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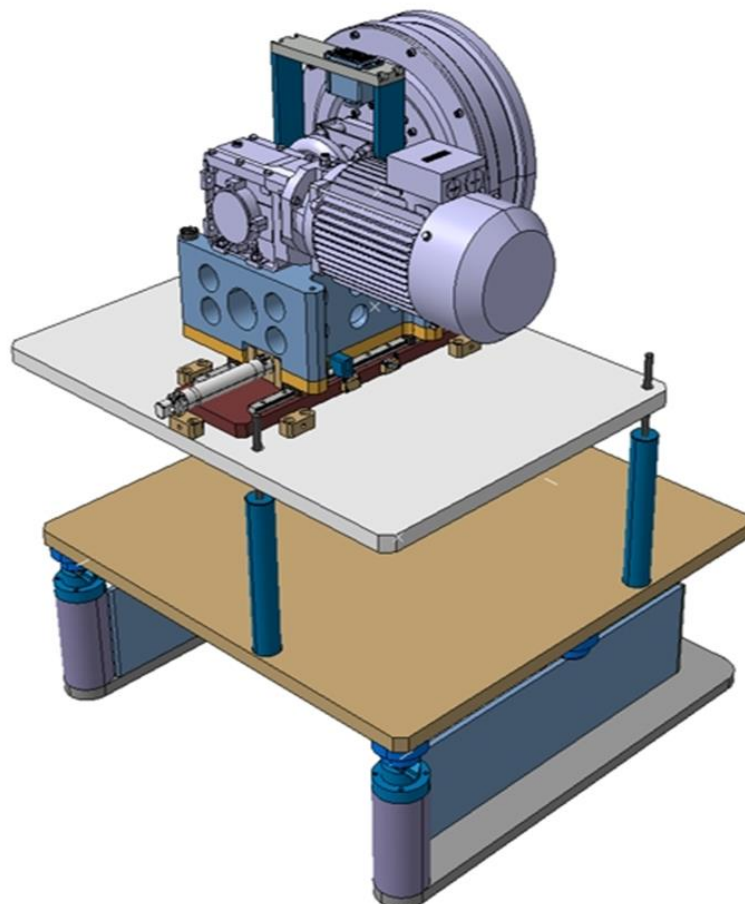Ferran BOIX PAMIES   EN/STI   Julien Marc RIEGERT   EN/STI
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ISOLDE
LIEBE Electromagnetic Pump Measurement
Measurement of October 24th, 2017

The EDMS document: **1894710**, containing this report is available at the following address:
https://edms.cern.ch/document/ **1894710**

1   General

On the demand of Ferran BOIX PAMIES the measurement of the LIEBE Electromagnetic pump took place on 24th of October, 2017
The purpose of this measurement has been to check the good alignment of the electromagnetic pump assembly with respect to the rotation axis. For this the following measurements have been done:
1. Control of the cylindricity and the coaxiality of the pump assembly in static position.
2. Control of the coaxiality of the pump assembly in four different rotations
3. Measured points of pump axis for three longitudinal positions to ensure the axis of the table and the axis of the pump are parallel.

2   Local Coordinate System

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

- **Origin**: Back point in axe of the pump in first table position.(see figure 2)

- **X-axis**: Towards small circle of rotation axis in first table position. (see figure 3)

- **Y-axis**: Perpendicular to X and horizontal.
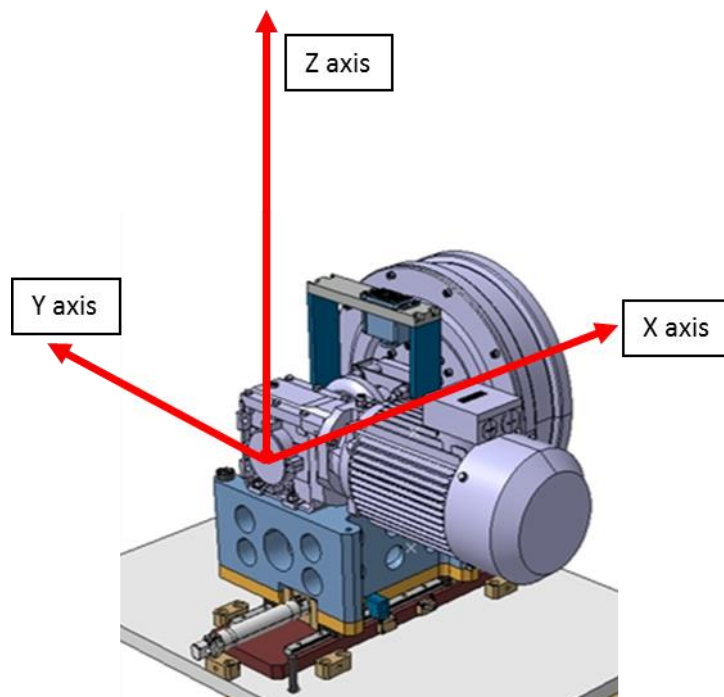
- **Z-axis**: Perpendicular to X and Y axis.

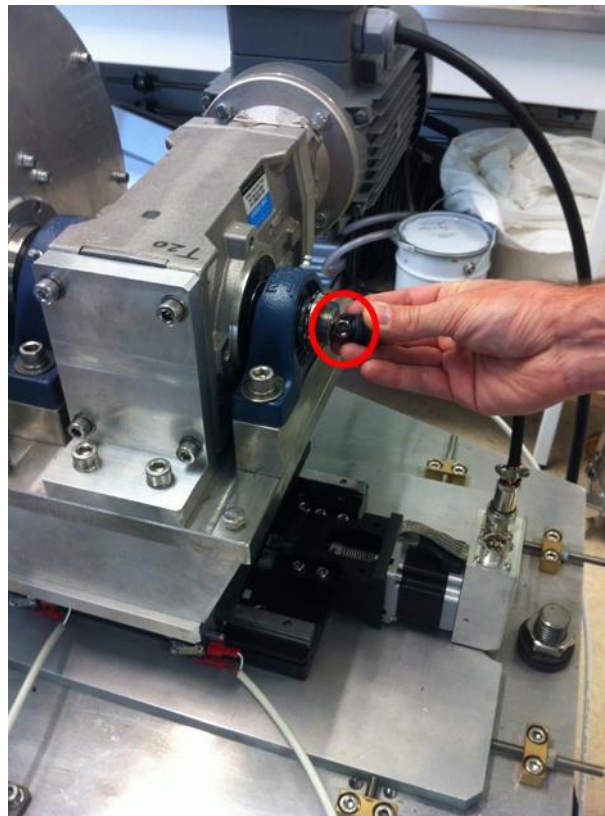*Figure1: Local Coordinate System for Electromagetic pump*

Figure2: Origin point of the system: AXEAR_01
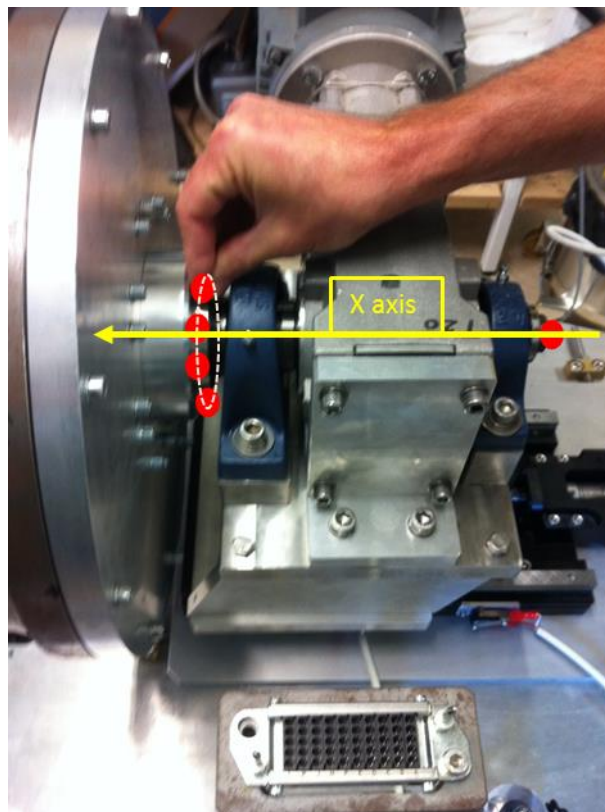
Figure3: X-axis determination by best fit circle on MIDDLE AXIS point.

3   Point Names and Distribution
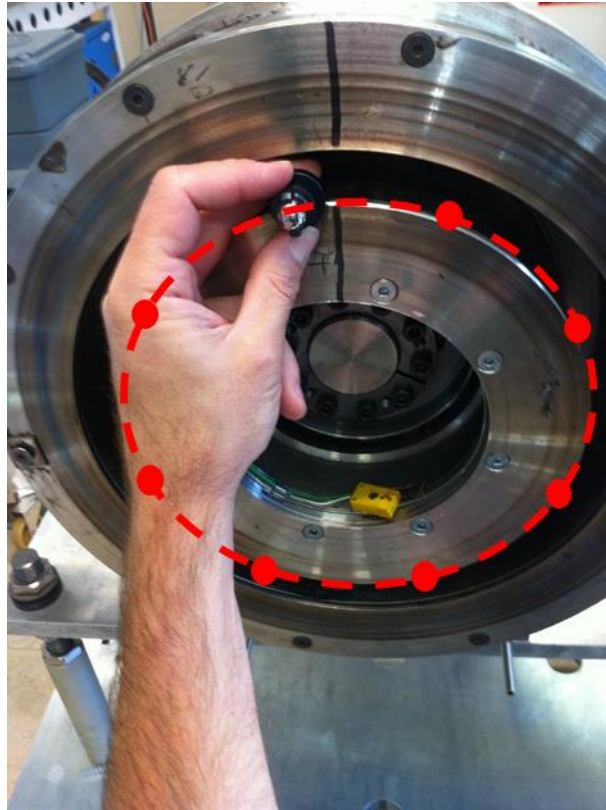
Figure4: Inner Pump assembly measured in static position.

Figure5: Outer Pump assembly measured in static position.

The rotating front end of the pump has been measured in four different rotations approximately (0°, 90°, 180° and 270°). See Figure 6 and § 5.4, § 5.5 for more details.
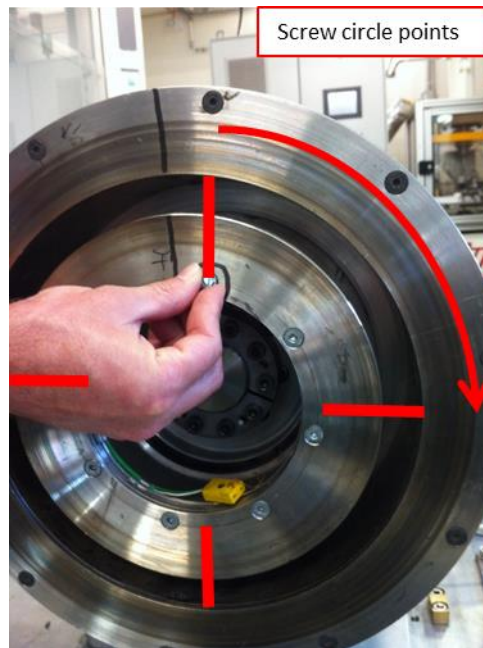
Figure 6: Screw circle measured in four differents rotations
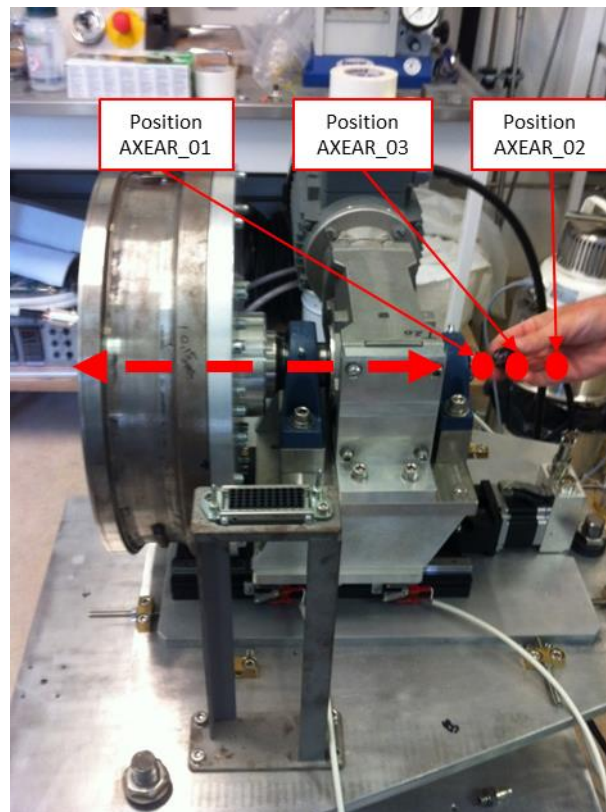
Figure7: AXEAR_XX, measured in three longitudinal positions of the table.

4   Results of the measurements

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

| ISOLDE MEASURMENT OF ELECTROMAGNETIC PUMP October 24th 2017					
Longitudinal Position of the table	Name	X (m)	Y (m)	Z (m)	Diameter with support adapter correction (m)
1	AXEAR_01	0.0000	0.0000	0.0000	
1	Middle Axis	0.2224	0.0000	0.0000	0.0710
1	Inner Circle	0.3963	0.0002	-0.0001	0.2420
1	Outer Circle	0.3966	0.0001	0.0002	0.2873
1	Screw Circle	0.3819	0.0001	-0.0001	0.1625
2	AXEAR_02	-0.1344	0.0010	0.0003	
2	Screw Circle 2	0.2475	0.0011	0.0006	0.1625
3	AXEAR_03	-0.0801	0.0006	0.0002	

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

5   ATTACHMENT

5.1   DETERMINATION OF MIDLE CIRCLE CENTRE OF THE PUMP

Results of Circle Fitting					*Date of Calculation:*	24/10/2017	
					Time of Calculation:	16:07:16	
Equation and Direction Cosines of the Plane :							
Eqn of a Plane: X + B*Y + C*Z + D = 0							
	B	0.000850		sig_B	1.01	mm/m	
	C	-0.000577		sig_C	1.37	mm/m	
	D (m)	-0.22236		sig_D	0.05	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	0.999999					
	b	0.000850					
	c	-0.000577					
	d (m)	-0.22236					
Co-ordinates of the centre of the circle - in the Local Plane							
	x (m)	0.0002		sig x	0.002	mm	
	y (m)	-0.0001		sig y	0.003	mm	
Co-ordinates of the centre of the circle - in Calculated Co-ordinate Axis							
	X (m)	0.2224					
	Y (m)	0.0000					
	Z (m)	0.0000					
Radius of the circle							
	Rad (m)	0.0418		sig R	0.00	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		
AXEMI_01A	0.2224	-0.0164	0.0385	1.000	0.00	0.01	
AXEMI_01B	0.2224	0.0016	0.0418	1.000	0.00	-0.02	
AXEMI_01C	0.2224	0.0312	0.0278	1.000	0.00	0.01	
AXEMI_01D	0.2223	0.0418	-0.0017	1.000	0.00	-0.01	

Maximum Distance from Circle (mm)	0.00	At Point AXEMI_01B	+ve outside circle
Minimum Distance from Circle (mm)	0.00	At Point AXEMI_01C	-ve inside circle

Distance from origin to Circle Centre (m)	0.22236
Bearing of Vector from origin to circle centre (grades)	100.0000
Vertical Angle of Vector from origin to circle centre (grades)	100.0000
Perpendicular distance from origin to plane containing circle (m)	0.22236
Bearing of the Vector from the origin to the plane (grades)	99.9459
Vertical Angle of the Vector from the origin to the plane (grades)	100.0368

5.2   DETERMINATION OF FRONT END INNER CIRCLE CENTRE OF THE PUMP

Results of Circle Fitting					Date of Calculation:	24/10/2017		
					Time of Calculation:	16:08:35		
Equation and Direction Cosines of the Plane :								
Eqn of a Plane: X + B*Y + C*Z + D = 0								
	B	0.000555	sig_B	0.64	mm/m			
	C	-0.001835	sig_C	0.64	mm/m			
	D (m)	-0.39633	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	0.999998						
	b	0.000555						
	c	-0.001835						
	d (m)	-0.39633						
Co-ordinates of the centre of the circle - in the Local Plane								
	x (m)	0.0001	sig x	0.15	mm			
	y (m)	-0.0006	sig y	0.15	mm			
Co-ordinates of the centre of the circle - in Calculated Co-ordinate Axis								
	X (m)	0.3963						
	Y (m)	0.0002						
	Z (m)	-0.0001						
Radius of the circle								
	Rad (m)	0.1250	sig R	0.10	mm			

Observed Coords					Dist. pt proj / plan to circle (mm) +ve outside circle -ve inside circle	Dist. point to plane (mm)		
Name	X (m)	Y (m)	Z (m)	Weight				
CERCLEINT_01A	0.3967	0.0129	0.1246	1.000	0.38	0.16		
CERCLEINT_01B	0.3965	0.1009	0.0732	1.000	-0.35	0.08		
CERCLEINT_01C	0.3961	0.1233	-0.0211	1.000	-0.11	-0.08		
CERCLEINT_01D	0.3960	0.0777	-0.0986	1.000	0.34	-0.11		
CERCLEINT_01E	0.3961	-0.0157	-0.1241	1.000	-0.04	0.03		
CERCLEINT_01F	0.3964	-0.0871	-0.0893	1.000	-0.16	0.19		
CERCLEINT_01G	0.3963	-0.1249	0.0010	1.000	0.05	-0.06		
CERCLEINT_01H	0.3963	-0.0828	0.0933	1.000	-0.11	-0.20		
Maximum Distance from Circle (mm)					0.38	At Point CERCLEINT_01A	+ve outside circle	
Minimum Distance from Circle (mm)					-0.35	At Point CERCLEINT_01B	-ve inside circle	
Distance from origin to Circle Centre (m)						0.39633		
Bearing of Vector from origin to circle centre (grades)						99.9742		
Vertical Angle of Vector from origin to circle centre (grades)						100.0197		
Perpendicular distance from origin to plane containing circle (m)						0.39633		
Bearing of the Vector from the origin to the plane (grades)						99.9647		
Vertical Angle of the Vector from the origin to the plane (grades)						100.1168		

5.3   DETERMINATION OF FRONT END OUTER CIRCLE CENTRE OF THE PUMP

Results of Circle Fitting						Date of Calculation:	24/10/2017
						Time of Calculation:	16:09:35
Equation and Direction Cosines of the Plane :							
Eqn of a Plane: X + B*Y + C*Z + D = 0							
	B	0.000156		sig_B	0.28	mm/m	
	C	0.000264		sig_C	0.29	mm/m	
	D (m)	-0.39660		sig_D	0.03	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	1.000000					
	b	0.000156					
	c	0.000264					
	d (m)	-0.39660					
Co-ordinates of the centre of the circle - in the Local Plane							
	x (m)	-0.0001		sig x	0.23	mm	
	y (m)	-0.0001		sig y	0.24	mm	
Co-ordinates of the centre of the circle - in Calculated Co-ordinate Axis							
	X (m)	0.3966					
	Y (m)	0.0001					
	Z (m)	0.0002					
Radius of the circle							
	Rad (m)	0.1396		sig R	0.16	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		
CERCLEEXT_01A	0.3964	0.0045	0.1393	1.000	-0.42	-0.12	
CERCLEEXT_01B	0.3967	0.1075	0.0894	1.000	-0.06	0.11	
CERCLEEXT_01C	0.3966	0.1403	-0.0003	1.000	0.51	0.01	
CERCLEEXT_01D	0.3966	0.1133	-0.0817	1.000	0.07	-0.05	
CERCLEEXT_01E	0.3966	0.0010	-0.1387	1.000	-0.69	-0.02	
CERCLEEXT_01F	0.3967	-0.1024	-0.0950	1.000	0.25	0.01	
CERCLEEXT_01G	0.3967	-0.1388	-0.0170	1.000	0.31	0.03	
CERCLEEXT_01H	0.3966	-0.0958	0.1017	1.000	0.03	0.02	

Maximum Distance from Circle (mm)			0.51	At Point CERCLEEXT_01C	+ve outside circle	
Minimum Distance from Circle (mm)			-0.69	At Point CERCLEEXT_01E	-ve inside circle	
Distance from origin to Circle Centre (m)					0.39661	
Bearing of Vector from origin to circle centre (grades)					99.9817	
Vertical Angle of Vector from origin to circle centre (grades)					99.9686	
Perpendicular distance from origin to plane containing circle (m)					0.39661	
Bearing of the Vector from the origin to the plane (grades)					99.9901	
Vertical Angle of the Vector from the origin to the plane (grades)					99.9832	

5.4 DETERMINATION OF FRONT END SCREW CIRCLE CENTRE OF THE PUMP BY FOUR ROTATION POSITIONS

Results of Circle Fitting					*Date of Calculation:*	24/10/2017	
					Time of Calculation:	16:10:20	
Equation and Direction Cosines of the Plane :							
Eqn of a Plane: X + B*Y + C*Z + D = 0							
	B	0.00031		sig_B	0.04	mm/m	
	C	-0.00041		sig_C	0.04	mm/m	
	D (m)	-0.38191		sig_D	0.00	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	1.000000					
	b	0.000308					
	c	-0.000413					
	d (m)	-0.38191					
Co-ordinates of the centre of the circle - in the Local Plane							
	x (m)	0.0000		sig x	0.01	mm	
	y (m)	-0.0001		sig y	0.01	mm	
Co-ordinates of the centre of the circle - in Calculated Co-ordinate Axis							
	X (m)	0.3819					
	Y (m)	0.0001					
	Z (m)	-0.0001					
Radius of the circle							
	Rad (m)	0.0813		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		
SCREW01_A	0.3819	0.0225	0.0780	1.000	-0.01	0.00	
SCREW01_B	0.3819	0.0754	-0.0306	1.000	0.01	0.00	
SCREW01_C	0.3819	-0.0348	-0.0734	1.000	-0.01	0.00	
SCREW01_D	0.3819	-0.0793	0.0176	1.000	0.01	0.00	
Maximum Distance from Circle (mm)				0.01	At Point SCREW01_D	+ve outside circle	
Minimum Distance from Circle (mm)				-0.01	At Point SCREW01_C	-ve inside circle	
Distance from origin to Circle Centre (m)					0.38191		
Bearing of Vector from origin to circle centre (grades)					99.9885		
Vertical Angle of Vector from origin to circle centre (grades)					100.0093		
Perpendicular distance from origin to plane containing circle (m)					0.38191		
Bearing of the Vector from the origin to the plane (grades)					99.9804		
Vertical Angle of the Vector from the origin to the plane (grades)					100.0263		

5.5   DETERMINATION OF FRONT END SCREW CIRCLE CENTRE 2 OF THE PUMP BY FOUR ROTATION POSITIONS

Results of Circle Fitting						*Date of Calculation:*	24/10/2017		
						Time of Calculation:	16:11:44		
Equation and Direction Cosines of the Plane :									
Eqn of a Plane: X + B*Y + C*Z + D = 0									
	B	-0.00004		sig_B	0.21	mm/m			
	C	0.00071		sig_C	0.21	mm/m			
	D (m)	-0.24754		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	1.000000							
	b	-0.000040							
	c	0.000712							
	d (m)	-0.24754							
Co-ordinates of the centre of the circle - in the Local Plane									
	x (m)	-0.0011		sig x	0.02	mm			
	y (m)	-0.0005		sig y	0.02	mm			
Co-ordinates of the centre of the circle - in Calculated Co-ordinate Axis									
	X (m)	0.2475							
	Y (m)	0.0011							
	Z (m)	0.0006							
Radius of the circle									
	Rad (m)	0.0812		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				
SCREW02_A	0.2475	0.0201	0.0796	1.000	0.01	-0.01			
SCREW02_B	0.2476	0.0818	0.0093	1.000	-0.01	0.01			
SCREW02_C	0.2476	0.0066	-0.0804	1.000	0.01	-0.01			
SCREW02_D	0.2476	-0.0779	-0.0186	1.000	-0.01	0.01			
Maximum Distance from Circle (mm)				0.01	At Point SCREW02_C		+ve outside circle		
Minimum Distance from Circle (mm)				-0.01	At Point SCREW02_B		-ve inside circle		
Distance from origin to Circle Centre (m)						0.24755			
Bearing of Vector from origin to circle centre (grades)						99.7256			
Vertical Angle of Vector from origin to circle centre (grades)						99.8347			
Perpendicular distance from origin to plane containing circle (m)						0.24754			
Bearing of the Vector from the origin to the plane (grades)						100.0026			
Vertical Angle of the Vector from the origin to the plane (grades)						99.9547			