(Form Template)		
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2D IR-TRACC Absolute Length Calibration Procedure

1 Introduction

Scope: Absolute Length Calibration of 2D-IR-TRACCs IF-367, IF-368, IF-371, IF-372
Dummies: WorldSID 50% male and 5% female, Q10
Software: 2D IR-TRACC Calibration Template 31October2014-absolute-tube-in-out.
Instructions: this document.
Manuals: Dummy manuals provide details on post processing formulas and sensor polarity checking.

Euro NCAP applies the WorldSID dummy with 2D IR-TRACCs in their side impact protocols starting 2015. The injury parameter is based on the lateral compression of the ribs. This requires calculation of the rib position in a co-ordinate system fixed to the thoracic spine of the dummy using length and angle data from the 2D IR-TRACC assembly. This Absolute Length Calibration procedure facilitates that the millimeter output will be expressed in absolute length with respect to the rotation axis of the angle sensor. In this procedure the parameters Absolute Intercept and Reference Angle are obtained. IR-TRACC Tubes In-Out length calibration and angle sensor calibration should be carried out prior to absolute length calibration part. Information how apply the resulting calibration parameters can be found in the dummy user manuals.

2 Equipment

- Reference Fixture part #11220 (Figure 1);
- Stable power supply with adjustable voltage up to 5V DC, able to power one IR-TRACC and one potentiometer simultaneously;
- Two calibrated digital voltmeters with resolution better than .00005V (.05mV);
- Calibration sheet of the angle sensor.

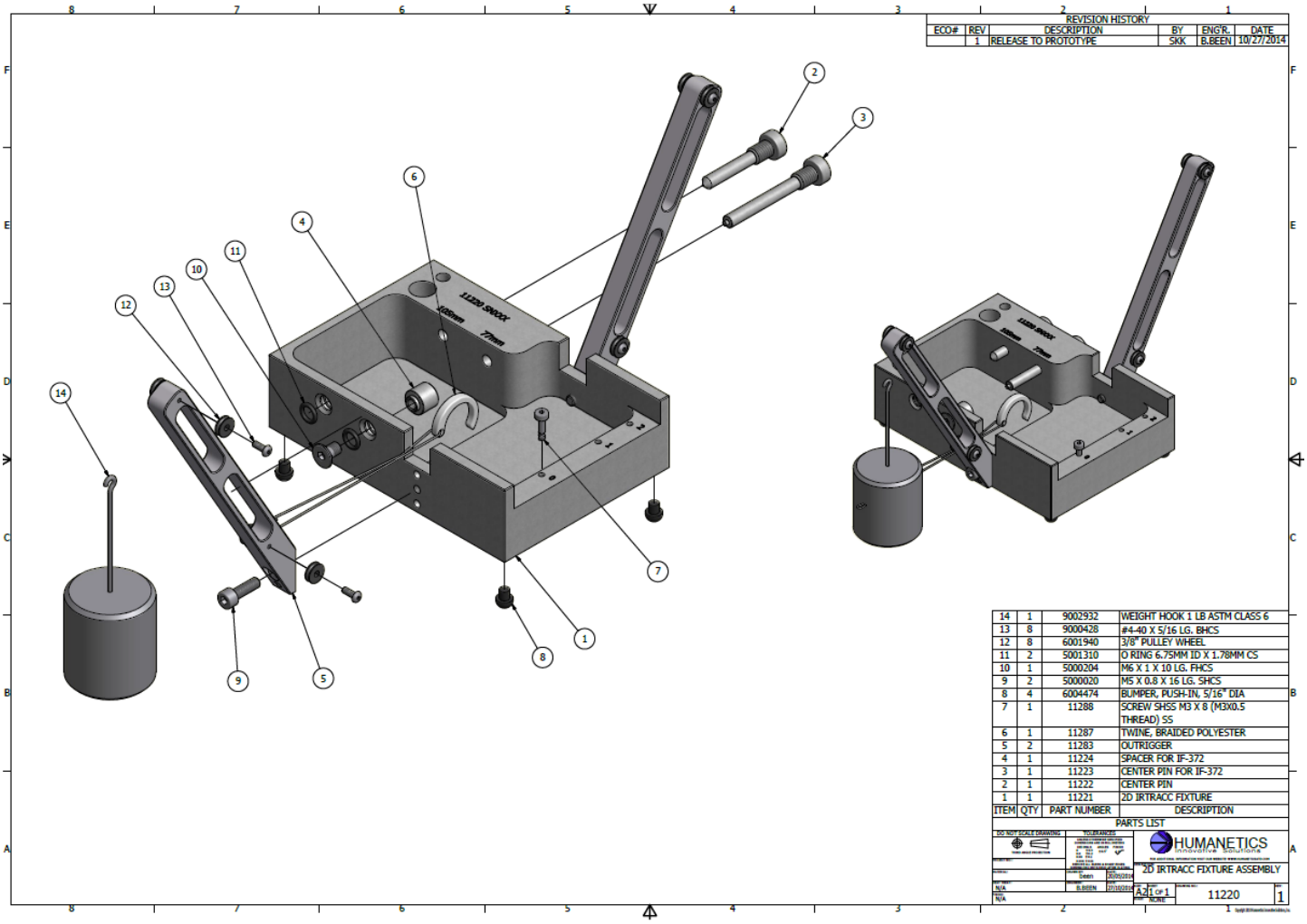


Figure 1 Reference Fixture part #11220

3 Absolute Intercept & Reference Angle

In this section data is obtained from the 2D IR-TRACC assembly on Reference Fixture part # 11220. The data is entered in the IR-TRACC calibration template tab '2D-ABSOLUTE INPUT'. The results of Tubes In-Out Length Calibration can be found in 'Tubes In-Out INPUT tab.

Step 2.0

- Place the 2D IR-TRACC assembly on the Reference Fixture part # 11220 with potentiometer facing up according Figure 2.
- For long range IR-TRACC (IF-367, IF-368: Table 3 Left column; IF-372: Table 4) use the position with 105mm reference length and for short range 2D IR-TRACC (IF-371: Table 3 Right column) use the 77mm reference length position.
- On IF-367, IF-368 & IF 371 use the short Centre Pin (Figure 2 Left).
- Push the pivot screw head inside the hole and make sure that the pot bracket arm is flush with the inner surface of the Reference Fixture.

- Screw in the Centre Pin lined up with the hexagon of the pivot screw on the opposite side and hand tighten the Centre Pin. Make sure there is no play between the Centre Pin and the pivot screw hexagon.
- On IF-372 use the Spacer and the long Centre Pin (Figure 2 Right). Secure the spacer with an M6x10 Flat Head Countersunk Screw. Push the IRTRAVV bracket pivot hole on the spacer spigot. Screw in the long Centre Pin on the opposite side into the fixture and align the spigot with the pivot hole of the IRTRACC bracket. Hand tighten the Centre Pin. Check there is no play and the bracket is flush with the spacer.
- Secure the ball joint in Pos0 (Table 3) with the 3mm screw and fasten until secure.

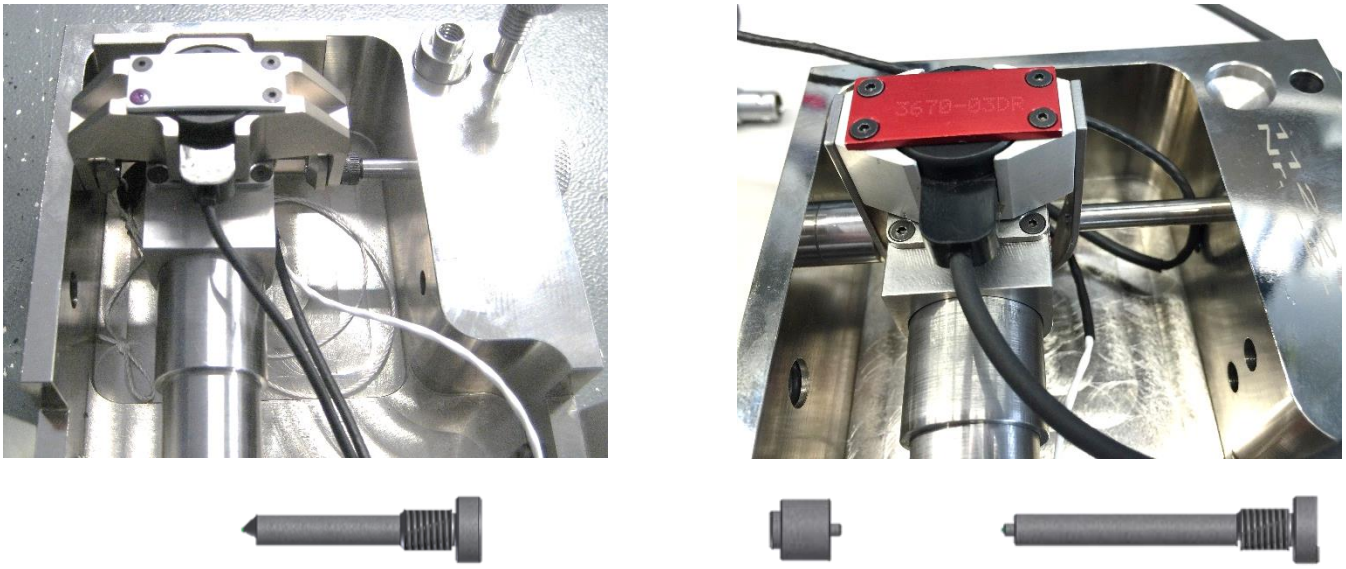


Figure 2 IF-367, IF-368, IF-371: use short Centre Pin *IF-372: use Spacer and long Centre Pin*

Step 2.1

- Starting point is a completed Tubes In-Out length calibration. Open the pertaining IR-TRACC calibration template for the serial nr that you are about to calibrate for absolute length. Check that Tubes In-Out Length calibration was carried out. If not carry out Tubes In-Out Length Calibration. Remember the calibration range in cell B14.
- Go to the 2D-ABSOLUTE INPUT tab. Copy the calibration range in cell B14 and **press enter**. This will set the calibration range and remove lines that are not used. Make sure that the Calibration Range is the same as 'Tubes In-Out INPUT' tab, cell B14.
- Save the file according data base file naming conventions.
- Open the calibration sheet of the angle sensor for the relevant serial number applied in the 2D IR-TRACC assembly. Enter angle sensor calibration test number and serial number in the cells DE11-DE12.
- Enter angle sensor calibration factor in cell D13 in $Volt_{sen}/Volt_{exc}$/degree unit. Please note that the unit is important. Some cal sheets show degree/mV, some mV/degree, some at 5V or 10V excitation. You may have to convert the calibration factor to the proper unit. If the calibration sheet gives the sensitivity in mV/V/degree, than convert the calibration factor by dividing the given number by a factor of 1000

(~ 0.003 V/V/degree). If the cal factor is given in degree/V the number must be inverted. For example 36degree/V = 1/36 = 0.028 V/degree.

- In orange fields G10-G13 enter calibration date, test number, operator and temperature from the current absolute calibration. (Default values are copied from Tubes In-Out tab).
- Save the file.

Step 2.2

- Connect the IR-TRACC to a stable power supply and a calibrated digital voltmeter with a resolution of 5 decimal places (Example: 1.23456V). Make sure to run a grounding cable from the calibration fixture casing to the grounding point of the voltmeter.
- Set the voltmeter to display voltage reading in 4 decimal places, for example 5.1234V. Measure the excitation voltage, adjust the power supply to 5V.
- Connect the voltmeter to measure the IR-TRACC output. See Table 1 Wire colors and functions.
- Enter the Reference length from step 2.0 in orange field G14 (105 or 77mm).
- Slide all floating IR-TRACC tubes **IN** to the big end
- Enter 'V_{REF} Tubes In' voltage reading in orange Field B16 (4 decimals 0.xxxx)
- Then, slide all floating IR-TRACC tubes **OUT** (to small end)
- Enter 'V_{REF} Tubes Out' voltage reading in orange field B17
- Save the file.

Table 1 Wire colors and functions

Wire Color	**Function IR-TRACC and Angle**
Red	+EXC
White	-SIG
Black	-EXC
Green	+SIG
Orange	ID
Shield	GD, Return ID

Step 2.3

- Reposition the ball joint of the IR-TRACC from Position 0 to Position 1 on the Reference Fixture (Table 3 middle row). Fasten 3mm screw until secure. Slide all tubes Out.
- Enter IR-TRACC voltage reading 'IR-TRACC pos1' in field B18
- For IF-372 calibration got to Step 2.4, as the rotation is limited to ±20° (skip position 2).
- Reposition the ball joint of the IR-TRACC from Position 1 to Position 2 on the Reference Fixture (Table 3 bottom row). Fasten 3mm screw until secure. Slide all tubes OUT.
- Enter IR-TRACC voltage reading 'IR-TRACC pos2' in field B19.
- Save the file.

Step 2.4

- Connect the angle sensor to a power supply and a second volt meter (Table 1).
- Adjust the excitation as close as possible to 5.0V. The polarity of the excitation voltage is important for correct registration of the zero angle of the angle sensor. Enter the angle sensor excitation reading in field D14 in 4 decimals (for example +5.1234 volts).
- Slide all tubes out, clip the nylon twine around the IR-TRACC tube, route the cable to the far side under the lower cable guide, to the top, over the top cable guide and hang a 0.45kg (1LBS) ballast on the end loop (Figure 3 FAR).
- Enter the angle sensor voltage reading in orange field D16 (V_{REF} far). Make sure to enter the correct sign (+/-) of the voltage reading.
- Remove the ballast, route the twine to the near side (Figure 3 NEAR) and repeat the previous steps, then entre the angle sensor voltage reading in orange field D17 (V_{REF} near). Make sure to enter the correct sign (+/-) of the voltage reading.
- Remove the ballast and twine clip.
- Check that the angle sensor polarity corresponds to the co-ordinate system. The angles in fields G16-G17 should be around +90degrees. If the value is around -90 degrees, flip the sign of the angle sensor calibration factor in field D13 (from + to -, or from – to +). If the angle is other than 90 degrees, check the calibration factor.

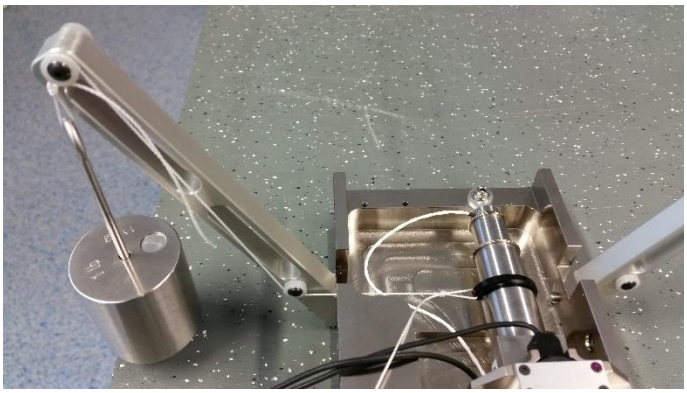
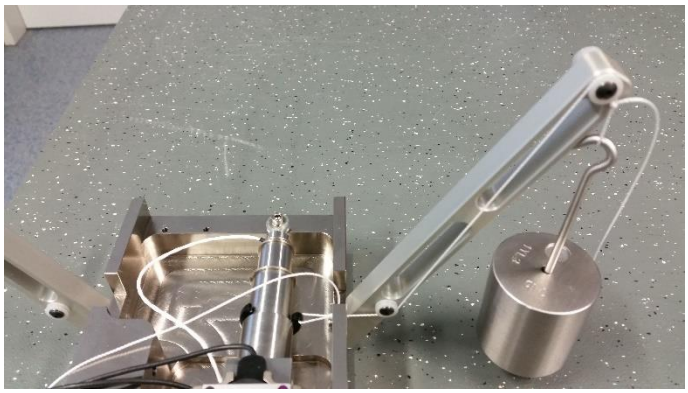


Figure 3 Ballast on FAR side



Ballast on NEAR side

Step 2.5

- Reposition the ball joint of the IR-TRACC from Position 0 to Position 1 on the Reference Fixture (See Table 3, middle row). Fasten 3mm screw until secure. Slide all tubes Out.
- Enter angle sensor voltage reading in field D18 (Ang pos1, enter > 6 decimals: i.e. -0.003123, make sure to enter the correct sign).
- For IF-372 skip position 2.
- Reposition the ball joint of the IR-TRACC to Position 2 on the Reference Fixture (Table 3, bottom row). Fasten 3mm screw until secure. Slide all tubes Out.
- Enter angle sensor voltage reading in field D19 (Ang pos2, enter > 6 decimals: i.e. -0.003123, make sure to enter the correct sign).

- The fields under φ_{IRT}, L, x and y should now be all green. Cells turn red when the tolerance of the conditional formatting are exceeded. This could occur if the IR-TRACC has a lot of play in the tubes, play in the angel sensor shaft, or the IR-TRACC has a large tube in-out error and simultaneous occurrence of both conditions. If cells are red, go back to previous steps make corrections as necessary. Consult Table 2 Fault tree for further assistance.
- Save the file.

Step 2.6

- The Absolute Length Calibration is now completed. Save the file in the appropriate manner in the test data base. Print PDF for distribution to customer.

Table 2 Fault tree

Possible cause of error	**Check action**
The IR-TRACC has a lot of play in the tubes or in the angle sensor shaft (see difference between φ_{IRT} far and near)	Wiggle the middle of the tube for large play. If there is no angle sensor voltage response, this indicates play in the angle sensor.
The IR-TRACC has a large tube in-out error and simultaneous occurrence of large play.	Check in –out errors of the absolute calibration point closest to 105mm (or 77mm). If large in-out error occurs, IR-TRACC should be refurbished.
The most common mistakes are the wrong sign of the angle voltages (forgot to type -).	Check and correct the angle sensor voltages at the relevant position(s)
Wrong sign or value of angle calibration factor.	Cross check with angle calibration sheet. Check if unit is converted correctly
Voltage readings of the IR-TRACC are entered in the angle cells.	Make sure that the angle sensor +SIG and – SIG are connected to the voltmeter.
Excitation voltage measured or entered wrong	Recheck the excitation voltage.
If the errors persist, the angle sensor could be bad.	Check if the output voltage changes smoothly under gradual rotation. If steps occur, there may be play in the sensor shaft. If necessary, recalibrate or exchange the angle sensor.
The calibration template functionality is lost as some cells have been overwritten accidentally. (Cells are not protected).	Open a valid template, copy only orange cells with data from suspected sheet. Paste values in new template (right mouse click ‘values’), only in corresponding cells.
Enter errors found here to expand knowledge base as we progress	Enter check and remedy here!

2D IR-TRACC ASSEMBLY- ABSOLUTE LENGTH CALIBRATION SHEET

Applies for Right Hand Side IR-TRACC Orientation

Calculate Absolute Length using formula: R = (Vsensor ^ -0.4507) * 33.94+11.56

IR-TRACC		Angle Sensor			Date	16-Oct-14	Absolute Length Calibration Factors		
Test No.	101614DS3170	Test Nr.	0162014DQ5978		TEST No.	101614DS3170	Linearization exponent		-0.4507
Model No.	IF-367-R2S7	Model / SN	3670-11s	DQ5978	Technician	B.Chadwick	Calibration Factor [mm/V]		33.9403
Serial No.	DS3170	Ang cal/polarity	-0.003169	V_{sen}/V_{exc}/deg	Temp [°C]	23.8	Absolute Intercept [mm]		11.56
Calibration Range [mm]	80	Excitation [V]	5.0060	90	REF Length [mm]	105	123.63	Inv CF V/mm 0.0294635	Abs.Int.Volt -0.340709
V_{REF} Length [V]	0.1058	V_{REF} Angle [V]	-0.0504	$\varphi 0ffset_{Sensor}$ [deg]	3.18	φ_{IRT} [deg]	R [mm]	x [mm]	y [mm]
V_{REF} Tubes In [V]	0.1055	V_{REF} far [V]	-0.0562	φ_{REF} RIGTH	-86.82	90.4	105.1	-0.7	105.1
V_{REF} Tubes Out [V]	0.1060	V_{REF} near [V]	-0.0446	Ang cal/polarity	-0.003169	89.6	104.9	0.7	104.9
IR-TRACC pos1 [V]	0.0918	Ang pos1 [V]	0.2541	φ_{REF} LEFT	93.18	70.8	111.2	36.5	105.0
IR-TRACC pos2 [V]	0.0777	Ang pos2 [V]	0.4009	φ_{REF} FRONT	3.18	61.5	118.9	56.7	104.6

Standard Calibration point	Absolute Calibration point	Average Tubes In-Out	Optimized Exponent		Error Voltage Variation Tubes In-Out				
[mm]	[mm]	V_{sensor} [V]	V_{linear} [V]	[mm]	R in [mm]	δR in [mm]	R out [mm]	δR out [mm]	Max [mm]
0	123.63	0.0708	3.2987	123.52	123.45	-0.17	123.59	-0.03	-0.14
5	118.63	0.0783	3.1523	118.55	118.49	-0.13	118.62	-0.01	-0.12
10	113.63	0.0869	3.0077	113.65	113.65	0.02	113.65	0.02	0.00
15	108.63	0.0973	2.8583	108.57	108.40	-0.23	108.75	0.13	-0.36
20	103.63	0.1092	2.7134	103.66	103.58	-0.04	103.73	0.11	-0.15
25	98.63	0.1236	2.5661	98.66	98.59	-0.03	98.72	0.10	-0.13
30	93.63	0.1410	2.4182	93.64	93.53	-0.09	93.74	0.12	-0.21
35	88.63	0.1618	2.2727	88.70	88.66	0.03	88.74	0.12	-0.09
40	83.63	0.1880	2.1243	83.66	83.62	0.00	83.71	0.08	-0.09
45	78.63	0.2207	1.9760	78.63	78.61	-0.01	78.64	0.02	-0.03
50	73.63	0.2620	1.8291	73.64	73.60	-0.03	73.69	0.07	-0.10
55	68.63	0.3161	1.6805	68.60	68.59	-0.03	68.61	-0.01	-0.02
60	63.63	0.3875	1.5332	63.60	63.60	-0.03	63.61	-0.02	-0.01
65	58.63	0.4856	1.3849	58.57	58.55	-0.08	58.58	-0.04	-0.03
70	53.63	0.6233	1.2375	53.56	53.57	-0.06	53.56	-0.06	0.01
75	48.63	0.8237	1.0914	48.61	48.63	0.00	48.58	-0.04	0.05
80	43.63	1.1288	0.9469	43.70	43.70	0.07	43.71	0.08	-0.01
				Maxima		0.23		0.13	0.36

Figure 4 Completed Absolute Length Calibration Sheet with calibration parameters (purple), validation (green) and error results

Table 3 IF-367, IF-368 and IF-371 positions on the Reference Fixture and checking parameters

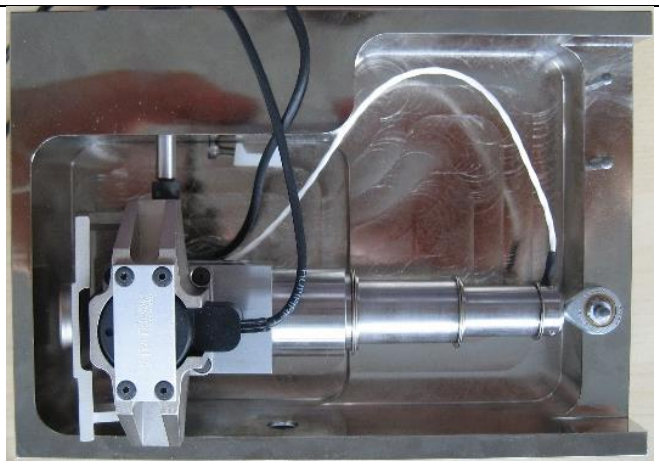
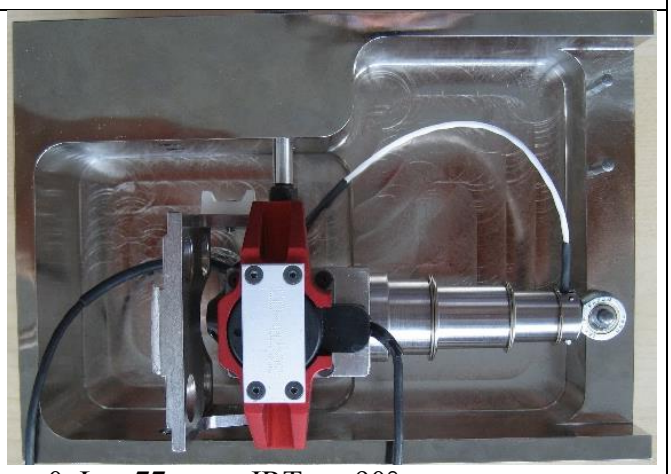
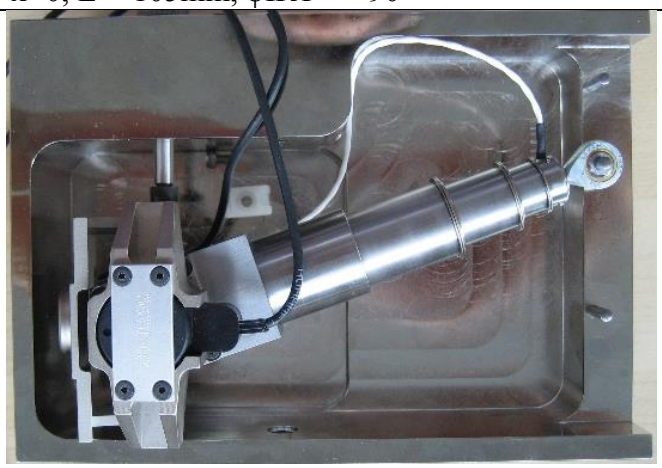
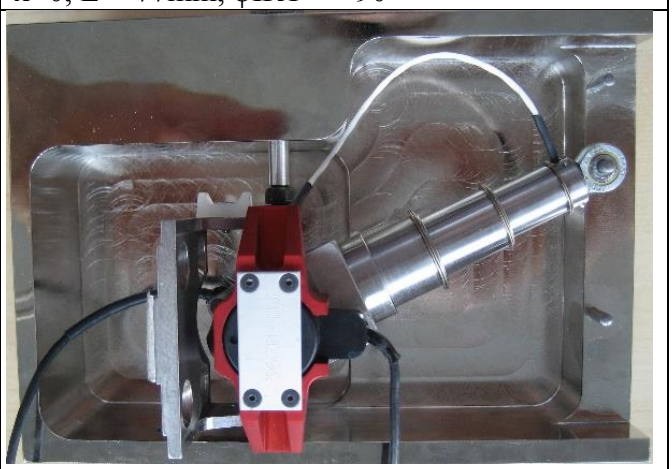
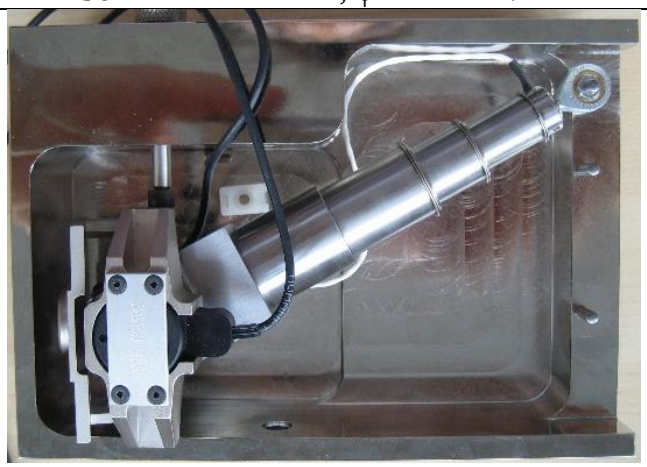
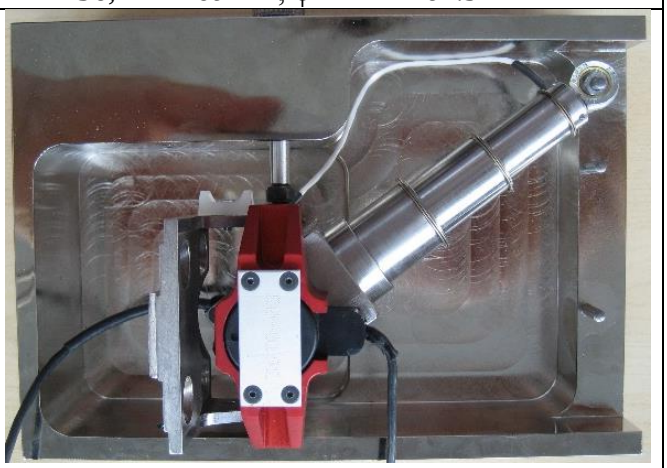
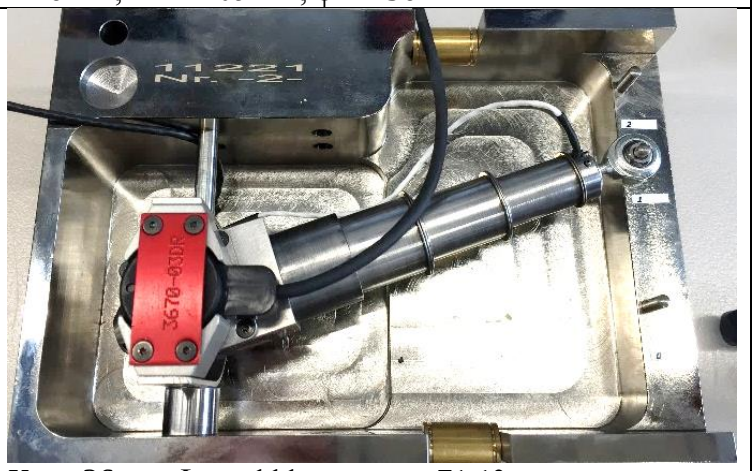
Position	**IF-367 & IF-368: y = 105mm**	**IF-371: y = 77mm**
Pos0	 x=0, L=+105mm, φIRT = +90°	 x=0, L=+77mm, φIRT = +90°
Pos1 X=36	 X = +36mm L = +111mm, φIRT = +71.1°	 X =+36, L = +85mm, φIRT = +64.9°
Pos2 X=56	 X=+56mm, L = +119mm, φ = +61.9°	 X=+56mm L = +95.2mm, φ = +54°

Table 4: Two position for IF-372 on the Reference Fixture and checking parameters

Position	**IF-372: y = +105mm**
Pos0	 X=0mm, L = +105mm, φ = +90°
Pos1	 X = +36mm, L = +111mm, φ = +71.1°
Pos2	Cannot be assessed with IF-372. Angle out of range.