION
CONDITIONS OF VERIFICATION

Spécifications : *Specifications*	NF E 11-091 (2013)
Procédure interne : *Internal procedure*	IM 02-300/1
Conditions d'environnement : *Environmental conditions*	Température : (20 ± 1) °C Température de référence : 20 °C
Date de la vérification : *Date of verification*	18/09/2018
Date d'émission du constat : *Date of issue*	20/09/2018

Ce document comprend 1 page
This document includes 1 page

LE DIRECTEUR

Dominique CATTEAU

CONSTAT
STATEMENT

Caractéristique	Constat	Incertitude
Erreur de contact (Pleine touche J)	Conforme	18 µm + 4 .10-6.L
Erreur de contact (Sur surface limitée E)	Conforme	18 µm + 4 .10-6.L
Erreur de fidélité (Sur surface limitée E)	Conforme	
Erreur de décalage d'échelle (Intérieur)	Conforme	18 µm + 4 .10-6.L
CONSTAT : Conforme		

Les incertitudes de mesure ne sont pas prises en compte pour la déclaration de conformité.

CE DOCUMENT NE PEUT ÊTRE UTILISÉ EN LIEU ET PLACE D'UN CERTIFICAT D'ÉTALONNAGE. IL EST RÉALISÉ SUIVANT LES RECOMMANDATIONS DU FASCICULE DE DOCUMENTATION X 07-011 DÉFINISSANT LE CONSTAT DE VÉRIFICATION. IL PEUT ÊTRE UTILISÉ POUR DÉMONTRER LE RACCORDEMENT DU MOYEN DE MESURE AUX ÉTALONS NATIONAUX OU INTERNATIONAUX SOUS RÉSERVE QU'IL RÉPONDE AUX RECOMMANDATIONS DU FASCICULE DE DOCUMENTATION X 07-015.

Manometer

Baumer salle banc d'essai

Passion for Sensors

Q1060 / 1070 PROCES-VERBAL D'ETALONNAGE
Q1060 / 1070 *Calibration report - Kalibrierungszertifikat* 81505

Client /*customer / Kunde*: LES AUTOMATISMES APPLIQUES
Votre référence / *Your reference*: CFZ47583
Désignation de l'appareil / *Designation / Bezeichnung*: MEX2-D50.B33
notre référence / *Our reference*: 1630435 Poste / *item / pos* 30
N° de série / *serial number / Seriennummer*: 22900200068802
Repère / *Tag / code*: N° plan /*Drawing Nbr*:
Etendue de mesure / *range / Messbereich*: 0 160 bar
classe de précision / *Class / Klasse*: 1,60
T° ambiante / *Room temp / Umgebungstemp*: 20°c+-5
Opérateur / operator.: F.Letourmy
Procédure / *Procedure / Verfahren*: FIQ 014
Etalons utilisé / *Master used / Eichmass*: 353.0039
Etalon rattaché COFRAC / *Cofrac attached master / Eichmass referenz Cofrac*: 155.0001

Lecture manomètre *Gauge reading Sollwert*	Pression de référence *master pressure /referenz druck*		ECARTS en % EM (1) / Differential / Abweichung		
	montée *rising Steigend*	descente *falling Fallend*	montée *rising Steigend*	descente *falling Fallend*	hysteresis
bar	bar	bar			
0,0	0,0	0,0	0,00	0,00	0,00
50,0	50,8	50,9	-0,50	-0,56	0,06
100,0	100,7	100,6	-0,44	-0,37	-0,06
150,0	149,7	149,9	0,19	0,06	0,13
160,0	159,5	160,0	0,31	0,00	0,31

incertitude de mesure / *Uncertainty / Ungewissheit*: **0,640** bar

erreur maximale d'indication / *max error of indication / max fehler*: **-0,56** % EM / % *FS*

Conforme à la classe demandée - Class in conformity - Präzisionklasse in ordnung

Date de vérification Date - Datum:
14/02/2020

SERVICE QUALITE:
Quality Dept. - Qualitatsabt:

BAUMER BOURDON-HAENNI SAS. 125 Rue de la marre. CS 70214. 41103 Vendôme Cedex. France.
Baumer Bourdon-Haenni SAS. Au capital de 3 920 280 € . 775 680 499 R.C.S Blois . Code APE 2651 B
exportsales@baumer.com - www.baumer.com - fr.bourdon.baumer.com

Inclinometer

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Mail : c2tpm@orange.fr

CERTIFICAT D'ÉTALONNAGE

CALIBRATION CERTIFICATE

N° 1812-JG/8355

DÉLIVRÉ À :
ISSUED TO

DUBE NOYER SAFIA
6 Rue Nicéphore Niépce
60203 COMPIEGNE

INSTRUMENT ÉTALONNÉ

CALIBRATED INSTRUMENT

Désignation : *Designation* — **Inclinomètre 0 / 90 ° dec**

Constructeur : *Manufacturer* — DIGITAL PROTRACTOR (ABSOLUTE/IP65)

Type : *Type* — /

N° de série : *Serial number* — QC1746

N° d'identification : *Identification number* — **N°59703** DSM.

Ce document comprend 3 pages
This document includes 3 pages

Date d'émission : *Date of issue* — 05/12/2018

LE DIRECTEUR

Dominique CATTEAU

N° d'identification :	**N°59703**		
Désignation :	**Inclinomètre**		
	0 / 90 ° dec		
Résolution :	**0,1 ° dec**		
Constructeur :	**DIGITAL PROTRACTOR (ABSOLUTE/IP65)**	Procédure interne :	IM 57/1-01
N° de série :	**QC1746**		

Mesures effectuées le 05/12/2018 à FRIVILLE-ESCARBOTIN par Julien GOSSET

1- Conditions d'environnement

Température : (20 ± 1) °C
Température de référence : 20 °C

2- Mode(s) opératoire(s) utilisé(s)

Erreur d'indication (MO 57-01)

Les mesures sont éffectuées par comparaison aux angles de référence, realisés à l'aide des cales étalons et de la barre sinus.
Angle 11,53° : cale de 20 mm
Angle 23,57° : cale de 40 mm
Angle 30,00° : cale de 50 mm
Angle 48,33° : cale de 75 mm

3- Moyen(s) de mesure utilisé(s)

Barre sinus 1000 mm identifié(e) : SIN001
Date d'étalonnage : 12/01/2017, N° de document : 1701/0026/CD, Prestataire : C.2.T

Jeu de cales étalons 0,5 mm à 100 mm identifié(e) : CEA004
Date d'étalonnage : 09/07/2018, N° de document : 1807-JG/5229-C, Prestataire : C.2.T

4- Commentaires

5- Résultats

Erreur d'indication

Pt	Référence (° dec)	Valeur mesurée (° dec)	Ecart (° dec)
1	0,00	0,00	0,00
2	11,53	11,55	0,02
3	23,57	23,55	-0,02
4	30,00	30,00	0,00
5	48,33	48,55	0,22

Erreur maxi : 0,22 ° dec Incertitude de mesure : 0,3 ° dec

CENTRE DE TRANSFERT DE TECHNOLOGIE DE PICARDIE MARITIME

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Fax : 03-22-60-20-21
Mail : c2tpm@orange.fr

CONSTAT DE VÉRIFICATION

VERIFICATION CERTIFICATE

N° 1812-JG/8355V

DÉLIVRÉ À : **DUBE NOYER SAFIA**
ISSUED TO 6 Rue Nicéphore Niépce
60203 COMPIEGNE

IDENTIFICATION DE L'INSTRUMENT
CALIBRATED INSTRUMENT

Désignation : *Designation*	**Inclinomètre 0 / 90 ° dec**
Constructeur : *Manufacturer*	DIGITAL PROTRACTOR (ABSOLUTE/IP65)
Type : *Type*	/
N° de série : *Serial number*	QC1746
N° d'identification : *Identification number*	**N°59703**

Ce document comprend 1 page
This document includes 1 page

CONDITIONS DE VÉRIFICATION
CONDITIONS OF VERIFICATION

Spécifications : *Specifications*	
Procédure interne : *Internal procedure*	IM 57/1-01
Conditions d'environnement : *Environmental conditions*	Température : (20 ± 1) °C Température de référence : 20 °C
Date de la vérification : *Date of verification*	05/12/2018
Date d'émission du constat : *Date of issue*	05/12/2018

LE DIRECTEUR

Dominique CATTEAU

CONSTAT
STATEMENT

Caractéristique	Constat
CONSTAT : N/A	

Les incertitudes de mesure ne sont pas prises en compte pour la déclaration de conformité.

CE DOCUMENT NE PEUT ÊTRE UTILISE EN LIEU ET PLACE D'UN CERTIFICAT D'ÉTALONNAGE. IL EST RÉALISÉ SUIVANT LES RECOMMANDATIONS DU FASCICULE DE DOCUMENTATION X 07-011 DÉFINISSANT LE CONSTAT DE VÉRIFICATION. IL PEUT ÊTRE UTILISÉ POUR DÉMONTRER LE RACCORDEMENT DU MOYEN DE MESURE AUX ÉTALONS NATIONAUX OU INTERNATIONAUX SOUS RÉSERVE QU'IL RÉPONDE AUX RECOMMANDATIONS DU FASCICULE DE DOCUMENTATION X 07-015