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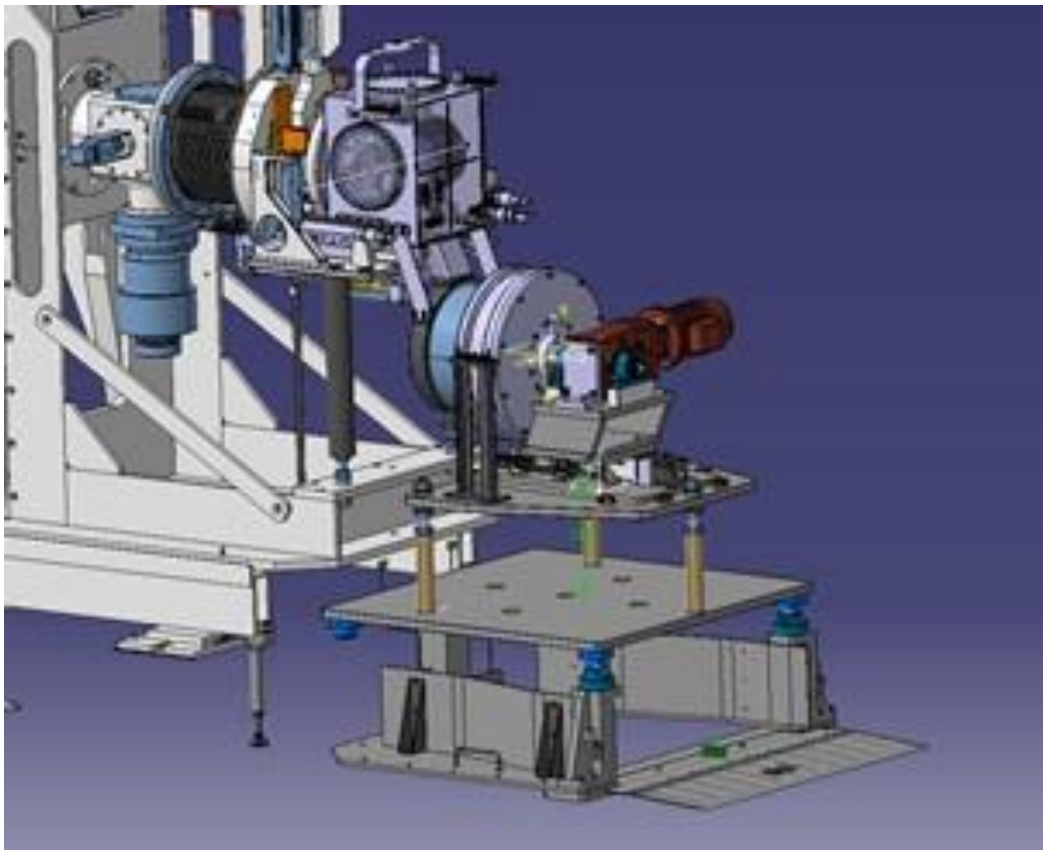
ISOLDE
LIEBE PUMP AND TARGET ALIGNMENT
Measurement of November 8th, 2017



The EDMS document: **1894735**, containing this report is available at the following address:
https://edms.cern.ch/document/1894735

1 General

On the demand of Ferran BOIX PAMIES the test of the good alignment of the LIEBE Electromagnetic Pump with respect to the LIEBE Target took place on 08th of November, 2017 The purpose of this test has been to align the Electromagnetic pump axis with respect to the LIEBE target assembly in the test laboratory (3/R-037).

2 Local Coordinate System

2.1 Local right-handed Cartesian coordinate system (see figure 1):

- **Origin**: Intersection of outer cylinder axis and front plane of the target cylinder.(see figure 3)
- **X-axis**: Outer cylinders axis, positive towards the pump.
- **Y-axis**: Perpendicular to X and horizontal.
- **Z-axis**: Perpendicular to X and Y axis.

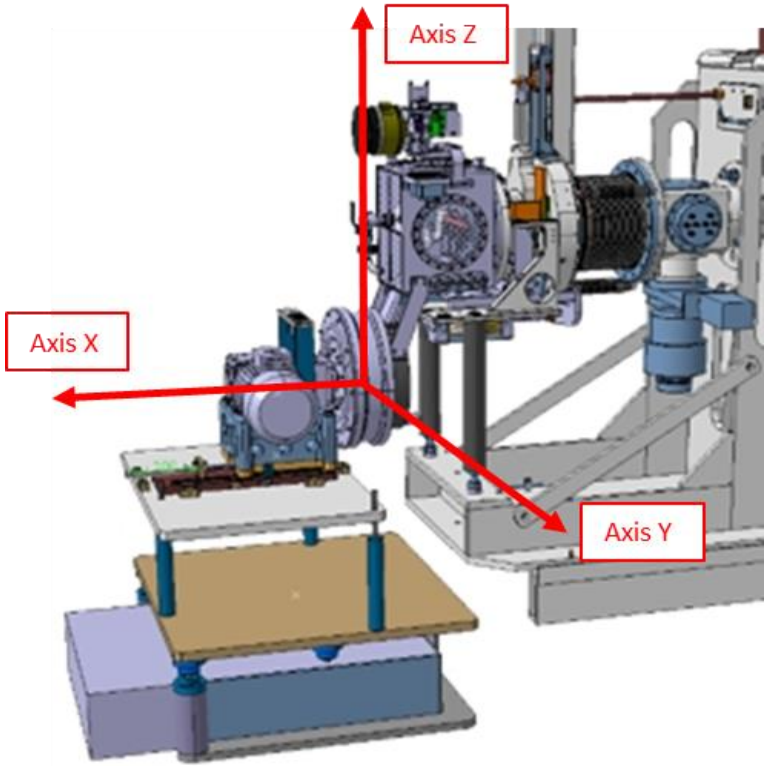


Figure1: Local Coordinate System for LIEBE Target and Electromagnetic Pump.

3 Distribution of the measured points – Survey Target and applied Adapter.

3.1 In order to determine the axis position of the LIEBE target, four references points on the top of the target (*Figure2*; Ref_01-02-03-04), and Front and back Cylinder (*Figures 3, 4, 5 & 6*) have been measured.

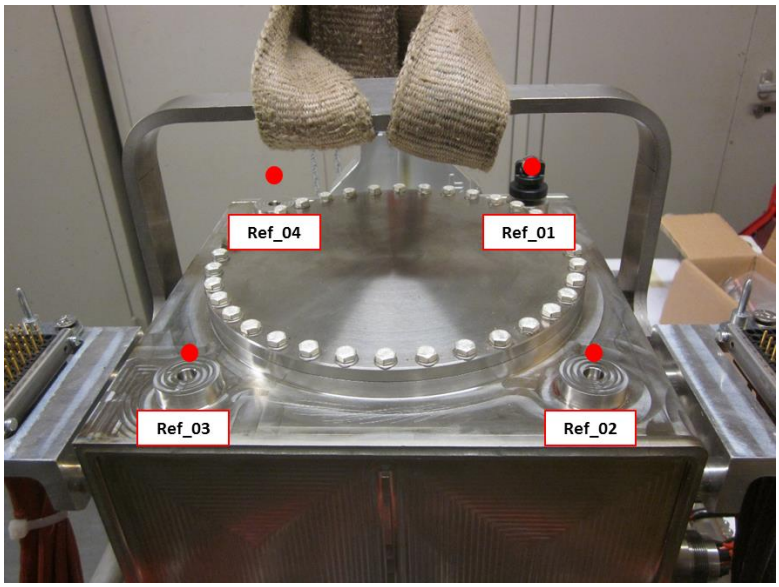


Figure2: Four References points measured on the top of target assembly.

Figure 3: Survey target and adapter used to measure front cylinder plane.

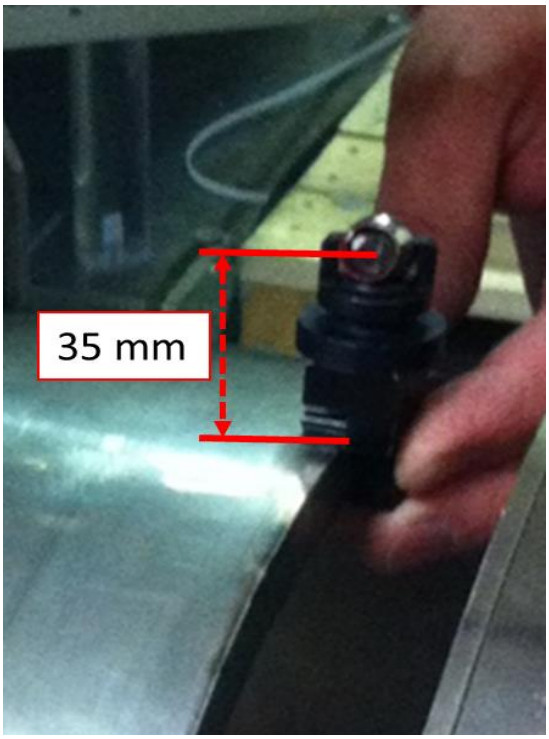


Figure 4: Survey target and adapter offset.

The offset of the measured points with respect to the contact surface is **approximately 35 mm**. The radius of the calculated circle include target offsets. The *Figures 3 & 4* show the survey target used.

Figures 5&6 : Survey target used to measure cylinder points and determinate axis of Cylback

The offset of the measured points with respect to the contact surface is **6.35 mm**. The radius of the calculated circle include target offsets. The *Figures 5 & 6* show the survey target used.

The aim of this first part of measure is to determinate the position of the LIEBE target assembly and create the reference system. (See §2.1 and in attachment § 5.1, 5.2 & 5.3 for calculations details)

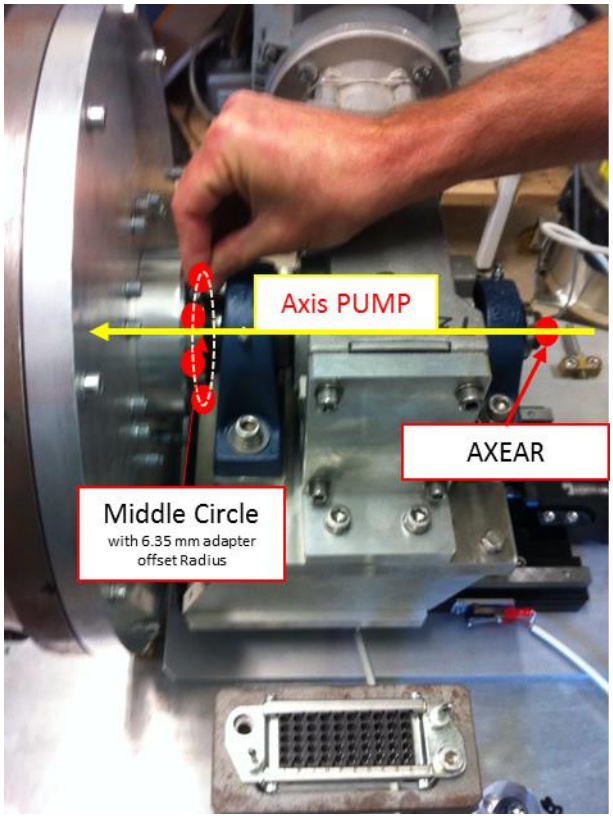


Figure 7: Survey target used to determinate the LIEBE Pump axis with one point and one circle with 6.35 mm offset (AXEAR. & Middle Circle)

The aim of this second part of measure is to determinate the axis of the LIEBE Electromagnetic Pump in the reference system and align it with respect to the LIEBE Target axis. (See in attachment § 5.4 & 5.5 for calculations details)

4 Results of the measurements

In the table below, results are given at the centre of survey target. Measured coordinates are given with precision: 0.2 mm

ISOLDE			
ALIGNMENT OF LIEBE PUMP AND TARGET			
NOVEMBER 8th 2017			
Name	X [m]	Y [m]	Z [m]
REF1	-0.3304	0.0813	0.5978
REF2	-0.1405	0.0819	0.5951
REF3	-0.1401	-0.0881	0.5943
REF4	-0.3299	-0.0889	0.5969
Cylfront	0.0299	-0.0008	-0.0006
Cylback	-0.0720	-0.0006	-0.0002
AXE_MILIEU	0.0627	-0.0008	-0.0007
AXEAR_01	0.3119	-0.0014	-0.0016

See § 5 for details on the different geometrical calculations. Several of the key values have been highlighted in red.

5 ATTACHMENT

5.1 EXTERNAL CYLINDER FRONT FITTING OF THE TARGET

Results of Circle Fitting							***Date of Calculation:***	08/11/2017	
							Time of Calculation:	16:07:33	
Equation and Direction Cosines of the Plane :									
Eqn of a Plane: X + B*Y + C*Z + D = 0									
	B	-0.002478		sig_B	1.90	mm/m			
	C	0.008863		sig_C	1.18	mm/m			
	D (m)	-0.03758		sig_D	0.20	mm			
Hence for Eqn of the form: a*x + b*y + c*z +d = 0 with a, b, c : Dir. Cosines of perp. Line to the Plane									
	a	0.999958							
	b	-0.002478							
	c	0.008862							
	d (m)	-0.03758							
Co-ordinates of the centre of the circle - in the Local Plane									
	x (m)	0.00570		sig x	0.09	mm			
	y (m)	-0.00269		sig y	0.05	mm			
Co-ordinates of the centre of the circle - in Calculated Co-ordinate Axis									
	X (m)	0.0375							
	Y (m)	-0.0058							
	Z (m)	0.0030							
Radius of the circle									
	Rad (m)	0.1746		sig R	0.05	mm			
Observed Coords					**Dist. pt proj / plan**		**Dist. point**		
					to circle (mm)		**to plane (mm)**		
Name	X (m)	Y (m)	Z (m)	Weight	+ve outside circle				
					-ve inside circle				
CYLFRONTA_01	0.0358	-0.0799	0.1613	1.000	0.08		-0.12		
CYLFRONTB_01	0.0358	-0.0220	0.1769	1.000	-0.01		-0.15		
CYLFRONTC_01	0.0366	0.0619	0.1639	1.000	-0.10		0.27		
CYLFRONTD_01	0.0373	0.1422	0.0958	1.000	-0.01		0.17		
CYLFRONTE_01	0.0381	0.1648	-0.0346	1.000	0.10		-0.25		
CYLFRONTF_01	0.0386	0.1174	-0.1208	1.000	0.03		-0.33		
CYLFRONTG_01	0.0395	0.0647	-0.1566	1.000	-0.08		0.41		
Maximum Distance from Circle (mm)				0.10	At Point CYLFRONTE_01			+ve outside circle	
Minimum Distance from Circle (mm)				-0.10	At Point CYLFRONTC_01			-ve inside circle	
Distance from origin to Circle Centre (m)							0.03811		
Bearing of Vector from origin to circle centre (grades)							109.7538		
Vertical Angle of Vector from origin to circle centre (grades)							94.9414		
Perpendicular distance from origin to plane containing circle (m)							0.03758		
Bearing of the Vector from the origin to the plane (grades)							100.1578		
Vertical Angle of the Vector from the origin to the plane (grades)							99.4358		

5.2 EXTERNAL CYLINDER BACK FITTING OF THE TARGET

Results of Circle Fitting							***Date of Calculation:***		08/11/2017
							Time of Calculation:		16:06:59
Equation and Direction Cosines of the Plane :									
Eqn of a Plane: X + B*Y + C*Z + D = 0									
	B	0.000155		sig_B	0.67	mm/m			
	C	0.009428		sig_C	0.47	mm/m			
	D (m)	0.06429		sig_D	0.06	mm			
Hence for Eqn of the form: a*x + b*y + c*z +d = 0 with a, b, c : Dir. Cosines of perp. Line to the Plane									
	a	0.999956							
	b	0.000155							
	c	0.009427							
	d (m)	0.06429							
Co-ordinates of the centre of the circle - in the Local Plane									
	x (m)	0.0054		sig x	0.08	mm			
	y (m)	-0.0026		sig y	0.06	mm			
Co-ordinates of the centre of the circle - in Calculated Co-ordinate Axis									
	X (m)	-0.0643							
	Y (m)	-0.0054							
	Z (m)	0.0020							
Radius of the circle									
	Rad (m)	0.1459		sig R	0.06	mm			

Observed Coords					**Dist. pt proj / plan to circle (mm)**	**Dist. point to plane (mm)**
Name	X (m)	Y (m)	Z (m)	Weight	+ve outside circle -ve inside circle	
CYLBACKA_01	-0.0656	0.0027	0.1476	1.000	-0.11	-0.04
CYLBACKB_01	-0.0655	-0.0777	0.1288	1.000	0.04	0.01
CYLBACKC_01	-0.0655	0.0914	0.1113	1.000	0.08	0.09
CYLBACKD_01	-0.0645	0.1365	0.0361	1.000	0.01	-0.11
CYLBACKE_01	-0.0637	0.1196	-0.0730	1.000	-0.06	0.09
CYLBACKF_01	-0.0630	0.0567	-0.1300	1.000	0.03	-0.04

Maximum Distance from Circle (mm)	0.08	At Point CYLBACKC_01	+ve outside circle
Minimum Distance from Circle (mm)	-0.11	At Point CYLBACKA_01	-ve inside circle

Distance from origin to Circle Centre (m)	0.06457
Bearing of Vector from origin to circle centre (grades)	294.6565
Vertical Angle of Vector from origin to circle centre (grades)	97.9970
Perpendicular distance from origin to plane containing circle (m)	0.06429
Bearing of the Vector from the origin to the plane (grades)	299.9902
Vertical Angle of the Vector from the origin to the plane (grades)	100.6002

5.3 CALCULATED LINE BETWEEN CYLINDER BACK AND FRONT AXIS OF THETARGET

Results of 3D Line Fitting						***Date of Calculation:***	08/11/2017	
						Time of Calculation:	16:08:58	
Coefficients of the Parametric Equations:								
*Y = A * X + P*								
*Z = B * X + Q*								
X = X								
	A	-0.00380		sig A	0.00	mm/m		
	P (m)	-0.00565		sig P	0.00	mm		
	B	0.00975		sig B	0.00	mm/m		
	Q (m)	0.00266		sig Q	0.00	mm		
Direction Cosines of the Spatial line								
	l	0.999945						
	m	-0.003795						
	n	0.009754						
Bearing of the Spatial Line (Cylback to Cylfront)						100.2416	grades	
Vertical Angle of the Line (Cylback to Cylfront)						99.3790	grades	
Perpendicular distance from origin to line						0.00625	m	
Bearing of the Vector from origin to line						200.5335	grades	
Vertical Angle of the Vector from origin to line						72.0259	grades	
Observed Coords								
Name	X (m)	Y (m)	Z (m)	sX (mm)	sY (mm)	sZ (mm)		
Cylback	-0.0643	-0.0054	0.0020	-	-	-		
Cylfront	0.0375	-0.0058	0.0030	-	-	-		
Sigmas on X Y Z are not used for weighting, almost one of them is missing in the input file								
X Y Z are all used with the same weight								
Mini. Spatial Dist. to Line D and dX, dY, dZ (Diff. co-ordinates = Pt. proj. - Pt. obs.)								
Name	D (mm)	dX (mm)	dY (mm)	dZ (mm)				
Cylback	0.00	0.00	0.00	0.00				
Cylfront	0.00	0.00	0.00	0.00				
Summary of the data in the Calculated Co-ordinate Axis								
Original Axis Conversion				X Calculated Co-ordinate Axis = X Observation Axis				
				Y Calculated Co-ordinate Axis = Y Observation Axis				
				Z Calculated Co-ordinate Axis = Z Observation Axis				
Parametric Equations of the line				y = -0.003796 x + -0.00565 m				
				z = 0.009754 x + 0.00266 m				
Maximum Dist to the Line (mm)				0.00	At Point Cylback			
Minimum Dist to the Line (mm)				0.00	At Point Cylback			

5.4 MIDDLE CIRCLE FITTING OF THE ELECTROMAGNETIC PUMP

Results of Circle Fitting							***Date of Calculation:***		08/11/2017
							Time of Calculation:		16:08:11
Equation and Direction Cosines of the Plane :									
Eqn of a Plane: X + B*Y + C*Z + D = 0									
	B	-0.003533		sig_B	0.24	mm/m			
	C	0.010332		sig_C	0.25	mm/m			
	D (m)	-0.0704		sig_D	0.01	mm			
Hence for Eqn of the form: a*x + b*y + c*z +d = 0 with a, b, c : Dir. Cosines of perp. Line to the Plane									
	a	0.999940							
	b	-0.003533							
	c	0.010331							
	d (m)	-0.0704							
Co-ordinates of the centre of the circle - in the Local Plane									
	x (m)	0.0056		sig x	0.02	mm			
	y (m)	-0.0026		sig y	0.02	mm			
Co-ordinates of the centre of the circle - in Calculated Co-ordinate Axis									
	X (m)	0.0703							
	Y (m)	-0.0059							
	Z (m)	0.0034							
Radius of the circle									
	Rad (m)	0.0609		sig R	0.01	mm			
Observed Coords					**Dist. pt proj / plan**		**Dist. point**		
					to circle (mm)		**to plane (mm)**		
Name	X (m)	Y (m)	Z (m)	Weight	+ve outside circle				
					-ve inside circle				
AXEMILA_02	0.0697	-0.0106	0.0641	1.000	0.01		0.02		
AXEMILB_02	0.0697	-0.0380	0.0550	1.000	-0.01		-0.01		
AXEMILC_02	0.0698	0.0134	0.0611	1.000	0.00		-0.01		
AXEMILD_02	0.0702	0.0454	0.0362	1.000	0.00		-0.01		
AXEMILE_02	0.0706	0.0550	0.0032	1.000	-0.01		0.01		
AXEMILF_02	0.0708	0.0472	-0.0264	1.000	0.01		0.00		
Maximum Distance from Circle (mm)				0.01	At Point AXEMILA_02			+ve outside circle	
Minimum Distance from Circle (mm)				-0.01	At Point AXEMILE_02			-ve inside circle	
Distance from origin to Circle Centre (m)							0.07067		
Bearing of Vector from origin to circle centre (grades)							105.2842		
Vertical Angle of Vector from origin to circle centre (grades)							96.9600		
Perpendicular distance from origin to plane containing circle (m)							0.07040		
Bearing of the Vector from the origin to the plane (grades)							100.2249		
Vertical Angle of the Vector from the origin to the plane (grades)							99.3423		

5.5 CALCULATED LINE BETWEEN MIDDLE CIRCLE AND AXEAR OF THE PUMP

Projection of a Point on to 3D Line					***Date of Calculation:***		08/11/2017					
					Time of Calculation:		16:09:26					
Parameters of 3D Line:												
Input :	Parametric equation from WorkSheet :				Results_Line							
Parametric equation of the Line												
	A	-0.003796		Y = A * X + P and Z = B * X + Q								
	P	-0.00565										
	B	0.009754										
	Q	0.00266										
Point of the Line												
	Name											
	X	0.0000										
	Y	-0.0057										
	Z	0.0027										
Vector of the Line				Direction Cosines of the Line								
	X vector	0.99995			l =	0.999945						
	Y vector	-0.00380			m =	-0.003795						
	Z vector	0.00975			n =	0.009754						
Table containing calculated data												
All angles are along the Vector from the Point to the Shape												
				Vector Point to Line			Co-ordinates of Projected Point					
Name	X	Y	Z	Distance	Bearing	Vert.Ang.	Xproj	Yproj	Zproj			
					(Grades)	(Grades)						
Axemil_02	0.0703	-0.0059	0.0034	0.0001	200.0000	124.8176	0.0703	-0.0059	0.0033	0.0000	0.0001	0.0000
AXEAR00_	0.3196	-0.0069	0.0058	0.0000	0.5095	125.9265	0.3196	-0.0069	0.0058	0.0000	0.0000	0.0000