Technical Report #34

M2/f15 and M2/f9 Hexapod Data Package

D. Gallieni

July 1998

PROGRAMME : **MMT CONVERSION**
SECONDARY MIRRORS SUPPORT
M2/F15 and M2/F9 HEXAPOD

CUSTOMER : **Steward Observatory**
The University of Arizona
Tucson – AZ 85721-0065 USA
Tel.: (520) 626-5231
Fax: (520) 621-9843

CONTRACTOR : **ADS Italia s.r.l.**
Corso Promessi Sposi $23/d_1$
23900 LECCO - ITALY
Tel.: +39-341-259231
Fax: +39-341-259235

DOCUMENT TITLE : **M2/F15 and M2/F9 HEXAPOD DATA PACKAGE**
Issue : 1
Date : 07/10/1998

DOCUMENT ID. : **H9-DP-AD-001**

DOCUMENT TYPE : **DATA PACKAGE**

ISSUED BY : D. Gallieni

ADS ITALIA
SISTEMI AVANZATI

Signature

Date

TABLE OF CONTENTS

1. SCOPE OF THE WORK

This document reports the informations related to the M2 Hexapod f9/f15 for the MMT upgrade.

Hexapod electromechanical parts are reported in terms of requirements fulfilment, parts and material list, assembly and workshop drawings, manufacturer's data sheets of commercial components, linear actuators testing in ambient conditions (test procedures and test results), installation and maintenance instructions and handling and transportation instructions for delivery.

2. APPLICABLE DOCUMENTS

- 1.1 W.Gallieni and R. Pozzi, «MMT CONVERSION - SECONDARY MIRRORS SUPPORT - M2/F15 and M2/F9 HEXAPOD DESIGN - TECHNICAL REPORT», Doc: D00001, Issue 3, January 1997;

- 1.2 Assembly drawings: 200505, 200513, 300931 and 300930.

3. HEXAPOD DESCRIPTION

The f9/f15 hexapod electromechanical parts include:

- seven (7) linear actuators (six + one spare);
- fixed and mobile platforms;
- six (6) interface supports for actuator joints fixture on the platforms.

The actuator is based by a direct drive configuration with frame-less motor and encoder on the same spindle axis.

The actuator nominal length (zero nominal stroke position) is 330 mm, measured between actuator's joints ledges.

The actuator nominal stroke is ± 10 mm from the zero position.

The max angular displacements of the flex joints is ± 1,0 degree.

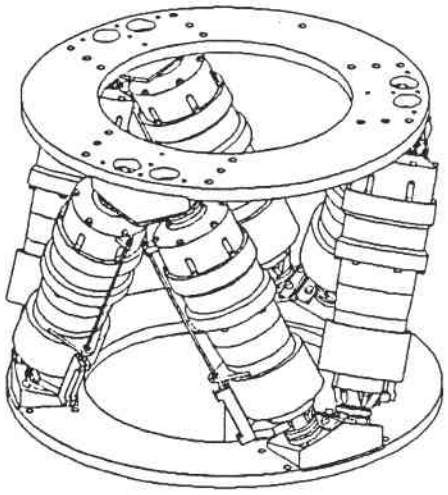
The satellite roller screw is of the re-circulating rollers type.

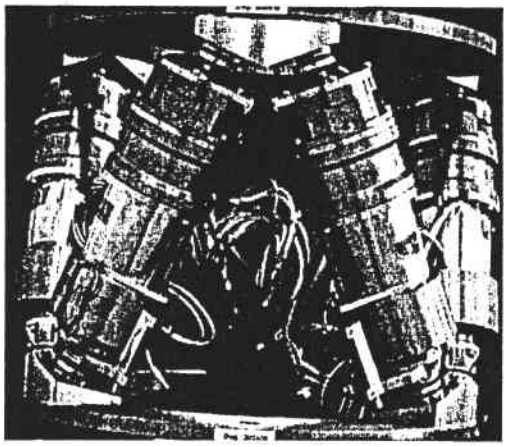
The motor gives 0,82 Nm continuous stall torque and 4,07 Nm peak torque.

The brake has 1,7 Nm static torque.

The incremental encoder has 3600 counts per revolution resolution, giving 0,28 μm linear resolution on the 1 mm pitch screw.

LVDT linear position sensor gains are reported in the functional test results.





4. LINEAR ACTUATORS

4.1. Parts and material list

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MMT HEXAPOD M2-F15
LINEAR ACTUATOR
WORKSHOP LIST

Parts list

Quantity 1	Quantity 2	DESIGNATION	Format A	Item	MATERIAL	Piece weight (kg)	REMARKS	Mod.
1	4+3	FLEXURE FOIL (4 Dx. +3 Sx.)	3	01	AISI 303	0.68	Dwg. n° 300933	B
1	7	ENCODER HOUSING	4	02	Anticorodal UNI 9006/4	0.2	Dwg. n° 400690	B
1	7	ENCODER-BEARING SUPPORT	4	03	AISI 303	0.36	Dwg. n° 400691	B
1	7	FRAMELESS MOTOR SUPPORT	3	04	Anticorodal UNI 9006/4	0.43	Dwg. n° 300934	A
1	7	BUSHING	4	05	AISI 303	0.12	Dwg. n° 400692	A
1	7	DISTANCE RING	4	06	AISI 303	0.025	Dwg. n° 400693	B
1	7	DISTANCE RING	4	07	AISI 303	0.008	Dwg. n° 400694	A
1	7	BRAKE-BEARINGS SUPPORT	3	08	AISI 303	1.85	Dwg. n° 300935	A
1	7	DISTANCE RING	4	09	AISI 303	0.015	Dwg. n° 400695	A
1	7	COVER	4	10	AISI 303	0.28	Dwg. n° 400696	A
1	7	PROXIMITY SUPPORT	3	11	Anticorodal UNI 9006/4	0.1	Dwg. n° 300936	A
1	7	PROTECTION	4	12	Anticorodal UNI 9006/4	0.045	Dwg. n° 400698	B
1	7	PROTECTION RING	4	13	Anticorodal UNI 9006/4	0.035	Dwg. n° 400699	A
1	7	SATELLITE ROLLER SCREW SUPPORT	3	14	Anticorodal UNI 9006/4	0.17	Dwg. n° 300937	A

Index				
Date				
Name				

Number of assemblies : 7
Weight for 1 ass. : 4.94 Kg.
Weight for all ass. : 34.58 Kg.

ACTUATOR ASSEMBLY DWG N°200505

MEDIA / LARGO

9.998 OK

1) Quantity for 1 assembly 2) Quantity for execution

sheet 01 of 02
FILE 400707/C

MMT CONVERSION

Doc.No : H9-DP-AD-001
Issue : 1
Date : Oct.1998

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MMT HEXAPOD M2-F15
LINEAR ACTUATOR
WORKSHOP LIST

Parts list

Quantity 1	Quantity 2	DESIGNATION	Format A	Item	MATERIAL	Piece weight (kg)	REMARKS	Mod.
1	7	FLEXURE JOINT	3	15	AISI 303	0.41	Dwg. n° 300938	B
2	14	RING	4	16	AISI 303	0.005	Dwg. n° 400700	A
1	7	LVDT SUPPORT	4	17	AISI 303	0.15	Dwg. n° 400701	A
1	7	BUSHING	4	18	B14	0.01	Dwg. n° 400702	A
1	7	STEM	4	19	INVAR	0.015	Dwg. n° 400703	A
1	7	BUSHING	4	20	AISI 303	0.03	Dwg. n° 400705	A
2	14	FLEXURE FOIL	4	21	50 Cr V4	0.003	Dwg. n° 400704	A
2	14	Distance plate	4	28	AISI 304	0.08	Dwg. n° 400748	A
1	7	Bushing	4	29	AISI 304	0.02	Dwg. n° 400749	A
1	1	Key	4		AISI 304	0.05	Dwg. n° 400751	A

Index				
Date				
Name				

Number of assemblies : 7
Weight for 1 ass. : 4.94 Kg.
Weight for all ass. : 34.58 Kg.

ACTUATOR ASSEMBLY DWG N°200505

1) Quantity for 1 assembly 2) Quantity for execution

sheet 02 of 02
FILE 400707/C

MMT CONVERSION

Doc.No : H9-DP-AD-001
Issue : 1
Date : Oct.1998

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MMT HEXAPOD M2-F15
LINEAR ACTUATOR
COMMERCIAL LIST

Parts list

Quantity 1	Quantity 2	DESIGNATION	Item	MATERIAL	Piece weight (kg)	REMARKS	Mod.
1	7	SATELLITE ROLLER SCREW (ROLLVIS RVR 20x1)	100	X46Cr13	~ 0.65	DWG.300939/C	
1	7	ENCODER (HEIDENHAIN ERO 1324)	101		0.145		
1	7	BALL BEARING (FAG 6000 Z15)	102		0.019		
2	14	SNAP RING FOR HOLES ø26 UNI 7437	103	50 Cr V 4	0.001		
1	7	SELF LOCKING RING (GUK M12x1)	104	Steel R490N/mm² Zinc plated	0.01		
3	21	GRUB SCREW M4x4 UNI 5923	105	INOX UNI 7323/8	0.002		
1	7	FRAMELESS BRUSHED MOTOR-ROTOR (INLAND)	106		1.08	Type QT-2404 "..." WINDING	
1	7	FRAMELESS BRUSHED MOTOR-STATOR (INLAND)	107				
1	7	BRAKE (ELECTROID Type EFSB 15) Armature plate	108		0.54		
1	7	BRAKE (ELECTROID Type EFSB 15) Hub	109				
1	7	KEY 4x4x14 UNI 6604-A	110	Steel R590 N/mm²	0.001	DWG.400750	
1	7	SELF LOCKING RING (GUK M20x1)	111	Steel R490N/mm² Zinc plated	0.02		
2	14	AXIAL RADIAL BEARINGS (FAG B7004E.T.P4S.DBH)	112		0.07		
2	14	BELLEVILLE WASHER 25 GR 3 UNI 8737-B	113	50 Cr V 4	0.001		

Index				Number of assemblies :	6
Date				Weight for 1 ass. :	4.15 Kg.
Name				Weight for all ass. :	24.9 Kg.

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1) Quantity for 1 assembly 2) Quantity for execution

sheet 01 of 03

FILE 400707/C

MMT CONVERSION

Doc.No : H9-DP-AD-001
Issue : 1
Date : Oct.1998

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SISTEMI AVANZATI

MMT HEXAPOD M2-F15
LINEAR ACTUATOR
COMMERCIAL LIST

Parts list

Quantity 1	Quantity 2	DESIGNATION	Item	MATERIAL	Piece weight (kg)	REMARKS	Mod.
1	7	SELF LOCKING RING (GUK M10x0.75)	114	Steel R490N/mm² Zinc plated	0.008		
1	7	LVDT Unit (SCHAEVITZ Type 500 MHR-Miniature)	115	AISI 400 (Housing)	0.019		
2	14	PROXIMITY (BAUMER Type IFR 05.26.35/L)	116	AISI 303 (Housing)	0.02		
20	140	SCREW M4x15 UNI 5931	117	INOX UNI 7323/8	0.018		
2	14	NUT M3 ISO 4032	118	INOX ISO 3506	0.015		
2	14	WASHER 3.2x7x0.5 UNI 6592	119	INOX UNI 7323/8	0.005		
6	42	SCREW M4x20 UNI 5931	120	INOX UNI 7323/8	0.020		
4	28	SCREW M3x40 UNI 7688	121	INOX UNI 7323/8	0.020		
6	42	SCREW M4x25 UNI 5931	122	INOX UNI 7323/8	0.025		
14	98	SCREW M5x12 UNI 5931	123	INOX UNI 7323/8	0.025		
8	56	SCREW M2.5x5 UNI 7688	124	INOX UNI 7323/8	0.005		
4	28	NUT M5 ISO 4032	125	INOX ISO 3506	0.020		
4	28	WASHER 5.3x9.5x1 UNI 6592	126	INOX UNI 7323/8	0.008		
2	14	SCREW M4x8 UNI 6107	127	INOX UNI 7323/8	0.001		

Index				Number of assemblies :	6
Date				Weight for 1 ass. :	4.15 Kg.
Name				Weight for all ass. :	24.9 Kg.

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QA 2

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1) Quantity for 1 assembly 2) Quantity for execution

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MMT HEXAPOD M2-F15
LINEAR ACTUATOR
COMMERCIAL LIST

Parts list

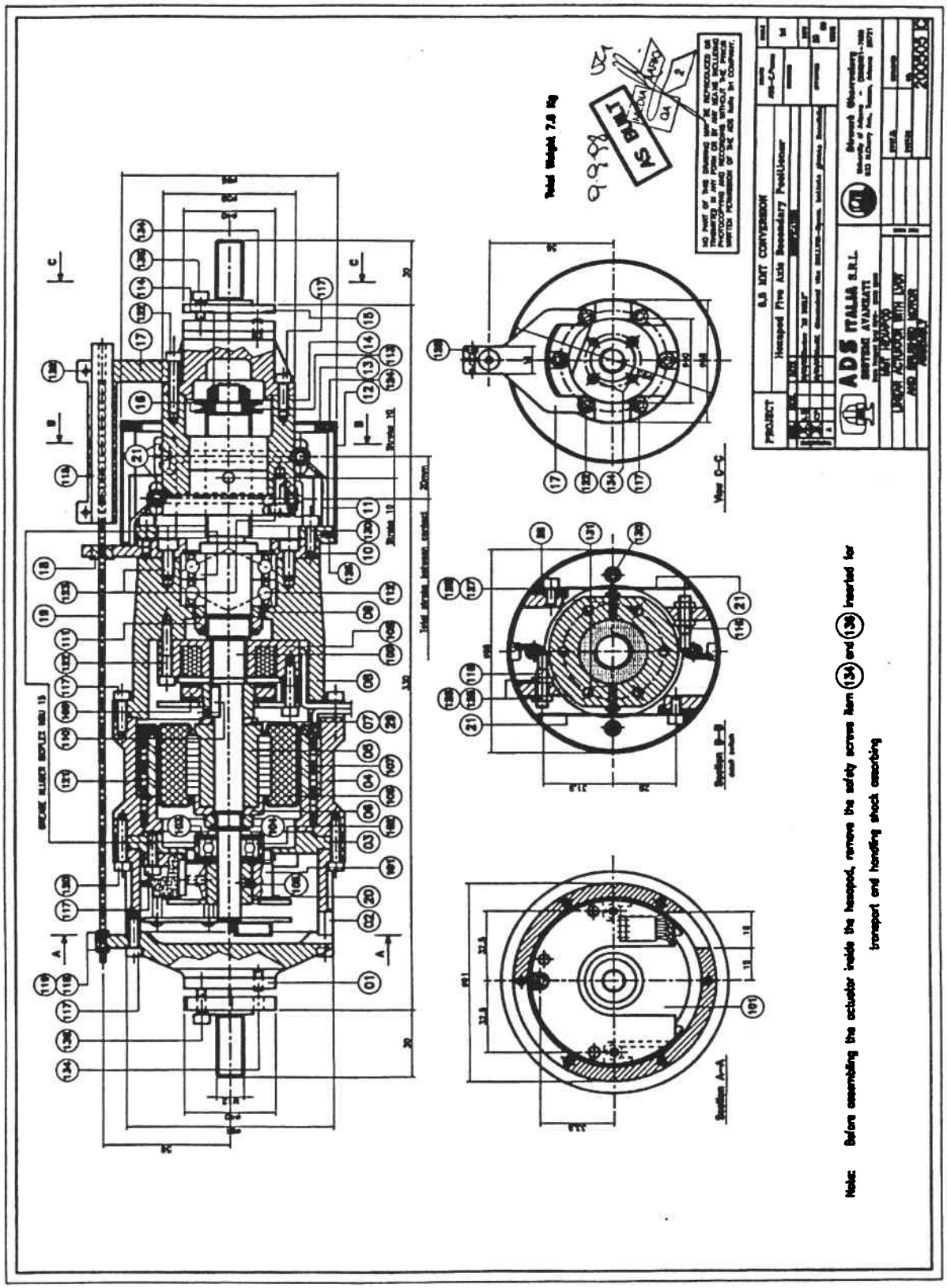
Quantity 1	Quantity 2	DESIGNATION	Item	MATERIAL	Piece weight (kg)	REMARKS	Mod.
2	14	WASHER 4.3x9x0.8 UNI 6592	128	INOX UNI 7323/8	0.006		
2	14	SCREW M2.5x10 UNI 5931	129	INOX UNI 7323/8	0.010		
4	28	SCREW M4x12 UNI 5931	130	INOX UNI 7323/8	0.015		
2	14	SCREW M3x10 UNI 7687	131	INOX UNI 7323/8	0.010		
24	24	SCREW M5x20 UNI 5931	132	INOX UNI 7323/8	0.020		
6	6	PIN ø5x30-A-St. UNI-ISO 8734	133		0.010		
4	28	GRUB SCREW M4x10 UNI 5923	134	INOX UNI 7323/8	0.008		
12	12	HEXAGON NUT M12 ISO 4032 8.8	135	INOX A2-70	0.015		
4	28	SCREW M4x10 UNI 5931	136	INOX UNI 7323/8	0.008		
	1	GREASE KLUBER ISOFLEX NBU 15					

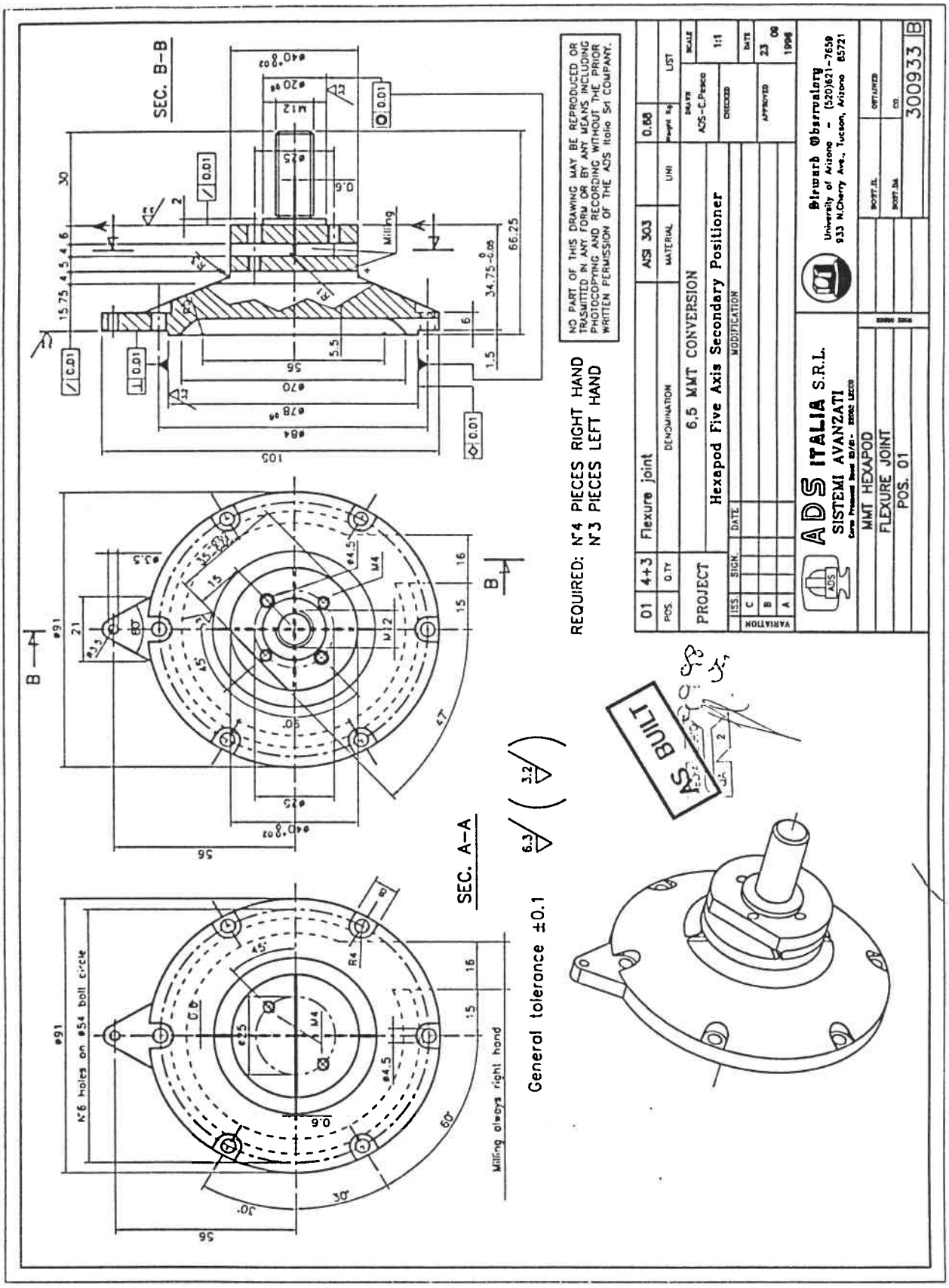
Index				Number of assemblies :	6
Date				Weight for 1 ass. :	4.15 Kg.
Name				Weight for all ass. :	24.9 Kg.

1) Quantity for 1 assembly 2) Quantity for execution

MEDIA LARIO DA 2 9.9.98

4.2. *Assembly and Workshop Drawings*


Note: Before assembling the actuator inside the hexapod, remove the safety screws item (134) and (136) inserted for transport and handling shock absorbing


SEC. B-B
SEC. A-A
B
B
Milling
Milling always right hand
N°6 holes on ø54 bolt circle
General tolerance ±0.1
REQUIRED: N°4 PIECES RIGHT HAND
N°3 PIECES LEFT HAND
NO PART OF THIS DRAWING MAY BE REPRODUCED OR TRASMITTED IN ANY FORM OR BY ANY MEANS INCLUDING PHOTOCOPYING AND RECORDING WITHOUT THE PRIOR WRITTEN PERMISSION OF THE ADS Italia Srl COMPANY.
01 4+3 Flexure joint AISI 303 0.88
POS. Q.TY DENOMINATION MATERIAL UNI Weight Kg LIST
PROJECT 6.5 MMT CONVERSION
Hexepod Five Axis Secondary Positioner
DRAWN ADS-C.Pesco
CHECKED
APPROVED
SCALE 1:1
DATE 23 08 1998
VARIATION ISS SIGN DATE MODIFICATION
A
B
C
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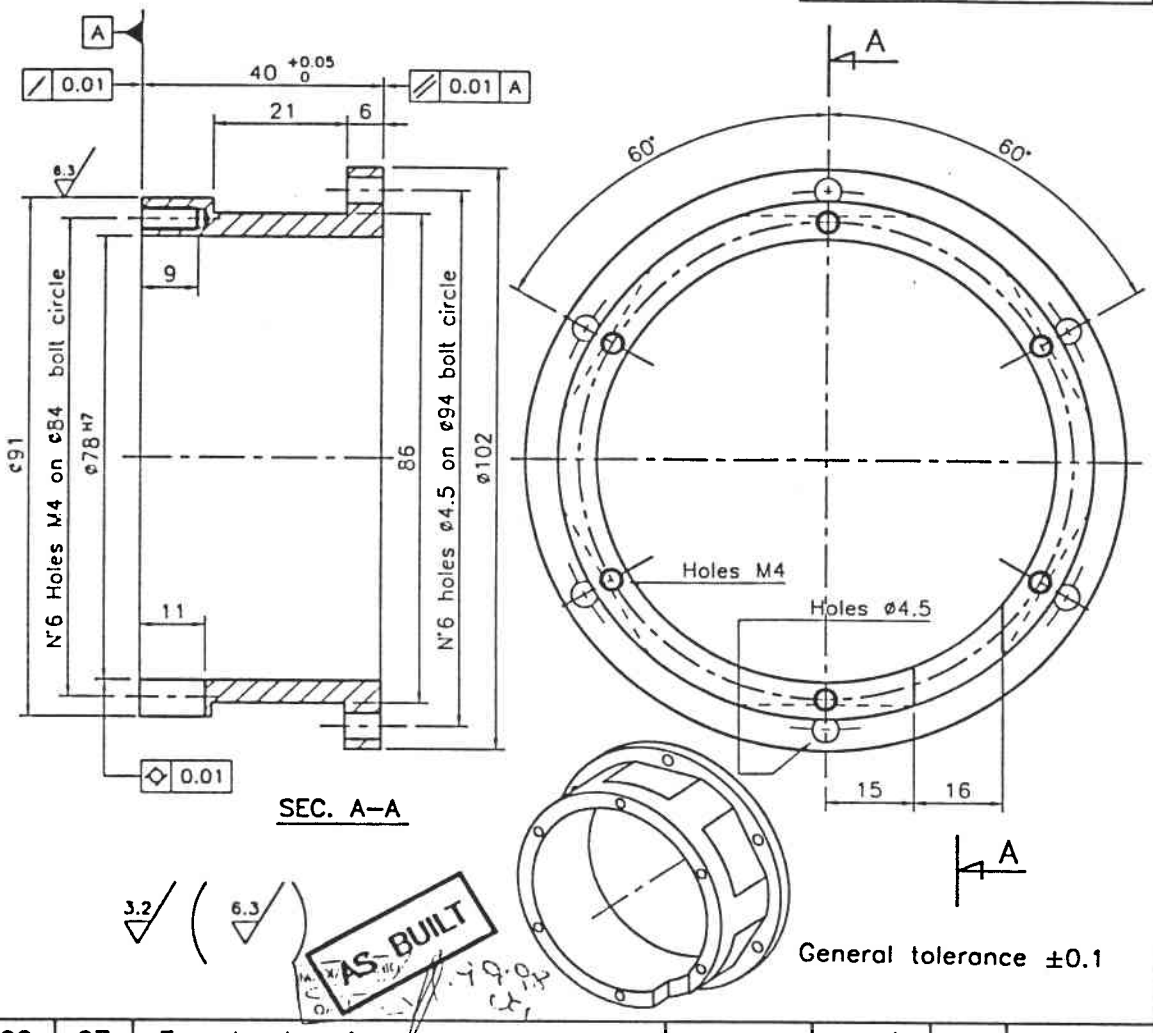
933 N.Cherry Ave., Tucson, Arizona 85721
MMT HEXAPOD
FLEXURE JOINT
POS. 01
DRAWING NO. 300933 B
BUILT



POS.	Q.TY	DENOMINATION	MATERIAL	UNI	Weight Kg	LIST
02	07	Encoder housing	Anticorodal	9006/4	0.2	

PROJECT	6,5 MMT CONVERSION	DRAWN	SCALE
	Hexapod Five Axis Secondary Positioner	ADS-C.Pesco	1:1
		CHECKED	
		APPROVED	DATE 23 09 1996

VARIATION	ISS.	SIGN.	DATE	MODIFICATION
	C			
	B			
	A			

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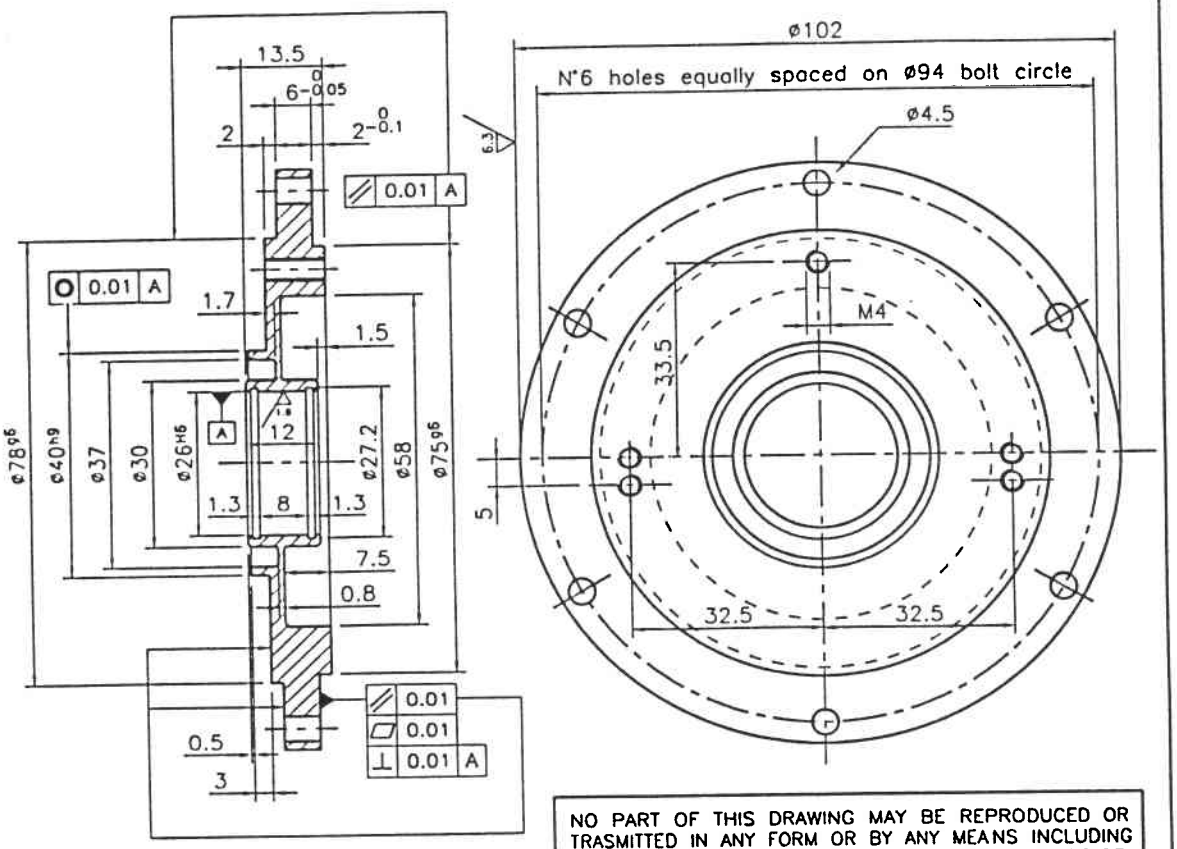
MMT HEXAPOD ENCODER HOUSING POS. 02	SOST.IL	OBTAINED
	SOST.DA	CO.
		400690 B



AS-BUILT

General tolerance ±0.1

3.2 (1.6 6.3)

POS.	Q.TY	DENOMINATION	MATERIAL	UNI	Weight Kg	LIST
03	07	Encoder – bearing –support	AISI 303		0.36	

PROJECT: 6,5 MMT CONVERSION
Hexapod Five Axis Secondary Positioner

DRAWN: ADS–C.Pesca
CHECKED:
APPROVED:
SCALE: 1:1
DATE: 23 09 1998

VARIATION	ISS.	SIGN.	DATE	MODIFICATION
	C			
	B			
	A			

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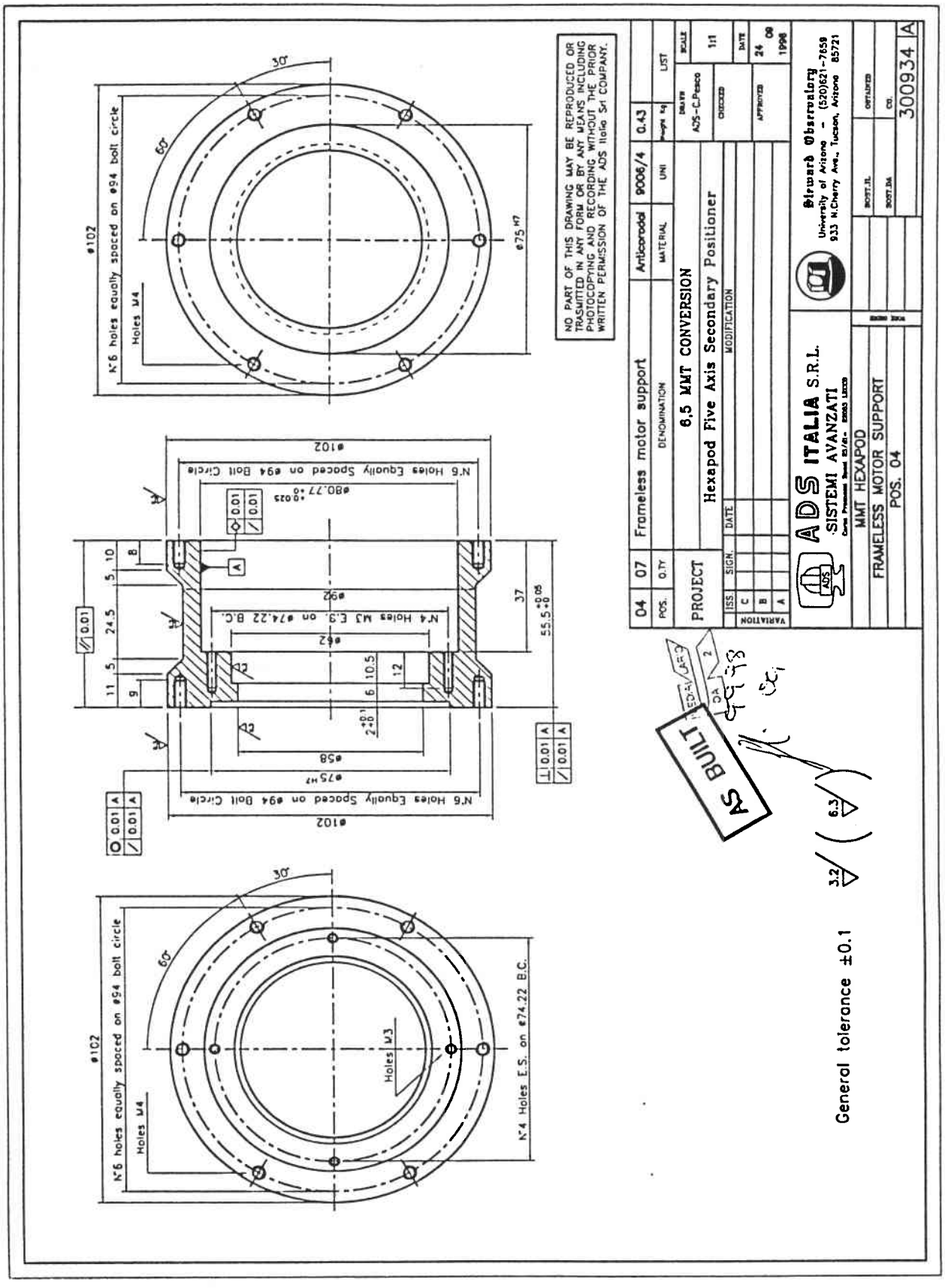
MMT HEXAPOD
ENCODER–BEARING– SUPPORT
POS. 03

WORK ORDER

SOST.IL | OBTAINED
SOST.DA | CO.
400691 B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Frameless motor support
Anticorodal
9006/4
0.43
6,5 MMT CONVERSION
Hexapod Five Axis Secondary Positioner
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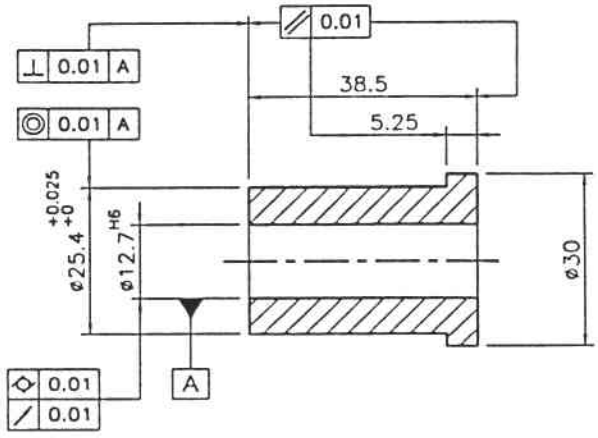
933 N.Cherry Ave. Tucson, Arizona 85721
MMT HEXAPOD
FRAMELESS MOTOR SUPPORT
POS. 04
300934 A
AS BUILT
General tolerance ±0.1



General tolerance ±0.1

3.2

AS BUILT

POS.	Q.TY	DENOMINATION	MATERIAL	UNI	Weight Kg	LIST
05	07	Bushing	AISI 303		0.12	

PROJECT: 6,5 MMT CONVERSION
Hexapod Five Axis Secondary Positioner

DRAWN: ADS-C.Pesco
CHECKED:
APPROVED:
SCALE: 1:1
DATE: 23 09 1998

VARIATION	ISS.	SIGN.	DATE	MODIFICATION
	C			
	B			
	A			

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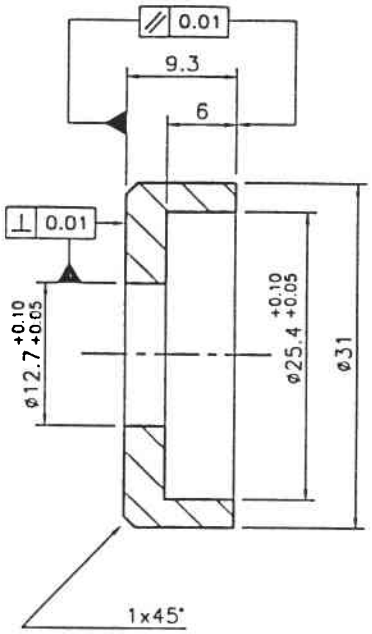
MMT HEXAPOD
BUSHING
POS. 05

SOST.IL | OBTAINED
SOST.DA | CO.
400692 A



General tolerance ±0.1

3.2

AS BUILT 49.98

POS.	Q.TY	DENOMINATION	MATERIAL	UNI	Weight Kg	LIST
06	07	Distance ring	AISI 303		0.025	

PROJECT: 6,5 MMT CONVERSION — Hexapod Five Axis Secondary Positioner

DRAWN: ADS–C.Pesco | SCALE: 2:1 | CHECKED | DATE | APPROVED: 24 09 1998

VARIATION	ISS.	SIGN.	DATE	MODIFICATION
	C			
	B	CP	18/07/97	Modifica tolleranza ø25.4
	A			

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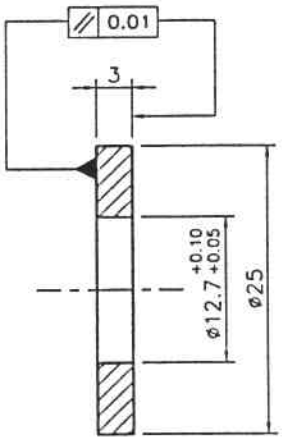
MMT HEXAPOD
DISTANCE RING
POS. 06

WORK ORDER

SOST.IL | OBTAINED
SOST.DA | CO.

400693 B



General tolerance ±0.1

3.2

AS BUILT

07	07	Distance ring	AISI 303		0.008	
POS.	Q.TY	DENOMINATION	MATERIAL	UNI	Weight Kg	LIST

PROJECT	6,5 MMT CONVERSION	DRAWN ADS-C.Pesco	SCALE 2:1
	Hexapod Five Axis Secondary Positioner	CHECKED	DATE
		APPROVED	24 09 1996

VARIATION	ISS.	SIGN.	DATE	MODIFICATION
	C			
	B			
	A			

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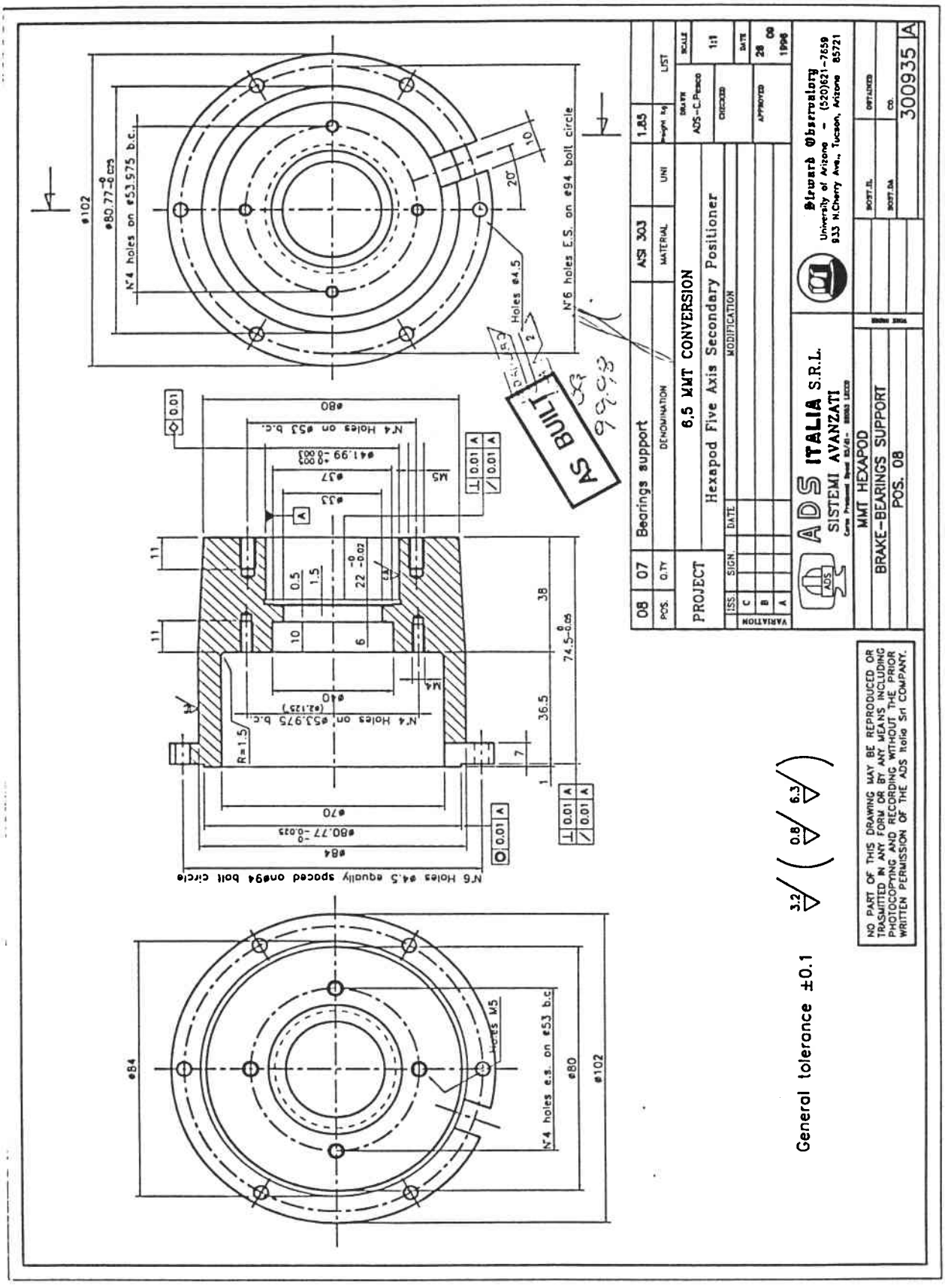
MMT HEXAPOD	WORK ORDER		SOST.IL	OBTAINED
DISTANCE RING			SOST.DA	CO.
POS. 07				400694 A


AS BUILT
08 07 Bearings support ASI 303 1.85 LIST
POS. Q.TY DENOMINATION MATERIAL UNI Weight Kg
PROJECT 6,5 MMT CONVERSION
Hexapod Five Axis Secondary Positioner
ISS SIGN DATE MODIFICATION
ADS ITALIA S.R.L.
SISTEMI AVANZATI
MMT HEXAPOD
BRAKE-BEARINGS SUPPORT
POS. 08
300935 A
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General tolerance ±0.1
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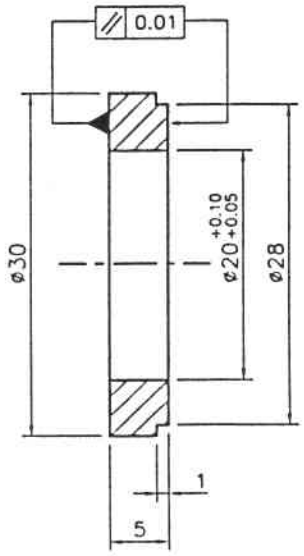

General tolerance ±0.1

3.2

9998

AS BUILT

POS.	Q.TY	DENOMINATION	MATERIAL	UNI	Weight Kg	LIST
09	07	Distance ring	AISI 303		0.015	

PROJECT: 6,5 MMT CONVERSION
Hexapod Five Axis Secondary Positioner

DRAWN: ADS–C.Pesca
CHECKED:
APPROVED:
SCALE: 2:1
DATE: 25 09 1998

VARIATION	ISS.	SIGN.	DATE	MODIFICATION
	C			
	B			
	A			

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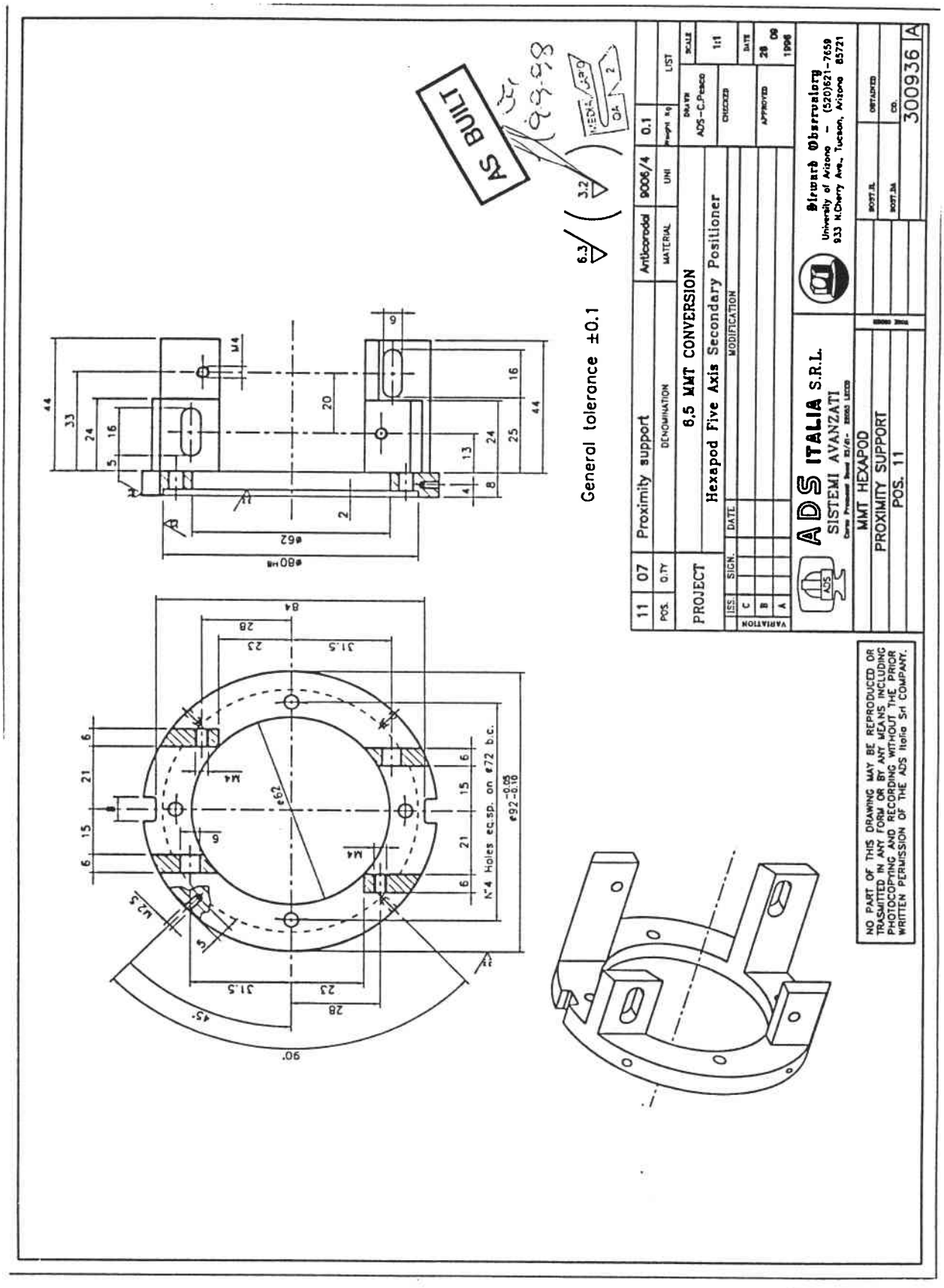
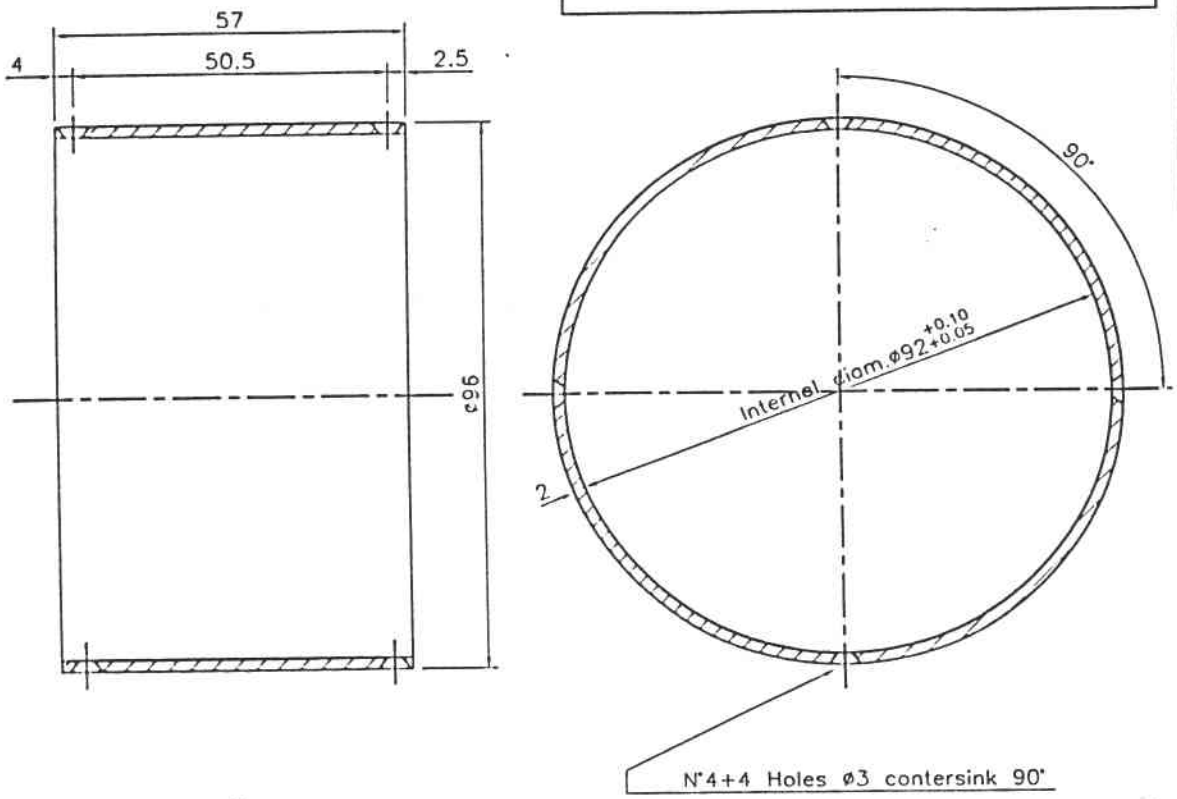
MMT HEXAPOD
DISTANCE RING
POS. 09

SOST.IL | OBTAINED
SOST.DA | CO.

400695 A


AS BUILT
General tolerance ±0.1
6.5 MMT CONVERSION
Hexapod Five Axis Secondary Positioner
PROJECT
Proximity support
DENOMINATION
Anticorodal
MATERIAL
9006/4
UNI
0.1
LIST
1:1
SCALE
ADS-C.Pesce
DRAWN
CHECKED
APPROVED
28 09 1998
DATE
11
07
POS.
0.1Y
ISS.
SIGN.
DATE
VARIATION
MODIFICATION
ADS ITALIA S.R.L.
SISTEMI AVANZATI
Corso Promessi Sposi 23/d - 23900 LECCO
Steward Observatory
University of Arizona - (520)621-7659
933 N.Cherry Ave., Tucson, Arizona 85721
MMT HEXAPOD
PROXIMITY SUPPORT
POS. 11
DEPARTED
CO.
300936 A
N°4 Holes eq.sp. on ø72 b.c.
NO PART OF THIS DRAWING MAY BE REPRODUCED OR TRASMITTED IN ANY FORM OR BY ANY MEANS INCLUDING PHOTOCOPYING AND RECORDING WITHOUT THE PRIOR WRITTEN PERMISSION OF THE ADS Italia Srl COMPANY.



AS BUILT

General tolerance ±0.1

6.3

POS.	Q.TY	DENOMINATION	MATERIAL	UNI	Weight Kg	LIST
12	07	Protection	Anticorodal	9006/4	0.045	

PROJECT: 6,5 MMT CONVERSION — Hexapod Five Axis Secondary Positioner

DRAWN: ADS–C.Pesca | SCALE: 1:1 | CHECKED | DATE | APPROVED: 26 09 1998

VARIATION	ISS.	SIGN.	DATE	MODIFICATION
	C			
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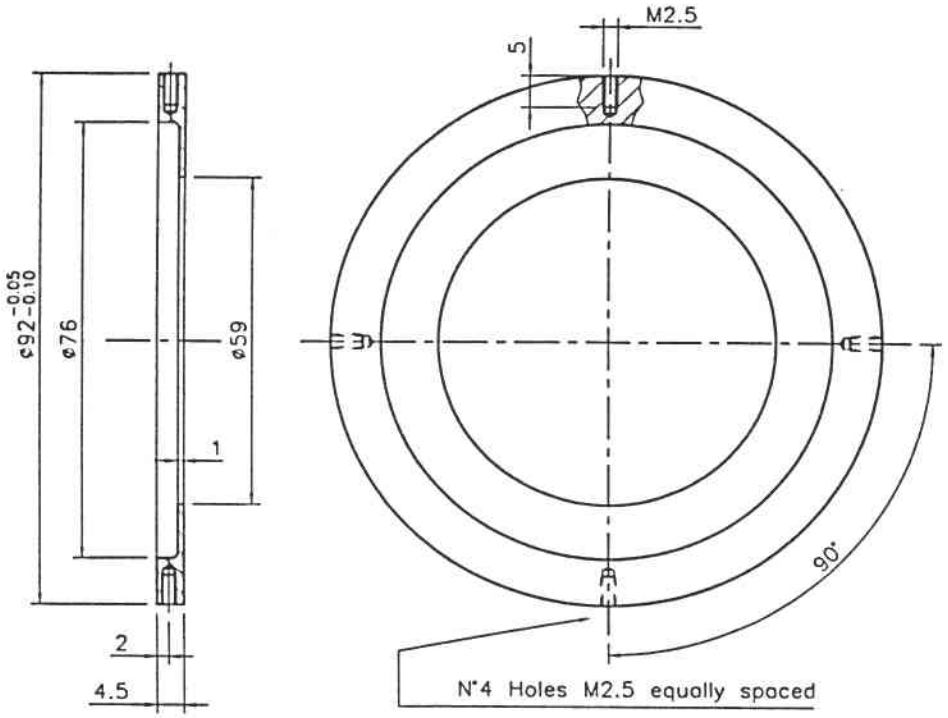
MMT HEXAPOD
PROTECTION
POS. 12

SOST.IL | OBTAINED
SOST.DA | CO.
400698 B



AS BUILT

General tolerance ±0.1

3.2

13	07	Protection ring	Anticorodal	9006/4	0.035	
POS.	Q.TY	DENOMINATION	MATERIAL	UNI	Weight Kg	LIST

PROJECT	6,5 MMT CONVERSION Hexapod Five Axis Secondary Positioner	DRAWN ADS-C.Pesco	SCALE 1:1
		CHECKED	
		APPROVED	DATE 27 09 1998

VARIATION	ISS.	SIGN.	DATE	MODIFICATION
	C			
	B			
	A			

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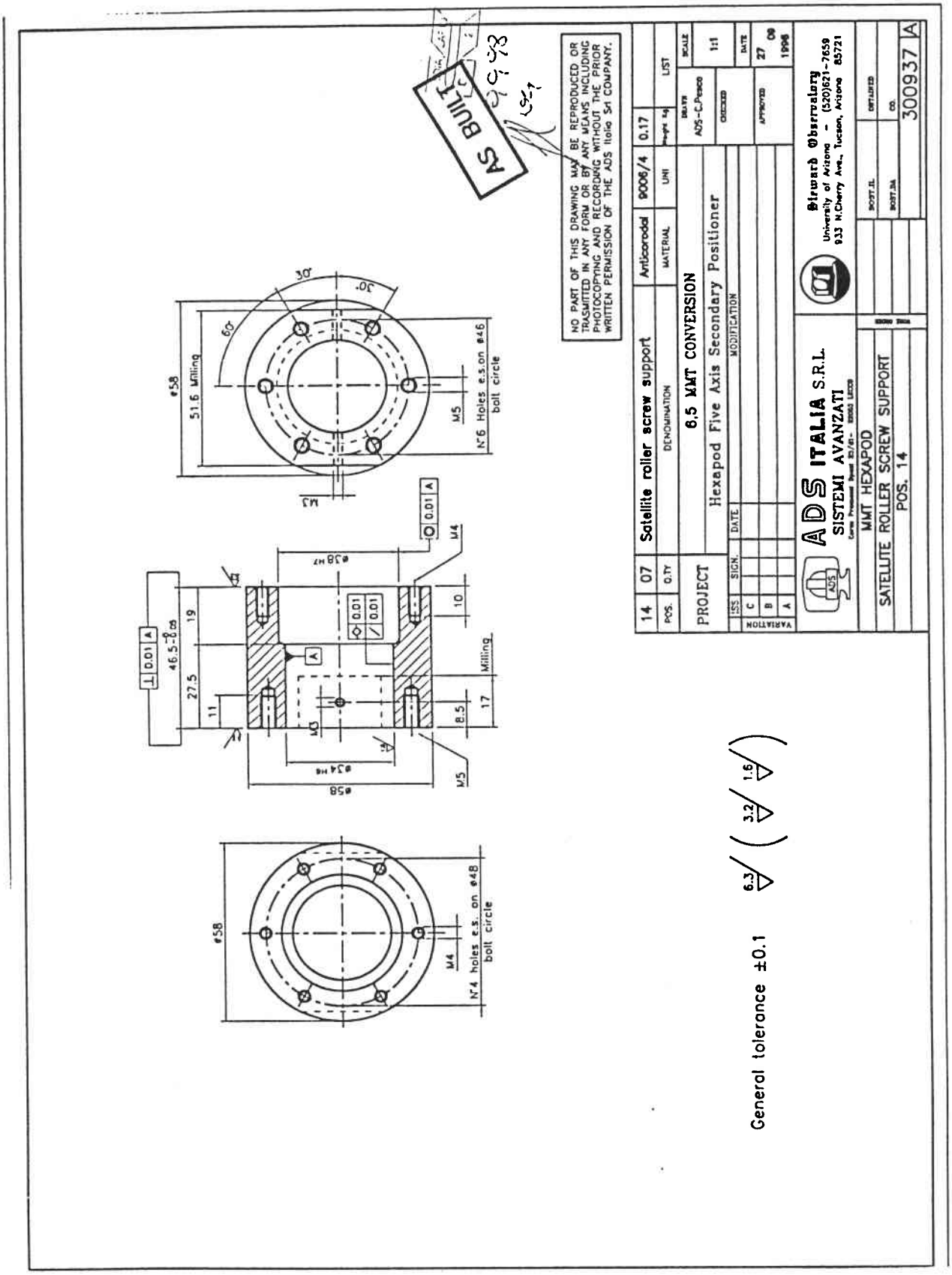
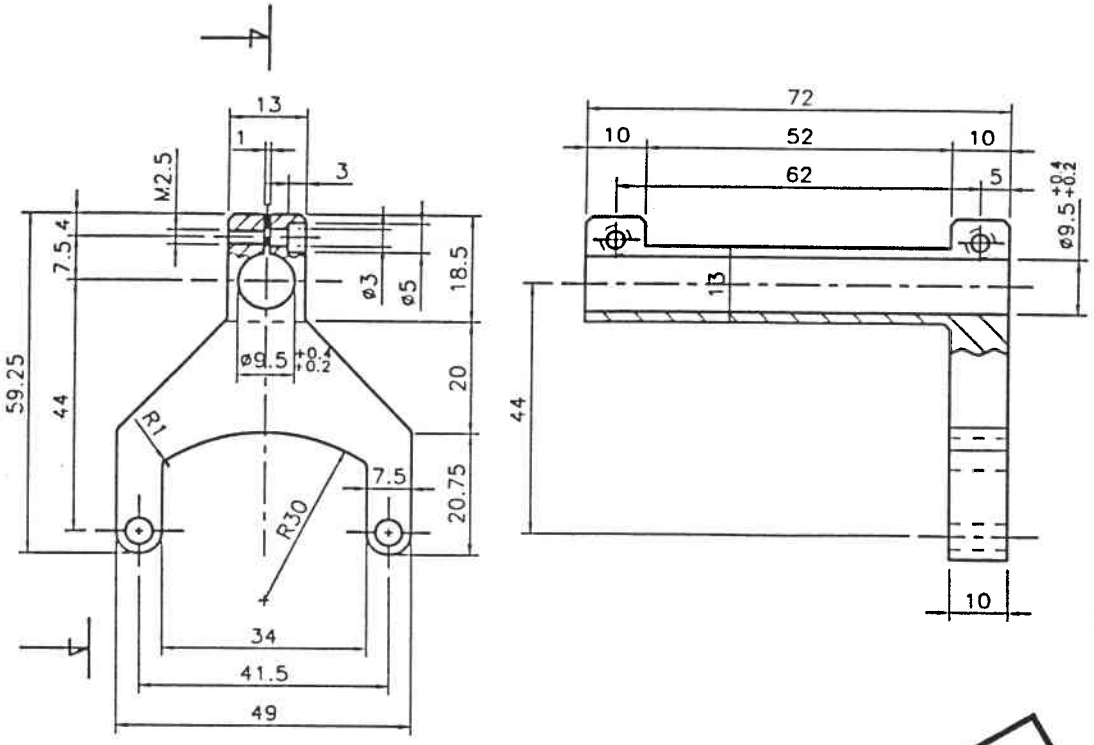
MMT HEXAPOD PROTECTION RING POS. 13	WORK ORDER	SOST.IL	OBTAINED
		SOST.DA	CO.
		400699	A


AS BUILT
NO PART OF THIS DRAWING MAY BE REPRODUCED OR TRASMITTED IN ANY FORM OR BY ANY MEANS INCLUDING PHOTOCOPYING AND RECORDING WITHOUT THE PRIOR WRITTEN PERMISSION OF THE ADS Italia Srl COMPANY.
14 07 Satellite roller screw support Anticorodal 9006/4 0.17
POS. Q.TY DENOMINATION MATERIAL UNI Weight kg LIST
PROJECT 6.5 MMT CONVERSION Hexapod Five Axis Secondary Positioner
DRAWN ADS-C.Pesce SCALE 1:1
CHECKED DATE
APPROVED 27 08 1998
ISS SIGN. DATE MODIFICATION
VARIATION C B A
ADS ITALIA S.R.L.
SISTEMI AVANZATI
Corso Promessi Sposi 23/d - 23900 LECCO
Steward Observatory
University of Arizona - (520)621-7659
933 N.Cherry Ave., Tucson, Arizona 85721
MMT HEXAPOD
SATELLITE ROLLER SCREW SUPPORT
POS. 14
SCOTT JIL
SCOTT JBA
CO.
300937 A
30°
60°
ø58
51.6 Milling
M5
N°6 Holes e.s.on ø46 bolt circle
M3
0.01 A
ø38H7
M4
10
0.01
0.01
46.5-0.05
19
27.5
11
Milling
17
8.5
ø34H8
ø58
M5
N°4 holes e.s. on ø48 bolt circle
General tolerance ±0.1
6.3
3.2
1.6



General tolerance ±0.1

6.3

AS BUILT 29.9.98

17	7	LVDT Support	AISI 303		0.15	
POS.	Q.TY	DENOMINATION	MATERIAL	UNI	Weight Kg	LIST

PROJECT	6,5 MMT CONVERSION Hexapod Five Axis Secondary Positioner	DRAWN ADS-C.Pesca	SCALE 1:1
		CHECKED	DATE
		APPROVED	30 09 1996

VARIATION	ISS.	SIGN.	DATE	MODIFICATION
	C			
	B			
	A			

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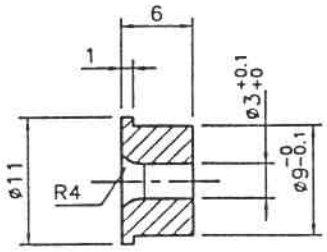
MMT HEXAPOD LVDT SUPPORT POS. 17	WORK ORDER		.SOST.IL	OBTAINED
			SOST.DA	CO.
				400701 A



AS BUILT

General tolerance ±0.1

3.2

POS.	Q.TY	DENOMINATION	MATERIAL	UNI	Weight Kg	LIST
18	7	Bushing	B14		0.01	

PROJECT	6,5 MMT CONVERSION Hexapod Five Axis Secondary Positioner				DRAWN ADS–C.Pesca	SCALE 2:1
					CHECKED	DATE
					APPROVED	30 09 1996

VARIATION	ISS.	SIGN.	DATE	MODIFICATION
	C			
	B			
	A			

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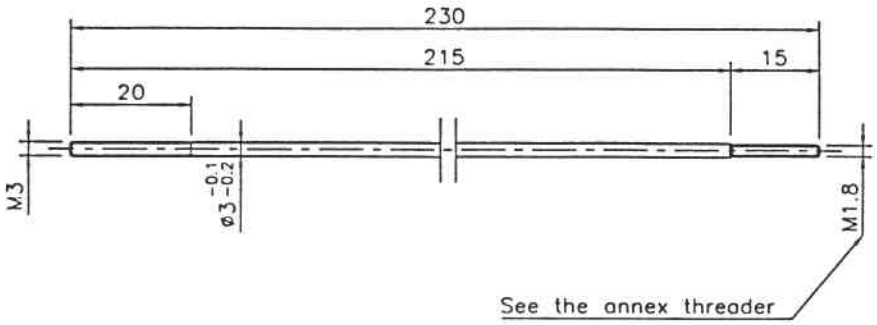
MMT HEXAPOD BUSHING POS. 18		SOST.IL	OBTAINED
		SOST.DA	CO.
			400702 A



AS BUILT 9.9.98

General tolerance ±0.1

3.2

19	6+1	Stem	INVAR		0,015	
POS.	Q.TY	DENOMINATION	MATERIAL	UNI	Weight Kg	LIST

PROJECT	6,5 MMT CONVERSION	DRAWN ADS–C.Pesco	SCALE
	Hexapod Five Axis Secondary Positioner	CHECKED	1:1

VARIATION	ISS.	SIGN.	DATE	MODIFICATION	APPROVED	DATE
	C					30 09 1998
	B					
	A					

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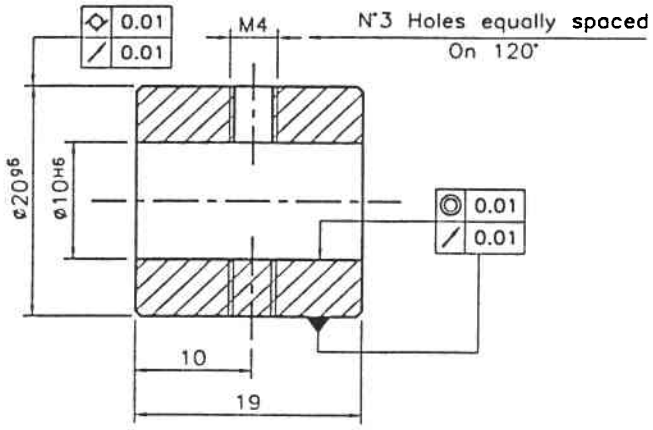
MMT HEXAPOD	WORK ORDER	SOST.IL	OBTAINED
STEM		SOST.DA	CO.
POS. 19			400703 A



AS BUILT

General tolerance ±0.1

20	7	Bushing	AISI 303		0.03	
POS.	Q.TY	DENOMINATION	MATERIAL	UNI	Weight Kg	LIST

PROJECT	6,5 MMT CONVERSION	DRAWN ADS–C.Pesca	SCALE
	Hexapod Five Axis Secondary Positioner	CHECKED	2:1
		APPROVED	DATE 30 09 1996

VARIATION	ISS.	SIGN.	DATE	MODIFICATION
	C			
	B			
	A			

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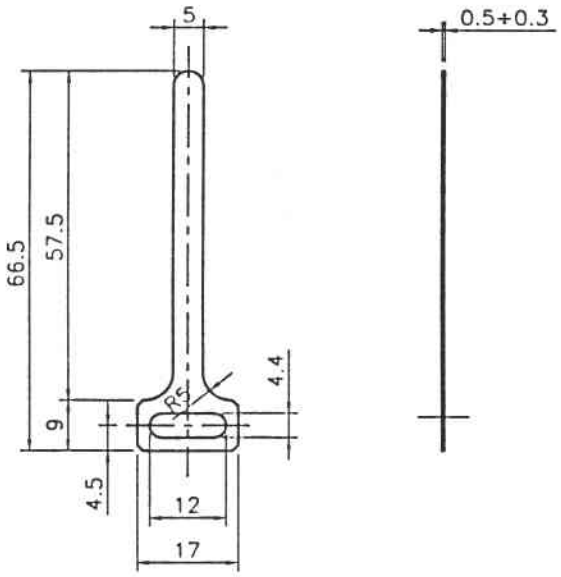
MMT HEXAPOD		SOST.IL	OBTAINED
BUSHING		SOST.DA	CO.
POS. 20			400705 A



6.3

General tolerance ±0.1

AS BUILT 4.9.98

POS.	PEZZI	DENOMINAZIONE	MATERIALE	UNI	Kg.	NOTE
21	14	Flexure foil	50 Cr V 4		0.003	

PROJECT: 6,5 MMT CONVERSION — Hexapod Five Axis Secondary Positioner

DISEGNATO: ADS–C.Pesce | SCALA: 1:1 | CONTROLLATO | DATA | VISTO: 30 09 1996

VARIAZIONI	IND	SIGLE	DATA	MODIFICHE
	C			
	B			
	A			

ADS ITALIA S.R.L.
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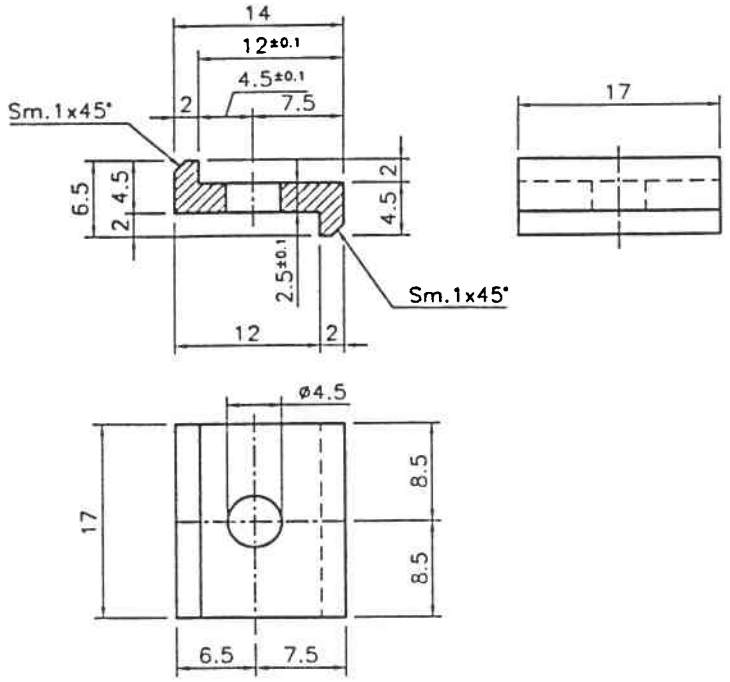
MMT HEXAPOD
FLEXURE FOIL
POS.21

CONTROLLO

SOST.IL | RICAV.DA
SOST.DA | CO.

400704 A



AS BUILT

General tolerance ±0.1

Item	Q.TY	DENOMINATION	MATERIAL	UNI	Weight Kg	LIST
28	14	Distance plate	AISI 304		0.08	

PROJECT	6,5 MMT CONVERSION Hexapod Five Axis Secondary Positioner			DRAWN Anoclerio	SCALE 2:1
				CHECKED	DATE
				APPROVED	09 09 1998

VARIATION	ISS.	SIGN.	DATE	MODIFICATION
	C			
	B			
	A			

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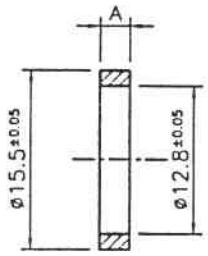
MMT HEXAPOD
Distance plate
Item 28

WORK ORDER

SOST.IL	OBTAINED
SOST.DA	CO.
	400748



	A	Tollerance
1	2.64	± 0.02
2	2.67	± 0.02
3	2.73	± 0.02
4	2.46	± 0.02
5	2.63	± 0.02
6	2.60	± 0.02
7	2.70	± 0.02

General tolerance ±0.1

3.2 MEDIA QA

AS BUILT 9.9.98

Item	Q.TY	DENOMINATION	MATERIAL	UNI	Weight Kg	LIST
29	7	Bushing	AISI 304		0.02	

PROJECT: 6,5 MMT CONVERSION
Hexapod Five Axis Secondary Positioner

DRAWN: Anaclerio | SCALE: 2:1 | CHECKED | DATE | APPROVED: 09 09 1998

VARIATION	ISS.	SIGN.	DATE	MODIFICATION
	C			
	B			
	A			

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SISTEMI AVANZATI
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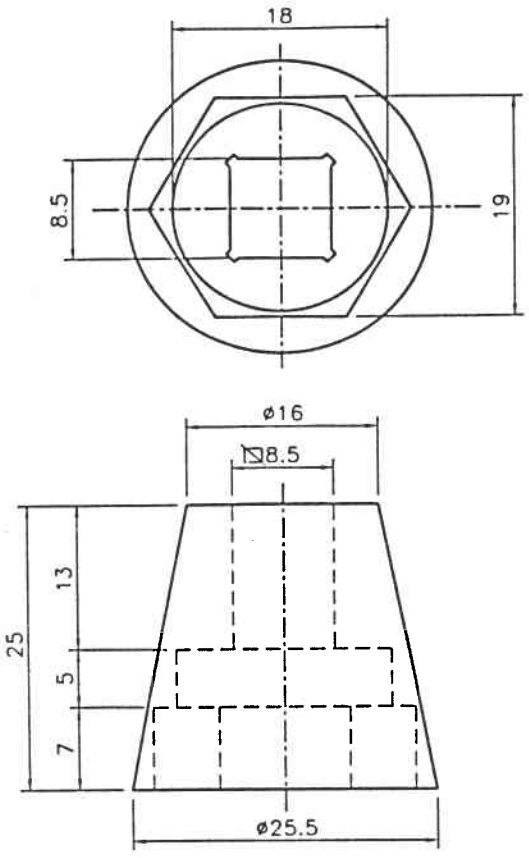
933 N.Cherry Ave., Tucson, Arizona 85721

MMT HEXAPOD
Bushing
Item 29

WORK ORDER | SOST.IL | OBTAINED | SOST.DA | CO. | 400749



General tolerance ±0.1

AS BUILT 9.98

	1	Key	AISI 304			
Item	Q.TY	DENOMINATION	MATERIAL	UNI	Weight Kg	LIST

PROJECT	6,5 MMT CONVERSION Hexapod Five Axis Secondary Positioner				DRAWN Anaclerio	SCALE 2:1
					CHECKED	DATE
					APPROVED	09 09 1998

VARIATION	ISS.	SIGN.	DATE	MODIFICATION
	C			
	B			
	A			

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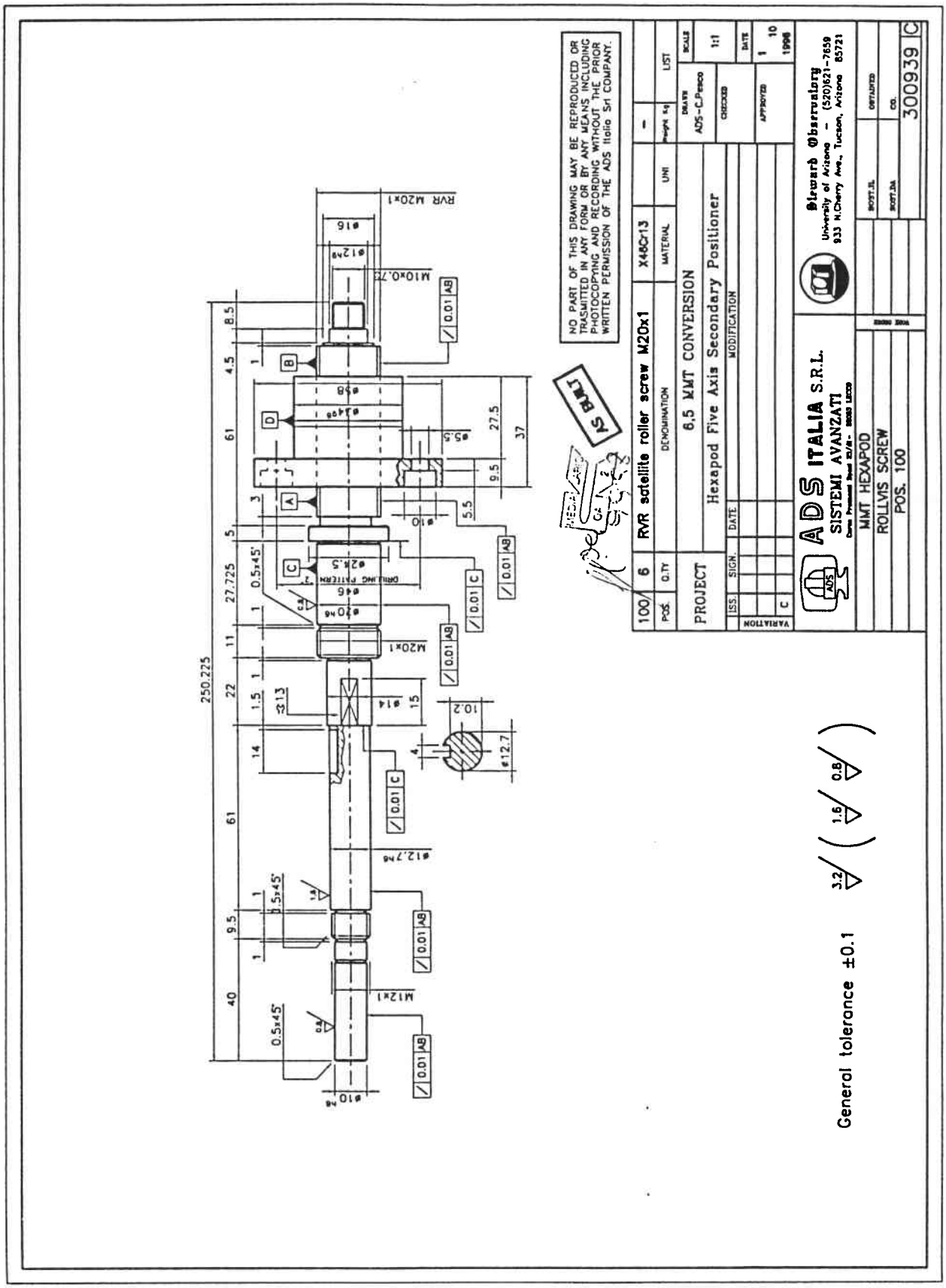
MMT HEXAPOD
Key for mounting Hexapod screw (item 135)

SOST.IL	OBTAINED
SOST.DA	CO.
	400751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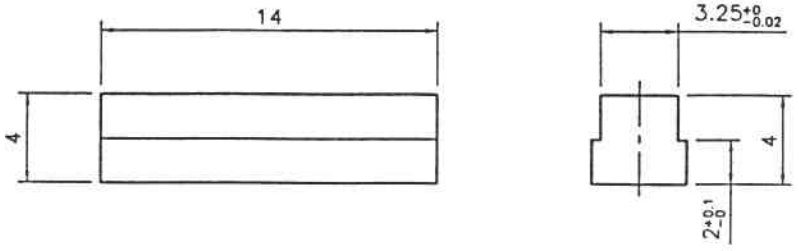
100 6 RVR satellite roller screw M20x1 X46Cr13
POS. Q.TY DENOMINATION MATERIAL UNI
PROJECT
6.5 MMT CONVERSION
Hexapod Five Axis Secondary Positioner
ISS. SIGN. DATE MODIFICATION
VARIATION
ADS ITALIA S.R.L.
SISTEMI AVANZATI
MMT HEXAPOD
ROLLVIS SCREW
POS. 100
Steward Observatory
University of Arizona - (520)621-7659
933 N.Cherry Ave., Tucson, Arizona 85721
300939 C
General tolerance ±0.1
3.2 1.6 0.8
RVR M20x1
M10x0.75
M20x1
M12x1
250.225



General tolerance ±0.1

3.2

AS BUILT 4.9.98

MEDIA OA 2

Item	Q.TY	DENOMINATION	MATERIAL	UNI	Weight Kg	LIST
110	7	Key 4x4x14 UNI 6604–A	Steel R590 N/mm			

PROJECT	6,5 MMT CONVERSION Hexapod Five Axis Secondary Positioner			DRAWN Anaclerio	SCALE 2:1
				CHECKED	DATE
				APPROVED	09 09 1998

VARIATION	ISS.	SIGN.	DATE	MODIFICATION
	C			
	B			
	A			

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SISTEMI AVANZATI
Corso Promessi Sposi 23/d1- 22053 LECCO

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University of Arizona – (520)621–7659
933 N.Cherry Ave., Tucson, Arizona 85721

MMT HEXAPOD Bush Item 110	BOX ORDER	SOST.IL	OBTAINED
		SOST.DA	CO.
			400750

5. HEXAPOD PLATFORMS

5.1. Parts and material list

ADS Srl - Corso Promessi Sposi, 23/d - 23900 Lecco - ITALY
Steward Observatory - University of Arizona - 933 N.Cherry Ave., Tucson Arizona 85721 - USA

ADS ITALIA S.R.L.
SISTEMI AVANZATI

MMT HEXAPOD M2-F15
LINEAR ACTUATOR
WORKSHOP LIST

Parts list

Quantity 1	Quantity 2	DESIGNATION	Format A	Item	MATERIAL	Piece weight (kg)	REMARKS	Mod.
3	3	LOWER SUPPORT	3	22	AISI 304	1.36	Dwg. n° 300942	A
3	3	UPPER SUPPORT	3	23	AISI 304	1.32	Dwg. n° 300943	A
6	6	PLATE	4	24	AISI 303	0.03	Dwg. n° 400708	A
6	6	PLATE	4	25	AISI 303	0.04	Dwg. n° 400709	A
1	1	LOWER PLATE	2	26	Anticorodal UNI 9006/4	3.88	Dwg. n° 200508	B
1	1	UPPER PLATE	2	27	Anticorodal UNI 9006/4	3.62	Dwg. n° 200512	A
1	6+1	LINEAR ACTUATOR	2			7.6	Dwg. n° 200505	C

Index				Number of assemblies : 1
Date				Weight for 1 ass. : 61.5 Kg.
Name				Weight for all ass. : 45.6+15.96= 61.9 Kg.

HEXAPOD ASSEMBLY DWG N°200513 M2-F15

99.98

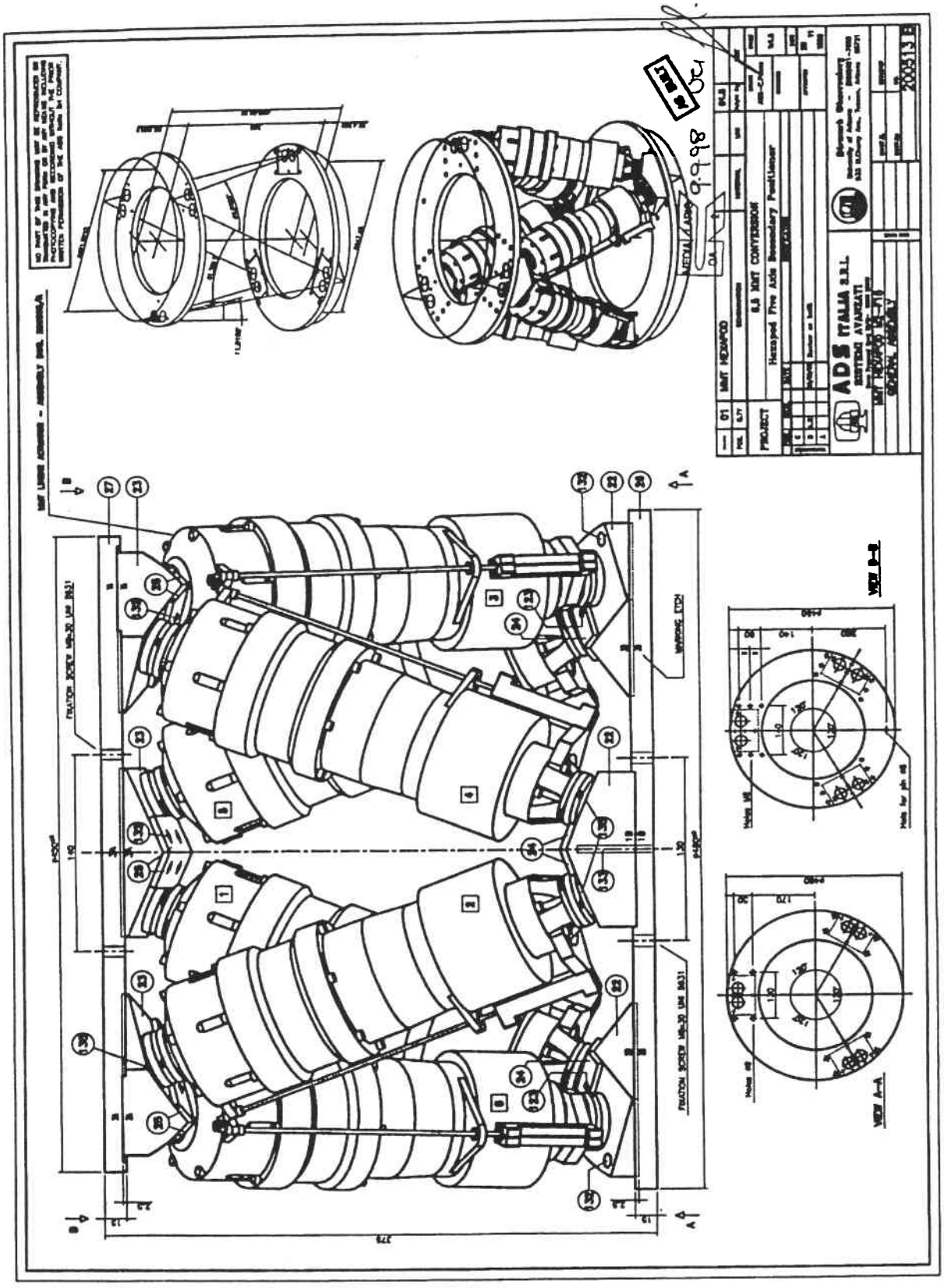
sheet 01 of 01
FILE 400707/C

1) Quantity for 1 assembly 2) Quantity for execution

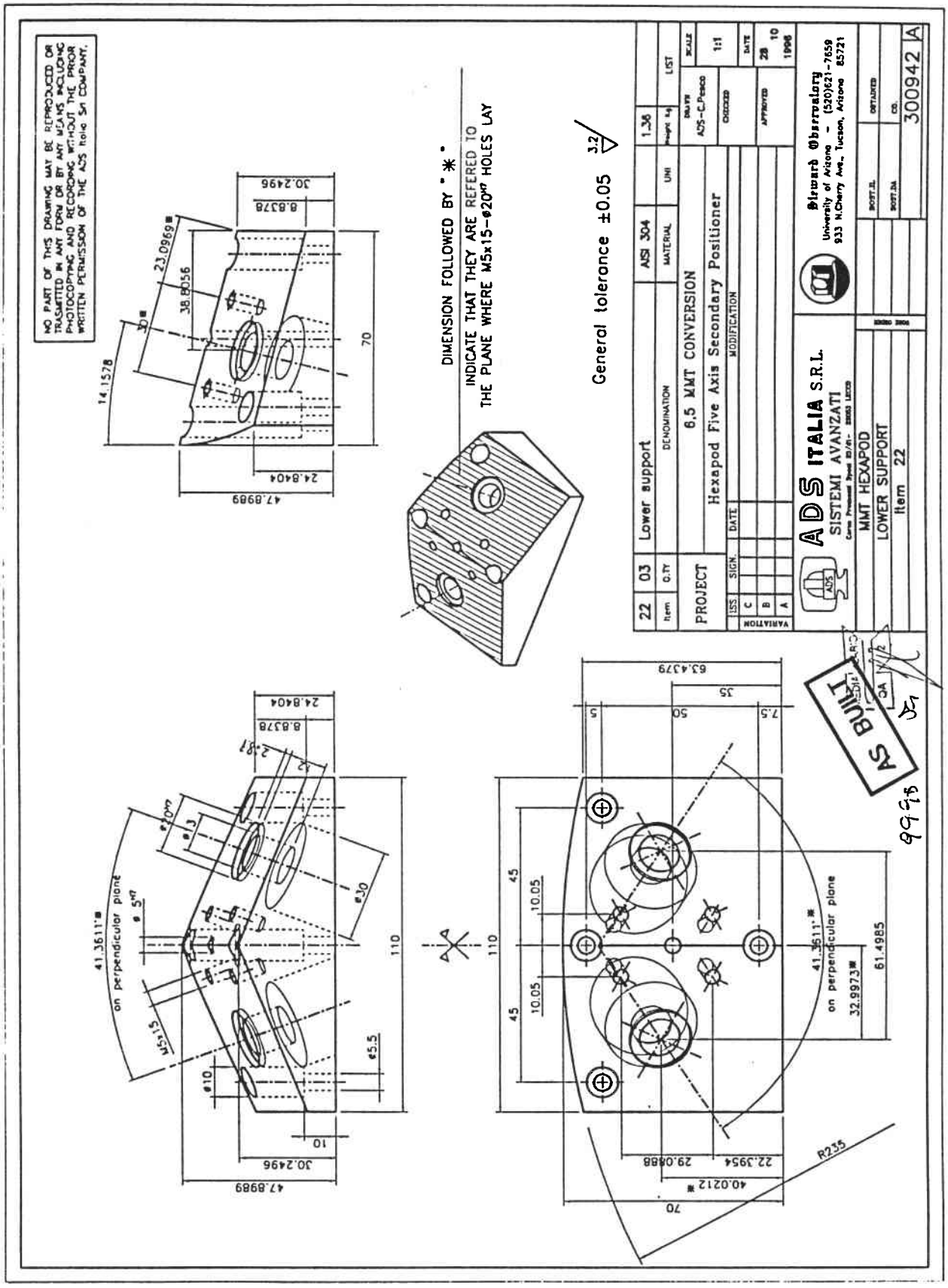
5.2.

Assembly and Workshop Drawings

ADS Srl - Corso Promessi Sposi, 23/d - 23900 Lecco - ITALY
Steward Observatory - University of Arizona - 933 N.Cherry Ave., Tucson Arizona 85721 - USA



ADS Srl - Corso Promessi Sposi, 23/d - 23900 Lecco - ITALY
Steward Observatory - University of Arizona - 933 N.Cherry Ave., Tucson Arizona 85721 - USA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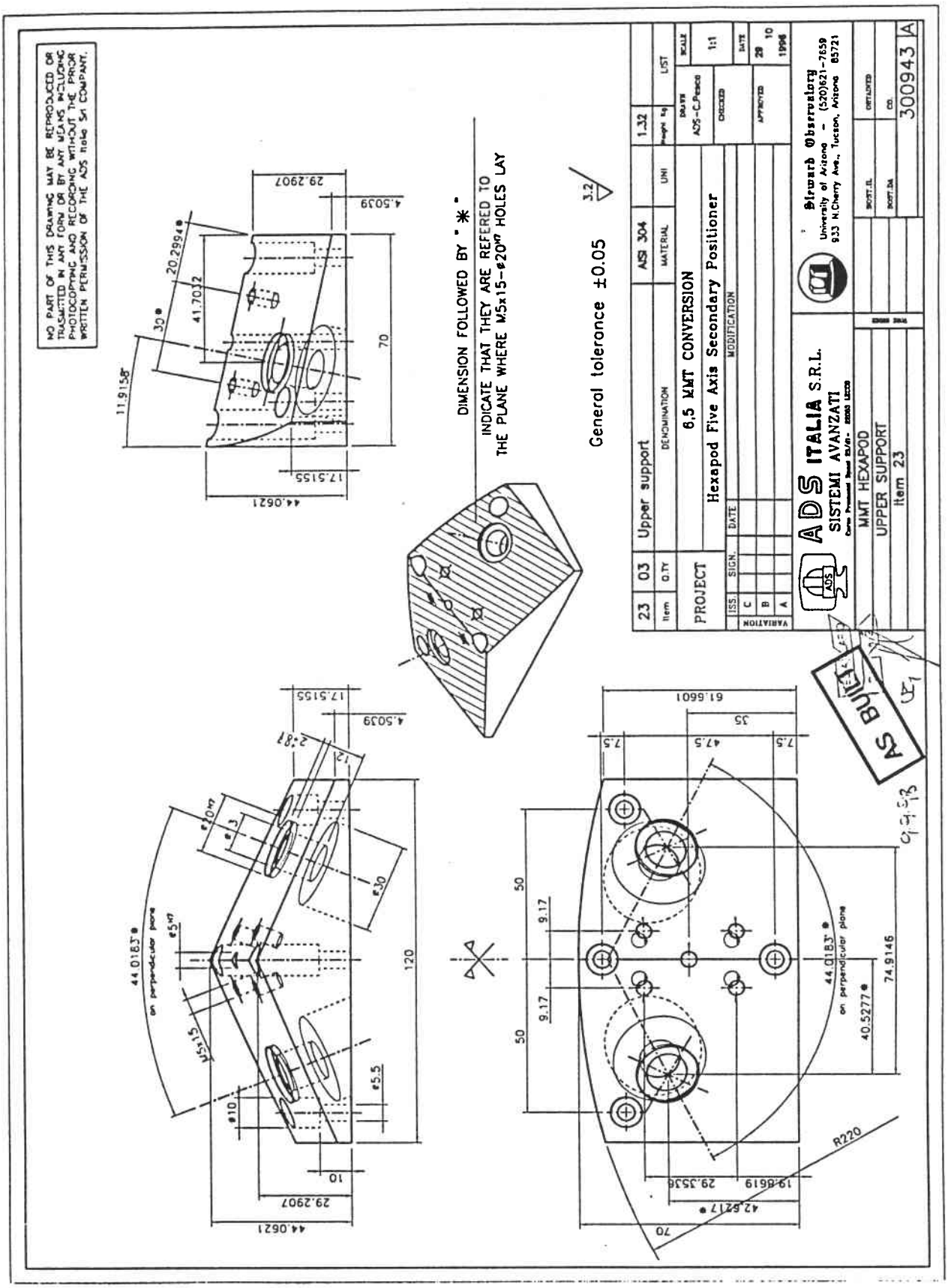
DIMENSION FOLLOWED BY "*"
INDICATE THAT THEY ARE REFERED TO
THE PLANE WHERE M5x15-Ø20H7 HOLES LAY
General tolerance ±0.05
3.2
22 | 03 | Lower support | AISI 304 | 1.36 | LST
Item | O.TY | DENOMINATION | MATERIAL | UNI | Weight Kg
PROJECT
6.5 MMT CONVERSION
Hexapod Five Axis Secondary Positioner
VARIATION | ISS | SIGN. | DATE | MODIFICATION
A | B | C
DRAWN ADS-C.Pesco
CHECKED
APPROVED
SCALE 1:1
DATE 28 10 1998
ADS ITALIA S.R.L.
SISTEMI AVANZATI
Steward Observatory
University of Arizona - (520)621-7659
933 N.Cherry Ave., Tucson, Arizona 85721
MMT HEXAPOD
LOWER SUPPORT
Item 22
DRAWING NO. 300942 A
AS BUILT
14.1578
23.0969
38.9056
30
70
30.2496
8.8378
24.8404
47.8989
M5x15
on perpendicular plane
41.3611
Ø20H7
Ø30
Ø5.5
Ø10
110
10
2.81
63.4379
35
50
7.5
5
45
10.05
32.9973
61.4985
40.0212
29.0688
22.3954
R235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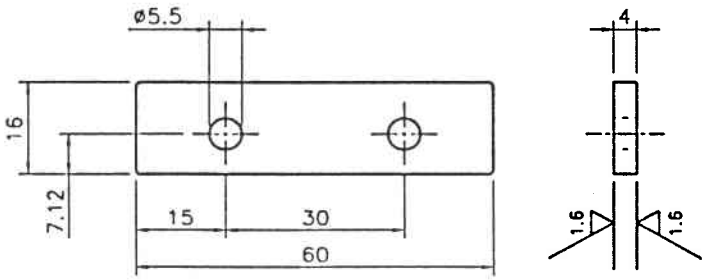
DIMENSION FOLLOWED BY " * "
INDICATE THAT THEY ARE REFERED TO THE PLANE WHERE M5x15-@20H7 HOLES LAY
General tolerance ±0.05
3.2
23 Item
03 Q.TY
Upper support DENOMINATION
AISI 304 MATERIAL
1.32
UNI
LIST
1:1 SCALE
29 10 1998 DATE
PROJECT
6,5 MMT CONVERSION
Hexapod Five Axis Secondary Positioner
MODIFICATION
DATE
SIGN.
ISS.
VARIATION
ADS ITALIA S.R.L.
SISTEMI AVANZATI
MMT HEXAPOD
UPPER SUPPORT
Item 23
Steward Observatory
University of Arizona - (520)621-7659
933 N.Cherry Ave., Tucson, Arizona 85721
CHECKED
APPROVED
300943 A
AS BUILT
29.2907
4.5039
20.2994
41.7012
30°
11.9158
70
17.5155
44.0621
61.6601
55
7.5
47.5
50
9.17
44.0183
on perpendicular plane
40.5277
74.9146
R220
19.8619
29.3536
42.6217
70
2.87
12
Ø10H7
Ø3
Ø30
Ø5H7
M5x15
Ø5.5
Ø10
120
10



General tolerance ±0.1

3.2

AS BUILT

Item	Q.TY	DENOMINATION	MATERIAL	UNI	Weight Kg	LIST
24	06	Plate	AISI 303		0,03	

PROJECT: 6,5 MMT CONVERSION
Hexapod Five Axis Secondary Positioner

DRAWN: ADS-C.Pesco
SCALE: 1:1
CHECKED:
APPROVED:
DATE: 24 09 1996

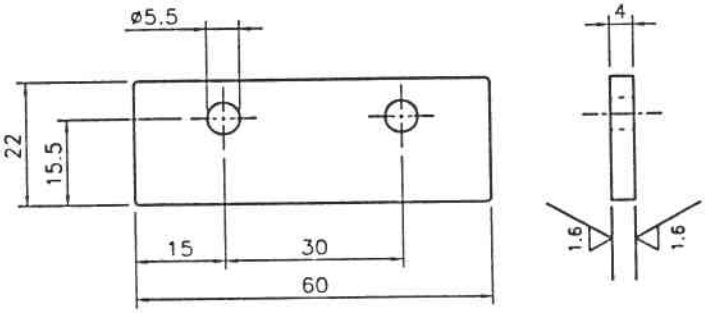
VARIATION	ISS.	SIGN.	DATE	MODIFICATION
	C			
	B			
	A			

ADS ITALIA S.R.L.
SISTEMI AVANZATI
Corso Promessi Sposi 23/d - 22053 LECCO

Steward Observatory
University of Arizona – (520)621-7659
933 N.Cherry Ave., Tucson, Arizona 85721

MMT HEXAPOD
PLATE
Item 24

SOST.IL | OBTAINED
SOST.DA | CO.
400708 A



General tolerance ±0.1

3.2

AS BUILT

Item	Q.TY	DENOMINATION	MATERIAL	UNI	Weight Kg	LIST
25	06	Plate	AISI 303		0,04	

PROJECT: 6,5 MMT CONVERSION — Hexapod Five Axis Secondary Positioner

DRAWN: ADS-C.Pesco | SCALE: 1:1 | CHECKED | DATE | APPROVED: 24 09 1998

VARIATION	ISS.	SIGN.	DATE	MODIFICATION
	C			
	B			
	A			

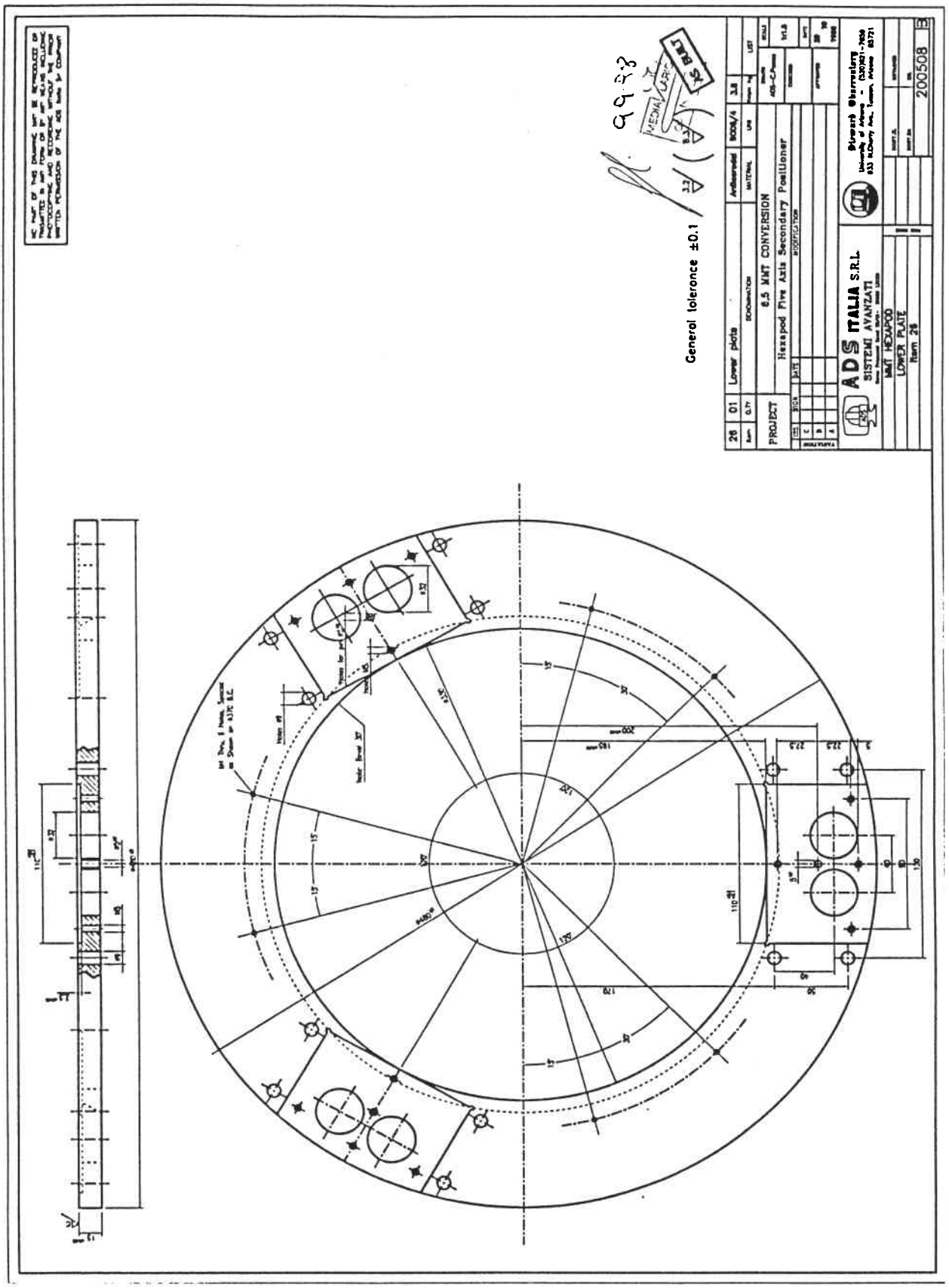
ADS ITALIA S.R.L.
SISTEMI AVANZATI
Corso Promessi Sposi 23/d- 22053 LECCO

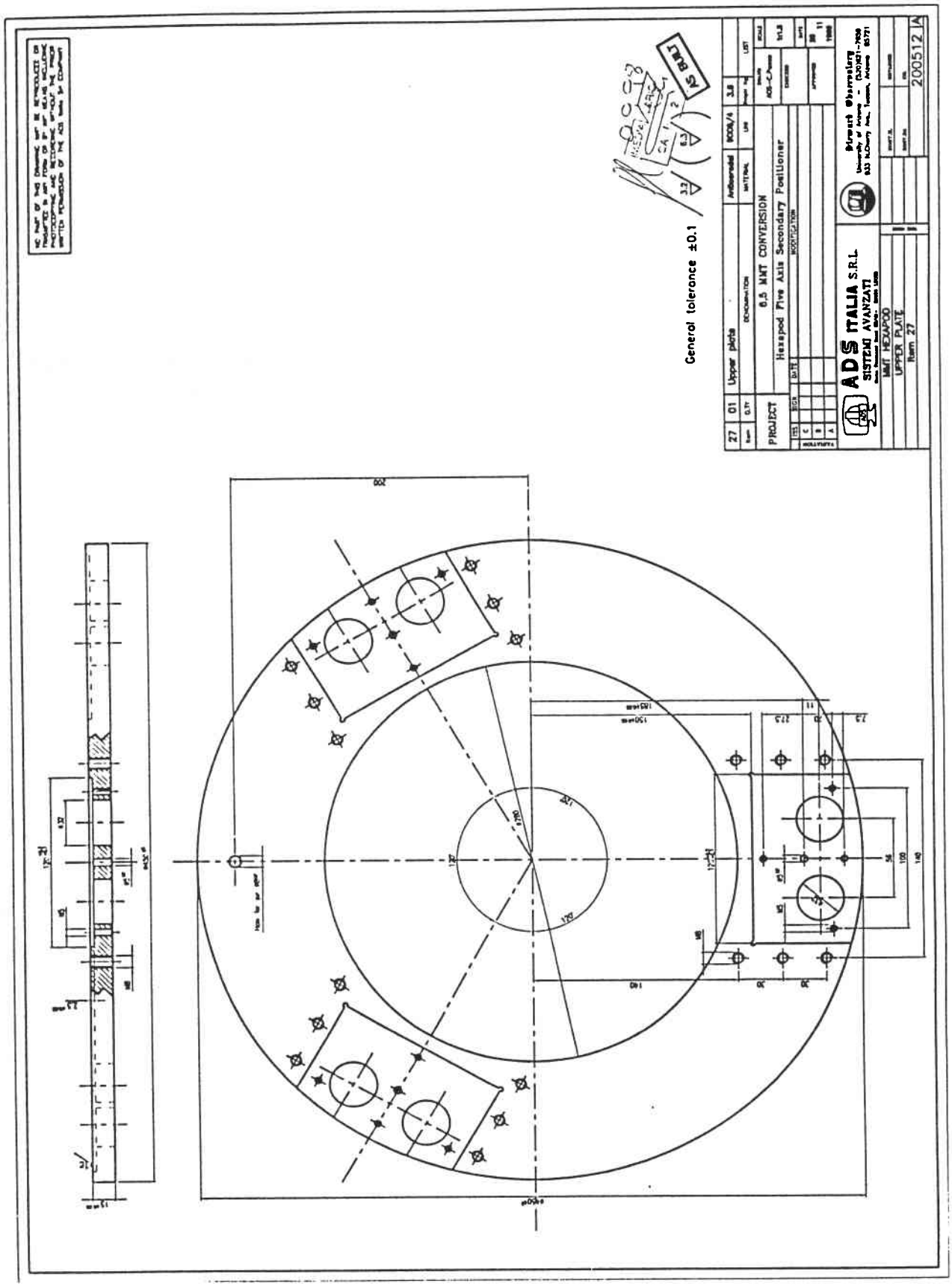
Steward Observatory
University of Arizona – (520)621-7659
933 N.Cherry Ave., Tucson, Arizona 85721

MMT HEXAPOD
PLATE
Item 25

WORK ORDER

SOST.IL | OBTAINED
SOST.DA | CO.
400709 A


General tolerance ±0.1
ADS ITALIA S.R.L.
SISTEMI AVANZATI
6.5 MMT CONVERSION
Hexapod Five Axis Secondary Positioner
PROJECT
MMT HEXAPOD
LOWER PLATE
Item 26
Steward Observatory
University of Arizona - (520)621-7850
933 N.Cherry Ave., Tucson, Arizona 85721
200508


AS BUILT
General tolerance ±0.1
ADS ITALIA S.R.L.
SISTEMI AVANZATI
0.5 MMT CONVERSION
Hexapod Five Axis Secondary Positioner
PROJECT
Upper plate
UPPER PLATE
Item 27
200512/A

6. COMPONENTS SELECTIONS AND MANUFACTURING DATA SHEETS

6.1. Roller screw

Manufacturer	ROLLVIS (Swiss)
Screw Diameter	20 mm
Screw Lead	1 mm
Number of Thread Starts	1
Lead Error	Tolerance class G1 : V_{300p}=6μm, e_p=6μm
Type of screw	Satellite roller screw with recirculating rollers
Nut Type	Split nut preloaded flanged at one end
Nut Preload	450 N
Torque due to Preload	0.061 Nm
Direct Efficiency (lifting)	η_1=0.737
Indirect Efficiency (lowering)	η_2=0.642
Static Load Capacity	13.8 KN
Dynamic Load Capacity	9.1 KN
Nut Axial Stiffness	446 N/μm
Material	Stainless steel X46Cr13
Lubrication	KLUBER ISOFLEX TOPAS NCA 52 (Rollvis roller screw standard grease)

6.2. Ball Bearings

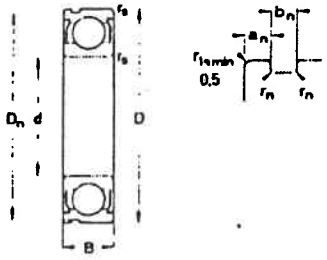
- Screw central support bearings - part number 112 (see actuator assembly drawing):
  - Manufacturer : FAG (Aerospace and Super Precision Bearings Division) - The Barden Corporation.
  - Type : medium preloaded (nominal value 256 N) angular contact ball bearings pair in "O" configuration.
  - Tolerance class : high precision P4S (ABEC 7).
  - Material : carbon chrome steel for rings and balls.
  - Cage : made of bakelized cloth guided along outer ring.
  - Non separable and without shields.

Albero	Dimensioni				Coeff. di carico		Velocità di riferimento[1]		Sigla	Massa ~
	d	D	B	a ~	din. C	stat. C_o	grasso	minimale ad olio	Cuscinetto	
	mm				kN		giri/min		FAG	kg
20	20	37	9	8	8,8	5,1	34000	45000	B71904C.TPA.P4.UL	0,034
	20	37	9	11	8,3	4,9	30000	40000	B71904E.TPA.P4.UL	0,034
	20	42	12	10	10	6	30000	40000	B7004C.TPA.P4	0,069
	20	42	12	10	10	6	30000	40000	B7004C.TPA.P4.UL	0,069
	20	42	12	10	10	6	30000	40000	B7004C.TPA.P4.K5.UL	0,069
	20	42	12	10	10	6	30000	40000	B7004C.TPA.HG.UL	0,069
→	20	42	12	13	9,5	5,7	26000	36000	B7004E.TPA.P4.UL	0,069
	20	47	14	12	12,9	7,5	28000	38000	B7204C.TPA.P4	0,108
	20	47	14	12	12,9	7,5	28000	38000	B7204C.TPA.P4.UL	0,108
	20	47	14	12	12,9	7,5	28000	38000	B7204C.TPA.P4.K5.UL	0,108
	20	47	14	12	12,9	7,5	28000	38000	B7204C.TPA.HG.UL	0,108
	20	47	14	15	12,5	7,2	24000	34000	B7204E.TPA.P4.UL	0,108
25	25	42	9	9	9,15	5,7	28000	38000	B71905C.TPA.P4.UL	0,04
	25	42	9	12	8,65	5,5	24000	34000	B71905E.TPA.P4.UL	0,04
	25	47	12	11	11	7,2	26000	36000	B7005C.TPA.P4	0,084
	25	47	12	11	11	7,2	26000	36000	B7005C.TPA.P4.UL	0,084
	25	47	12	11	11	7,2	26000	36000	B7005C.TPA.P4.K5.UL	0,084
	25	47	12	11	11	7,2	26000	36000	B7005C.TPA.HG.UL	0,084
	25	47	12	14	10,6	6,95	24000	34000	B7005E.TPA.P4.UL	0,084
	25	52	15	13	14,6	9,3	24000	34000	B7205C.TPA.P4	0,133
	25	52	15	13	14,6	9,3	24000	34000	B7205C.TPA.P4.UL	0,133
	25	52	15	13	14,6	9,3	24000	34000	B7205C.TPA.P4.K5.UL	0,133
	25	52	15	13	14,6	9,3	24000	34000	B7205C.TPA.HG.UL	0,133
	25	52	15	13	14,6	9,3	24000	34000	B7205C.TPA.HG.K5.UL	0,133
	25	52	15	17	13,7	8,8	22000	32000	B7205E.TPA.P4.UL	0,133
30	30	47	9	10	10	6,95	24000	34000	B71906C.TPA.P4.UL	0,046
	30	47	9	14	9,5	6,55	22000	32000	B71906E.TPA.P4.UL	0,046
	30	55	13	12	14,3	10	22000	32000	B7006C.TPA.P4	0,117
	30	55	13	12	14,3	10	22000	32000	B7006C.TPA.P4.UL	0,117
	30	55	13	12	14,3	10	22000	32000	B7006C.TPA.P4.K5.UL	0,117
	30	55	13	12	14,3	10	22000	32000	B7006C.TPA.HG	0,117
	30	55	13	12	14,3	10	22000	32000	B7006C.TPA.HG.UL	0,117
	30	55	13	16	13,4	9,5	20000	30000	B7006E.TPA.P4.UL	0,117
	30	62	16	14	20,8	13,7	20000	30000	B7206C.TPA.P4	0,204
	30	62	16	14	20,8	13,7	20000	30000	B7206C.TPA.P4.UL	0,204
	30	62	16	14	20,8	13,7	20000	30000	B7206C.TPA.P4.K5.UL	0,204
	30	62	16	14	20,8	13,7	20000	30000	B7206C.TPA.HG.UL	0,204
	30	62	16	14	20,8	13,7	20000	30000	B7206C.TPA.HG.K5.UL	0,204
	30	62	16	19	20	13,2	18000	26000	B7206E.TPA.P4.UL	0,204
35	35	55	10	11	11	8,5	22000	32000	B71907C.TPA.P4.UL	0,076
	35	55	10	16	10,4	8,15	18000	26000	B71907E.TPA.P4.UL	0,076

- Screw end support bearing - part number 102:
  - Manufacturer : FAG.
  - Type : radial ball bearing.
  - Tolerance class : P4 with reduced radial play (ISO class 4).
  - Material : carbon chrome steel for rings and balls.
  - Cage : made of steel.
  - Non separable and without shields.

Cuscinetti radiali rigidi a sfere

ad una corona



2ZRN

Albero	Dimensioni								Coeff. di carico		Velocità di riferimento		Sigla		Massa ~
	d	D	B	r_s min	D_n	a_n	b_n	r_n	din. C	stat. C_o	grasso	olio	Cuscinetto FAG	Anello di ancoraggio FAG	
	mm								kN		giri/min				kg
8	8	16	4	0,2					1,5	0,64	36000	43000	618/8		0,003
	8	22	7	0,3					3,25	1,37	30000	36000	608		0,013
	× 8	22	7	0,3					3,25	1,37	19000		608RSR		0,013
	8	22	7	0,3					3,25	1,37	19000		608.2RSR		0,013
	8	22	7	0,3					3,25	1,37	19000		608.2RSR.C3		0,013
	8	22	7	0,3					3,25	1,37	30000		608ZR		0,013
	8	22	7	0,3					3,25	1,37	30000		608.2ZR		0,013
	8	22	7	0,3					3,25	1,37	30000		608.2ZR.C3		0,013
9	9	24	7	0,3					3,65	1,63	30000	36000	609		0,015
	9	24	7	0,3					3,65	1,63	18000		609RSR		0,015
	9	24	7	0,3					3,65	1,63	18000		609.2RSR		0,015
	9	24	7	0,3					3,65	1,63	30000		609ZR		0,015
	9	24	7	0,3					3,65	1,63	30000		609.2ZR		0,015
	9	24	7	0,3					3,65	1,63	30000		609.2ZR.C3		0,015
	9	26	8	0,6					4,55	1,96	28000	34000	629		0,02
	9	26	8	0,6					4,55	1,96	19000		629RSR		0,02
	9	26	8	0,6					4,55	1,96	19000		629.2RSR		0,02
	9	26	8	0,6					4,55	1,96	19000		629.2RSR.C3		0,02
	9	26	8	0,6					4,55	1,96	28000		629ZR		0,02
	9	26	8	0,6					4,55	1,96	28000		629.2ZR		0,02
	9	26	8	0,6					4,55	1,96	28000		629.2ZR.C3		0,02
10	10	19	5	0,3					1,73	0,83	34000	40000	61800T		0,005
	10	26	8	0,3					4,55	1,96	28000	34000	6000		0,019
	10	26	8	0,3					4,55	1,96	28000	34000	6000.C3		0,019
	10	26	8	0,3					4,55	1,96	17000		6000RSR		0,019
	10	26	8	0,3					4,55	1,96	17000		6000.2RSR		0,019
→	10	26	8	0,3					3,45	1,46	28000	34000	6000Z15		0,019
	10	26	8	0,3					3,45	1,46	17000		6000Z15.2RSR		0,019
	10	26	8	0,3					4,55	1,96	28000		6000ZR		0,019
	10	26	8	0,3					4,55	1,96	28000		6000.2ZR		0,019
	10	26	8	0,3					4,55	1,96	28000		6000.2ZR.C3		0,019
	10	28	8	0,3					4,55	1,96	26000	32000	16100		0,023
	10	30	9	0,6					6	2,6	26000	32000	6200		0,03
	10	30	9	0,6					6	2,6	26000	32000	6200.C3		0,03
	10	30	9	0,6					6	2,6	17000		6200RSR		0,03
	10	30	9	0,6					6	2,6	17000		6200.2RSR		0,03
	10	30	9	0,6					6	2,6	17000		6200.2RSR.C3		0,03
	10	30	9	0,6					4,5	1,96	26000	32000	6200Z15		0,03
	10	30	9	0,6					4,5	1,96	17000		6200Z15.2RSR		0,03
	10	30	9	0,6					6	2,6	26000		6200ZR		0,03
	10	30	9	0,6	28,17	2,06	1,35	0,4	6	2,6	26000		6200ZRN	SP30	0,03
	10	30	9	0,6					6	2,6	26000		6200.2ZR		0,03
	10	30	9	0,6					6	2,6	26000		6200.2ZR.C3		0,03
	10	30	9	0,6	28,17	2,06	1,35	0,4	6	2,6	26000		6200.2ZRN	SP30	0,03

ADS Srl - Corso Promessi Sposi, 23/d - 23900 Lecco - ITALY
Steward Observatory - University of Arizona - 933 N.Cherry Ave., Tucson Arizona 85721 - USA

All the bearings were lubricated with KLUBER ISOFLEX NBU 15.

6.3. DC Motor

Manufacturer	KOLLMORGEN Inland Motor
Type	Direct Drive Torque Motor in frameless configuration with embedded Hall sensor for phases commutation : • QT-2404
Cont. Stall torque	0.82 Nm
Number of Poles	4
Peak Torque	4.3 Nm
Peak power at stall	260 W
Motor Constant	0.25 Nm/$\sqrt{W}$

More details about the QT-2404 are reported in the attached data sheet.

Direct Drive Torque Motors **DC Servomotors**

PERFORMANCE DATA

Model Number	Peak Torque at Stall T_p lb-ft	Motor Constant K_m lb-ft/√Watt	Peak Power at Stall P_p Watts	No-load Speed ω_{nl} rad/sec	Electrical Time Constant τ_e ms	Static Friction T_f lb-ft	Rotor Inertia J_m lb-ft-sec²	Physical Dimensions OD in	ID in	Length in	Motor Weight lb
QT-2404	3.00	0.190	260	64	1.0	0.060	0.0002	3.18	1.00	1.53	2.4

KOLLMORGEN
Motion Technologies Group
Industrial and Commercial Products

C87

1-800-77-SERVO
(777-3786)

Kollmorgen Motion Technologies Group
Sales Offices

Industrial and Commercial Products
1-800-77-SERVO

Southern Region
4330 Georgetown Square,
Suite 512
Atlanta, GA 30338
TEL: 404/451-1840
FAX: 404/451-1883

Western Region
23011 Moulton Parkway,
Unit H5
Laguna Hills, CA 92653
TEL: 714/581-3626
FAX: 714/581-3628

Midwestern Region
1985 W. Big Beaver Road,
Suite 312
Troy, MI 48084
TEL: 810/816-8740
FAX: 810/816-9855

Eastern Region
49 Mall Drive
Commack, NY 11725
TEL: 516/864-1000
FAX: 516/864-2084

International
49 Mall Drive
Commack, NY 11725
TEL: 516/864-1000
FAX: 516/864-2084

Kollmorgen U.K.
Kollmorgen Hightech Ltd.
Servo House
14-16 Mulfords Hill
Tadley, Hampshire RG26 6HX
England
TEL: 44/734 813 922
FAX: 44/734 811 532

Aerospace and Defense Products
1-800-753-6686

Inland Motor
501 First Street
Radford, VA 24141
TEL: 703/639-9045
FAX: 703/731-4193

Kollmorgen Artus
Chemin du Champ des
Martyrs, B.P. 9
49241 Avrille Cedex
France
TEL: 33/41.33.63.40
FAX: 33/41.33.63.63

KMTG Europe
Suite 34, Wyvols Court
Swallowfield
Near Reading
Berkshire RG7 1PY
England
TEL: 44/734 880253
FAX: 44/734 880360

Kollmorgen Hightech Ltd.
Servo House
14-16 Mulfords Hill
Tadley, Hampshire RG26 6HX
England
TEL: 44/734 813922
FAX: 44/734 811532

Kollmorgen Motion Technologies Group
Manufacturing Locations

Industrial Drives
201 Rock Road
Radford, VA 24141

SMG
201 Rock Road
Radford, VA 24141

PMI Motion Technologies
49 Mall Drive
Commack, NY 11725

Inland Motor
501 First Street
Radford, VA 24141

VMG
201 Rock Road
Radford, VA 24141

KTI
Unit No. 3, SDF-1
Seepz, Andheri (E)
Bombay 400 096
India

Kollmorgen Artus
Chemin du Champ des
Martyrs, B.P. 9
49241 Avrille Cedex
France

KOLLMORGEN
Motion Technologies Group

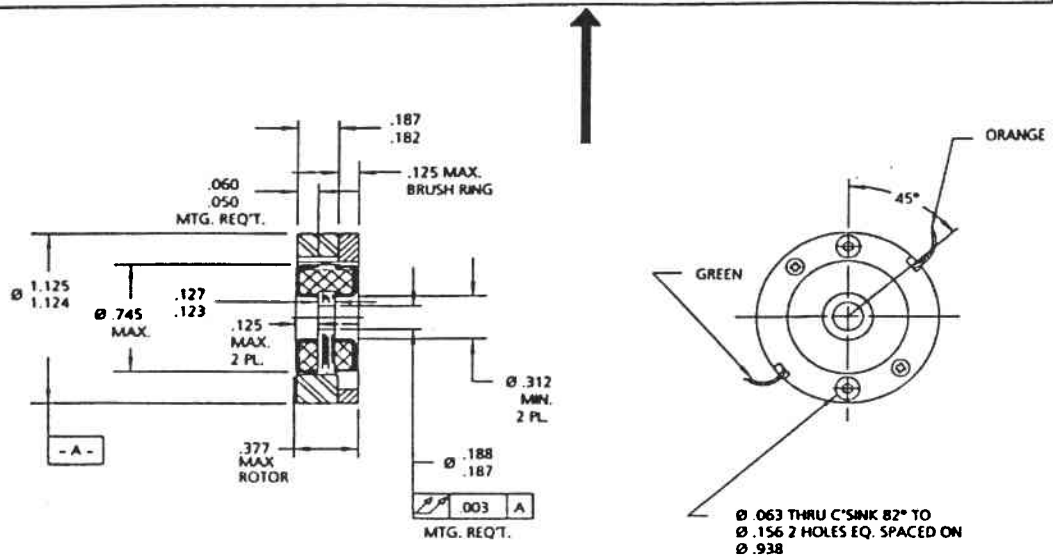
PMI • Industrial Drives • SMG • Inland Motor • Artus • VMG

I.P.S.

INTERNATIONAL PROMOTION SERVICES s.r.l.
Via Gide, 33 ; 00143 Roma
Tel: +39-6-5020321 (3 linee)
Telefax: +39-6-5005069

QT-0717 Direct Drive Torque Motor DC Servomotors

DIMENSIONS (Example Motor)



Notes:
1. Motor to be shipped as three separate components: Brush Ring Assembly, Rotor Assembly, and Stator Assembly.
2. With a positive voltage applied to green lead, with respect to orange lead, rotation shall be C.C.W. facing brush ring end.
3. Gold-plated commutator.

Size Constants	Symbols	Values	Units
Peak torque rating	T_p	3.84	oz-in
Motor constant	K_m	0.529	oz-in/√Watt
Power input, stalled, at T_p*	P_p	53	Watts
No-load speed (theoretical) at V_p	ω_{nl}	1950	rad/sec
Viscous damping–zero impedance	F_v	1.97×10^{-3}	oz-in per rad/sec
Viscous damping–infinite impedance	F_i	0.0003	oz-in per rad/sec
Electrical time constant	τ_e	0.12	ms
Temperature rise per Watt	TPR	45	°C/Watt
Max winding temperature	–	155	°C
Ripple torque, average to peak	T_R	7	percent
Ripple frequency, fundamental	–	13	cycles/rev
Number of poles	–	4	–
Static friction (max)	T_f	0.25	oz-in
Rotor inertia	J_m	4×10^{-4}	oz-in-sec²
Motor weight	–	1.4	oz

Winding Constants	Winding Designation									
	Symbols	Units	Tolerances	A	B	C	D	E	F	G
DC resistance*	R_m	ohms	±12.5%	7.50	47.5	11.9	1.91	16.9		
Voltage, stalled at T_p*	V_p	Volts	nom	19.9	50.3	25.1	9.93	28.4		
Peak current	I_p	amps	rated	2.65	1.06	2.11	5.20	1.68		
Torque sensitivity	K_t	oz-in/amps	±10%	1.45	3.64	1.82	0.738	2.29		
Back EMF constant	K_e	V per rad/sec	±10%	0.0102	0.0257	0.0128	0.0052	0.0162		
Inductance	L_m	mH	±30%	0.90	5.7	1.4	0.23	2.2		

*25°C

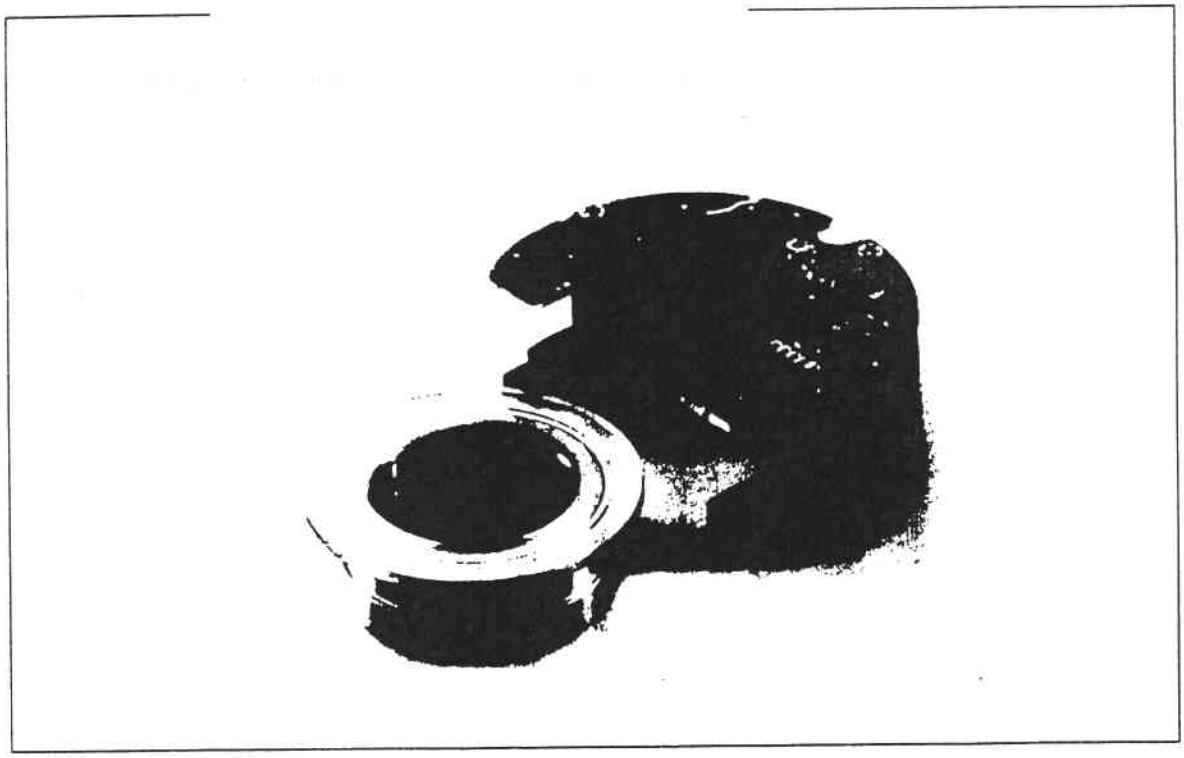
6.4. Optical Incremental Encoder

Manufacturer	HEIDENHAIN (Germany)
Type	Optical incremental encoder in frameless configuration : ERO 1324.
Line Counts	3600, sinus-cosinus (incremental) and reference signals, analog output.

More details about the ERO 1324 are reported in the attached data sheet.

HEIDENHAIN

Incremental Modular Rotary Encoders ERO 1324



Manufacturers are increasingly calling for **rotary encoders** for **mounting on through shafts** with comparatively **large diameters** and which allow **fast mounting times.** The modular rotary encoders of the ERO 1300 series are directed at such applications.

These encoders consist of a **graduated disk/hub assembly** and a **scanning unit.** The graduated disk/hub assembly, with **line counts of 100 to 5000**, is installed directly on the shaft. The scanning unit is centered on the mounting surface with a centering collar. The scanning gap is set with a spacer foil by sliding the disk/hub assembly on the motor shaft. Depending on the line count, the scanning gap ranges from 0.2 mm to 0.3 mm.

The **ERO 1324** with its **outside diameter** of **75 mm** allows **through shafts** with diameters up to **30 mm**. For **shaft diameters** up to **40 mm** the **ERO 1325** or **ERO 1355** can be employed, although this requires a scanning unit with a larger **outside diameter of 88 mm.** The overall length of the ERO 1324 is approximately 39 mm, that of the ERO 1325 and ERO 1355 approximately 44 mm.

Direct mounting of the graduated disk/hub assembly on the shaft assures **high connection rigidity** since only the torsion spring rate of the shaft between the graduated disk and the scanning unit has any influence. Furthermore, the ERO family encoders produce **no additional starting torque.** Since the encoders of the ERO 1300 series are exposed optical measuring systems, the user must provide a cover to prevent extraneous light from falling on the photovoltaic cells and to protect the encoder from contamination.

The **output signals** are either **TTL square-wave signals or 11 µApp sinusoidal signals** and a reference mark signal. With sinusoidal output signals it is possible to increase the resolution as against square-wave signals through the use of external interpolation electronics units. The encoders receive current through a **PCB connector.** The **maximum scanning frequency** for square-wave pulse trains is **160 kHz**, although **optional electronics** with **400 kHz or 800 kHz** maximum scanning frequency are also available.

September 1993

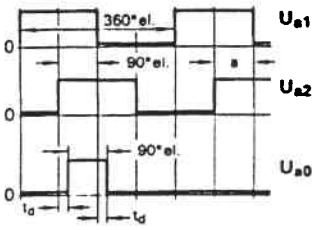
Electrical Data

ERO 1324

Power supply

5 V ± 5 %/max. 160 mA (with no load)
Light source: LED

Output signals



Incremental signals TTL square wave pulse trains U_{a1}, U_{a2} and their inverted pulse trains $\overline{U_{a1}}$ and $\overline{U_{a2}}$. U_{a2} lags U_{a1} with clockwise rotation (when viewing mounting surface at the scanning unit)

Edge separation
a ≥ 0.14 µs with scanning freq. 800 kHz (ERO 1324 .□008)
a ≥ 0.28 µs with scanning freq. 400 kHz (ERO 1324 .□004)
a ≥ 0.7 µs with scanning freq. 160 kHz (ERO 1324 .□000 and ERO 1325 .□000)

Reference signal One square-wave pulse U_{a0} per revolution and its inverted pulse $\overline{U_{a0}}$
Width: 90° el.
$t_d \leq 50$ ns

Error signal One square-wave pulse $\overline{U_{aS}}$
(only with ERO 1324 .□004 and ERO 1324 .□008)
$\overline{U_{aS}}$ = High: proper function
$\overline{U_{aS}}$ = Low: error condition

Signal levels
$U_{High} \geq 2.5$ V at $-I_{High} \leq 20$ mA
$U_{Low} \leq 0.5$ V at $I_{Low} \leq 20$ mA
(with supply voltage + 5 V at encoder)

Load capacity
$-I_{High} \leq 20$ mA
$I_{Low} \leq 20$ mA
$C_{Load} \leq 1000$ pF

Switching times
Rise time $t_+ \leq 100$ ns
Fall time $t_- \leq 100$ ns

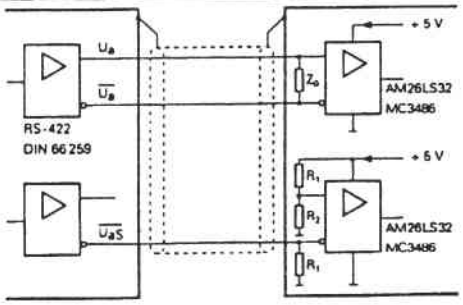
Scanning frequency f

f ≤ 800 kHz (ERO 1324 .□008)
f ≤ 400 kHz (ERO 1324 .□004)
f ≤ 160 kHz (ERO 1324 .□000 and ERO 1325 .□000)

Electrically permissible speed n

$$n \leq \frac{\text{Scanning frequency f in kHz}}{z} \cdot 60 \cdot 10^3 \text{ rpm} \qquad z = \text{line count}$$

Recommended input circuitry of the subsequent electronics



$R_1 = 4.7$ kΩ
$R_2 = 1.8$ kΩ
$Z_0 = 120$ Ω

Cable length to subsequent electronics Max. 100 m (329 ft) with HEIDENHAIN cable [4(2x0.14)+(4x0.5)]mm²

6.5. *LVDT and conditioning board*

The DCM-1000 is single channel DC-operated signal conditioner capable of providing conditioning of most LVDTs and RVDTs. Operating from ±15V DC, the DCM-1000 provides all necessary circuitry required to operate the position sensor and provide a high level, low noise analog DC output suitable for feeding analog or digital indicators, PLCs and other system indicating and control instrumentation.

Manufacturer	Macro Sensor (U.S.A.)
Power input voltage & Current	±15V DC, 50mA max
Excitation Voltage	3V rms
Excitation Freq.	3kHz, 5kHz or 10kHz
Input Impedance	200 Ohms (min)
Output Voltage	±10V DC
Output Current	5mA
Frequency Response	-3db at 250Hz
Output Ripple	<10mV rms
Output Impedance	<10 Ohms
Nonlinearity	±0.01% FSO
Operating Temp. range	-18° to +70°C
Temp. Coeff. of Sens	0.18% FSO/°C
Controls	Zero and Span
Weight	24 g
Mating Connector	Cinch #50-10A-20 or equiv.

6.6. *Inductive Proximity Switch*

Manufacturer	BAUMER ELECTRIC (Swiss)
Type	inductive proximity switch normally open (NO) with LED, type IFR 05.26.35/L.
Voltage supply	10÷30 VDC
Temperature Range	(-25°C,+75°C)

More details about the switch are reported in the attached data sheet.

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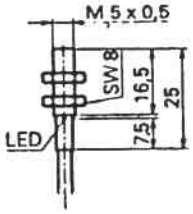
Cylindrical design
DC version / cable connection

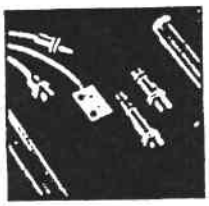
	● 0,8 mm ○
	
IFR 05.28.35/L IFR 05.28.45/L	
	10 - 30 VDC
	< 10 mA
	100 mA
	< 2,5 V
	5 kHz
	0,8 mm
	3...20 %
	red LED
	yes
	yes
	-25...+75 °C
	chrome-nickel-steel (1.4305)
	IP 67
	

Complete sensor Know How


Inductive Sensors


Capacitive Sensors


Photoelectric Sensors


Precision Limit Switches


Ultrasonic Sensors


Glass and plastic fibers


Electronic Hand Wheels


Tag Identification Systems

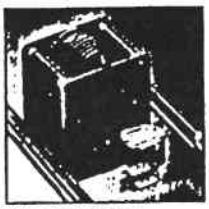

Peripheral Amplifiers


Encoders


Laser Sensors


Pressure Sensors


Resolvers


Micro Switches Programmable Limit Switches


Actuator Sensor Interface Sensors and Peripheral Devices

Baumer electric

. Baumer Electric S.r.l.
. 20090 Assago (MI) - Via E. Fermi, 8
. Tel. (02) 45.70.60.65. (4 linee r.a.)
Fax (02) 26.12.62.70

Baumer Electric AG
Hummelstrasse 17
CH- 8500 Frauenfeld
Switzerland
Phone +41 54 728 11 22
Fax +41 54 728 11 44

Baumer Electric Ltd.
33/36 Shrivenham Hundred
GB-Watchfield, Swindon, SN6 8TZ
United Kingdom
Phone +44 793 783 839
Fax+44 793 783 814

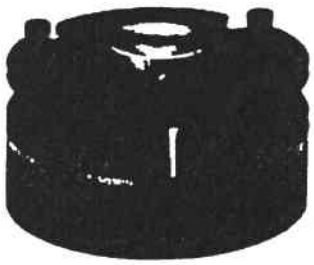
Baumer electric

6.7. Brake

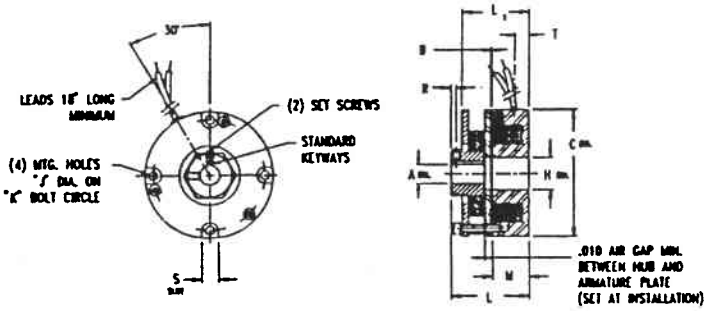
Manufacturer	ELECTROID COMPANY
Type	EFSB 15
Torque	1.7 Nm
Weight	0.37 Kg
Inertia of rotating armature	3.5 e^{-6} Kgm^2
Response time	45 Millisec

More details about the EFSB 15 are reported in the attached data sheet.

EFSB SERIES



EFSB-1-3-7-15-35-50



MODEL #	A DIA.	B AIR GAP	C DIA.	H DIA.	J	K	L	L_1	M	R	S
EFSB-1	1/8 • 3/16 • 1/4	.003 TO .006	1.375	.280	(3) .126 DIA.	1.180 B.C.	.88	.73	.44	.09	.19
EFSB-3	3/16 • 1/4 • 3/8	.006 TO .010	1.750	.410	(3) .126 DIA.	1.545 B.C.	1.06	.87	.53	.11	.20
EFSB-7	1/4 • 3/8 • 1/2	.005 TO .015	2.44	.625 .627	(4) .172 DIA.	2.125 B.C.	1.45	1.25	.69	.10	.31
EFSB-15	1/4 • 3/8 • 1/2	.005 TO .015	2.44	.625 .627	(4) .172 DIA.	2.125 B.C.	1.45	1.25	.69	.10	.31
EFSB-35	1/2 • 5/8 • 3/4	.005 TO .015	3.50	1.000 1.002	(4) .203 DIA.	3.125 B.C.	1.89	1.63	1.00	.17	.34
EFSB-50	1/2 • 5/8 • 3/4	.005 TO .015	3.50	1.000 1.002	(4) .203 DIA.	3.125 B.C.	1.89	1.63	1.00	.17	.34

NOTES:

1. Attachment of armature hub is secured by key (where noted) and two set screws.
2. Maximum rated speed 7500 RPM.
3. 90 & 24/28 Volt DC are standard, built-in rectifiers for direct A.C. use. (Other voltages available upon request)
4. These models are also available with ZERO BACKLASH spring release armature assemblies. Consult ELECTROID for details.

	MECHANICAL				ELECTRICAL		
MODEL #	RATED STATIC TORQUE (IN. - LBS.)	UNIT WEIGHT (LBS.)	INERTIA OF ROTATING ARMATURE (LBS.-IN.²)	RESPONSE TIME (MILLI-SEC.)	COIL #	RATED VOLTAGE (V.D.C.)	CURRENT (AMPERES)
EFSB-1	1	0.3	.001	25	1	90	.05
					2	24/28	.13
EFSB-3	3	0.4	.004	35	1	90	.05
					2	24/28	.13
EFSB-7	7	1.2	.012	45	1	90	.07
					2	24/28	.20
EFSB-15	15	1.2	.012	45	1	90	.12
					2	24/28	.30
EFSB-35	35	2.7	.127	95	1	90	.06
					2	24/28	.25
EFSB-50	50	2.7	.127	95	1	90	.09
					2	24/28	.39

6.8. Structural Parts

All the structural parts such as the actuator housing and joints forks are made of aluminium alloy ANTICORODAL alloy 6082 UNI 9006/4 with ALODINE 1200 anodising treatment.
The joints crosses and covers and other rings are made of stainless steel AISI 304 for stiffness reasons.
All the fixation screws are made of stainless steel in accordance to UNI classes.

More details about the certificate material are reported in the attached sheet.

ADS Srl - Corso Promessi Sposi, 23/d - 23900 Lecco - ITALY
Steward Observatory - University of Arizona - 933 N.Cherry Ave., Tucson Arizona 85721 - USA

Sede :
V. Tocco 11
20052 Monza (MI)
Tel \ Fax :
039\2020826

F.lli Re sas
Galvanica e Verniciatura
dal 1911

CERTIFICATO N° B 410

SPETT. MEDIALARIO Srl DATA 21/7/97

VS. BOLLA N° 149 DEL 16/7/97

VS. ORDINE N° 954/1997

RELATIVAMENTE AI PEZZI DEL VS. ORDINE IN OGGETTO, SI GARANTISCE L'AVVENUTO CONTROLLO AI FINI ESTETICI E IL RISPETTO DELLE SUPERFICI E DEI PROFILI.

CODICE PEZZO // //
CODICE TRATTAMENTO ALODINE 1200

SPESSORE / /
BRILLANTEZZA / /
ADERENZA POSITIVO DOPO TEST CON NASTRO ADESIVO

MEDIA LARIO
C. Q. ACCETTAZIONE
FIRMA
DATA 31.07.97
N° LOTTO ML 373/01-08
MATERIALE
ACCETTATO NO
NOTE:
mod. 8010d

F.lli RE s.a.s.
di G. Schiavi & C.
Via Tocco 11
20052 Monza
C.F. 01557430157
P.IVA 00717210967

ADS Srl - Corso Promessi Sposi, 23/d - 23900 Lecco - ITALY
Steward Observatory - University of Arizona - 933 N.Cherry Ave., Tucson Arizona 85721 - USA

AIROLDI METALLI S.R.L.

Alluminio - Rame - Ottone - Bronzo - Inox

ANNONE BRIANZA (LC) Via Provinciale, 34
Tel. 0341 / 260 916 r. a. - Telefax 0341 / 260.562

Annone Brianza, 20/05/97

Spettabile O.S.C. SNC DI SCARCIA
VIA DEGLI ARTIGIANI 15
CASATENOVO

CERTIFICATO DI CONFORMITÀ N° 448

VS ORDINE DI ACQUISTO N° 07/04/97

RIFERIMENTO NOSTRA BOLLA N° 3663 DEL 21/04/97

SI CERTIFICA CHE IL SEGUENTE MATERIALE INOX TONDO LAMINATO 120
LEGA INOX 303

E' STATO SOTTOPOSTO A REGOLARE COLLAUDO E RISULTA CONFORME ALLE PRESCRIZIONI DELLA LEGA AISI 303

NORMA UNI X 10 Cr Ni S 1809

NELLO STATO DI FORNITURA LAMINATO

DIS. ADS 300933/A
ADS 400896/A
ADS 400691/A
ADS 300935/A

MEDIA LARIO
C. Q. ACCETTAZIONE
FIRMA
DATA 13.06.97
N° LOTTO ML 885/01-03-08-10
MATERIALE OK
ACCETTATO NO
NOTE:
mod. 8010d

AIROLDI METALLI S.R.L.
UFFICIO TECNICO

AIROLDI METALLI S.R.L.

Alluminio - Rame - Ottone - Bronzo - Inox

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Tel. 0341 / 260.916 r. a. - Telefax 0341 / 260.562

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Spettabile O.S.C. SNC DI SCARCIA
VIA DEGLI ARTIGIANI 15
CASATENOVO

CERTIFICATO DI CONFORMITÀ N° 449

VS ORDINE DI ACQUISTO N° 07/04/97

RIFERIMENTO NOSTRA BOLLA N° 3663 DEL 21/04/97

SI CERTIFICA CHE IL SEGUENTE MATERIALE ANTICORODAL TONDO 110
LEGA 6082 T 6 LOTTO 454

E' STATO SOTTOPOSTO A REGOLARE COLLAUDO E RISULTA CONFORME ALLE PRESCRIZIONI DELLA LEGA 6082 T 6

NORMA UNI 9006/4

NELLO STATO DI FORNITURA T 6

Dis. ADS 300934/A
ADS 400690/B

MEDIA LARIO
C. Q. ACCETTAZIONE
FIRMA
DATA 30.06.97
N° LOTTO ML 985/01-02
MATERIALE
ACCETTATO NO
NOTE:
mod. 8010d rl

AIROLDI METALLI S.R.L.
UFFICIO TECNICO

AIROLDI METALLI S.R.L.

Alluminio - Rame - Ottone - Bronzo - Inox

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Tel. 0341 / 260 916 r. a. - Telefax 0341 / 260.562

Annone Brianza, 20/05/97

Spettabile O.S.C. SNC DI SCARCIA
VIA DEGLI ARTIGIANI 15
CASATENOVO

CERTIFICATO DI CONFORMITÀ N° 453

VS ORDINE DI ACQUISTO N° 07/04/97

RIFERIMENTO NOSTRA BOLLA N° 3663 DEL 21/04/97

SI CERTIFICA CHE IL SEGUENTE MATERIALE INOX AISI 304 TAGLIATO SP 50
LEGA 304

È STATO SOTTOPOSTO A REGOLARE COLLAUDO E RISULTA CONFORME ALLE
PRESCRIZIONI DELLA LEGA AISI 304

NORMA UNI X 5 Cr Ni 18-10

NELLO STATO DI FORNITURA GREZZO DI LAMINAZIONE

DIS. ADS 200692/A

MEDIA LARIO
C. Q. ACCETTAZIONE
FIRMA
DATA 13.06.97
N° LOTTO ML 225/05
MATERIALE
ACCETTATO NO
NOTE: IN DEROGA
SINC n° 124/97

AIROLDI METALLI S.R.L.
UFFICIO TECNICO

AIROLDI METALLI S.R.L.

Alluminio - Rame - Ottone - Bronzo - Inox

ANNONE BRIANZA (LC) Via Provinciale, 34
Tel. 0341 / 260.916 r. a. - Telefax 0341 / 260.582

Annone Brianza, 20/05/97

Spettabile O.S.C. SNC DI SCARCIA
VIA DEGLI ARTIGIANI 15
CASATENOVO

CERTIFICATO DI CONFORMITÀ N° 446

VS ORDINE DI ACQUISTO N° 07/04/97

RIFERIMENTO NOSTRA BOLLA N° 3663 DEL 21/04/97

SI CERTIFICA CHE IL SEGUENTE MATERIALE INOX TONDO TRAFILATO 35
LEGA INOX 303

E' STATO SOTTOPOSTO A REGOLARE COLLAUDO E RISULTA CONFORME ALLE PRESCRIZIONI DELLA LEGA AISI 303

NORMA UNI X 10 CR NI S 1809

NELLO STATO DI FORNITURA TRAFILATO

DIS. ADS 400693/A
ADS 400695

MEDIA LARIO
C. Q. ACCETTAZIONE
FIRMA
DATA 6.06.97
N° LOTTO ML 285/06-09
MATERIALE ACCETTATO SI NO
NOTE:
mod. 80/90d

AIROLDI METALLI S.R.L.
UFFICIO TECNICO

AIROLDI METALLI S.R.L.

Alluminio - Rame - Ottone - Bronzo - Inox

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Tel. 0341 / 260.916 r. a. - Telefax 0341 / 260.562

Annone Brianza, 20/05/97

Spettabile O.S.C. SNC DI SCARCIA
VIA DEGLI ARTIGIANI 15
CASATENOVO

CERTIFICATO DI CONFORMITÀ N° 446

VS ORDINE DI ACQUISTO N° 07/04/97

RIFERIMENTO NOSTRA BOLLA N° 3663 DEL 21/04/97

SI CERTIFICA CHE IL SEGUENTE MATERIALE INOX TONDO TRAFILATO 35
LEGA INOX 303

E' STATO SOTTOPOSTO A REGOLARE COLLAUDO E RISULTA CONFORME ALLE PRESCRIZIONI DELLA LEGA AISI 303

NORMA UNI X 10 CrNiS 1809

NELLO STATO DI FORNITURA TRAFILATO

DIS. ADS 400693/A
ADS 400695

MEDIA LARIO
C. Q. ACCETTAZIONE
FIRMA
DATA 6.06.97
N° LOTTO ML 985/06-09
MATERIALE OK
ACCETTATO NO
NOTE:
mod. 8010d rl

AIROLDI METALLI S.R.L.
UFFICIO TECNICO

AIROLDI METALLI S.R.L.

Alluminio - Rame - Ottone - Bronzo - Inox

ANNONE BRIANZA (LC) Via Provinciale, 34
Tel. 0341 / 260.916 r. a. - Telefax 0341 / 260.562

Annone Brianza, 20/05/97

Spettabile O.S.C. SNC DI SCARCIA
VIA DEGLI ARTIGIANI 15
CASATENOVO

CERTIFICATO DI CONFORMITÀ N° 450

VS ORDINE DI ACQUISTO N° 07/04/97

RIFERIMENTO NOSTRA BOLLA N° 3663 DEL 21/04/97

SI CERTIFICA CHE IL SEGUENTE MATERIALE ANTICORODAL TONDO 100
LEGA 6082 T 6 LOTTO 489

E' STATO SOTTOPOSTO A REGOLARE COLLAUDO E RISULTA CONFORME ALLE PRESCRIZIONI DELLA LEGA 6082 T 6

NORMA UNI 9006/4

NELLO STATO DI FORNITURA T 6

Dis. ADS 400699/A
ADS 400698/A
ADS 300936

MEDIA LARIO
C. Q. ACCETTAZIONE
FIRMA
DATA 13.06.97
N° LOTTO ML 985 / 11.12.13
MATERIALE ACCETTATO SI / NO
NOTE: BNC n° 124/97
mod. 8010d rl

AIROLDI METALLI S.R.L.
UFFICIO TECNICO

AIROLDI METALLI S.R.L.

Alluminio - Rame - Ottone - Bronzo - Inox

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Tel. 0341 / 260.918 r. a. - Telefax 0341 / 260.562

Annone Brianza, 20/05/97

Spettabile O.S.C. SNC DI SCARCIA
VIA DEGLI ARTIGIANI 15
CASATENOVO

CERTIFICATO DI CONFORMITÀ N° 451

VS ORDINE DI ACQUISTO N° 07/04/97

RIFERIMENTO NOSTRA BOLLA N° 3663 DEL 21/04/97

SI CERTIFICA CHE IL SEGUENTE MATERIALE ANTICORODAL TONDO 60
LEGA 6082 T 6 LOTTO 487

E' STATO SOTTOPOSTO A REGOLARE COLLAUDO E RISULTA CONFORME ALLE PRESCRIZIONI DELLA LEGA 6082 T 6

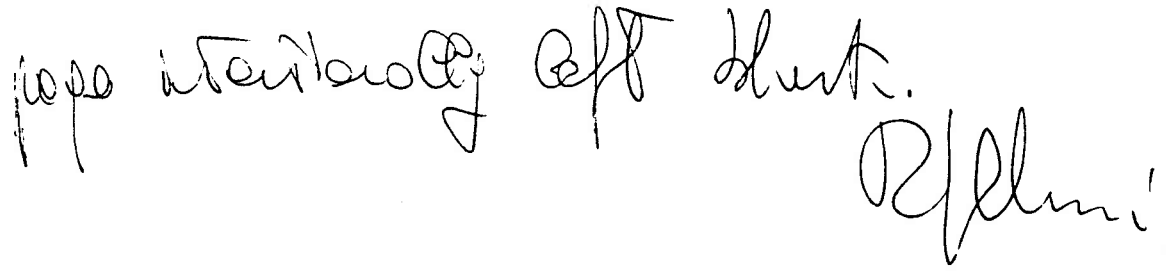
NORMA UNI 9006/4

NELLO STATO DI FORNITURA T 6

DIS. ADS 300937/A

MEDIA LARIO
C. Q. ACCETTAZIONE
FIRMA
DATA 13/06/97
N° LOTTO ML 285/14
MATERIALE 281
ACCETTATO NO
NOTE: IN BERGAMO
QINC n° 1211/97 mod. 8010d

AIROLDI METALLI S.R.L.
UFFICIO TECNICO



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AIROLDI METALLI S.R.L.

Alluminio - Rame - Ottone - Bronzo - Inox

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Tel. 0341 / 260.916 r. a. - Telefax 0341 / 260.562

Annone Brianza, 20/05/97

Spettabile O.S.C. SNC DI SCARCIA
VIA DEGLI ARTIGIANI 15
CASATENOVO

CERTIFICATO DI CONFORMITÀ N° 445

VS ORDINE DI ACQUISTO N° 07/04/97

RIFERIMENTO NOSTRA BOLLA N° 3663 DEL 21/04/97

SI CERTIFICA CHE IL SEGUENTE MATERIALE INOX TONDO TRAFILATO 30
LEGA INOX 303

E' STATO SOTTOPOSTO A REGOLARE COLLAUDO E RISULTA CONFORME ALLE PRESCRIZIONI DELLA LEGA AISI 303

NORMA UNI X 10 CrNiS 1809

NELLO STATO DI FORNITURA TRAFILATO

ADS
DIS. 400700
400694/A

MEDIA LARIO
C. Q. ACCETTAZIONE
FIRMA
DATA 13.06.97
N° LOTTO ML 985/16-07
MATERIALE
ACCETTATO SI NO
NOTE:
mod. 8010d rl

AIROLDI METALLI S.R.L.
UFFICIO TECNICO

AIROLDI METALLI S.R.L.

Alluminio - Rame - Ottone - Bronzo - Inox

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Tel. 0341 / 260.916 r. a. - Telefax 0341 / 260.562

Annone Brianza, 20/05/97

Spettabile O.S.C. SNC DI SCARCIA
VIA DEGLI ARTIGIANI 15
CASATENOVO

CERTIFICATO DI CONFORMITÀ N° 447

VS ORDINE DI ACQUISTO N° 07/04/97

RIFERIMENTO NOSTRA BOLLA N° 3663 DEL 21/04/97

SI CERTIFICA CHE IL SEGUENTE MATERIALE INOX TONDO LAMINATO Ø0
LEGA INOX 303

E' STATO SOTTOPOSTO A REGOLARE COLLAUDO E RISULTA CONFORME ALLE PRESCRIZIONI DELLA LEGA AISI 303

NORMA UNI X 10 CrNi S 1809

NELLO STATO DI FORNITURA LAMINATO

DIS. ADS 300938/A
ADS 400701/A

MEDIA LARIO
C. Q. ACCETTAZIONE
FIRMA
DATA 13.08.97
N° LOTTO ML 285/15-17
MATERIALE OK
ACCETTATO NO
NOTE:
mod. 8010d rl

AIROLDI METALLI S.R.L.
UFFICIO TECNICO

AIROLDI METALLI S.R.L.

Alluminio - Rame - Ottone - Bronzo - Inox

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Tel. 0341 / 260.916 r. a. • Telefax 0341 / 260.562

Annone Brianza, 20/05/97

Spettabile O.S.C. SNC DI SCARCIA
VIA DEGLI ARTIGIANI 15
CASATENOVO

CERTIFICATO DI CONFORMITÀ N° 443

VS ORDINE DI ACQUISTO N° 07/04/97

RIFERIMENTO NOSTRA BOLLA N° 3663 DEL 21/04/97

SI CERTIFICA CHE IL SEGUENTE MATERIALE BRONZO TONDO 15
LEGA 85.5.5.5

E' STATO SOTTOPOSTO A REGOLARE COLLAUDO E RISULTA CONFORME ALLE PRESCRIZIONI DELLA LEGA 85.5.5.5

NORMA UNI

NELLO STATO DI FORNITURA GREZZO DI FUSIONE

ADS
DIS. 400709

MEDIA LARIO
C. Q. ACCETTAZIONE
FIRMA
DATA 13.06.97
N LOTTO ML 285/18
MATERIALE
ACCETTATO SI NO
NOTE:
mod. 8010d rl

AIROLDI METALLI S.R.L.
UFFICIO TECNICO

AIROLDI METALLI S.R.L.

Alluminio - Rame - Ottone - Bronzo - Inox

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Tel. 0341 / 260.916 r. a. - Telefax 0341 / 260.562

Annone Brianza, 20/05/97

Spettabile O.S.C. SNC DI SCARCIA
VIA DEGLI ARTIGIANI 15
CASATENOVO

CERTIFICATO DI CONFORMITÀ N° 444

VS ORDINE DI ACQUISTO N° 02/04/97

RIFERIMENTO NOSTRA BOLLA N° 3663 DEL 21/04/97

SI CERTIFICA CHE IL SEGUENTE MATERIALE INOX TONDO TRAFILATO 25
LEGA INOX 303

E' STATO SOTTOPOSTO A REGOLARE COLLAUDO E RISULTA CONFORME ALLE PRESCRIZIONI DELLA LEGA AISI 303

NORMA UNI X 10 CrNi 18 09

NELLO STATO DI FORNITURA TRAFILATO

MEDIA LARIO
C. Q. ACCETTAZIONE
FIRMA
DATA 13.05.97
N° LOTTO ML 285/1
MATERIALE
ACCETTATO NO
NOTE:
mod. 8010d d

DIS. ADS 400705

AIROLDI METALLI S.R.L.
UFFICIO TECNICO

AIROLDI METALLI S.R.L.

Alluminio - Rame - Ottone - Bronzo - Inox

ANNONE BRIANZA (LC) Via Provinciale, 34
Tel. 0341 / 260.916 r. a - Telefax 0341 / 260.562

Annone Brianza, 20/05/97

Spettabile O.S.C. SNC DI SCARCIA
VIA DEGLI ARTIGIANI 15
CASATENOVO

CERTIFICATO DI CONFORMITÀ N° 442

VS ORDINE DI ACQUISTO N° 07/04/97

RIFERIMENTO NOSTRA BOLLA N° 3663 DEL 21/04/97

SI CERTIFICA CHE IL SEGUENTE MATERIALE INOX PIATTO 25X5
DA NASTRO LEGA 304

E' STATO SOTTOPOSTO A REGOLARE COLLAUDO E RISULTA CONFORME ALLE PRESCRIZIONI DELLA LEGA INOX AISI 304

NORMA UNI X 5 Cr Ni 1810

NELLO STATO DI FORNITURA CESOIATO DA NASTRO

MEDIA LARIO
C. Q. ACCETTAZIONE
FIRMA
DATA 13.06.97
N° LOTTO ML 285/21-22
MATERIALE SI
ACCETTATO NO
NOTE:
mod. 8010d rl

DIS. ADS 400708
400709

AIROLDI METALLI S.R.L.
UFFICIO TECNICO

AIROLDI METALLI S.R.L.

Alluminio - Rame - Ottone - Bronzo - Inox

ANNONE BRIANZA (LC) Via Provinciale, 34
Tel. 0341 / 260.916 r. a. - Telefax 0341 / 260.562

Annone Brianza, 20/05/97

Spettabile O.S.C. SNC DI SCARCIA
VIA DEGLI ARTIGIANI 15
CASATENOVO

CERTIFICATO DI CONFORMITÀ N° 452

VS ORDINE DI ACQUISTO N° 07/04/97

RIFERIMENTO NOSTRA BOLLA N° 3663 DEL 21/04/97

SI CERTIFICA CHE IL SEGUENTE MATERIALE ANTICORODAL TAGLIATO SP 20
LEGA 6082 T 651 LOTTO 02/97

E' STATO SOTTOPOSTO A REGOLARE COLLAUDO E RISULTA CONFORME ALLE PRESCRIZIONI DELLA LEGA 6082 T 651

NORMA UNI 9006/1

NELLO STATO DI FORNITURA T 651

MEDIA LARIO
C. Q. ACCETTAZIONE
FIRMA
DATA 18.06.97
N° LOTTO ML 286/95-96
MATERIALE BT
ACCETTATO NO
NOTE:
mod. 80/00/d

AIROLDI METALLI S.R.L.
UFFICIO TECNICO

Disegni : MMT - HEXAPOD
ADS 200508/B
ADS 200512

Unavia CONTROLLO QUALITÀ

LA RIMOZIONE O DISTRUZIONE DI QUESTO CARTELLINO DA PARTE DI PERSONE NON AUTORIZZATE È VIETATA.

☑ CLIENTE MEDIALARIO ☑ FORNITORE UNAVIA	TIPO	DISEGNO N° 300943	LOTTO N° 1
	QUANTITÀ 3	PARTITA ☐ COLATA ☐ INOX AISI 304	S/N. ☐ N/C ☐ COSTR. NR. VEDI ALLEGATI
DENOMINAZIONE PARTICOLARE UPPER SUPPORT POS 23		PRESERVATO CON SCADENZA	CARTELLINO N° 41
ASSIEME SUCCESSIVO DISEGNO N° HEXAPOD		RINNOVO PRESERV. IL SCADENZA	
BOLLA CLIENTE N° DEL		RINNOVO PRESERV. IL SCADENZA	
BOLLA DI SPEDIZIONE N° DEL		MATERIALE IN ARRIVO CONTROLLO	MATERIALE IN SPEDIZIONE CONTROLLO
CERTIFICATO DI CONFORMITÀ N° 41 del 13/05/97			

MEDIA LARIO

C. Q. ACCETTAZIONE

FIRMA
DATA 20.05.97
N° LOTTO MI 957/09
MATERIALE ACCETTATO SI NO
NOTE:

mod. 8010d rl

UNAVIA

Servizio di assicurazione qualità

Certificato di conformità

Numero 41 Del 13/05/1997

Cliente MEDIA - LAZIO Ordine 0424 - 1997

N.Disegno 300943 Rev. - Tipo -

Denominazione UPPER SUPPORT POS 23

Quantità 3 Materiale INOX AISI 304 Colata MEDI ALLEGATI

Lotto 1 Serial Number 1 - 2 - 3 Fase COMPLETA

Materiale ricevuto con vs. bolla n. - del -

Rapporto di concessione n. - del -

Ciclo di lavoro n. ed edizione - del -

Si certifica che tutta la sopracitata fornitura è stata collaudata e se non altrimenti dichiarato, è stata trovata conforme al capitolato, disegno ed ordine ad essa relativo.

Note .....

il controllo qualità

ADS Srl - Corso Promessi Sposi, 23/d - 23900 Lecco - ITALY
Steward Observatory - University of Arizona - 933 N.Cherry Ave., Tucson Arizona 85721 - USA

COMMERCIALE FOND s.r.l.
GHISA - BRONZO - ALLUMINIO - OTTONE
IN BARRE E FUSIONI A MODELLO

CONTROLLO QUALITÀ
Quality Control Department

CERTIFICATO DI COLLAUDO
Rilasciato dal fornitore della Clas S.p.A.
Test Certificate - Certificat d'Essai - Werkprüfzeugnis

N. 97/004250
Data 9/04/97
Bollino n. 9602154
COLATA N. (Heat - Coulée - Schmelze) 224612

QUALITÀ (Quality - Qualité - Qualität) X5CRNI1810 (304) LAM.SOLUB. PIATTO P.100X50 UNI 6901-EU58

QUANTITÀ (Quantity - Quantité - Menge) KG 40

CLIENTE (Customer - Client - Besteller) UNAVIA MO

NS. RIFERIMENTO (Our reference) bolla del 09/04/97. N. 2565

COMPOSIZIONE CHIMICA % - CHEMICAL ANALYSIS % - COMPOSITION CHIMIQUE % - CHEMISCHE ZUSAMMENSETZUNG %

C	MN	SI	P	S	CR	NI	MO	PB
0,050	1,510	0,490	0,030	0,029	18,810	8,540		

CARATTERISTICHE MECCANICHE - CARACTERISTIQUES MECANIQUES - MECHANICAL PROPERTIES - MECHANISCHE EIGENSCHAFTEN

	TRATTAMENTO TERMICO	RS N/mm²	R N/mm²	A % 5	Z	HB
DI RIFERIMENTO ☐						
SU PRODOTTO ☒	SOLUDILIZZAZIONE	267,0	592,0	57,0	68,0	

PROVA JOMINY - JOMINY TEST - ESSAI JOMINY - STIRNABSCHRECKVERSUCH

T°C		1,5	3	5	7	9	11	13	15	20	25	30	35	40	45	50

INCLUSIONI NON METALLICHE | GRANO AUSTENITICO | ESAMI NON DISTRUTTIVI

CERTIFICATO EN 10204 2.2

ALTRE PROVE | COLLAUDI PARTICOLARI (RINA, ETC.) | NOTE

SI DICHIARA CHE QUESTO CERTIFICATO CORRISPONDE ESATTAMENTE ALL'ORIGINALE IN NOSTRO POSSESSO

Unavia
CONTROLLO QUALITÀ

LA RIMOZIONE O DISTRUZIONE DI QUESTO CARTELLINO DA PARTE DI PERSONE NON AUTORIZZATE È VIETATA

CLIENTE MEDIA-LARIO
FORNITORE UNAVIA

TIPO

DISEGNO N° 300942

LOTTO N° 1

QUANTITÀ 3

PARTITA ☐ , COLATA ☐

AISI 304

S/N ☐ COSTR. NR.

N/C ☐

DENOMINAZIONE PARTICOLARE
LEWER Support pos 22

PRESERVATO CON
SCADENZA

CARTELLINO N° 40

ASSIEME SUCCESSIVO DISEGNO N°
HEXAPOD

RINNOVO PRESERV. IL
SCADENZA

BOLLA CLIENTE N°
DEL

RINNOVO PRESERV. IL
SCADENZA

BOLLA DI SPEDIZIONE N°
DEL

MATERIALE IN ARRIVO

MATERIALE IN SPEDIZIONE

CERTIFICATO DI CONFORMITÀ N° 40 del 13/05/97

NOTE

MEDIA LARIO

C. Q. ACCETTAZIONE

FIRMA
DATA 20-05-97
N° LOTTO MIL 257/01
MATERIALE ACCETTATO SI NO
NOTE:

mod. 8010d rl

ADS Srl - Corso Promessi Sposi, 23/d - 23900 Lecco - ITALY
Steward Observatory - University of Arizona - 933 N.Cherry Ave., Tucson Arizona 85721 - USA

UNAVIA

Servizio di assicurazione qualità

Certificato di conformità

Numero 41 Del 13/05/1997

Cliente MEDIA-LARIO Ordine 0424-1997

N.Disegno 300942 Rev. - Tipo -

Denominazione LOWER SUPPORT

Quantità 3 Materiale ACC INOX 304 Colata VEDI CONF. MATER.

Lotto 1 Serial Number 1-2-3 Fase COMPLETI

Materiale ricevuto con vs.bolla n. - del

Rapporto di concessione n. 03 SN 01 00 03 300942 del 29/04/97

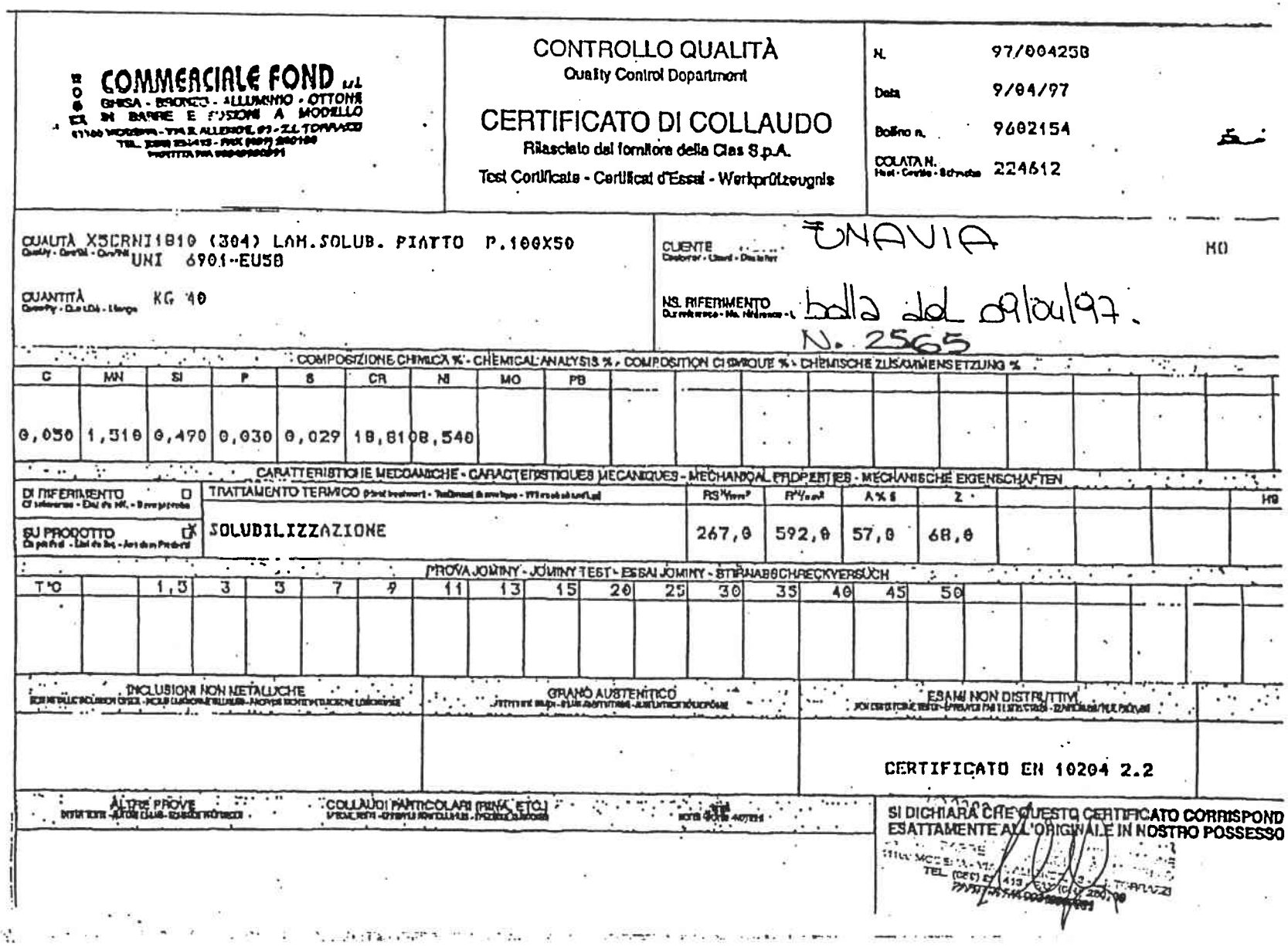
Ciclo di lavoro n. ed edizione / del /

Si certifica che tutta la sopracitata fornitura è stata collaudata e se non altrimenti dichiarato, è stata trovata conforme al capitolato, disegno ed ordine ad essa relativo.

Note .....

il controllo qualità

ADS Srl - Corso Promessi Sposi, 23/d - 23900 Lecco - ITALY
Steward Observatory - University of Arizona - 933 N.Cherry Ave., Tucson Arizona 85721 - USA



COMMERCIALE FOND s.r.l.
GHISA - BRONZO - ALLUMINIO - OTTONE
IN BARRE E FUSIONI A MODELLO

CONTROLLO QUALITÀ
Quality Control Dopartment

CERTIFICATO DI COLLAUDO
Rilasciato dal fornitore della Clas S.p.A.
Test Certificate - Certificat d'Essai - Werkprüfzeugnis

N. 97/0042SB
Data 9/04/97
Bollino n. 9602154
COLATA N. 224612

QUALITÀ X5CRNI1810 (304) LAM.SOLUB. PIATTO P.100X50
UNI 6901-EU58

QUANTITÀ KG 40

CLIENTE #UNAVIA

NS. RIFERIMENTO bolla del 09/04/97. N. 2565

COMPOSIZIONE CHIMICA % - CHEMICAL ANALYSIS % - COMPOSITION CHIMIQUE % - CHEMISCHE ZUSAMMENSETZUNG %

C	MN	SI	P	S	CR	NI	MO	PB
0,030	1,310	0,470	0,030	0,029	18,61	08,540		

CARATTERISTICHE MECCANICHE - CARACTERISTIQUES MECANIQUES - MECHANICAL PROPERTIES - MECHANISCHE EIGENSCHAFTEN

DI RIFERIMENTO	TRATTAMENTO TERMICO	RS N/mm²	RP 0,2	A %	Z	HB
SU PRODOTTO X	SOLUBILIZZAZIONE	267,0	592,0	57,0	68,0	

PROVA JOMINY - JOMINY TEST - ESSAI JOMINY - STIRNABSCHRECKVERSUCH

T °C		1,5	3	5	7	9	11	13	15	20	25	30	35	40	45	50

INCLUSIONI NON METALLICHE

GRANO AUSTENITICO

ESAMI NON DISTRUTTIVI

CERTIFICATO EN 10204 2.2

ALTRE PROVE

COLLAUDI PARTICOLARI (PRINC. ETC.)

SI DICHIARA CHE QUESTO CERTIFICATO CORRISPONDE ESATTAMENTE ALL'ORIGINALE IN NOSTRO POSSESSO

MMT CONVERSION

Doc.No : H9-DP-AD-001
Issue : 1
Date : Oct.1998

ADS Srl - Corso Promessi Sposi, 23/d - 23900 Lecco - ITALY
Steward Observatory - University of Arizona - 933 N.Cherry Ave., Tucson Arizona 85721 - USA

7. ACTUATOR COMPONENTS TESTING AT MANUFACTURERS PREMISES

7.1. Roller Screw

All the seven (7) roller screws were tested at the manufacturer premises (Rollvis, Geneve) to verify the static lead accuracy and the friction torque due to the applied preload (torque without load).
The following table reports the roller screws serial number and the corresponding tests executed for acceptance of components (roller screws test matrix):

Roller Screw S/N (spindle-nut)	Static Lead Accuracy	Torque without Load
8868-971508	✓	✓
8863-971509	✓	✓
8867-971510	✓	✓
8862-971511	✓	✓
8861-971513	✓	✓
8865-971514	✓	✓
8866-971507	✓	✓

The following pages report :

Test procedures for :
- measurement of the static lead accuracy,
- measurement of the preload torque,

Test results for :
- roller screws (7 items) tested for static lead accuracy and preload torque,

ROLLER SCREWS PERFORMANCE TESTING

ADS Srl - Corso Promessi Sposi, 23/d - 23900 Lecco - ITALY
Steward Observatory - University of Arizona - 933 N.Cherry Ave., Tucson Arizona 85721 - USA

ROLLVIS S.A. GENEVE

MESURE ET ANALYSE SUR CENTRE DE MESURE S.I.P.-422-M

TYPE DE VIS: RVR 260/20.1.R1.597089/1

NO. PIECE: 8861-971513

MESURE DU PAS AVEC/SANS ECROU

DIST. ENTRE 2 PTS. DE MES.: 6 MM LG. TOT. MESUREE: 48 MM

CALAGE DE LA MES.: 3 MM

CLIENT: 1655

DATE: 26 / 05 / 1997

OPERATEUR: R. Miszri

MES.NO.	ERREUR PAS(MM)	GRAPHIQUE DU PAS
0	0.000	
1	0.000	
2	-0.000	
3	-0.000	
4	-0.001	
5	-0.000	
6	-0.000	
7	0.000	
8	-0.000	

-10 +10

..=0.001 MM.

ROLLVIS SA
PROTOCOLLO DI MISURA DI UNA VITA

Tipo: RVRZ60.20.1.R1
Ordinazione No: 970186
No: 971513
Diametro [mm]: 20
Passo [mm]: 1
Lunghezza totale [mm]: 250
Lunghezza filetto [mm]: 22
Precarica [daN]: 45
Coppia [Ncm]: 6
Velocità [1/min]: 150
Lubrificazione: Topas

	Coppia media [Ncm]	Coppia max [Ncm]	Posizion. [mm]	Coppia min [Ncm]	Posizion. [mm]	Variazione [%]
——>	6.2	7.9	11.3	4.8	14.4	± 11.6
<——	-7.3	-8.9	9.2	-5.6	15.0	± 9.6

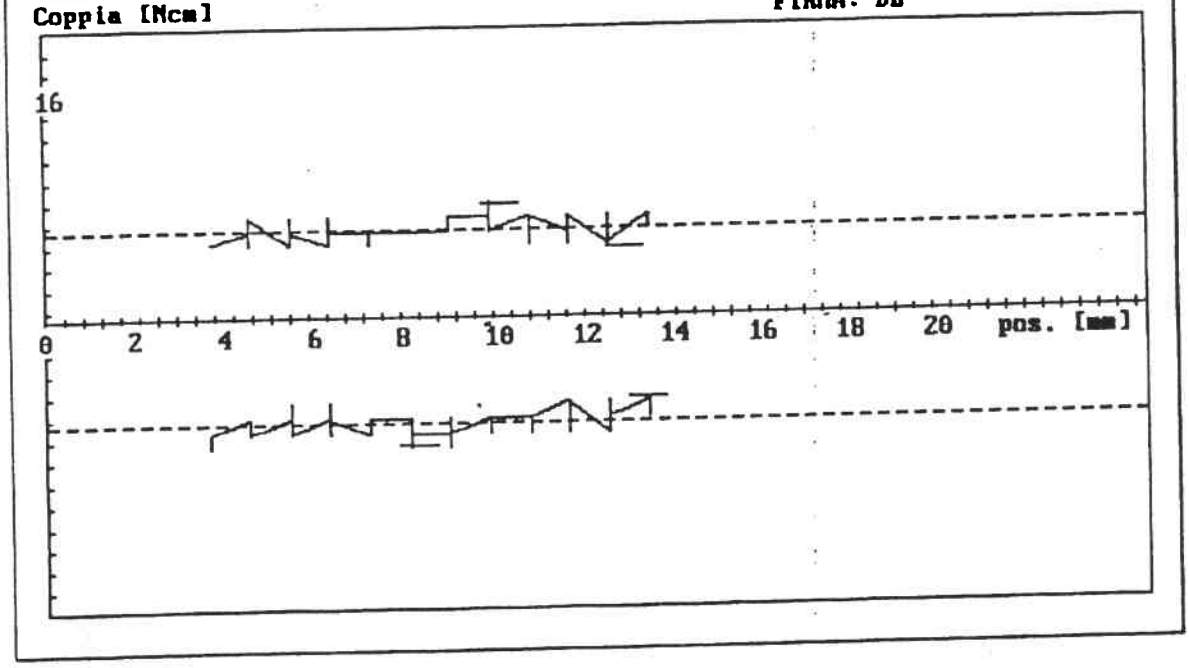
FIRMA: DB

Data: 06-03-1997

DIAGRAMMA DI COPPIA

No: 971513
Data: 06-03-1997
FIRMA: DB

ROLLVIS SA
Coppia [Ncm]



ROLLVIS S.A. GENEVE

MESURE ET ANALYSE SUR CENTRE DE MESURE S.I.P.-422-M

TYPE DE VIS: RVR 260/20.1.R1.597089/1

NO. PIECE: 8862 - 971511

MESURE DU PAS AVEC/SANS ECROU

DIST. ENTRE 2 PTS. DE MES.: 6 MM LG. TOT. MESUREE: 48 MM

CALAGE DE LA MES.: 3 MM

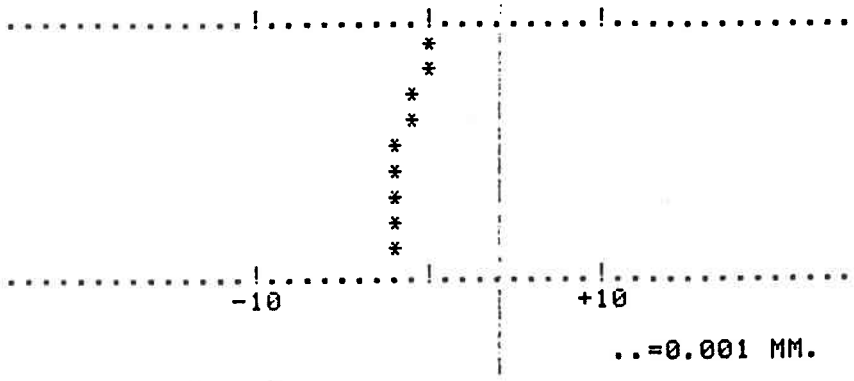
CLIENT: 1655

DATE: 26 / 05 / 1997

OPERATEUR: R. Misri

MES.NO.	ERREUR PAS(MM)
0	0.000
1	0.000
2	-0.000
3	-0.000
4	-0.001
5	-0.001
6	-0.001
7	-0.001
8	-0.002

GRAPHIQUE DU PAS



ROLLVIS SA
PROTOCOLO DI MISURA DI UNA VITA
Tipo: RVRZ60.20.1.R1
Ordinazione No: 970186
No: 971511
Diametro [mm]: 20
Passo [mm]: 1
Lunghezza totale [mm]: 250
Lunghezza filetto [mm]: 22
Precarica [daN]: 45
Coppia [Ncm]: 6
Velocità [1/min]: 150
Lubrificazione: Topas

	Coppia media [Ncm]	Coppia max [Ncm]	Posizion. [mm]	Coppia min [Ncm]	Posizion. [mm]	Variazione [%]
---->	7.1	9.5	4.8	5.1	16.2	± 12.3
<----	-6.0	-7.4	16.5	-4.9	10.8	± 9.2

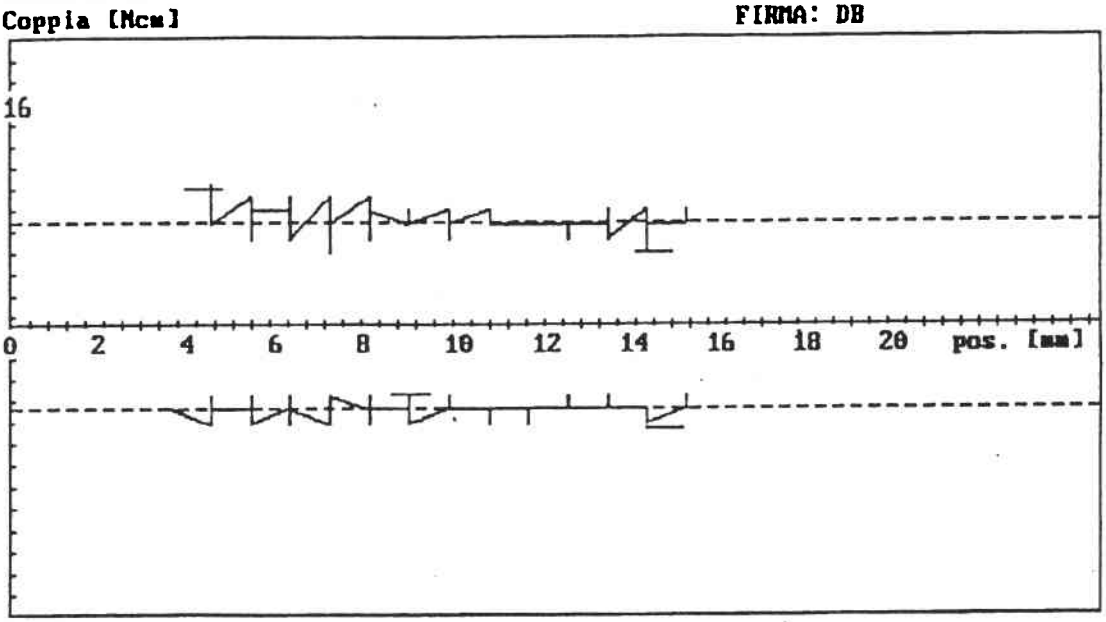
FIRMA: DB

Data: 06-03-1997

DIAGRAMMA DI COPPIA

No: 971511
Data: 06-03-1997
FIRMA: DB

ROLLVIS SA
Coppia [Ncm]



ROLLVIS S.A. GENEVE

MESURE ET ANALYSE SUR CENTRE DE MESURE S.I.P.-422-M

TYPE DE VIS: RVR 260/20.1.R1.597089/1

NO. PIECE: 8863 - 971509

MESURE DU PAS AVEC/SANS ECROU

DIST. ENTRE 2 PTS. DE MES.: 6 MM LG. TOT. MESUREE: 48 MM

CALAGE DE LA MES.: 3 MM

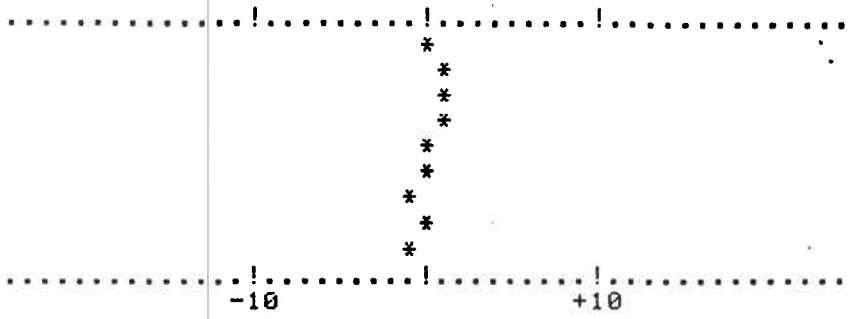
CLIENT: 1655

DATE: 26 / 05 / 1997

OPERATEUR: R. Misani

MES.NO.	ERREUR PAS(MM)
0	0.000
1	0.001
2	0.001
3	0.001
4	0.000
5	0.001
6	-0.000
7	0.000
8	-0.001

GRAPHIQUE DU PAS



..=0.001 MM.

ROLLVIS SA
PROTOCOLO DI MISURA DI UNA VITA
Tipo: RVR260.20.1.R1
Ordinazione No: 970186
No: 971509
Diametro [mm]: 20
Passo [mm]: 1
Lunghezza totale [mm]: 250
Lunghezza filetto [mm]: 22
Precarica [daN]: 45
Coppia [Ncm]: 6
Velocità [1/min]: 150
Lubrificazione: Topas

	Coppia media [Ncm]	Coppia max [Ncm]	Posizion. [mm]	Coppia min [Ncm]	Posizion. [mm]	Variazione [%]
——>	6.2	7.5	10.8	4.7	9.3	± 11.1
<——	-6.3	-8.0	7.3	-5.0	12.8	± 10.6

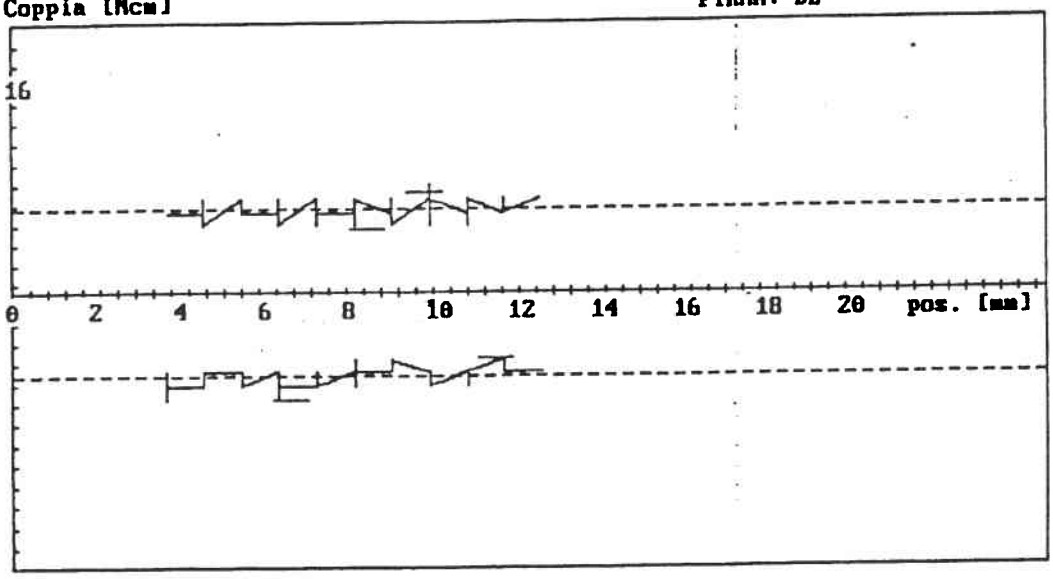
FIRMA: DB

Data: 06-03-1997

DIAGRAMMA DI COPPIA

No: 971509
Data: 06-03-1997
FIRMA: DB

ROLLVIS SA
Coppia [Ncm]



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Steward Observatory - University of Arizona - 933 N.Cherry Ave., Tucson Arizona 85721 - USA

ROLLVIS S.A. GENEVE

MESURE ET ANALYSE SUR CENTRE DE MESURE S.I.P.-422-M

TYPE DE VIS: RVR 260/20.1.R1.597089/1

NO. PIECE: 8865 - 97.1514

MESURE DU PAS AVEC/SANS ECROU

DIST. ENTRE 2 PTS. DE MES.: 6 MM LG. TOT. MESUREE: 48 MM

CALAGE DE LA MES.: 3 MM

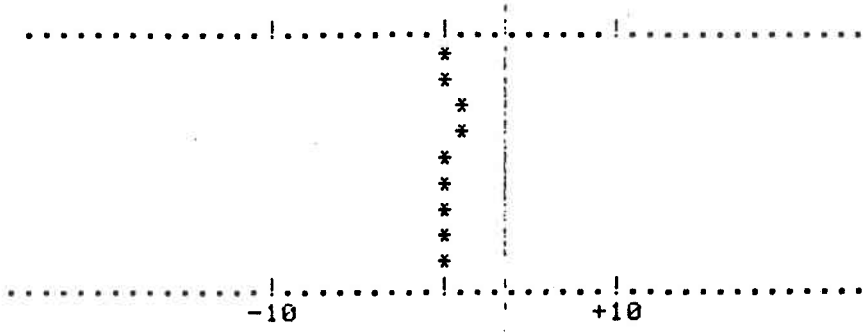
CLIENT: 1655

DATE: 26 / 05 / 1997

OPERATEUR: R. Misaru

MES.NO.	ERREUR PAS(MM)
0	0.000
1	0.001
2	0.001
3	0.001
4	0.000
5	0.001
6	0.000
7	0.001
8	0.000

GRAPHIQUE DU PAS



..=0.001 MM.

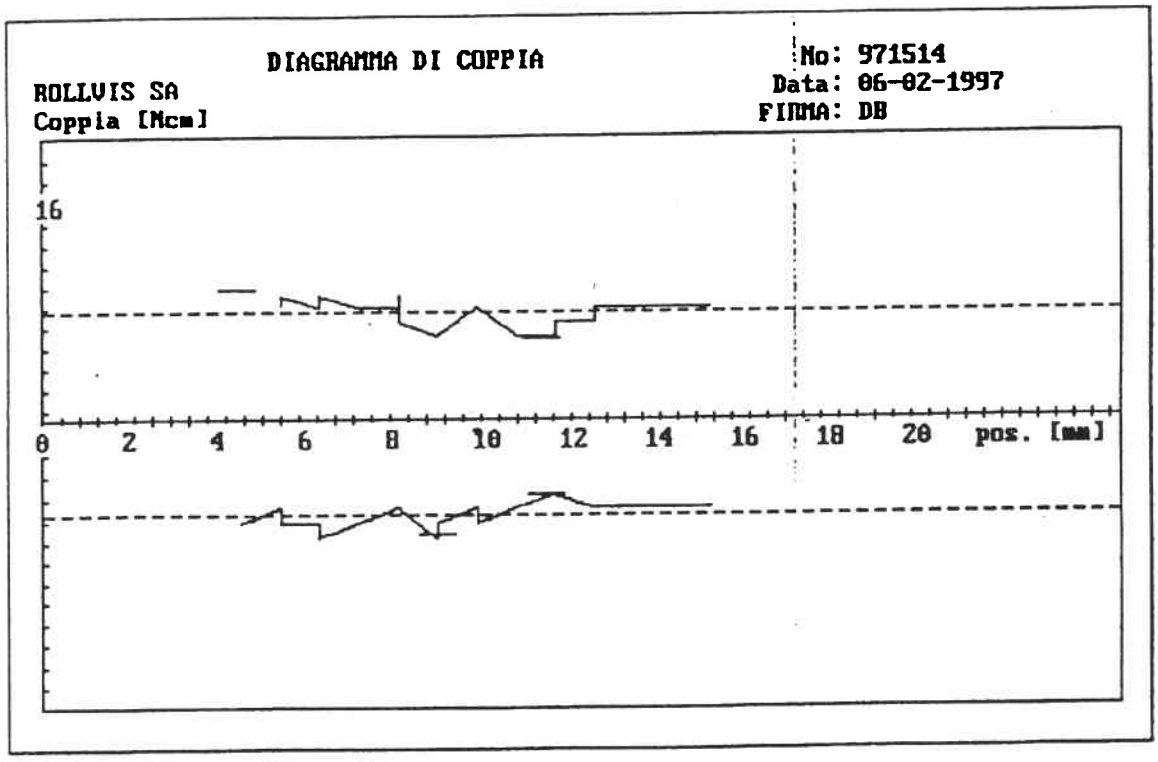
ROLLVIS SA
PROTOCOLLO DI MISURA DI UNA VITA

Tipo: RVR260.20.1.R1
Ordinazione No: 970186
No: 971514
Diametro [mm]: 20
Passo [mm]: 1
Lunghezza totale [mm]: 250
Lunghezza filetto [mm]: 22
Precarica [daN]: 45
Coppia [Ncm]: 6
Velocità [1/min]: 150
Lubrificazione: Topas

	Coppia media [Ncm]	Coppia max [Ncm]	Posizion. [mm]	Coppia min [Ncm]	Posizion. [mm]	Variazione [%]
---->	7.0	9.5	4.9	5.8	12.6	± 12.6
<----	-6.4	-7.7	10.0	-5.1	12.7	± 10.0

FIRMA: DB

Data: 06-02-1997



ADS Srl - Corso Promessi Sposi, 23/d - 23900 Lecco - ITALY
Steward Observatory - University of Arizona - 933 N.Cherry Ave., Tucson Arizona 85721 - USA

ROLLVIS S.A. GENEVE

MESURE ET ANALYSE SUR CENTRE DE MESURE S.I.P.-422-M

TYPE DE VIS: RVR 260/20.1.R1.597089/1

NO. PIECE: 8866.-.971507

MESURE DU PAS AVEC/SANS ECROU

DIST. ENTRE 2 PTS. DE MES.: 6 MM LG. TOT. MESUREE: 48 MM

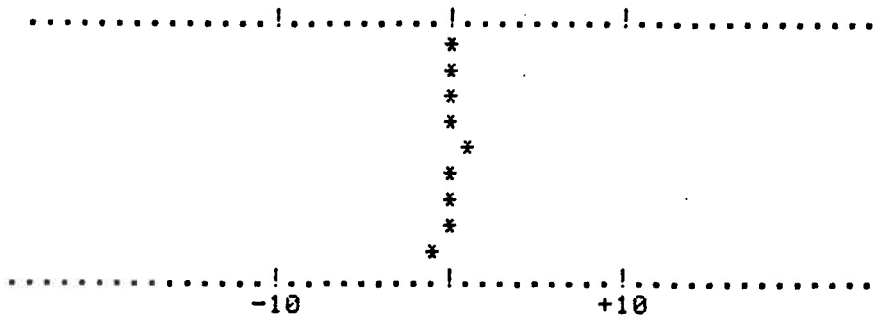
CALAGE DE LA MES.: 3 MM

CLIENT: 1655

DATE: 26 / 05 / 1997

OPERATEUR: R. Misani

MES.NO.	ERREUR PAS(MM)	GRAPHIQUE DU PAS
0	0.000	
1	0.000	
2	0.000	
3	0.000	
4	0.001	
5	0.000	
6	0.000	
7	0.000	
8	-0.000	

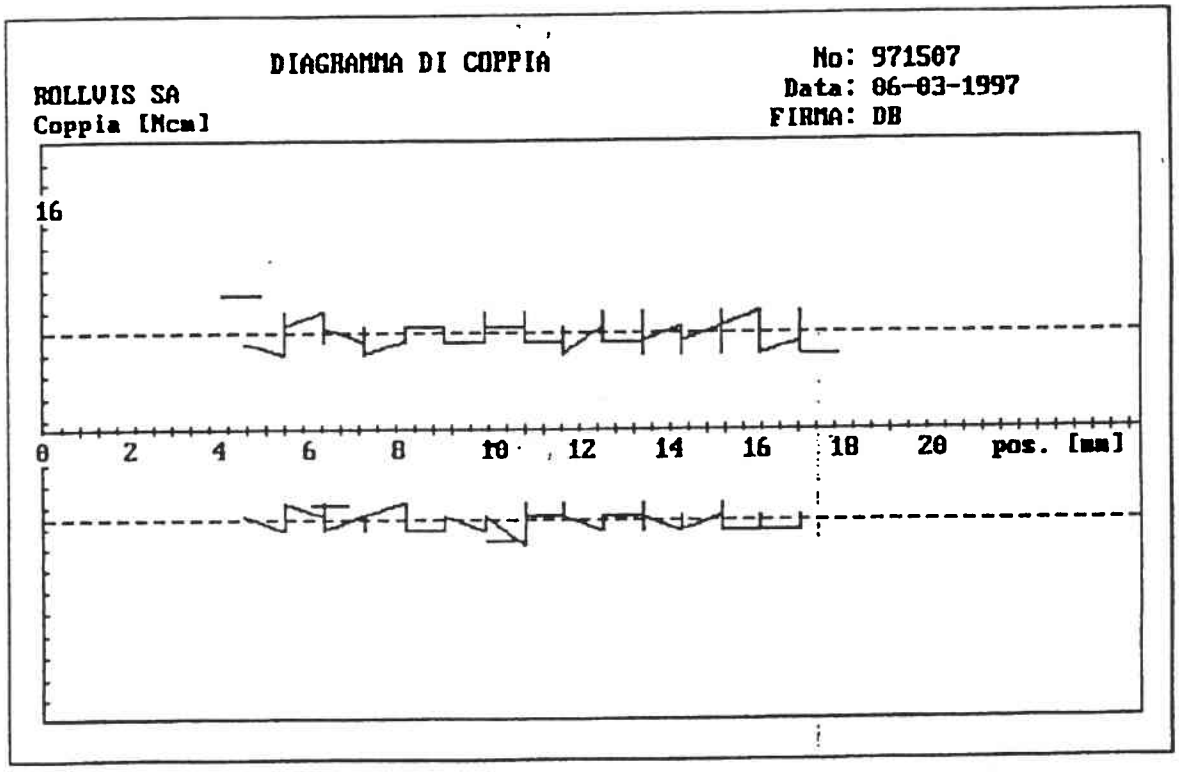


..=0.001 MM.

ROLLVIS SA
PROTOCOLLO DI MISURA DI UNA VITA
Tipo: RVR260.20.1.R1
Ordinazione No: 970186
No: 971507
Diametro [mm]: 20
Passo [mm]: 1
Lunghezza totale [mm]: 250
Lunghezza filetto [mm]: 22
Precarica [daN]: 45
Coppia [Ncm]: 6
Velocità [1/min]: 150
Lubrificazione: Topas

	Coppia media [Ncm]	Coppia max [Ncm]	Posizion. [mm]	Coppia min [Ncm]	Posizion. [mm]	Variazione [%]
——>	6.6	9.2	4.9	5.1	19.5	± 12.5
<——	-6.3	-7.7	11.5	-5.2	7.1	± 9.2

FIRMA: DB **Data: 06-03-1997**



ROLLVIS S.A. GENEVE

MESURE ET ANALYSE SUR CENTRE DE MESURE S.I.P.-422-M

TYPE DE VIS: RVR 260/20.1.R1.597089/1

NO. PIECE: 8868 - 971508

MESURE DU PAS AVEC/SANS ECROU

DIST. ENTRE 2 PTS. DE MES.: 6 MM LG. TOT. MESUREE: 48 MM

CALAGE DE LA MES.: 3 MM

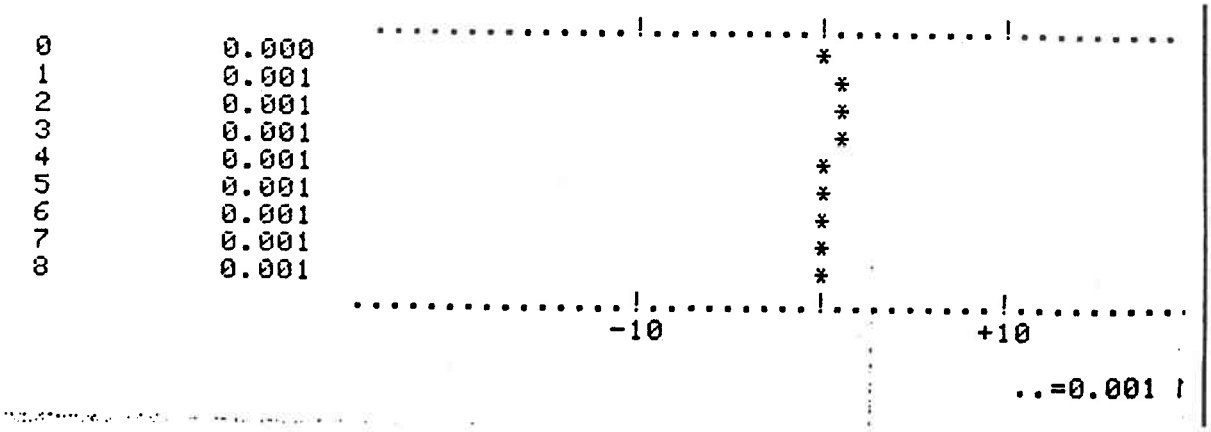
CLIENT: 1655

DATE: 26 / 05 / 1997

OPERATEUR: R. Misani

MES.NO.	ERREUR PAS(MM)
0	0.000
1	0.001
2	0.001
3	0.001
4	0.001
5	0.001
6	0.001
7	0.001
8	0.001

GRAPHIQUE DU PAS



ROLLVIS SA
PROTOCOLLO DI MISURA DI UNA VITA
Tipo: RVR260.20.1.R1
Ordinazione No: 970186
No: 971508
Diametro [mm]: 20
Passo [mm]: 1
Lunghezza totale [mm]: 250
Lunghezza filetto [mm]: 22
Precarica [daN]: 45
Coppia [Ncm]: 6
Velocità [1/min]: 150
Lubrificazione: Topas

	Coppia media [Ncm]	Coppia max [Ncm]	Posizion. [mm]	Coppia min [Ncm]	Posizion. [mm]	Variazi [%]
——>	5.7	7.3	0.5	4.1	17.0	± 12.
<——	-6.3	-7.8	18.1	-4.9	14.4	± 9.

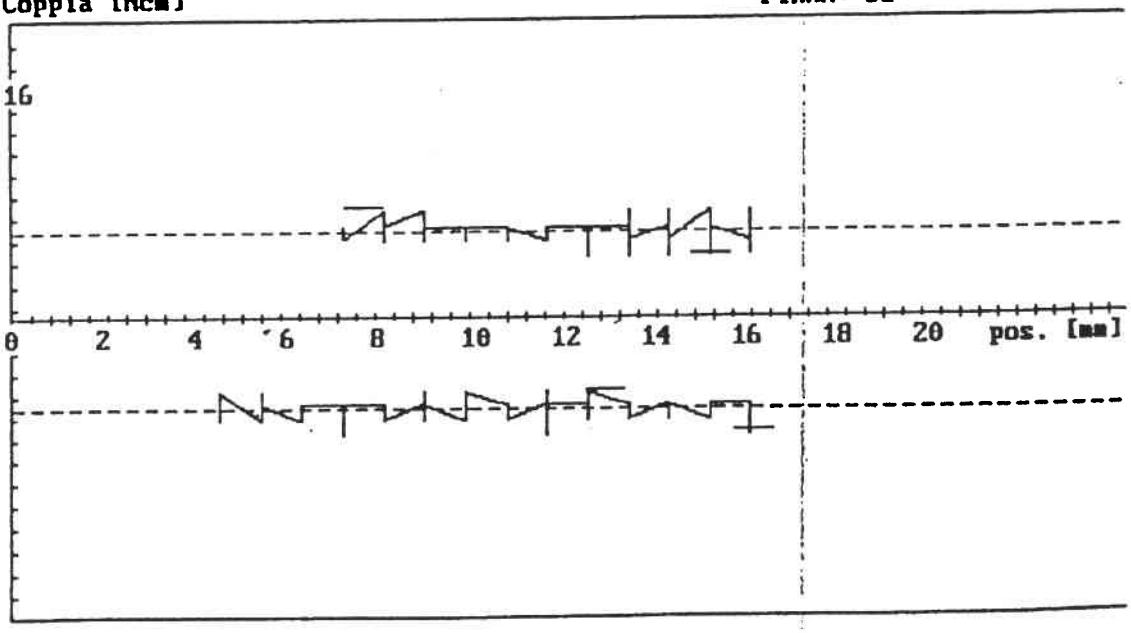
FIRMA: DB

Data: 06-03-19

DIAGRAMMA DI COPPIA

No: 971508
Data: 06-03-1997
FIRMA: DB

ROLLVIS SA
Coppia [Ncm]



ROLLVIS S.A. GENEVE

MESURE ET ANALYSE SUR CENTRE DE MESURE S.I.P.-422-M

TYPE DE VIS: RVR 260/20.1.R1.597089/1

NO. PIECE: 8867 - 971510

MESURE DU PAS AVEC/SANS ECROU

DIST. ENTRE 2 PTS. DE MES.: 6 MM LG. TOT. MESUREE: 48 MM

CALAGE DE LA MES.: 3 MM

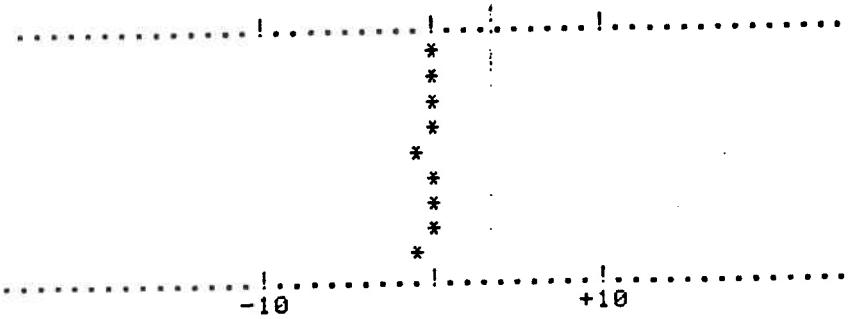
CLIENT: 1655

DATE: 26 / 05 / 1997

OPERATEUR: R. Misani

MES.NO.	ERREUR PAS(MM)
0	0.000
1	0.001
2	0.000
3	0.000
4	-0.000
5	0.000
6	0.000
7	0.000
8	-0.000

GRAPHIQUE DU PAS



..=0.001 MM.

ROLLVIS SA
PROTOCOLLO DI MISURA DI UNA VITE
Tipo: RVR260.20.1.R1
Ordinazione No: 970186
No: 971510
Diametro [mm]: 20
Passo [mm]: 1
Lunghezza totale [mm]: 250
Lunghezza filetto [mm]: 22
Precarica [daN]: 45
Coppia [Ncm]: 6
Velocità [1/min]: 150
Lubrificazione: Topas

	Coppia media [Ncm]	Coppia max [Ncm]	Posizion. [mm]	Coppia min [Ncm]	Posizion. [mm]	Variazione [%]
——>	7.6	9.5	11.5	5.3	7.0	± 12.3
<——	-7.3	-8.9	5.0	-6.2	8.0	± 11.8

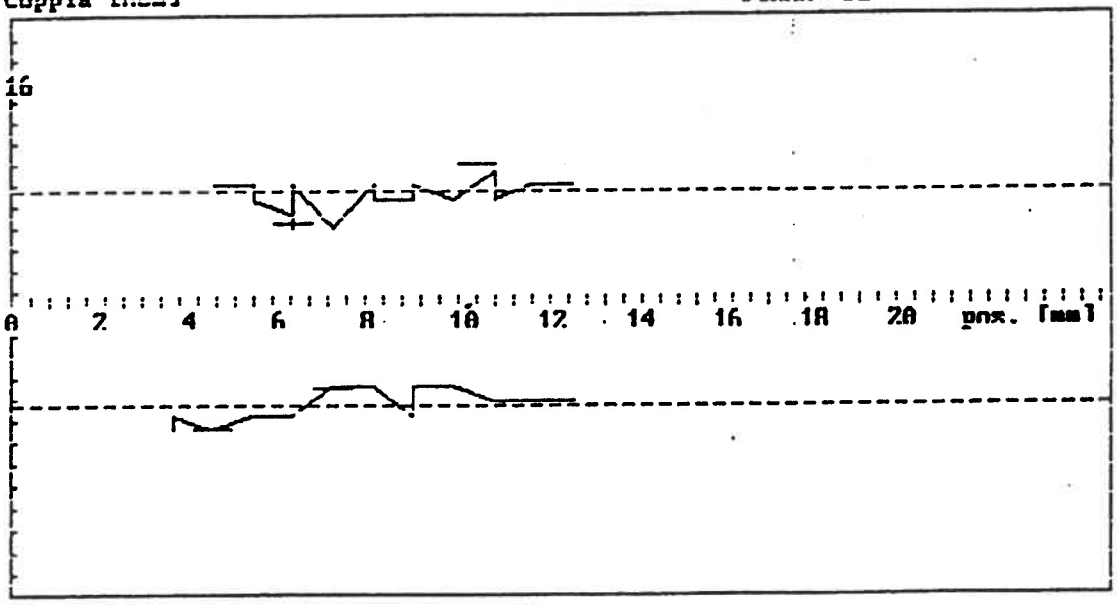
FIRMA: DB

Data: 06-02-1997

DIAGRAMMA DI COPPIA

No: 971510
Data: 06-02-1997
FIRMA: DB

ROLLVIS SA
Coppia [Ncm]



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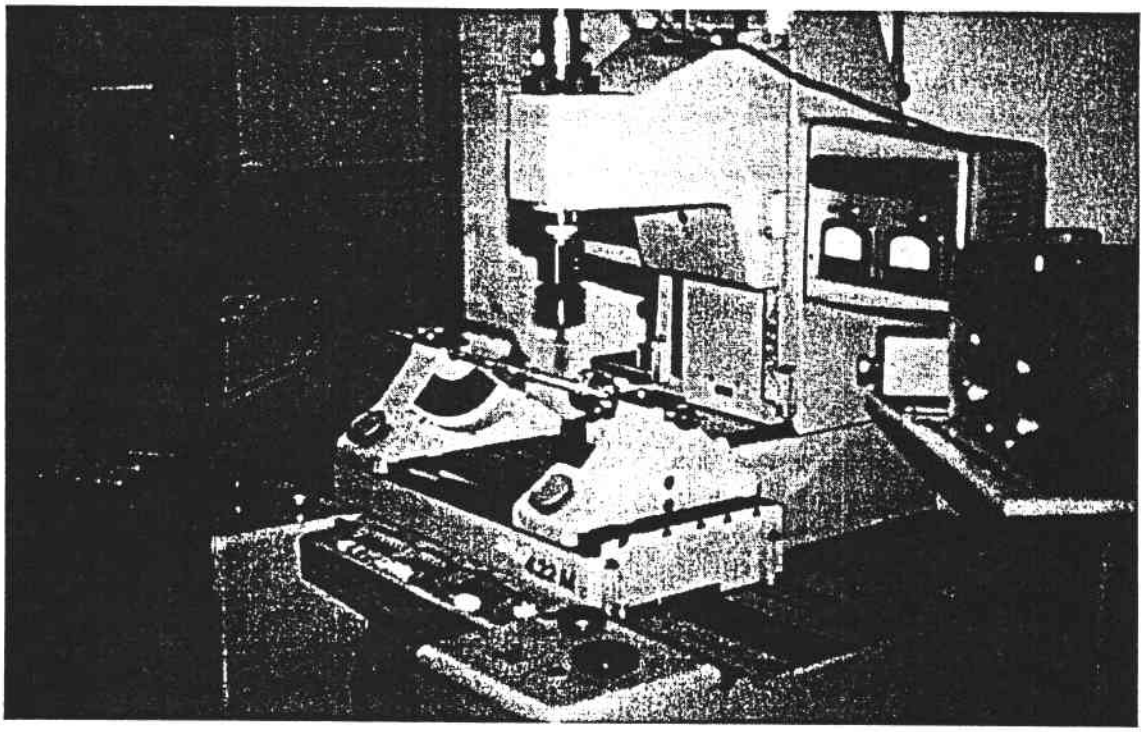
Measurement of Roller Screw Static Accuracy at Rollvis premises:



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8. ACTUATORS ACCEPTANCE TESTING IN AMBIENT CONDITION

The linear actuators were subjected to a performance test program in ambient conditions at ADS premises.

The following paragraphs describe these subjects:
(8.1) test equipment;
(8.2) test procedures;
(8.3) tests results;
(8.4) results analysis.

8.1. Test Equipment

The test equipment used for performance testing in ambient conditions is composed of:

1 mechanical test bench able to support the linear actuator and the measuring system
2 VME computer with acquisition and command units
3 electronics box (signal conditioners, motor driver etc.)
4 PC integrating optical measuring system controller, AD converter, serial connection (RS-232) to control the remote VME computer.

1. The mechanical test bench is composed by the following elements (see figures in the next page):

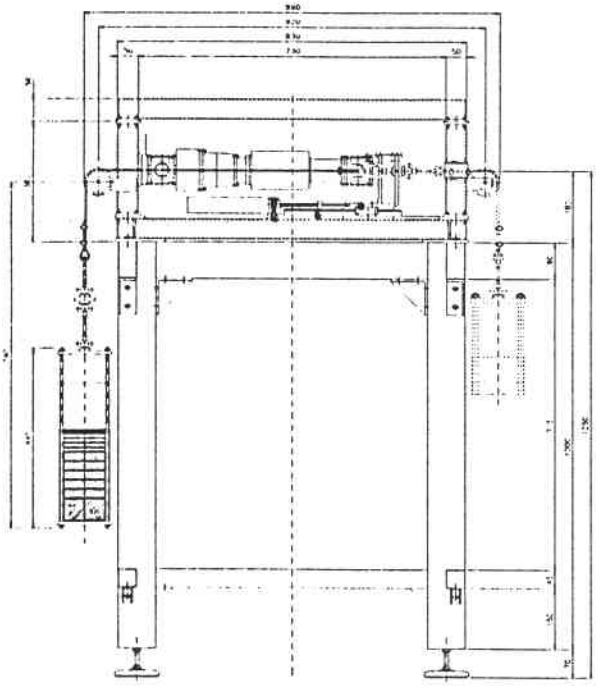
- An aluminum frame to support the test bench;
- A stainless steel frame supporting the linear actuator and with the corresponding load application system. The fixed part of the actuator is connected to an end column of the support structure through bolts while the movable part of the actuator is connected through bolts to a flange mounted to a preloaded sliding carrier running on a high precision linear guide.
- A high precision measuring system to be used as reference for the actuator position measurements, consisting on a Heidenhain optical linear incremental scale type MT101K (100 mm stroke, 0.1μm resolution) and the Heidenhain interpolation & digitizing electronics PC plug-in board).

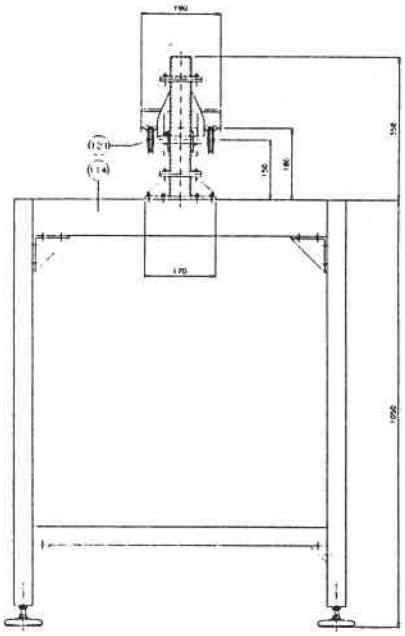
The test bench is designed to conduct the following tests on the actuators:

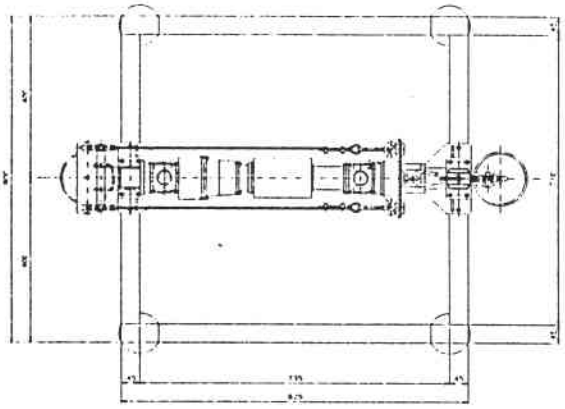
a) LVDT noise test
b) Positioning accuracy
c) Brake's effects
d) Axial stiffness,

The tests can be performed using different load conditions (tension or compression, and load level from 20N to 300N)

Mechanical Test Bench for Linear Actuator Testing in Ambient Condition:







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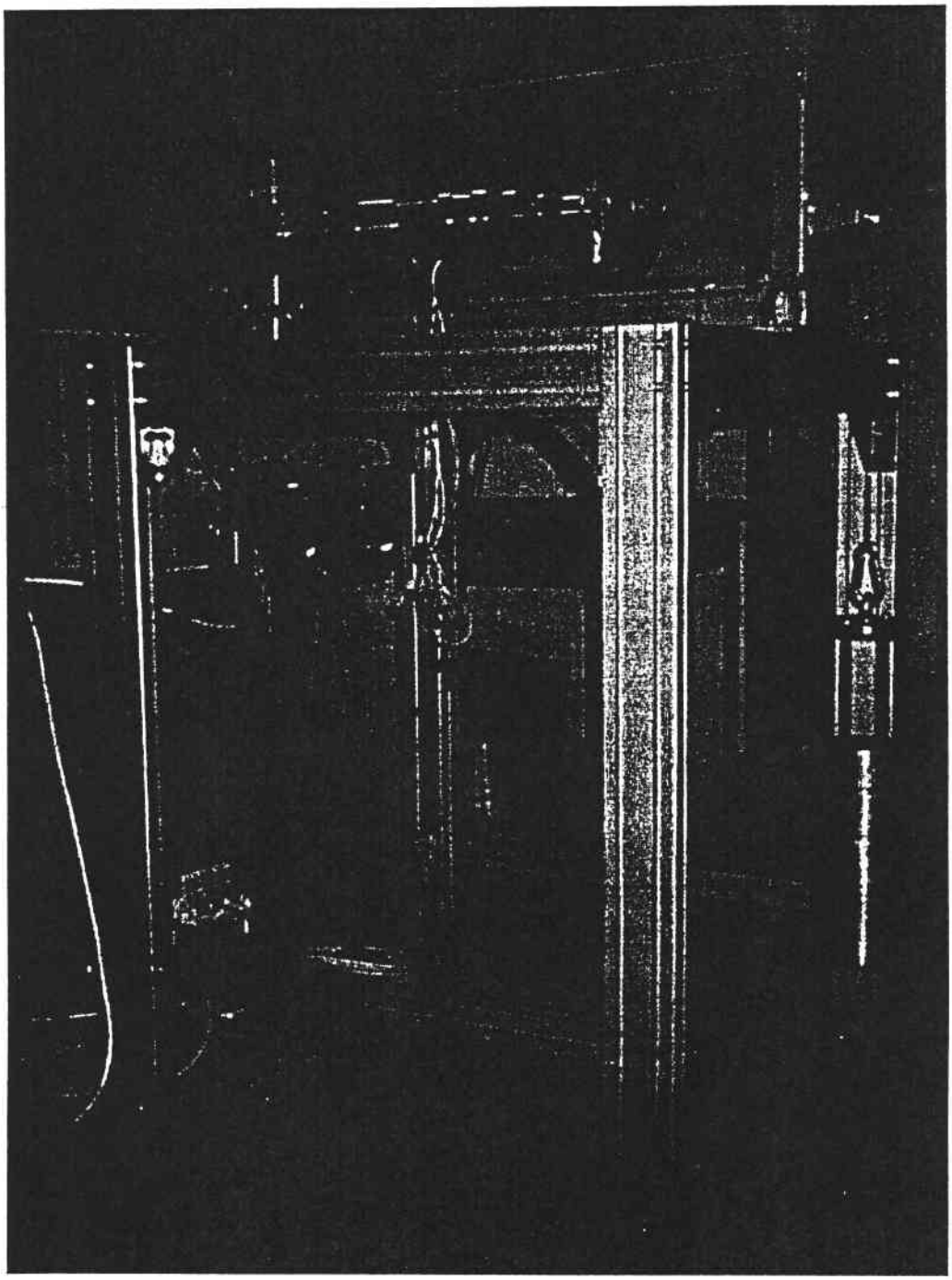
Mechanical Test Bench for Linear Actuator Testing in Ambient Condition:



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2. The VME computer, based on a Motorola processor, is provided by the University Of Arizona and it contains all the electronics needed to acquire analog and digital signals sent by the actuator and send back the desired position commands.
It also contains the control program that closes a position and velocity loop on the actuator. The computer works as a remote unit interfaced via RS-232 to the PC.

3. The electronics box, also provided by the University Of Arizona, works as an interface between the VME computer and the actuator.
It contains several devices:

- the motor driver
- the LVDT signal conditioner
- the brake driver (designed by University Of Arizona)
- the encoder signal conditioner (designed by University Of Arizona)

The motor driver is a 211A model made by Copley Control Corp.

The LVDT signal conditioner is a DCM-1000 direct current operated signal conditioner made by Macro Sensor, a division of Howard A. Schaevitz Technologies, Inc.

4. The PC used is an Intel Pentium based computer, with two ISA additional cards:

- optic linear transducer controller, Heidenhain EXE 922
- 12 bit, variable gain ADC, made by Intelligent Instrumentation (PCI 20248 W1)

The PC is used as an advanced terminal, capable of self-driving (via RS-232 port) all the necessary tests. The main program permits to send a pre-selected list of sequential VME command (i.e. "moverel", "showstat" etc...) and read the VME echo; besides, it permits to access the data read by the internal boards.

Through the information carried by the echo strings and through the readings made by the internal boards and their relative transducers, it's possible to collect all the informations about the actuator status: absolute actuator position (by optical linear reference), LVDT position, (by VME "showp" echo), embedded rotating encoder position (by VME "showstat" echo), LVDT analog out [DC Volts] (by PC AD Converter) and all the system informations provided by the VME commands called "showstat", "showp", "showc"....

8.2. Test procedure

8.2.1. Definitions

It's useful to report some definitions applicable to the actuator performances tests and measurements in order to have a common understanding to interpret and evaluate the test results.

a) LVDT typical noise

It's defined as the *standard deviation of the LVDT DC analog out*.

b) Positioning closed-loop accuracy of the actuator:

When a displacement is commanded to the actuator, the positioning accuracy of the actuator is defined as the *difference between the actual position reached by the actuator* (and measured by the optical linear scale of the test bench, considered as absolute reference for the measurement) *and the position measured by the LVDT sensor* .

The positioning closed-loop accuracy of the actuator depends on:

- the control law chosen, the sensors accuracy;
- the screw lead error distribution along the stroke;
- the roller screw behavior considered as a whole driving unit;
- motor and encoder angular resolution;
- hysteresis due to the inversion of motion;
- stick-slip phenomena;
- thermo-elastic deformation due to temperature gradients;
- changes in axial stiffness (therefore in elongation at constant applied load) depending on the actuator stroke;
- command discretization and controller error;
- other mechanical errors (misalignments, etc).

c) Brake induced error

It is defined as the *actuator displacement*, read by the optical linear external reference, *due to the brake status commutation (On/Off).*

d) Axial stiffness

It is the *actuator axial stiffness*, the ratio between the axial load and the displacement measured by the optical linear scale of the test bench.

8.2.2. Procedures

The tests were performed on each one of the seven (6+1) linear actuators.

a) LVDT noise test
This test was performed to characterize the noise level of the LVDT sensor. The test consists in acquiring the LVDT analog out by the previously described acquisition card (PCI 20248 W1).

The test is arranged in two different configuration. In the first case only the LVDT sensor and its conditioning electronic are supplied and the ADC reads a signal relative to a fixed position of the actuator.

In the second case the same kind of measurement is performed after having:

1) powered the complete system
2) initialized the closed loop controller
3) killed the closed loop controller (open loop conditions)

Obviously, the actuator is perfectly still in both the cases but in the second one the noise level can be affected by electric crosstalk between the LVDT and the motor.

b) Position accuracy test

This kind of test permits to obtain the position accuracy through twelve series of measures that cover all the screw length.
Each one of this series is composed by twenty independent absolute positioning commands between two fixed stations.
The first fixed position is always the same (A) for all tests, near the maximum actuator elongation, while the second one (B) *moves from the maximum elongation point to the minimum one* as the series number increases (see figure below).

Set 1 14000 to (14000+3000) LVDT counts A ⟷ B

Set 2 14000 to (14000+6000) LVDT counts A ⟷ B

... ...

Set 12 14000 to (14000+36000) LVDT counts A ⟷ B

Because of the absence of an absolute positioning VME command, we used the "moverel" keyword in such a way that permits to arrange an absolute positioning.
This is possible because of another VME keyword: "showp".
In fact, as the *Test Manager Program* reads the new absolute commanded position (point A or B), it checks the current position ("showp") and calculates the distance between this position and the desired one.
After having sent a new command, the *Test Manager* waits for the complete positioning of the actuator and then reads the reached position through the optical linear reference.

For each set, the *worst accuracy positioning achieved and the accuracy positioning standard deviation* are evaluated.

Here is presented the test sequence performed by the Test Manager:

- read the desired absolute command from ASCII file (X1)
- **SHOWP**
- read VME echo: **Chan 0: curp: CURPOS**
- store CURPOS (LVDT reading) that is the current absolute position
- calculate X2 to get (by MOVEREL X2) the desired absolute position (X1) moving from CURPOS
- **MOVEREL X2**
- read VME echo: **value = X3**
- store X3 that represents the really commanded final position
- .....wait for the actuator positioning .....
- read Heidenhain linear reference (before) = h1
- **SHOWP**
- read VME echo: **Chan 0: curp: X4**
- store X4 (LVDT reading) that is the actual position
- read Heidenhain linear reference (after) = h2
- calculate the average linear reference position h =(after+before) = (h2+h1)/2
- store the generic step data: X1; X4; h; X3

The positioning error is defined as follows:

Error := X3 / sens – h * 1000

where:

[X3] = counts
[sens] = counts/micron
[h] = mm

c) Brake's effects test

The test is performed to evaluate the typical brake induced error.
In fact the brake's action determines a perturbation of the current actuator position and the magnitude of this phenomena depends on the control system reactivity.

The measure we arranged is characterized by thirty status changes ("brake 0"/"brake 1"); after having initialized the closed loop controller, the actuator position is read before and after each status change (through the optical linear reference).
Once calculated the displacements caused by the brake's commutations (from 0 to 1), the *brake induced error standard deviation and the biggest brake induced error are evaluated.*

The test is performed in two different load conditions (traction load): 0 and 250 N.

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The same kind of test has been repeated in open loop conditions. The informations provided by this kind of test are very useful because they are independent from the control law reactivity and permit to separate the brake's effect from the control law effects.

d) Axial stiffness

This test permits to obtain the actuator axial stiffness through the measurement of two sets of displacements caused by a known set of axial load conditions.
At first, the load set is applied to the actuator and a first set of displacement is measured. Then the same kind of load set is applied to a stainless steel beam of known stiffness, replacing the actual actuator. In this way it is possible to calculate the test bench stiffness and then the real actuator stiffness.

The displacements have been measured by the optical linear reference with a resolution of 0.1 micron while the loading masses have been evaluated with an accuracy of 0.01 kg.
The stiffness is calculated in two different system configuration:

a) Switched off system, brake close
b) Switched on system, brake close

The loading procedure, repeated three times for each of the two configurations, consists in a load increase course and a decreasing one.

The sequence of applied masses is the following:

0 - 2 - 4 - 6 - 8 - 9 - 11 - 13 - 14 - 16 - 18 - 23 - 18 - 16 - 14 - 13 - 11 - 9 - 8 - 6 - 4 - 2 - 0 Kg

In this way it is possible to show the hysteresis of the axial load response.

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8.3. Test results

This paragraph summarizes settings and test results for the seven (6+1) linear actuators. One actuator caused a failure in the control electronics, possibly because a damage occurred in its encoder board (TBC). It was left as spare and not further tests were carried out.

8.3.1. Actuators setting

In the following table the most significant setting values (LVDT counts, LVDT analog out, linear displacement) of each actuator, relative to the two limit switch positions, are reported. The actual stroke set during the functional tests is about ± 7.5 mm and the LVTD calibration refers to this configuration. The limit switch contacts can be modified to achieve larger strokes if needed.
Besides the LVDT sensitivity, in terms of counts/μm and mV/μm, is evaluated.
Before starting the initialization procedure, each actuator has been set to its nominal length (0.330 m) and then the LVDT bar position has been regulated so that the sensor DC out would be nearly 0 V.

	Act. 1 SX	**Act. 2 SX**	**Act. 3 SX**	**Act. 4 DX**	**Act. 5 DX**	**Act. 6 DX**	**Extra Act.**
LVDT out volts ^	-5.09	-6.55	-6.33	- 5.93	-5.62	-5.38	-
LVDT out volts *	5.19	5.67	6.68	5.96	6.30	6.05	-
Δ LVDT [V]	10.28	12,22	13.01	11.89	11.92	11.43	-
LVDT counts ^	16097	11335	12041	13338	14361	15129	-
LVDT counts *	49748	51309	54606	52270	53372	52576	-
Δ LVDT counts	33651	39974	42565	38932	39011	37447	-
Δ x axial displ. μm	12573.0	15075.1	15904.9	14800.4	14743.0	14019.5	-
LVDT sens: count/μm	**2.67**	**2.65**	**2.67**	**2.63**	**2.64**	**2.67**	-
LVDT sens: mV/μm	**0.817**	**0.810**	**0.817**	**0.803**	**0.808**	**0.815**	-

(^) positive limit switch position; (*) negative limit switch position

8.3.2. Results

Each test is discussed independently and then a final table is reported.

a) LVDT noise

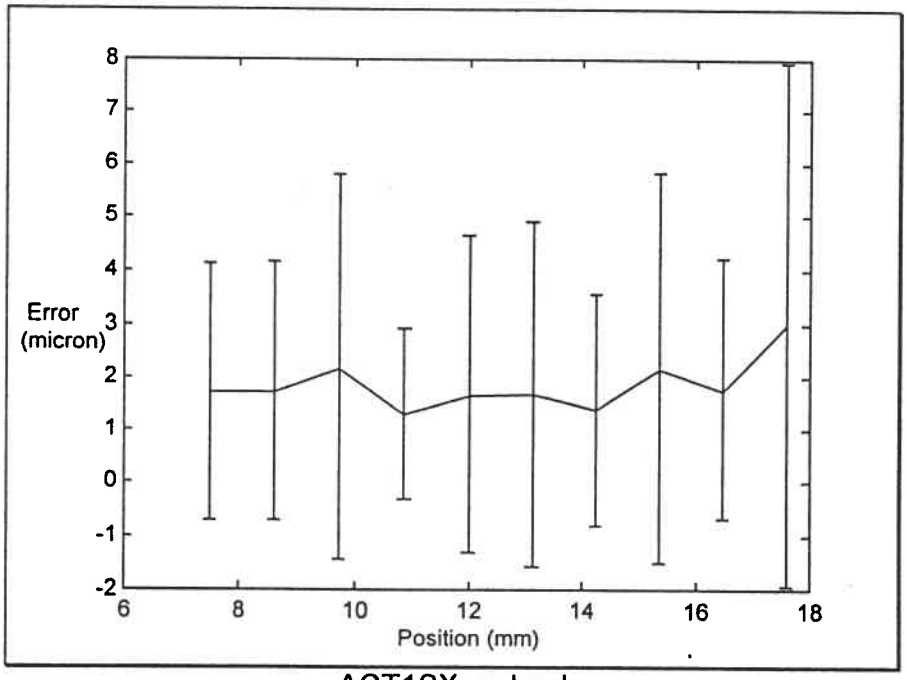
σ [mV]	Act. 1 SX	Act. 2 SX	Act. 3 SX	Act. 4 DX	Act. 5 DX	Act. 6 DX	Extra Act.
LVDT only	1.29	1.23	1.21	1.33	1.44	1.04	-
Op. cond.	12.43	12.53	12.50	12.40	13.71	12.22	-

Though the actuator is perfectly still in both the cases (motor off and on), in the second one the noise level is a order of magnitude bigger.
It's our opinion that this extra-noise depends on the grounding layout of the whole system, but we can't find a better test configuration than the test one.
This factor *strongly affects the overall system performances*.

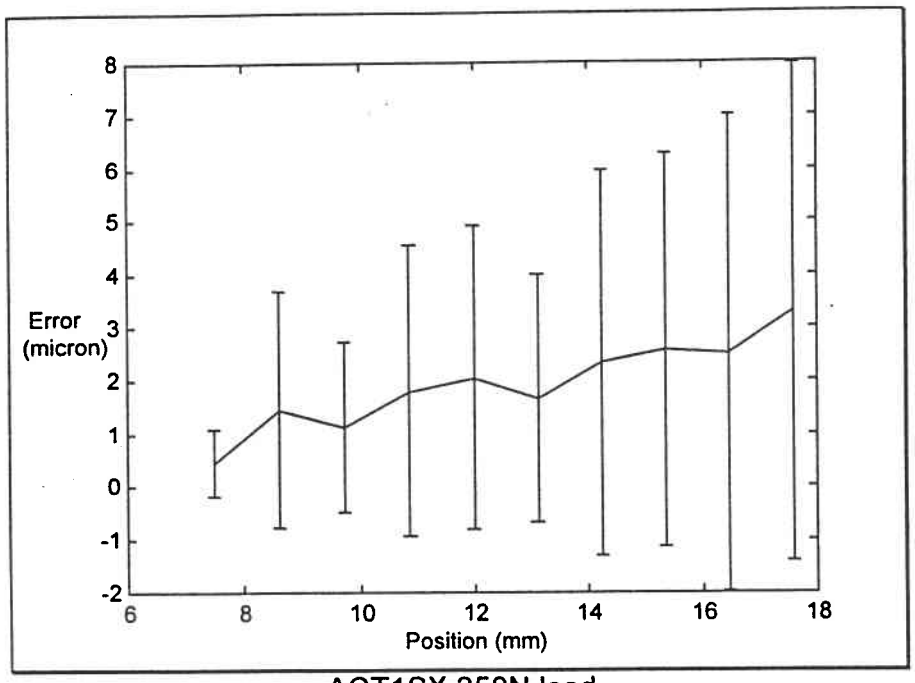
b) Closed loop accuracy

The position accuracy achieved for each actuator is plotted. The continuous line is the positioning error standard deviation, computed over each set of movement that arrives to the same position on the screw starting.

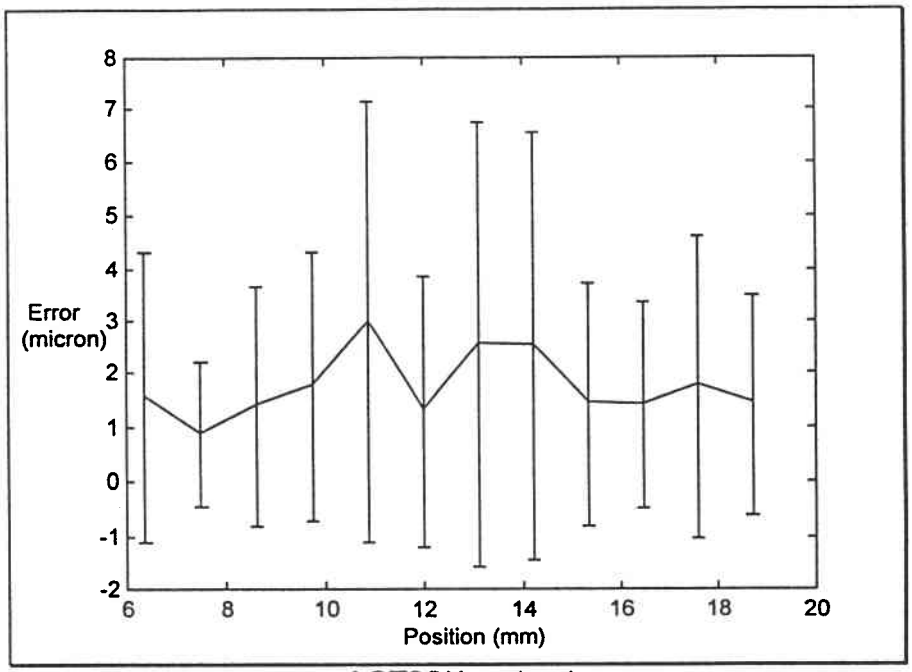
The error bar represent the delta between the smaller and the larger error around each nominal position.



ACT1SX no load



ACT1SX 250N load



ACT2SX no load

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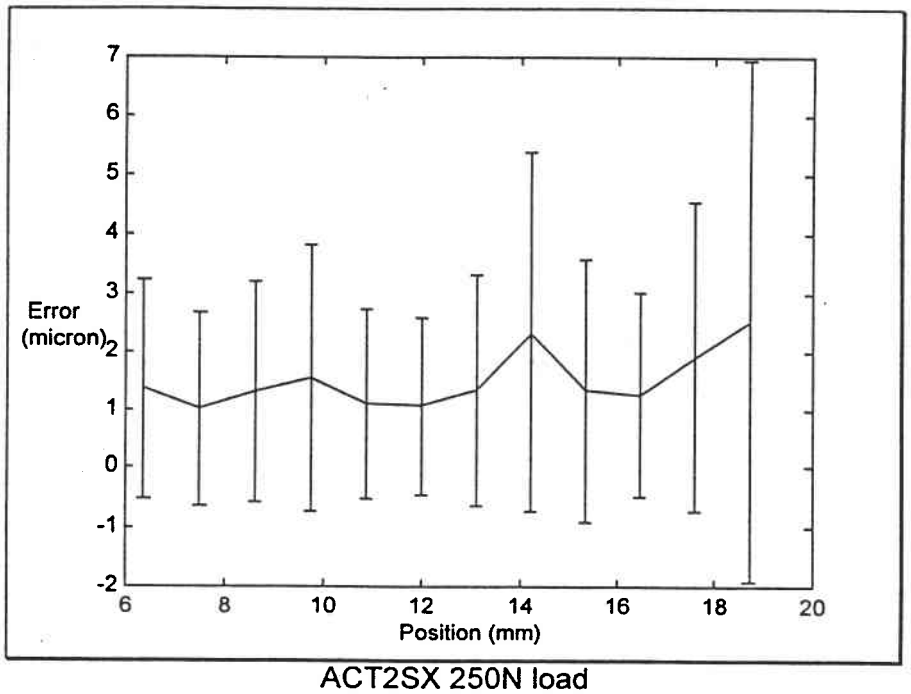
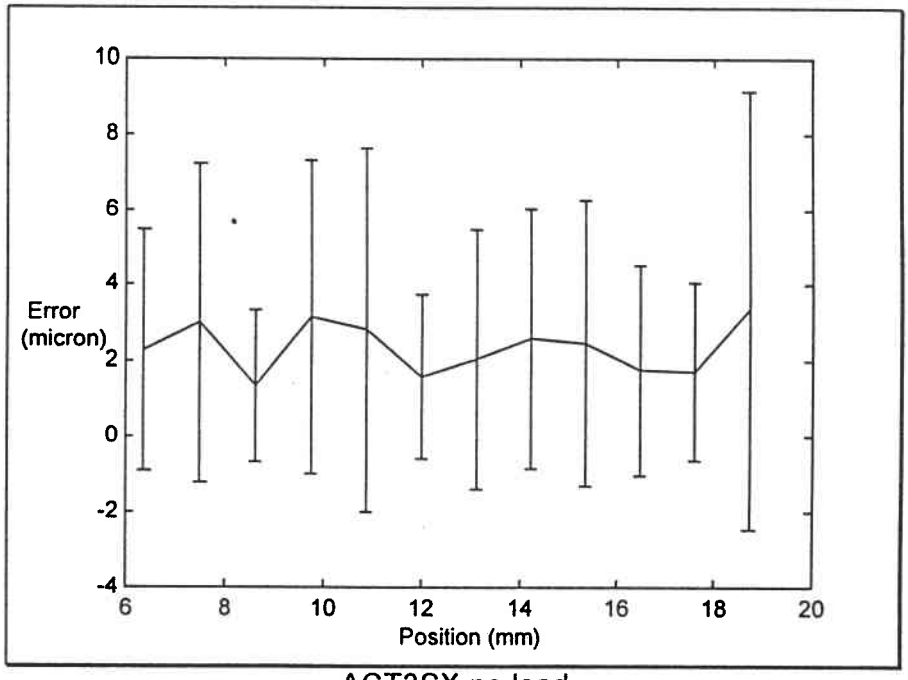
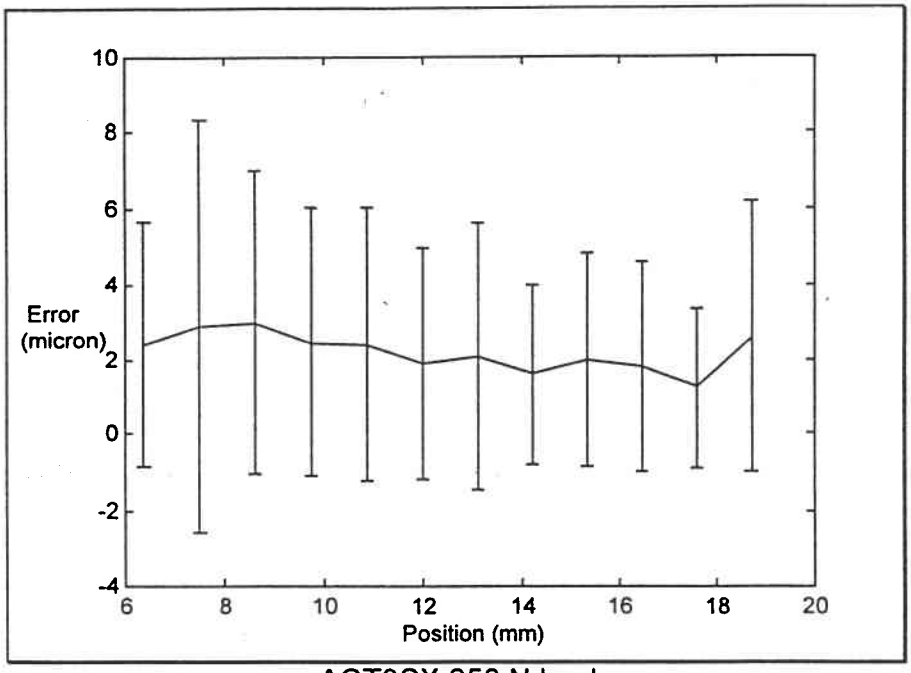


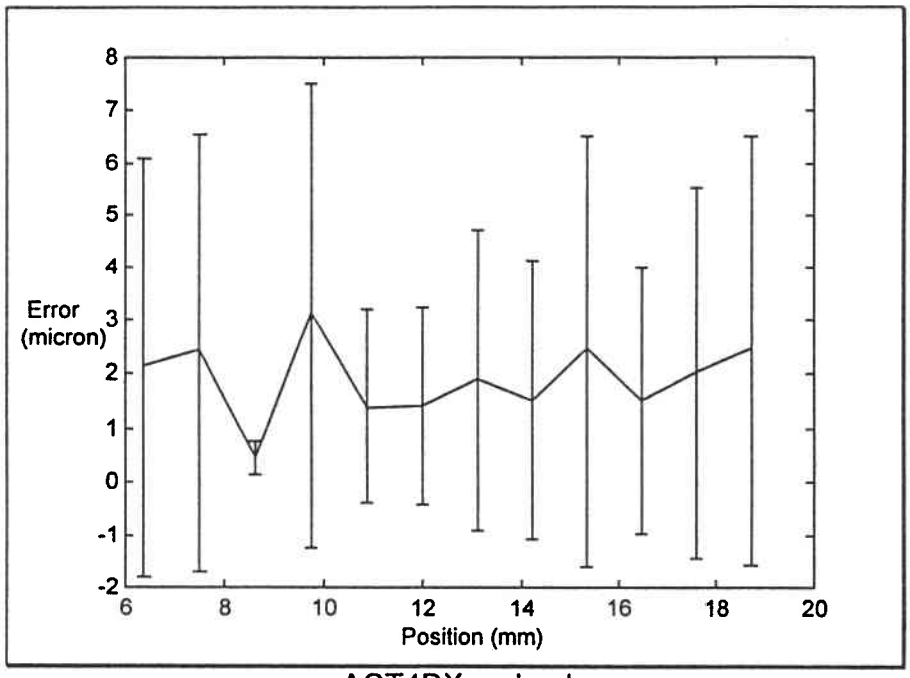
ACT2SX 250N load



ACT3SX no load



ACT3SX 250 N load



ACT4DX no load

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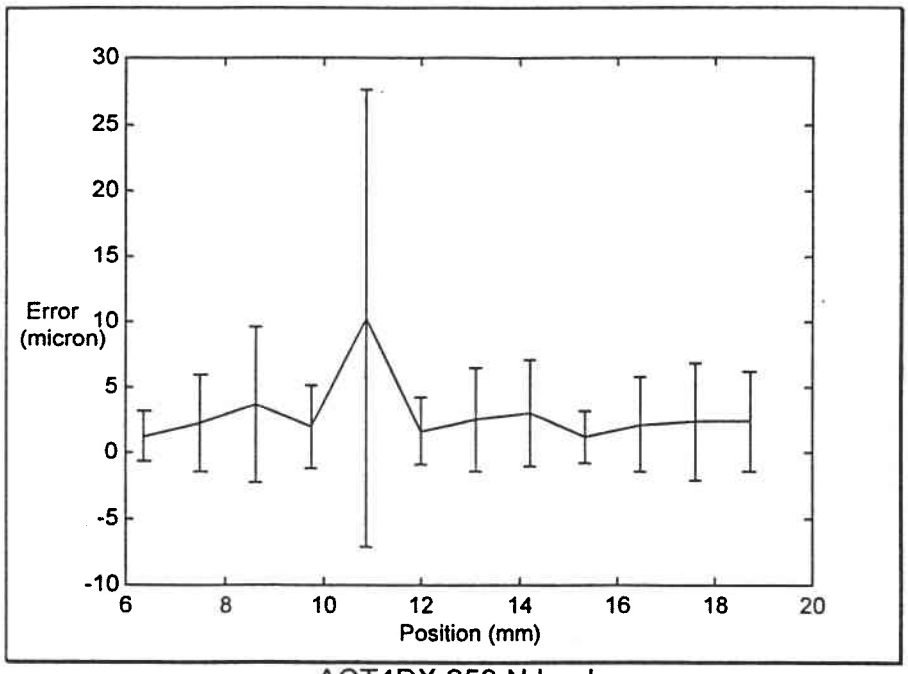
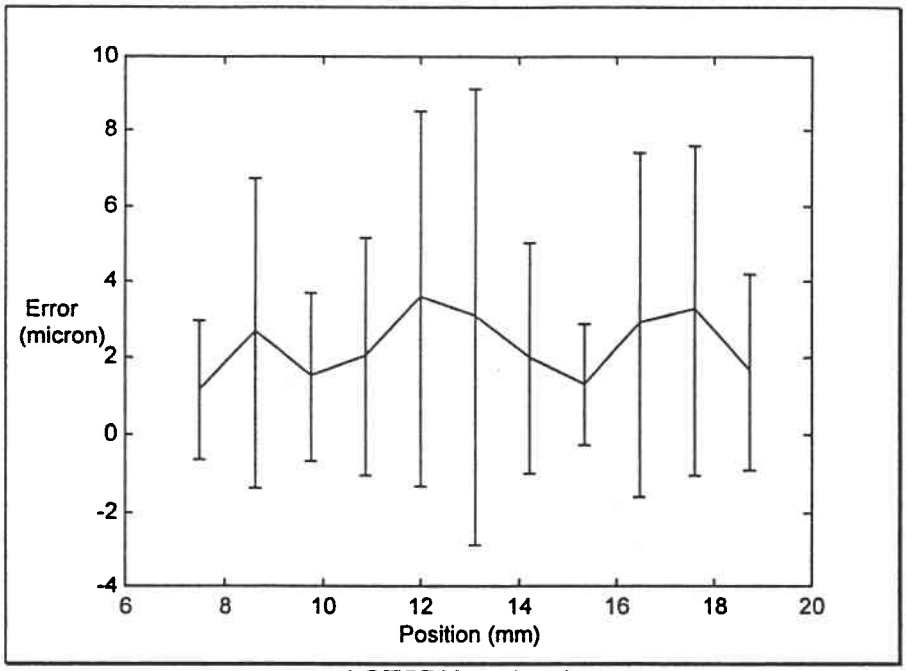
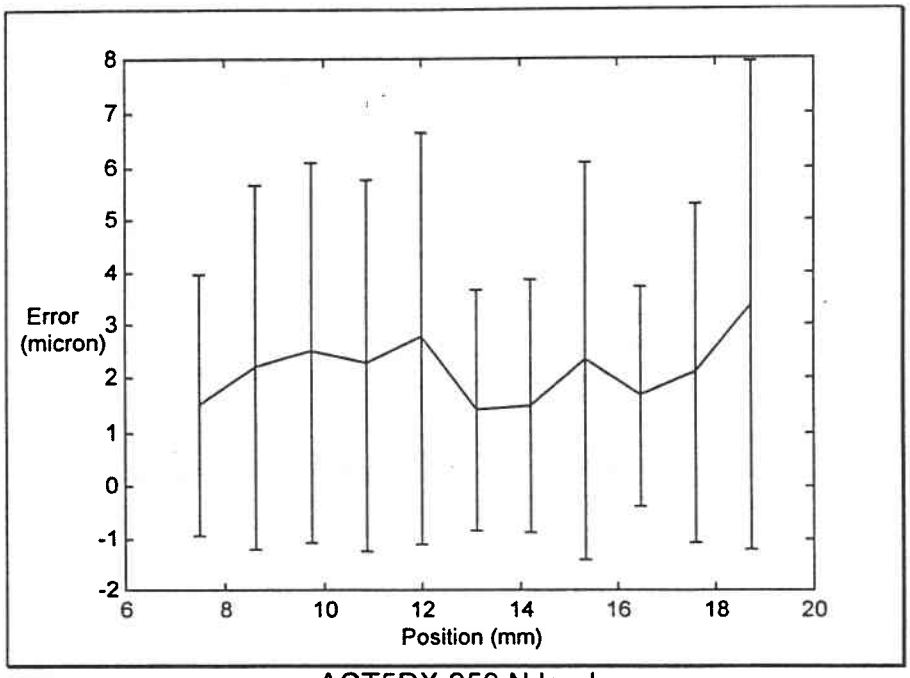


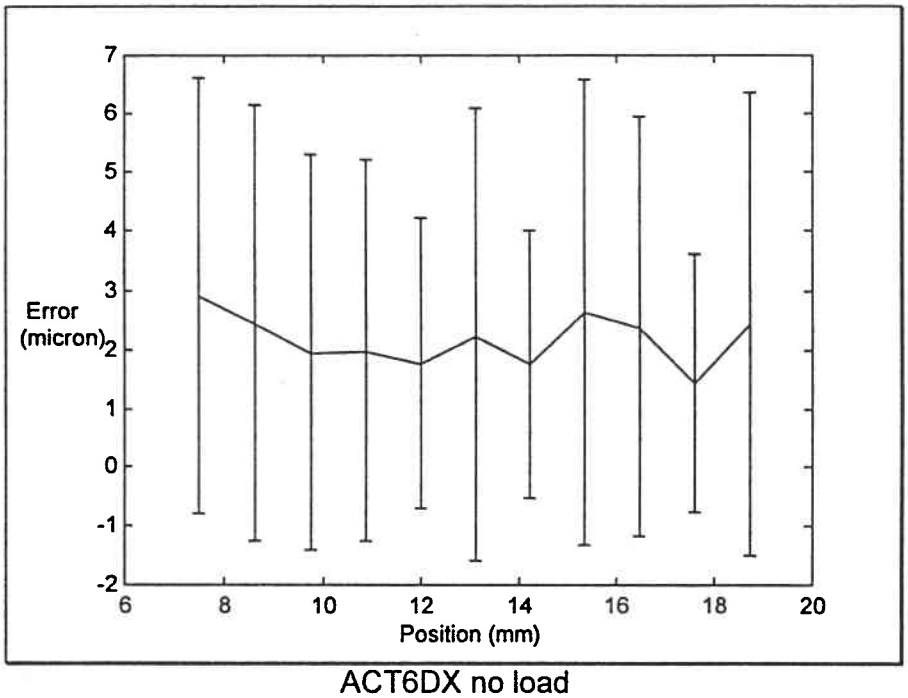
ACT4DX 250 N load



ACT5DX no load



ACT5DX 250 N load



ACT6DX no load

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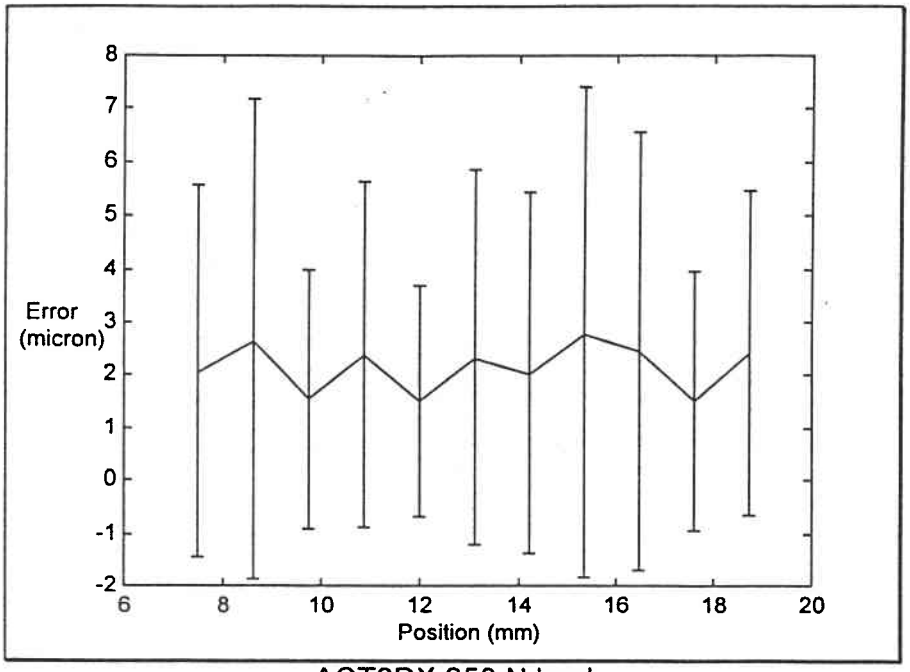


ACT6DX 250 N load

iii) Brake's effects

The positioning error is reported for each actuator both for the Closed Loop control and the Open Loop one.

Closed loop results:

[μm]	Act. 1 SX	Act. 2 SX	Act. 3 SX	Act. 4 DX	Act. 5 DX	Act. 6 DX	Extra Act.
σ	0.22	0.54	0.10	0.4	0.57	0.29	-
σ (+W) (*)	0.25	0.39	0.12	0.7	0.57	0.21	-
max	0.55	1.65	0.30	0.9	1.65	1.25	-
max (+ W)	0.75	1.15	0.35	1.7	1.60	0.75	-

(*) The «+ W» tests are performed with an additional mass as traction load (25 Kg)

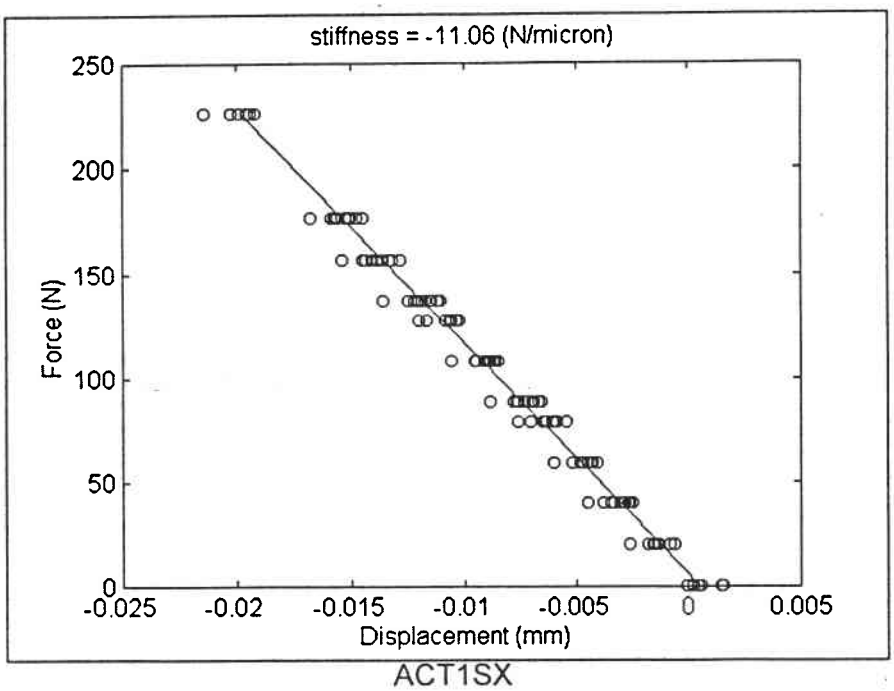
Open loop results:

[μm]	Act. 1 SX	Act. 2 SX	Act. 3 SX	Act. 4 DX	Act. 5 DX	Act. 6 DX	Extra Act
σ	0.027	0.045	0.041	0.041	0.048	0.041	-
max	0.50	0.25	0.25	0.25	0.20	0.25	-

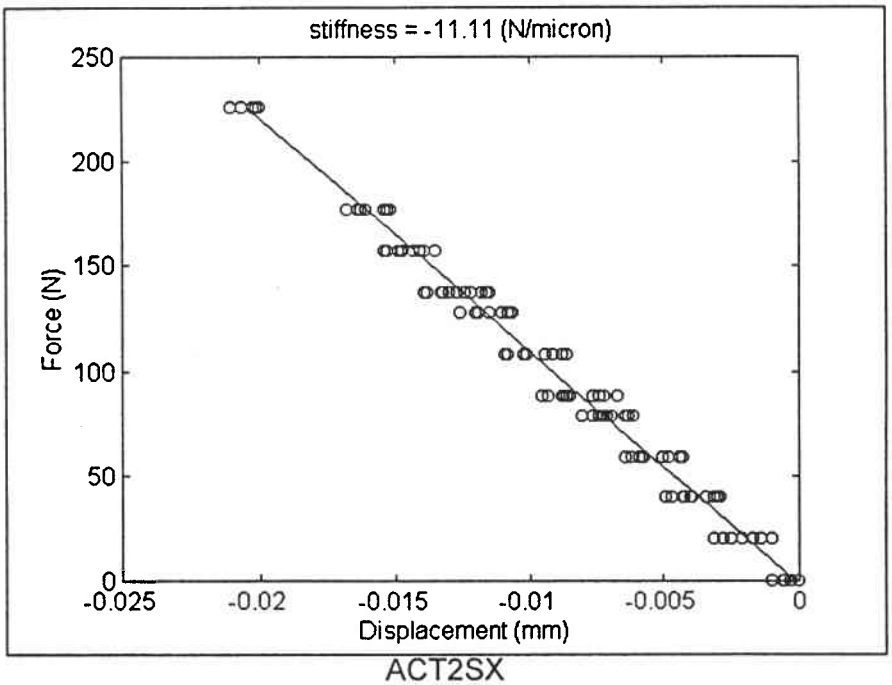
The LVDT output corresponding to these measurements showed many times (for some actuators) large variations that do not agree with the optical linear reference.

A cross check with the simultaneous measure of the actuator own encoder demonstrated that LVDT measures were affected by electric disturbances.

iv) Axial stiffness



ACT1SX



ACT2SX

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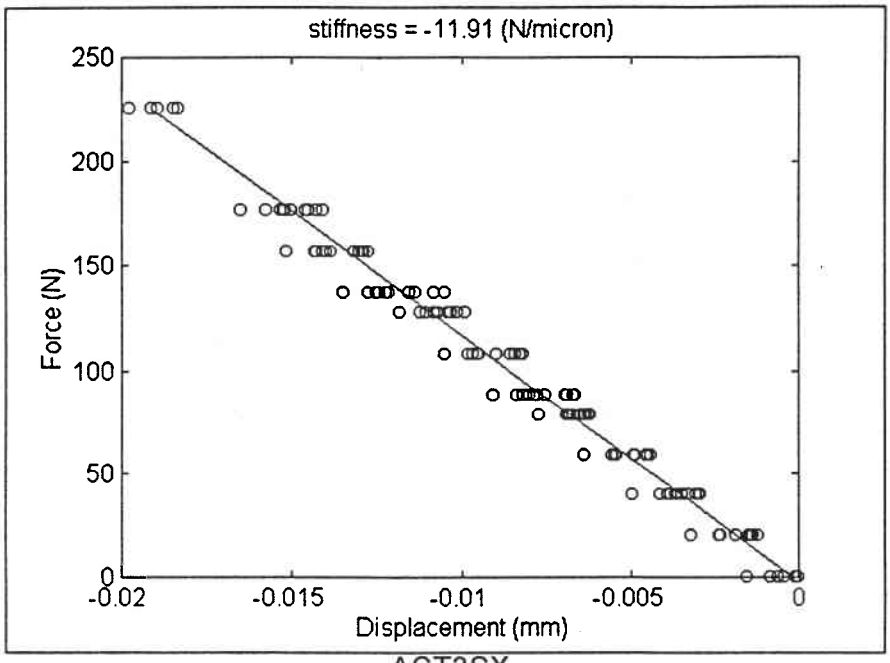
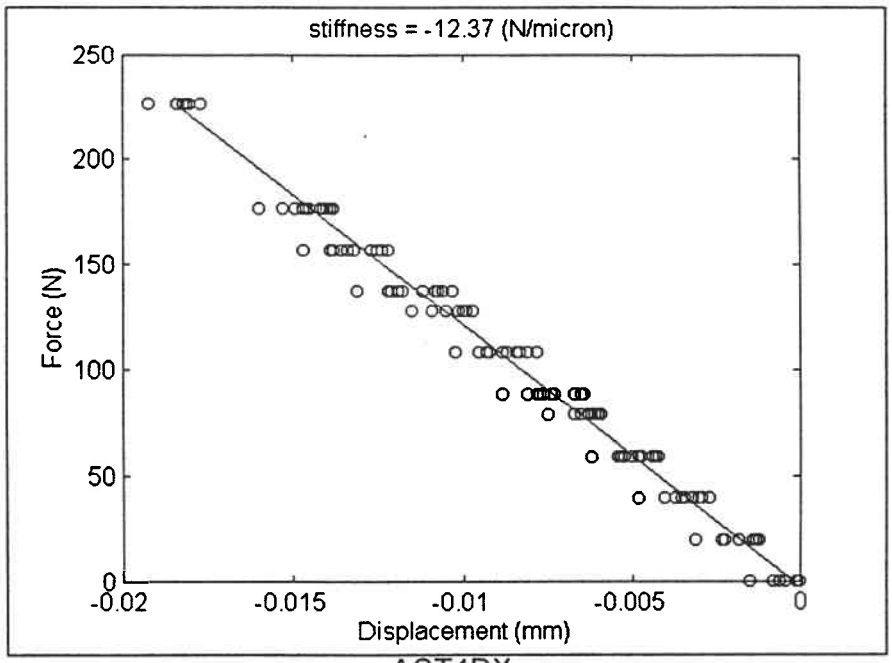
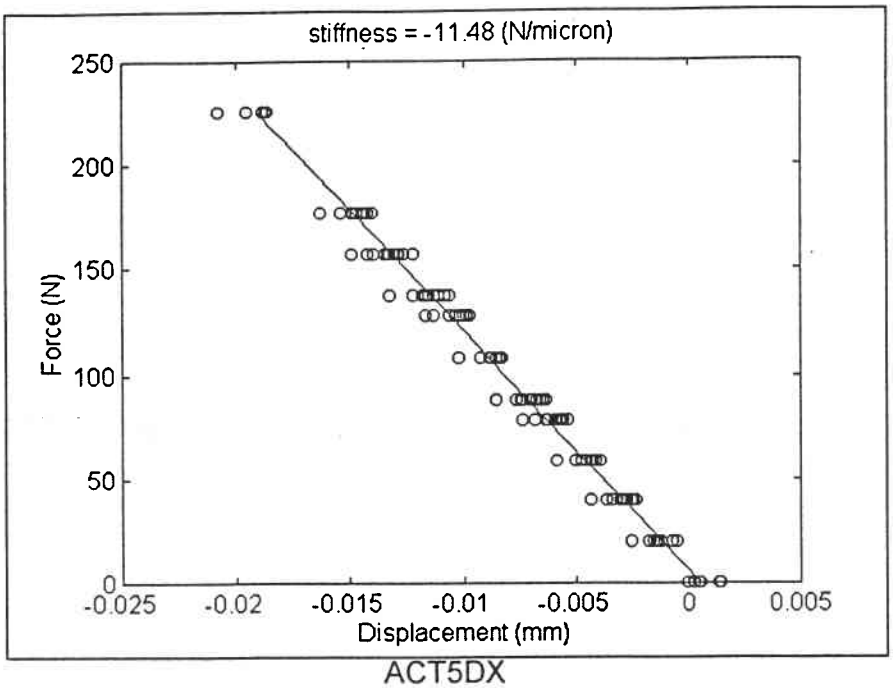


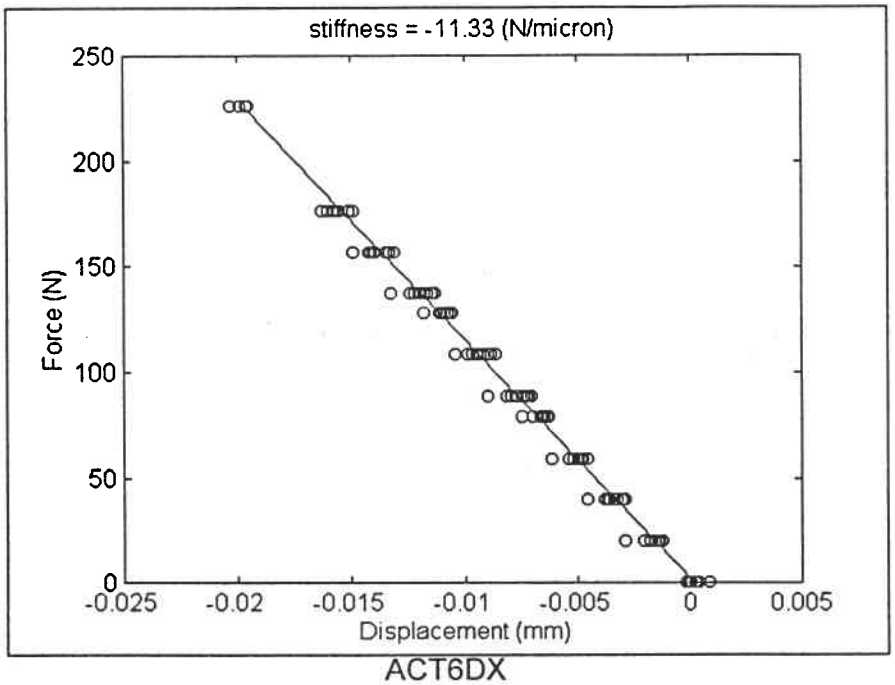
ACT3SX



ACT4DX



ACT5DX



ACT6DX

The following results have been reduced by accounting for the test bench own stiffness of 17 N/μm (TBC).

	Act. 1 SX	Act. 2 SX	Act. 3 SX	Act. 4 DX	Act. 5 DX	Act. 6 DX	Extra Act.
[N/μm]	31.7	32.1	39.8	45.4	35.4	34.0	-

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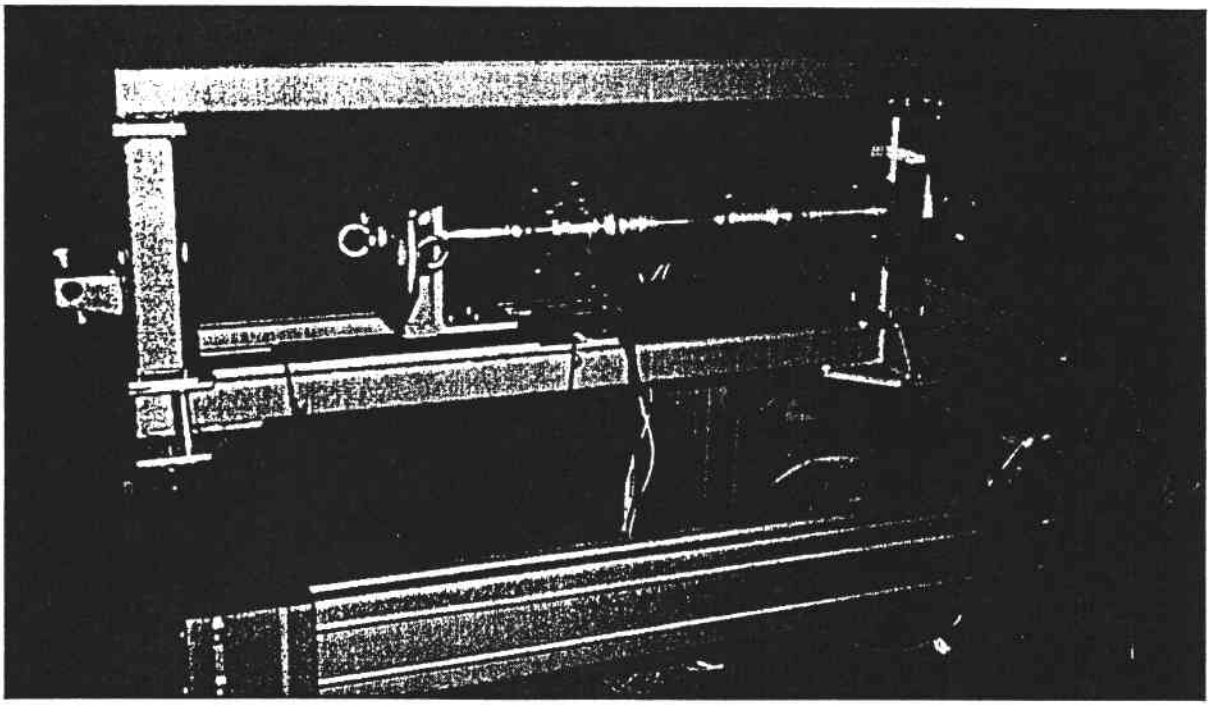
8.4. Results analysis

The tests were affected by the lack of the capability to tune the control system.
This drawback heavily affected the quality of the positioning accuracy reached by all the actuators, that resulted worse than the specified value.
The achieved pointing repeatability, that ultimately is given by the Closed Loop accuracy standard deviation, is about 3 μm, larger than the specified 1 μm.

Another factor that affected actuators accuracy is the noise level on the LVDT signal. This can be partially due to poor electrical setup of the test bench. Nevertheless, the results demonstrated that the noise intrinsic to this sensor clearly suggests not using it as on line position feedback.
The encoder signal provides much clear signal with the appropriate resolution to achieve the micron level accuracy.
The LVDT could likely be used as background absolute position monitor, for system bootstrapping and to follow thermal deformations not measured by the encoder.

Finally, the results of the brake test shows that this device is not a significant source of positioning error, being compliant with the final specified accuracy of 1 μm.

Linear Actuator under testing



9. DIMENSIONAL CONTROL OF HEXAPOD MECHANICAL ASSEMBLY AND COMPONENTS

9.1. Linear Actuators

The linear components were subjected to a dimensional control screening as part of the acceptance procedure (incoming inspection at delivery from workshop). Critical dimensions were checked using the 3D dimensional control machine.

After completion of the accuracy performances testing campaign the linear actuators were positioned at nominal length (see Dwg. 200505) of (330±0.1) mm using the test bench and control electronics for commanding the actuator and a calibre for the length measurement (accuracy of ±0.1mm). So, the linear actuator length for integration is (330±0.1)mm.

9.2. Platforms

The two subassemblies consisting of the I/F supports mounted on the platforms were subjected to dimensional control to verify manufacturing and assembly dimensions and to measure some important values needed for the kinematics simulation of Hexapod in the "as built" configuration.

a) Subassembly consisting of all three upper I/F supports (Dwg. N°300943) mounted on the upper platform (Dwg. N°200512):

The subassembly is placed on top of the UPMC marble table, and the subassembly is placed with the face up.
The test equipment is a 3D Measuring Machine UPMC 1200 Carat manufactured by Carl Zeiss (S/N 91442, calibration certificate C 871/95/HnB).
For location of measured dimensions with respect to the Upper Platform, please refer to redlined drawing (enclosed at the end of this paragraph).

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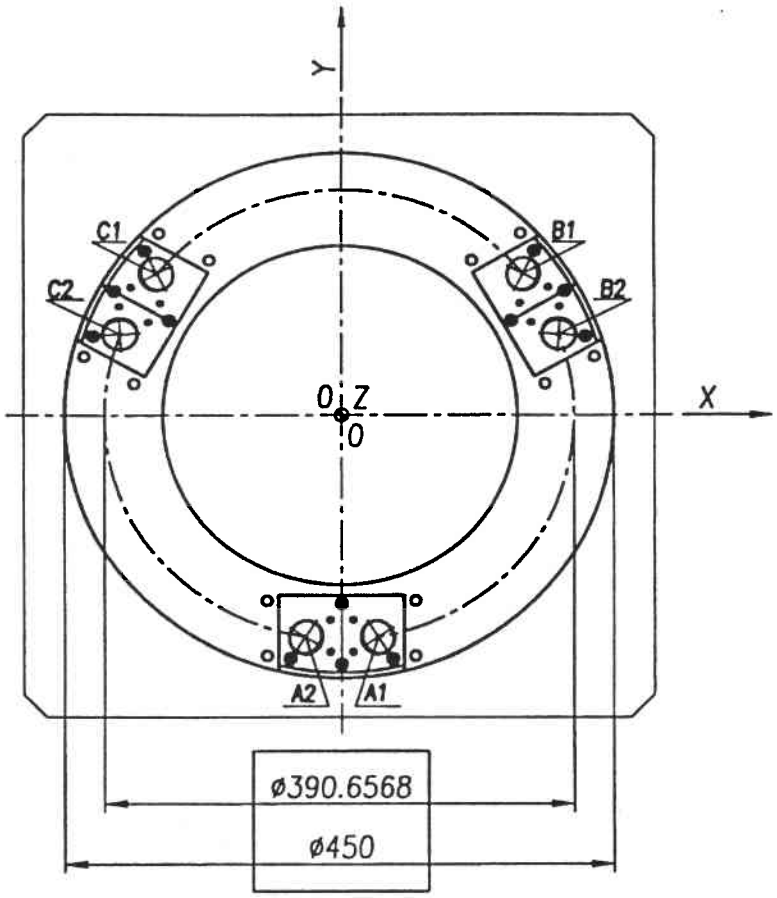
Metrology results:

Upper I/F Supports (Dwg. N°300943) mounted on the Upper Platform (Dwg. N°200512)

Dimensional Check Upper Plate Support



Coord	X Nominal	X Measured	Y Nominal	Y Measured	Z Nominal	Z Measured
A1	37.4573	37.8091	-191.7032	-191.6035	35.1168	34.9354
A2	-37.4573	-37.7953	-191.7032	-191.6359	35.1168	34.8497
B1	147.2912	146.9745	128.2906	128.5262	35.1168	34.8881
B2	184.7485	184.7953	63.4127	63.0504	35.1168	34.8668
C1	-147.2912	-147.0367	128.2906	128.5698	35.1168	34.8315
C2	-184.7485	-184.8065	63.4127	63.0783	35.1168	34.9584

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b) Subassembly consisting of all three lower I/F supports (Dwg. N°300942) mounted on the lower platform (Dwg. N°200508), based on the three basefoot:

The subassembly is placed on top of the UPMC marble table, and the subassembly is placed with the face up.
The test equipment is a 3D Measuring Machine UPMC 1200 Carat manufactured by Carl Zeiss (S/N 91442, calibration certificate C 871/95/HnB).
For location of measured dimensions with respect to the Upper Platform, please refer to redlined drawing (enclosed at the end of this paragraph).

Metrology results:

Lower I/F supports (Dwg. N°300942) mounted on the Lower Platform (Dwg. N°200508)

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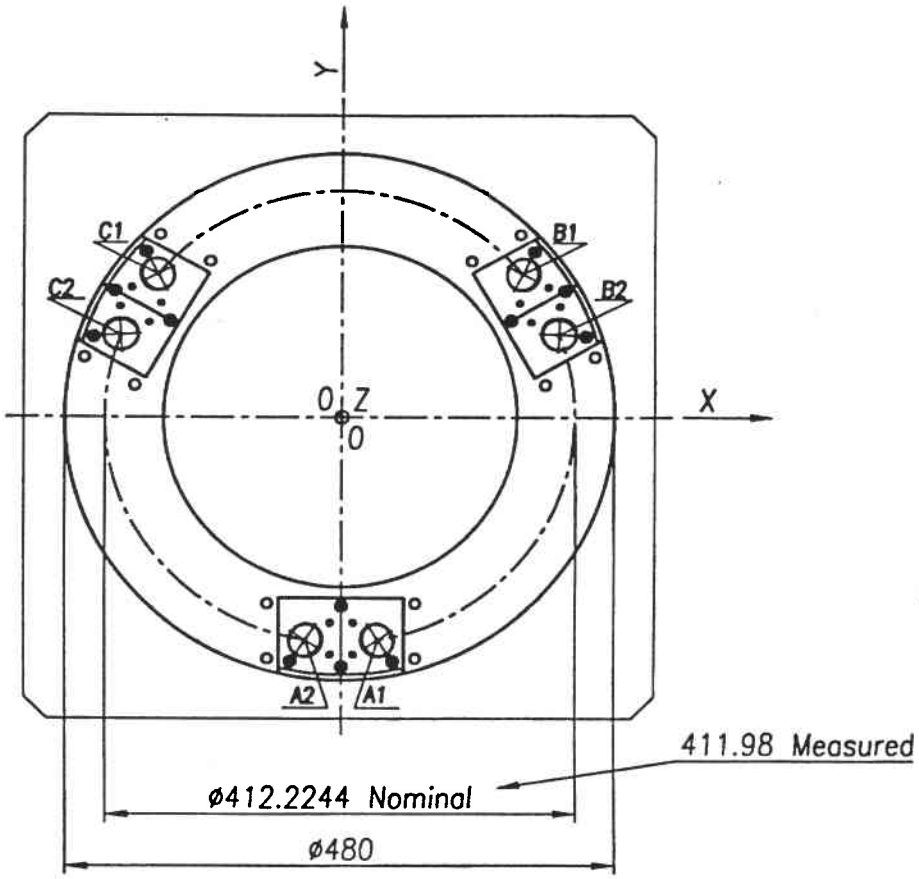
Dimensional Check Lower Plate Support



Coord	X Nominal	X Measured	Y Nominal	Y Measured	Z Nominal	Z Measured
A1	30.7493	31.1267	-203.8056	-203.6592	40.5676	40.2867
A2	-30.7493	-31.0429	-203.8056	-203.6909	40.5676	40.2365
B1	161.1262	160.7459	128.5324	128.6345	40.5676	40.4985
B2	191.8754	191.8959	75.2731	74.8297	40.5676	40.4119
C1	-161.1262	-160.8462	128.5324	128.7325	40.5676	40.3978
C2	-191.8754	-191.9145	75.2731	74.8787	40.5676	40.4162

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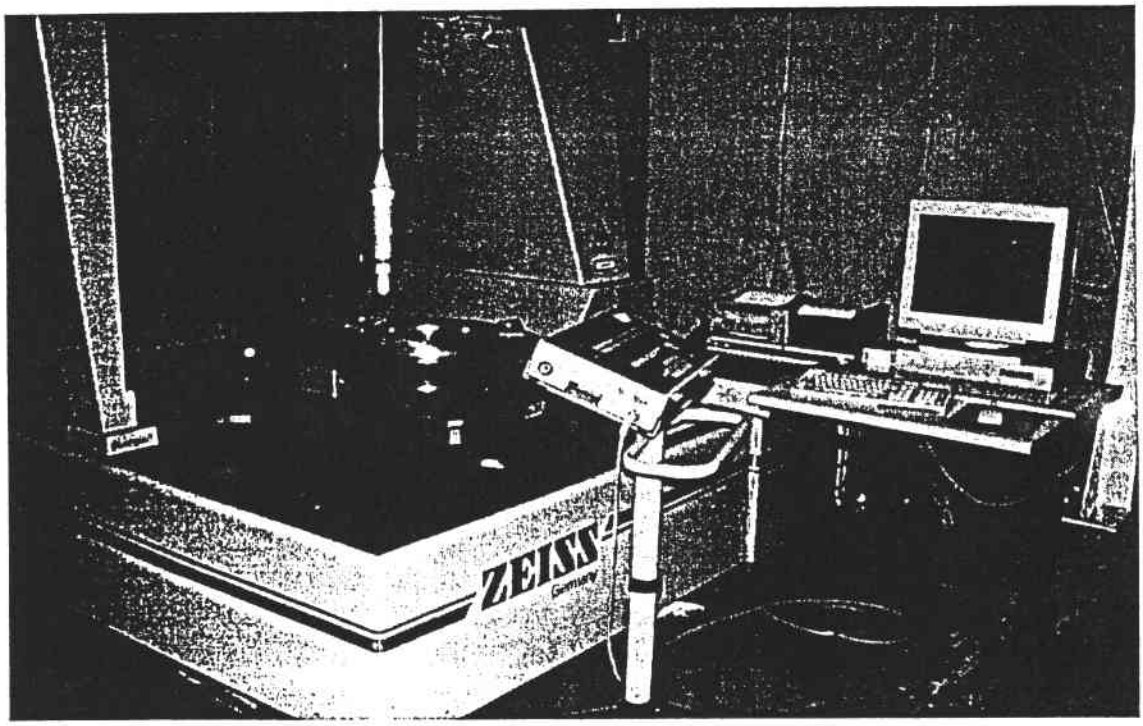
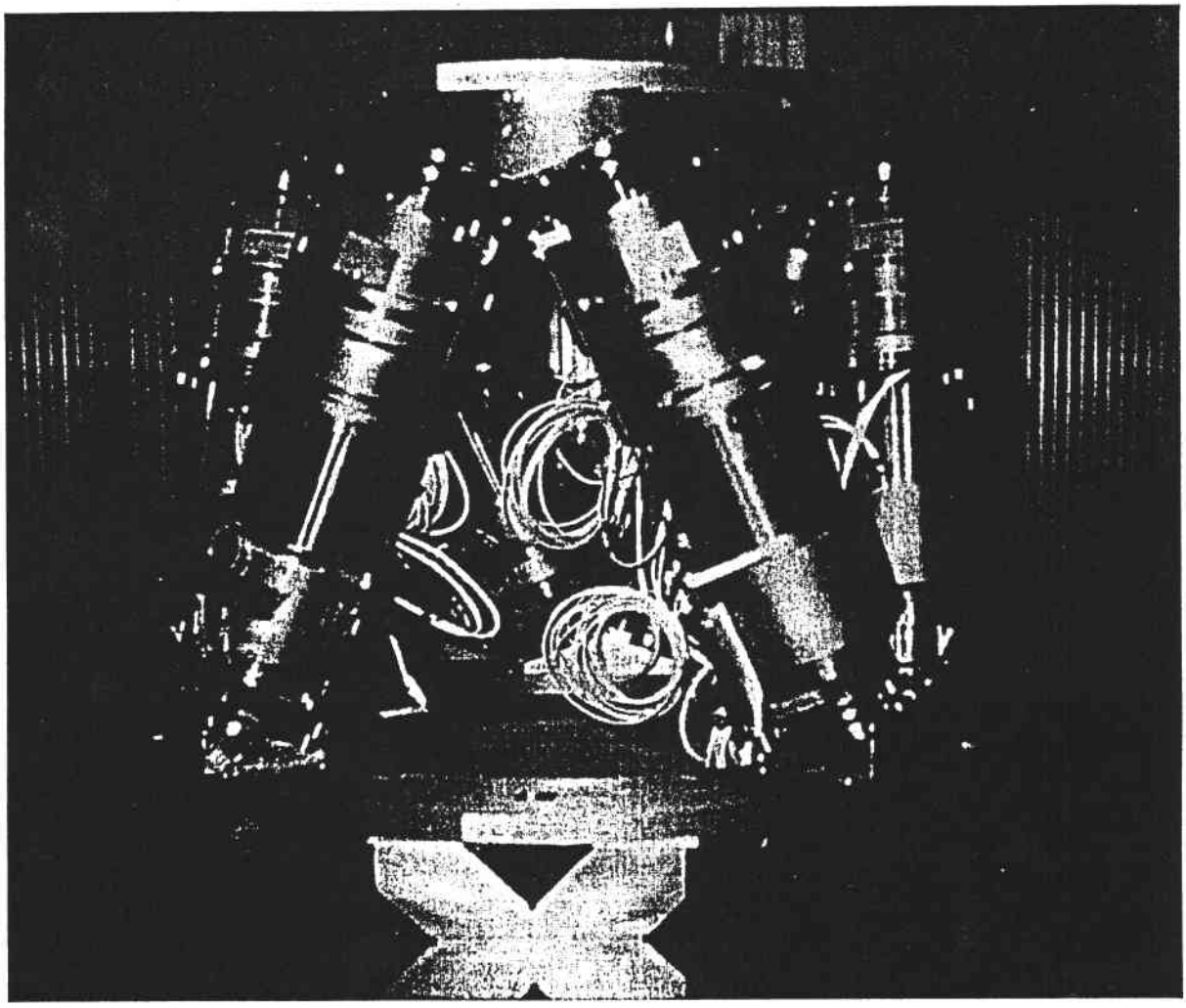
3D Measuring Machine UPMC 1200 Carat (Carl Zeiss) (at Media Lario premises):



9.3. Mechanical Assembly

The complete mechanical assembly as been integrated with the actuators calibrated at 330±0.1mm length.
All the mechanical actuator as been integrated as dwg ADS 200513 and has been all the interfaces with lower and upper platform. (see picture)

Mechanical Assembly



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10. WEIGHT OF HEXAPOD MECHANICAL ASSEMBLY AND COMPONENTS

The following table reports the measured weight of the Mechanical Assembly components:

Item Description	Drawing N°	Estimated Weight [kg]	**Measured Weight [kg]**
Linear Actuator S/N 01 SX	200505	7.6	7.613
Linear Actuator S/N 02 SX	200505	7.6	7.594
Linear Actuator S/N 03 SX	200505	7.6	7.582
Linear Actuator S/N 04 DX	200505	7.6	7.585
Linear Actuator S/N 05 DX	200505	7.6	7.595
Linear Actuator S/N 06 DX	200505	7.6	7.582
Linear Actuator S/N 07 DX	200505	7.6	7.583
Upper Platform (with 3 support)	N.A.	7.93	7.830
Lower Platform (with 3 support)	N.A.	8.25	7.835
Eyebolt M24	N.A.	0.60	0.500
	TOTAL :	69.98	**69.299**

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11. Assembling procedure of the single actuator

The assembling procedure of the single actuator for the "MMT Secondary Hexapod f/9" is hereafter described.

11.1. References

- DWG ADS 200513 "General assembly"
- DWG ADS 200505 "Linear actuator"

11.2. Operative Procedures

For all the following activities, it is necessary to wear rubber gloves (surgery type).

1.0 - Subassembly stator
1.1 - Wear the antistatic bracelet for all the **1.X** operations.
1.2 - Look for p/n and s/n of the motor and write them on the event sheet attached to the work order.
1.3 - Insert four pulling M3 for 100mm as frameless motor guide (item 04).
1.4 - Heat the frameless motor support (item 04) at 50°C.
1.5 - Insert the stator into the frameless motor support (item 04), taking care of the direction of the feeding cable of the brush holder ring and push the stator until the end stop.
1.6 - Fix the frameless brushed stator (item 107) to the frameless motor support (item 04) with screws (item 121), and lock.
1.7 - Mount the brush holder ring to the stator (item 107) and lock the screws, check the direction of the cables with respect to the vertical axis - 20°.
1.8 - Put a heatshrink sleeve on the feeding cables of the stator.

2.0 - Subassembly screw/scroll
1.0 - Look for p/n and s/n of the screw and write them on the event sheet attached to the work order.
2.0 - Mount the couple BelleVille washers (item 113), on the screw, positioning them among the ring (item 16) and lock with the self-locking ring nut (item 114). Use socket spanner.

3.0 - Subassembly central bearing
3.1 - Grease the axial radial bearings (item 112) with Kluber Isoflex NBU15, 0.7 cmc each.
3.2 - Mount the two axial radial bearings (item 112) in the brake/bearings support (item 8) in configuration < > and close with a cover (item 10) using the screws (item 123).
3.3 - A bronze bushing (item 18) has to be inserted in the cover (item 10) in a forced manner.

4.0 - Subassembly flange terminal bearing
4.1 - Grease the ball bearing (item 102) with Kuber Isoflex NBU15, 0.35 cmc.
4.2 - Mount the ball bearing (item 102) in the encoder/bearing support (item 03), locking it with two outside Snap rings (item 103).

5.0 - Subassembly screw/brake/rotor
5.1 - Wear the antistatic bracelet for all the operations of the paragraph **5.X**.
5.2 - Prepare a double electrical 24V DC power supplier to test brake and motor simultaneously.
5.3 - Mount the scroll of the satellite roller screw (item 100) with the satellite roller screw support (item 14) using the screws (item 123). To make the following assembling easier, position cylinder/screws vertically. Mount the key (item 110) in the seat of the screw.
5.4 - Mount the screw in the subassembly central bearings (3.0), insert the distance ring (item 09) and lock with the self-locking ring nut (item 111). Use socket spanner.
5.5 - Measure the gap between brake and housing, write it on the event sheet attached to the work order.
5.6 - Mount the spacer bush and verify the coupling with the brake.
5.7 - Mount the brake (item 108, 109) on the its key, lock with the screws (item 122) interfacing it with the subassembly central bearing seat (3.0) taking care of the direction of the feeding cable, feed the brake and verify that no friction is present between brake and screw. Close the grub screw on the key.
5.8 - Put a heatshrink sleeve 50mm long.
5.9 - Mount the distance ring (item 07) the bush (item 05) on the screw, wear the frameless brushed motor/rotor (item 106), the distance ring (item 06) and lock with the self-locking ring nut (item 104). Use socket spanner.

6.0 - Final Assembling.
6.1 - Wear the antistatic bracelet for all the **6.X** operations.
6.2 - Mount the subassembly flange terminal bearing seat (4.0), to the subassembly stator seat (1.0) using the shorter screws M4 X 15 in the seat of the screws (item 120) and lock.
6.3 - Mount the subassembly screw/brake/rotor (5.0), interfacing it to the subassembly stator seat (1.0) using the screws (item 117) and lock.
6.4 - Mount the bush (item 20) on the terminal part of the screw, lock the three grub screws (item 105).
6.5 - Look for p/n and s/n of the Encoder and write them on the event sheet attached to the work order.
6.6 - Mount the rotor of the Encoder (item 101) without fixing it.

6.7 - Mount the stator of the Encoder (item 101) (horseshoe shaped) without touching the rotor, the screws (item 117) and fix it definitely.
6.8 - Check very carefully the play stator/rotor of the Encoder, which has to be 0.2 mm. Turn the screw by hand and verify that no interferences or centring mistakes are present. Lock definitely the rotor fixing grub screw of the Encoder.
6.9 - Connect the wiring of the Encoder into the proper socket.
6.10 - Mount the encoder housing (item 02) taking care of the direction of the passage for the Encoder cable, fixing it with screws (item 120).
6.11 - Before mounting the flexible joint (item 01) to the encoder housing (item 02) with screws (item 117), screw temporarily some grub screw (item 134) for safety reasons, taking care of the direction of the passage for the cables.
6.12 - Mount the Proximity support (item 11) to the cover (item 10) and fix with screws (item 130).
6.13 - As regards the sequence for the Proximity assembling, see section. B-B, of the drawing 200505
1° Close the two screws to the satellite roller screw support (item 14)
2° Mount the two Proximity (item 116) with proper nuts (item 125) and washers (item 126), Proximity will be regulated afterwards.
3° Mount the flexure foil (item 21) using screws (item 127) and washers (item 128) and lock.
6.14 - The protection (item 12) and the protection ring (item 13) with the relative screws (item 124) have to be mounted after verification of the actuator run ($20^{+0.0}_{+1.0}$ mm).
6.15 - Before mounting the flexible joint (item 15) to the satellite roller screw support (item 14) with screws (item 117), screw temporarily some grub screw (item 134) for safety reasons.
6.16 - Mount the support LVDT (item 17) to the flexible joint (item 15) with screws (item 122).
6.17 - Look for p/n and s/n of the LVDT and write it on the event sheet attached to the work order.
6.18 - Mount in the support (item 17) LVDT (item 115) closing the screws (item 129) of the collars softly.
6.19 - The last operation is to insert the stem (item 19), which has to run freely in the coupling (item 01) in the cover (item 10) and in the support LVTD (item 17) acting eventually on the screws (item 117) and (item 122) so that the stem (item 19) is parallel to the actuator axis, after check close the nuts (item 118) and its washers (item 119). Close the screws (item 129).

12. Assembling procedure of the Hexapod

The procedure of assembling of the Hexapod system for the MMT secondary Mirror is hereafter described.

12.1. Reference

DWG ADS 200513 "General Assembly"
DWG ADS 200505 "Linear Actuator"

12.2. Operative Instruction

For all the activities below described it is necessary to wear gloves to minimise contamination of the components.
Before attempting to assemble the device it should be noted that at least four persons will be needed for the final assembly.

12.3. Actuators

The actuators have been pre-adjusted to a lenght of 330±0.1mm, be careful not change this length and avoiding rotating single parts of the actuator.
For safety precaution each flexible joint has been locked by four screws that **must be removed before assembly**.

12.4. Lower interface ring assembly (DWG ADS 200508)

Three lower slope supports (item 22) have been pre-assembled to the interface ring (item 26) by using the bolts (item 132) and also the plugs (item 24) have been fixed onto lower slope supports (item 22) by the bolts (item 123).
Place the lower interface ring assembly on a granite table (or similar solid, level surface) resting on three equal height X or V type blocks of height 100 mm approximately at radius ≈180 mm at about 120° being sure to leave free the area of the lower slope support on which be mounted the linear actuators and enough room to close the nuts (item 135).
Note the position of the X and Y axis marked on the interface ring.

12.5. Upper interface ring assembly (DWG ADS 200512)

Three lower slope supports (item 23) have been pre-assembled to the

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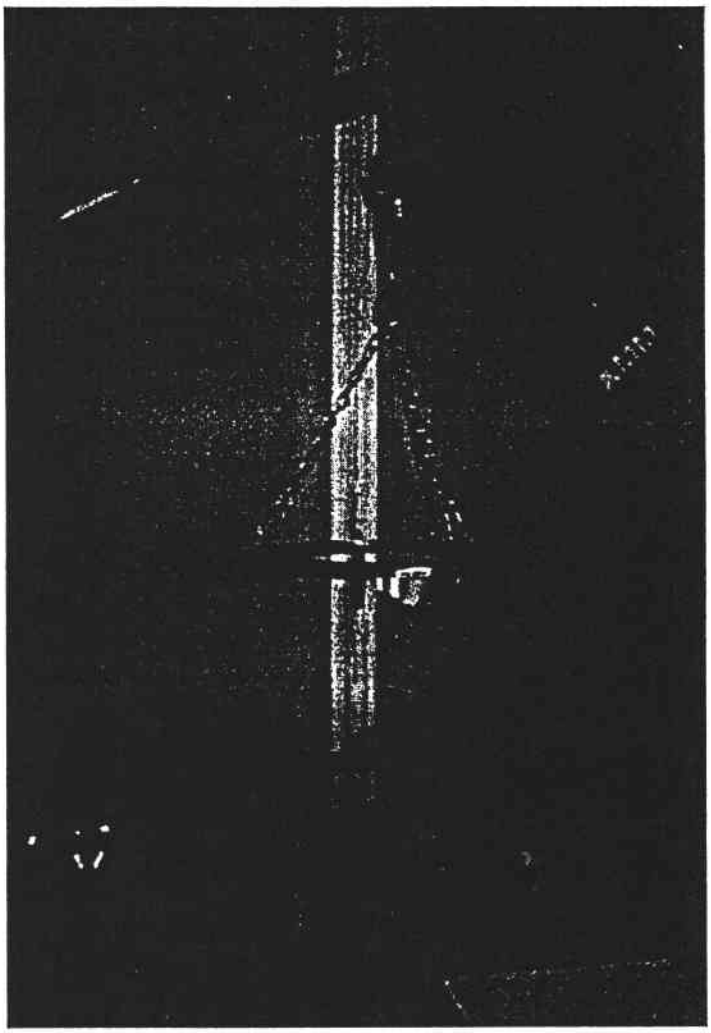
interface ring (item 27) by 1 (item 23) by the bolts (item 123).
Suspend the upper interface ring from a crane or controlled hoisting device using the three ring bolts (see packing list) mounted three of the available threaded holes.
Note the position of the X and Y axis marked on the ring.

12.6. Hexapod final assembly (DWG ADS 200513)

Position the upper interface ring assembly aligned with the vertical axis of the lower interface ring assembly at height about 400 mm (see the following picture).

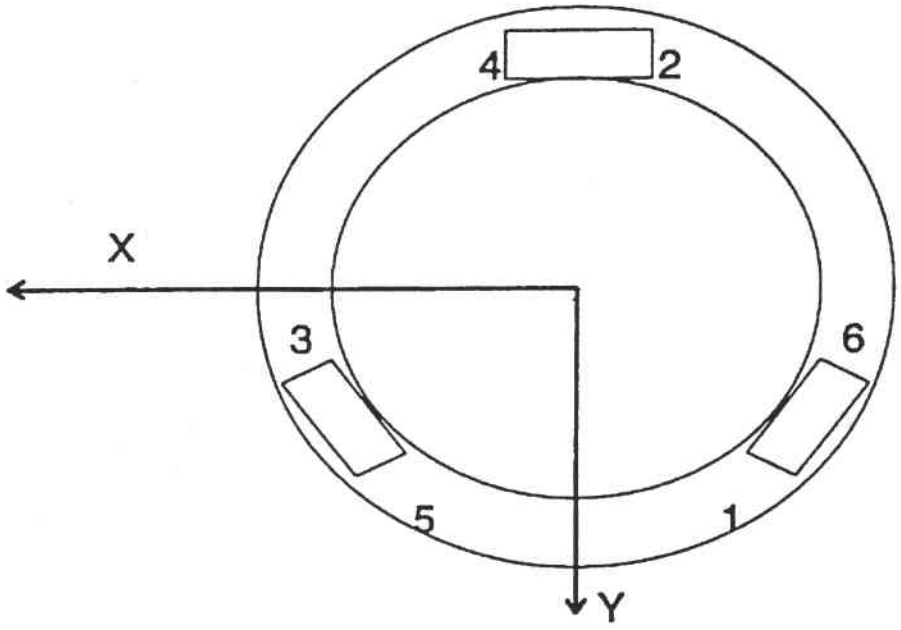


Mount the six actuators, DWG. 200505, according to the diagram below, to the lower interface ring assembly without closing the nuts (item 135), ensuring that all actuators are the correct way up.

Maintain the position of the six actuators, (three persons are needed) lower the upper interface ring (a fourth person is needed) and align the actuators to the holes of the slope supports ensuring correct alignment of the X and Y axis of the upper and lower interface rings.

Mount and close all of the 12 nuts (item 135) and washers by using the appropriate tool (see packing list)

Fix the electrical cables in a manner that will avoid excessive flexing and consequent damage by fatigue.

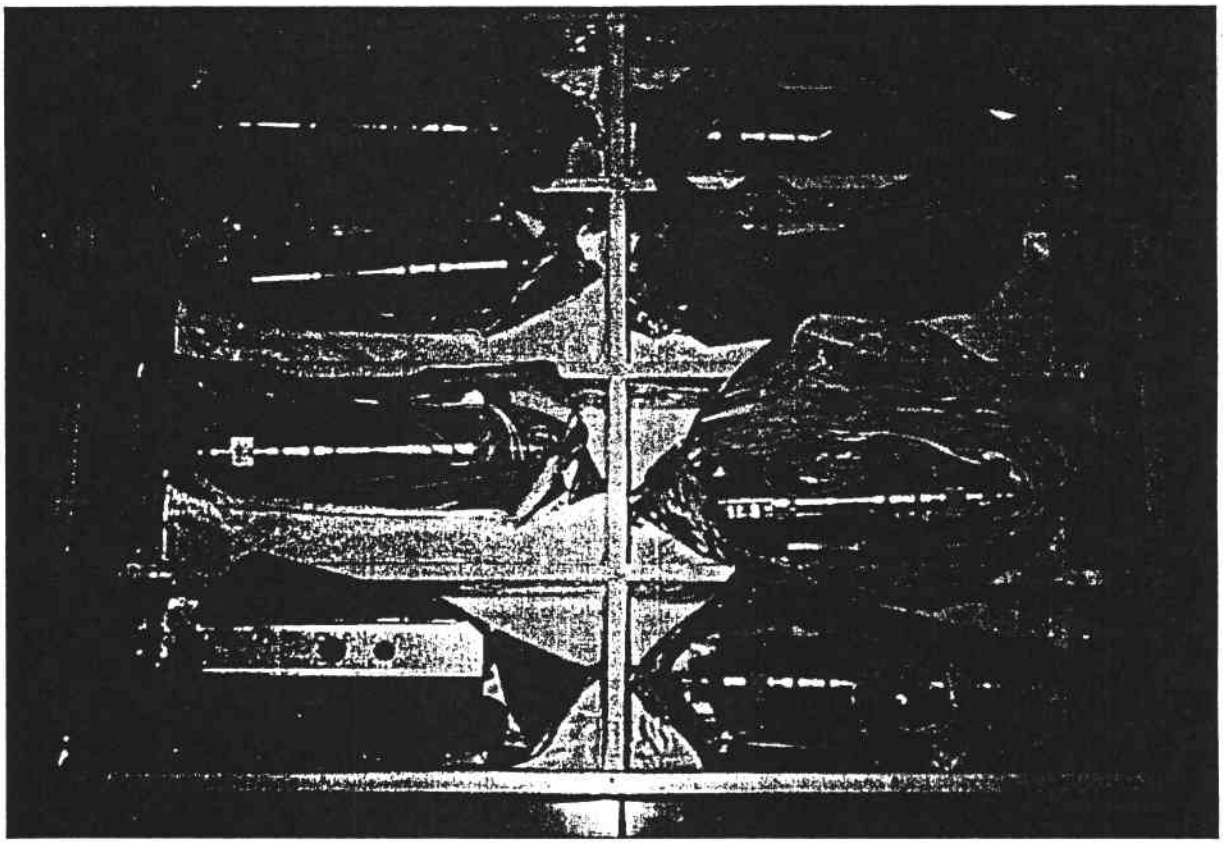


lower interface ring

13. HANDLING, PACKING LIST

13.1. Handling and transportation

The actuator mechanical assembly is delivered to Steward closed in an aluminium bag to prevent contamination, and then installed in a wooden box where it is blocked by means of screwed wooden bars to the box sides.



13.2. Packing list

Full description of goods	Encoder s/n	Brake s/n	Drive s/n	Screw Rollvis s/n
Actuator n.01 SX	228/397/23 5-543-**035**-B\248- 789-01	201-467-8100 30EFSB15 8 28V gap 0.15 N.**1**	QT2404 E 97G17 **890** 11384	8861/971**513**
Actuator n.02 SX	228/397/23 5-543-**037**-B\248- 789-01	201-467-8100 30EFSB15 8 28V gap 0.15 N.**2**	QT2404 E 97G17 **891** 11384	8861/971**511**
Actuator n.03 SX	228/397/23 5-543-**033**-B\248- 789-01	201-467-8100 30EFSB15 8 28V gap 0.15 N.**3**	QT2404 E 97G17 **892** 11384	8861/971**509**
Actuator n.04 DX	228/397/23 5-543-**038**-B\248- 789-01	201-467-8100 30EFSB15 8 28V gap 0.15 N.**5**	QT2404 E 97G17 **894** 11384	8861/971**514**
Actuator n.05 DX	228/397/23 5-543-**039**-B\248- 789-01	201-467-8100 30EFSB15 8 28V gap 0.15 N.**4**	QT2404 E 97G17 **643** 11384	8861/971**507**
Actuator n.06 DX	228/397/23 5-543-**040**-B\248- 789-01	201-467-8100 30EFSB15 8 28V gap 0.15 N.**6**	QT2404 E 97G17 **645** 11384	8861/971**508**
Actuator n.07 DX	228/397/23 5-543-**034**-B\248- 789-01	201-467-8100 30EFSB15 8 28V gap 0.15 N.**7**	QT2404 E 97G17 **888** 11384	8861/971**510**
	ADS DWG N.	**Qty.**	**Item**	
Lower plate with support and plate	200508 300942 400708	1 3 6	26 22 24	
Upper plate with support and plate	200512 300943 400709	1 3 6	27 23 25	
Treader M1.8		1		
Eyebolt M6		3		
Special Key	400751	1		
Cable		14		
Electrical box		1		
Pliers		100		
Motor Drivers		2 (spares)		
Connectors		20		

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