DAΦNE TECHNICAL NOTE

INFN - LNF, Accelerator Division

Frascati, July 11, 1991

Note: **V-4**

VACUUM CHAMBER OF THE MAIN RING

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DEMOUNTABLE JOINTS

The main ring vacuum chamber is likely to be made in Aluminum. The use of Al will give many advantages but also some inconvenience. First of all there is the necessity to make reliable seals Al - Al and even between Aluminum and Stainless Steel. In this second case welded transitions were used but now flanged seals are preferred (one flange in Al, the second one in S.S. with a proper gasket between them).

In the past years (1988 - 1990) the Vacuum Group made some tests in the field of Al demountable U.H.V. joints, and we give, in the following, a summary of our experience.

These joints, taking also in account the experience of other Labs, seem to be a good candidate for the vacuum chamber flanges of DAΦNE.

Goal: to find a reliable joint between Aluminum flanges or Aluminum - Stainless Steel flanges:
- bakeable to 150 °C
- leak Tightness < 2×10^{-10} mbar liters/sec.

Type of Gaskets taken into consideration:
- ConFlat
- Diamond-edge
- Helicoflex

Materials:

Stainless Steel AISI 304 LN.

Aluminum: flanges ASTM 6061 - T6
gaskets, 6061, vacuum annealed (380 °C - 6 hours).
Bolts and nuts: 2024-T4, Washers 6061-T6
Bolts and washers anodized.

Note: 99.5 Al - .5 Mg is recomended for gaskets (e.g. see: W. Unterlechner, NON STANDARD VACUUM HARDWARE FOR AN ACCELERATOR VACUUM SYSTEM, CERN/LEP-VA/89-50). We used the 6061 alloy because it is easy to obtain.

Cleaning treatements.
Use of standard detergents.

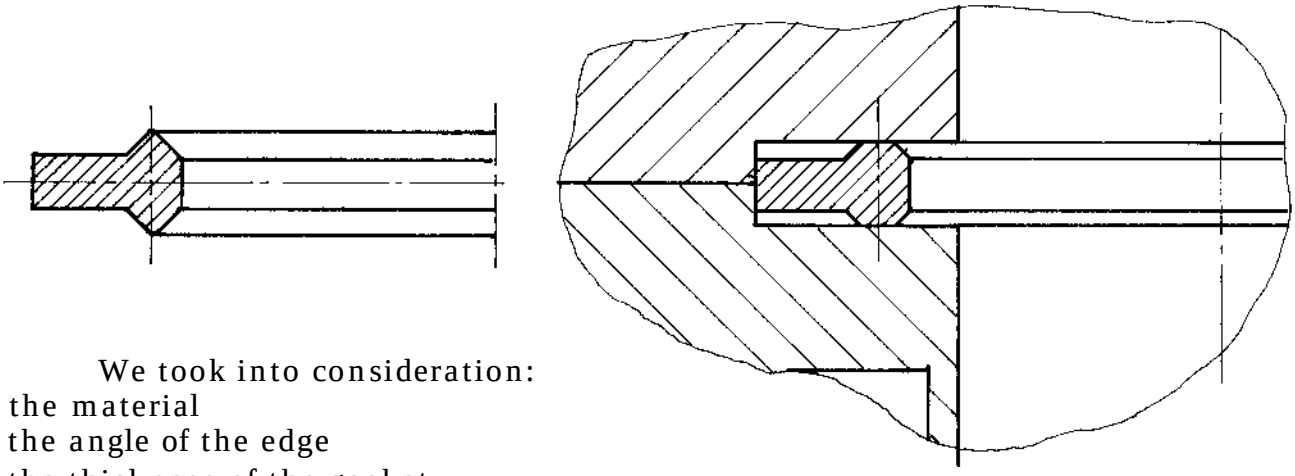
Diameter of flanges tested: i.d. 63, or i.d.100.

CONFLAT FLANGES

Gasket material: Aluminum
Test n.1: Al-Al flanges in Aluminum 6061-T6; bolts in Al 2024 - T4.
Results: no leaks also after a 200 °C bake. The problem is the sticking of the gasket to the flanges after the bake. We tried to overcome this problem in the following ways.
Test n.2: Al-Al flanges as above but Nickel plated.
Good results in any case but after a certain number of tests the nickel layer tends to peel off (too thick or bad deposition). Other tests would be necessary.
Test n. 3: as test n.1 but Al flanges anodized.
No good results after a 200 °C bake. Leaks probably due to a porosity of the oxide layer. Other tests would be necessary.

DIAMOND EDGE TYPE

We are referring to a seal as follows (see also Fig. 1):



We took into consideration:
- the material
- the angle of the edge
- the thickness of the gasket
- the torque
- the bolts

The material.
We have always used Aluminum 6061 - T6, for flanges and for gaskets. Gaskets were vacuum annealed (380 °C, 6 hours).
An alloy Al 99.5% - Mg .5% is raccomended, but we did non have time to buy it in small quantities.

The angle of the edge.
We tried to reduce this angle (standard is 90 degrees) just to decrease the torque. We obtained very good results (vacuum tight after repeated baking cycles to 250 °C). Inconvenients: the torque is more or less the same and the 60 °C edge is sufficiently sharp to damage the flange: it would be necessary to change the Al alloy, for the flange or for the gasket. For these reasons we adopted the standard 90 degrees angle.

The thickness of the gasket.
We have reduced the thickness in order to have the possibility to couple this type of Al flanges to Conflat flanges, using in this case an Helicoflex gasket. Al flanges were drawn just to adapt them to the Conflat dimensions. We mean that we can couple Al - Al flanges with a Diamond seal and one of these with a S.S. Conflat only changing type of gasket.

The torque.
Our standard torque is 1.2 Kgr*metre, per bolt (flanges have 8 bolts, i.d. 63 mm). When the flanges are in contact the edge deformation is .5 mm.

The bolts.
Firstly we tried to use the 6061-T6 alloy but obvioiusly without good results.
Second test. The alloy 2011-T4 gave bad results, as above.
Third test. The alloy 7075-T6. This alloy has good mechanical properties but it loses them at 150 °C and therefore its use is not advisable.
Finally we tested the alloy 2024-T4. Mechanical caracteristics are not as good as those of 7075 but remain good also after 150 °C.
Therefore we adopted the 2024-T6 alloy and continue to use it with good results. Remember that we use bolts and washers anodized (fig. 2 and 3).

THE HELICOFLEX SEALS

We began to use this kind of seals on some flanges of the Electron Cooling Machine in Legnaro and on the big flanges of the Adone Al R.F. cavity.

Afterwards we wanted to test them for the Aluminum - Stainless Steel Joints because in this case the Diamond type seal did not give good results.

We have to point out that our first goal in this case is the use of the Helicoflex for Aluminum - Conflat S.S. flanges (see fig. 4). This gives the possibility to connect directly pumps, gauges and so on, witch have S.S. flanges, to an Aluminum vacuum chamber, avoiding the use of the expensive Al - S.S. junctions.

The second very important goal is the possibility to use them for non circular (e.g. rectangular) flanges, because in this case the Diamond type seals seem not to work satisfactorily.

We used Al 2024-T4 bolts for Al - Al flanges and Stainless Steel bolts for AL-S.S. flanges. As usual, test parameters were: 250 °C bakeout temperature and Leak Detector sensitivity < 2×10^{-10} mbar liters/s.

Results.
They were always good, without any inconvenience, both in laboratory tests and on real vacuum chambers.

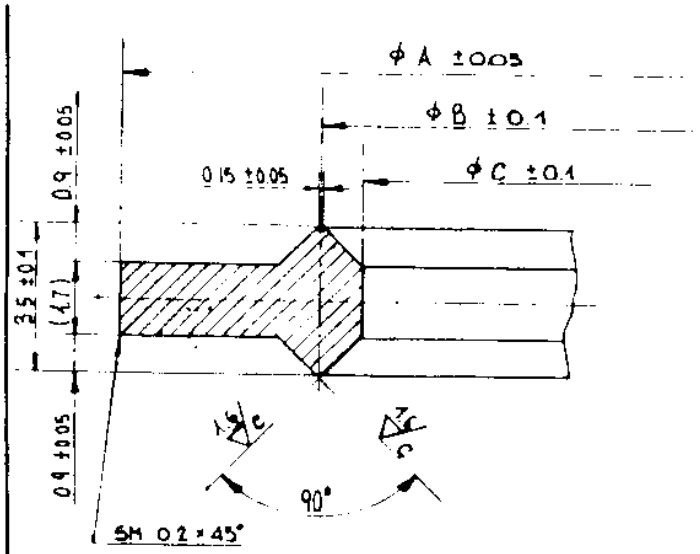
Note.
1) For the welded junctions between Al flanges and tubes it is not recommended to use the same drawing as for S.S. flanges. It is advisable to have the welding far from the flange (see fig. 5) just to avoid its annealing.
2) We have no experience on large diameter Diamond type seals; anyway gaskets for 600 mm i.d. flanges are on sale.
3) We began to test Al-Al and Al-S.S. soft soldered joints, using a Tin - Silver alloy (99.5% Sn - .5% Ag, 230 °C Melting Point) with good results, but we did not go on with these tests.

CONCLUSIONS

Both Diamond and Helicoflex type seals give very good results for Al - Al flanges. In this case the choice could be related to the price: Diamond type are less expensive.

For flanges Al - S.S. or for flanges of not circular shape we recommend the use of Helicoflex type.

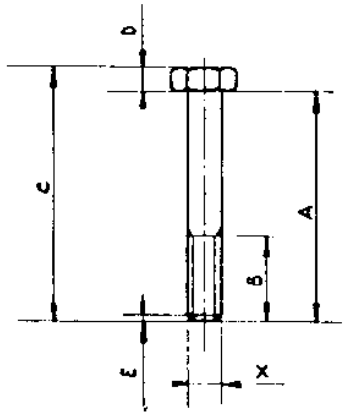
Our experience is based on about 40 tests per type of flange in laboratory. We have used this experience for the vacuum line of LISA.



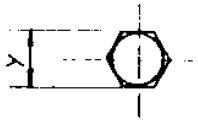
TIPO	A	B	C	Mod. FLANGIA	
001-G	21.30	18	16	NW 16	
002-G	48.15	42	40	NW 35	
003-G	82.40	75	73	NW 63	
004-G	120.50	115	113	NW 100	
005-G	171.30	166	164	NW 150	
006-G	222.10	217	215	NW 200	

FIG. 1

POS.	DENOMINAZIONE	QUANT.	MATERIALE	DISEGNO	NOTE
scostamenti per quote senza indicazione di tolleranza (UNI 9006)					
Dimensioni	< 7 | 7÷30 | 31÷120 | 121÷315 | 315÷1000 | 1001÷2000 | 2001÷4000 | oltre 4000				
Tolleranze	±0.1 | ±0.2 | ±0.3 | ±0.5 | ±0.8 | ±1.2 | ±2 | ±3				
Angoli	± 1° | ± 30' | ± 20' | ± 10' | ± 05' | scostamenti riferiti al lato più corto				
SOSTITUISCE IL		SOSTITUITO DAL			SCALA
LISA-				DISEGNATO	10:1
GUARNIZIONI METALLICHE IN ALLUMINIO TIPO "X5".				CONTROLLATO	DATA 29.11.89
INFN	ISTITUTO NAZIONALE DI FISICA NUCLEARE LABORATORI NAZIONALI DI FRASCATI			COMPLESSIVO N°	
				DISEGNO N°	V.093



TIPO	A	B	C	D	E	X	Y	MOD. FLANGIA	
001	28	20	31.2	3.2	0.4×45°	M4×0.5	7	NW 16	
002	40	18	44.5	4.5	0.6×45°	M6×0.75	10	NW 35	
003	30	18	34.5	4.5	0.6×45°	M6×0.75	10	NW 35 - FORI FRESATI	
004	55	22	61	6	1×45°	M8×1	13	NW 63 -	
005	40	24	46	6	1×45°	M8×1	13	NW 63 - FORI F. NW 100 - FORI F.	
006	60	22	66	6	1×45°	M8×1	13	NW 100	
007	64	24	70	6	1×45°	M8×1	13	NW 150	
008	46	26	52	6	1×45°	M8×1	13	NW 150 - FORI F. NW 200 - FORI F.	
009	66	24	72	6	1×45°	M8×1	13	NW 200	
010									



CARATTERISTICHE GENERALI :

MATERIALE : AVIONAL 2024 T4 - UNI 3583

TRATTAMENTI : ANODIZZAZIONE BIANCA

TEMPERATURA MAX di ESERCIZIO : 250°C

RUGOSITÀ di LAVORAZIONE : 1.6

FIG. 2

POS.	DENOMINAZIONE	QUANT.	MATERIALE	DISEGNO	NOTE

scostamenti per quote senza indicazione di tolleranza (UNI 5307)

Dimensioni	< 7	7-30	31-120	121-315	316-1001	1001-2000	2001-4000	oltre 4000
Tolleranze	±0.1	± 0.2	±0.3	±0.5	± 0.8	±1.2	± 2	± 3
Angoli	± 1°	± 30'	± 20'	± 10'	± 0.5'	scostamenti riferiti al lato più corto		

SOSTITUISCE IL | SOSTITUITO DAL | SCALA 1:1

LISA

BULLONI IN ALLUMINIO PER CONNESSIONI da VUOTO.

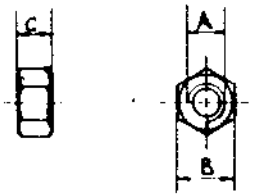
DISEGNATO Valudolla | CONTROLLATO | DATA 25.10.89

INFN — ISTITUTO NAZIONALE DI FISICA NUCLEARE LABORATORI NAZIONALI DI FRASCATI

COMPLESSIVO N°

DISEGNO N° V 091

TIPO	A	B	C	MOD. FLANGIA	
001-D	M4×0.5	7	4	NW 16	
002-D	M6×0.75	10	6	NW 35	
003-D	M8×1	13	8	NW-63,100,150,200	



CARATTERISTICHE GENERALI :

MATERIALE : AVIONAL 2024 T4 - UNI 3583

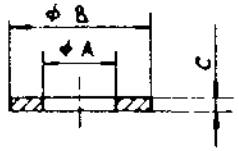
TRATTAMENTI SUPERFICIALI : ANODIZZAZIONE BIANCA

TEMPERATURA MAX di ESERCIZIO : 250°C

RUGOSITÀ di LAVORAZIONE : 1.6 ▽

FIG. 3

TIPO	A	B	C	MOD. FLANGIA	
001-R	4.2	8	1	NW 16	
002-R	6.3	12	1.5	NW 35	
003-R	8.4	16	1.5	NW,63,100,150,200	



CARATTERISTICHE GENERALI :

MATERIALE : ANTICORODAL 6061 - UNI 6170 (IN ALTERNATIVA ANTIC. 6082 - UNI 3571)

TRATTAMENTI SUPERFICIALI : ANODIZZAZIONE BIANCA

TEMPERATURA MAX di ESERCIZIO : 250°C

RUGOSITÀ di LAVORAZIONE : 3.2 ▽

POS.	DENOMINAZIONE				QUANT.	MATERIALE	DISEGNO	NOTE
scostamenti per quote senza indicazione di tolleranza (UNI 6307)								
Dimensioni	< 7	7-30	31-120	121-315	316-1001	1001-2000	2001-4000	oltre 4000
Tolleranze	±0.1	± 0.2	±0.3	±0.5	± 0.8	±1.2	± 2	± 3
Angoli	± 1°	± 30'	± 20'	± 10'	± 0.5'	scostamenti riferiti al lato più corto		

SOSTITUISCE IL	SOSTITUITO DAL	SCALA 1:1 , 2:1
LISA DADI E RONDELLE IN ALLUMINIO PER CONNESSIONI da VUOTO.	DISEGNATO CONTROLLATO	DATA 13.11.89
		COMPLESSIVO N°
INFN ISTITUTO NAZIONALE DI FISICA NUCLEARE LABORATORI NAZIONALI DI FRASCATI		DISEGNO N° V-092

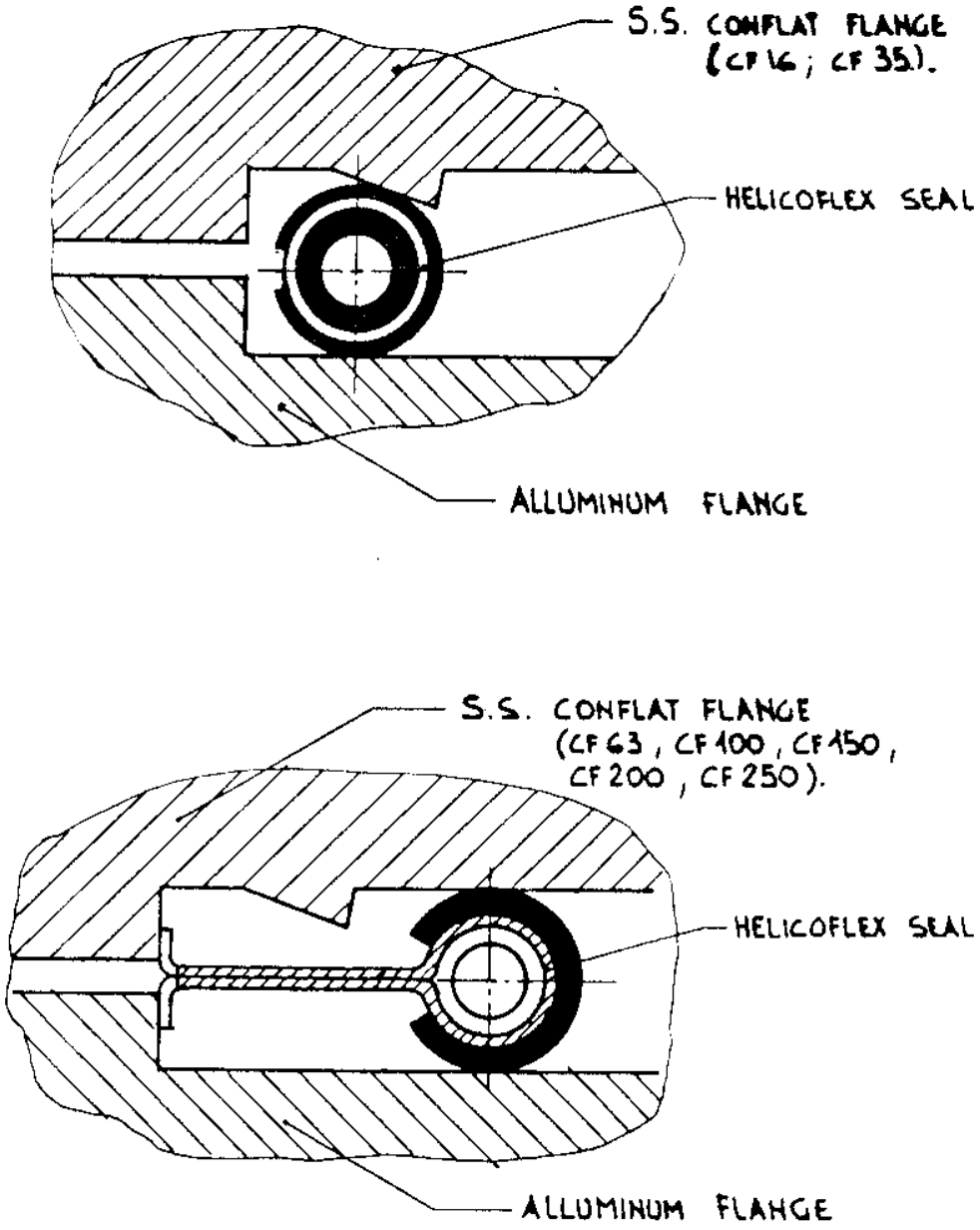

S.S. CONFLAT FLANGE
(CF 16 ; CF 35).
HELICOFLEX SEAL
ALLUMINUM FLANGE
S.S. CONFLAT FLANGE
(CF 63 , CF 100 , CF 150 ,
CF 200 , CF 250).
HELICOFLEX SEAL
ALLUMINUM FLANGE

FIG. 4

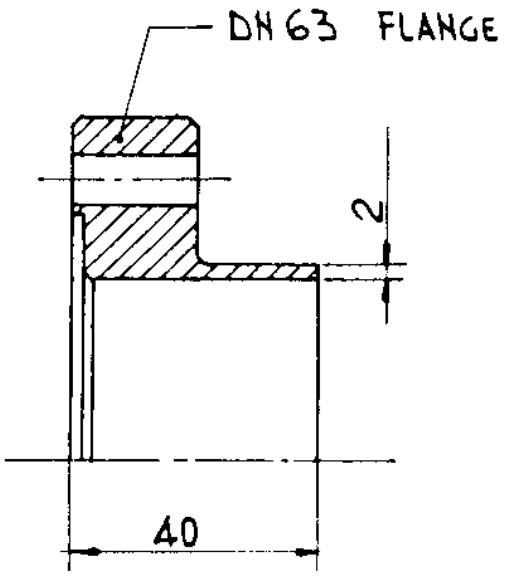


FIG. 5 - AN ALLUMINUM PROPER WELDING BETWEEN A TUBE AND A FLANGE.