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

1 Introduction

Scope: Absolute Length Verification of 2D-IR-TRACCs IF-367, IF-368, IF-371, IF-372
Dummies: WorldSID 50% male and 5% female, Q10
Software: 2D IR-TRACC Absolute Verification Template 24April2015
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 Verification 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 length calibration and angle sensor calibration should be carried out prior to absolute length verification part.
The dummy manuals define the spine box coordinate system, positive directions for the x and y coordinates and positive angle; the manuals define how to deal with various orientations of 2D IRTRACC sensors inside the dummy (Left hand, Right hand, frontal facing, mounting up or down) and define formulae to calculate rib position in x and y direction. Finally ISO MME codes are defined and a method how to implement constants and offset values necessary for this procedure into data acquisition systems.

2 Equipment

- Reference Fixture part #11220 (Figure 1);
- Stable power supply with adjustable voltage up to at least 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 and IRTRACC.

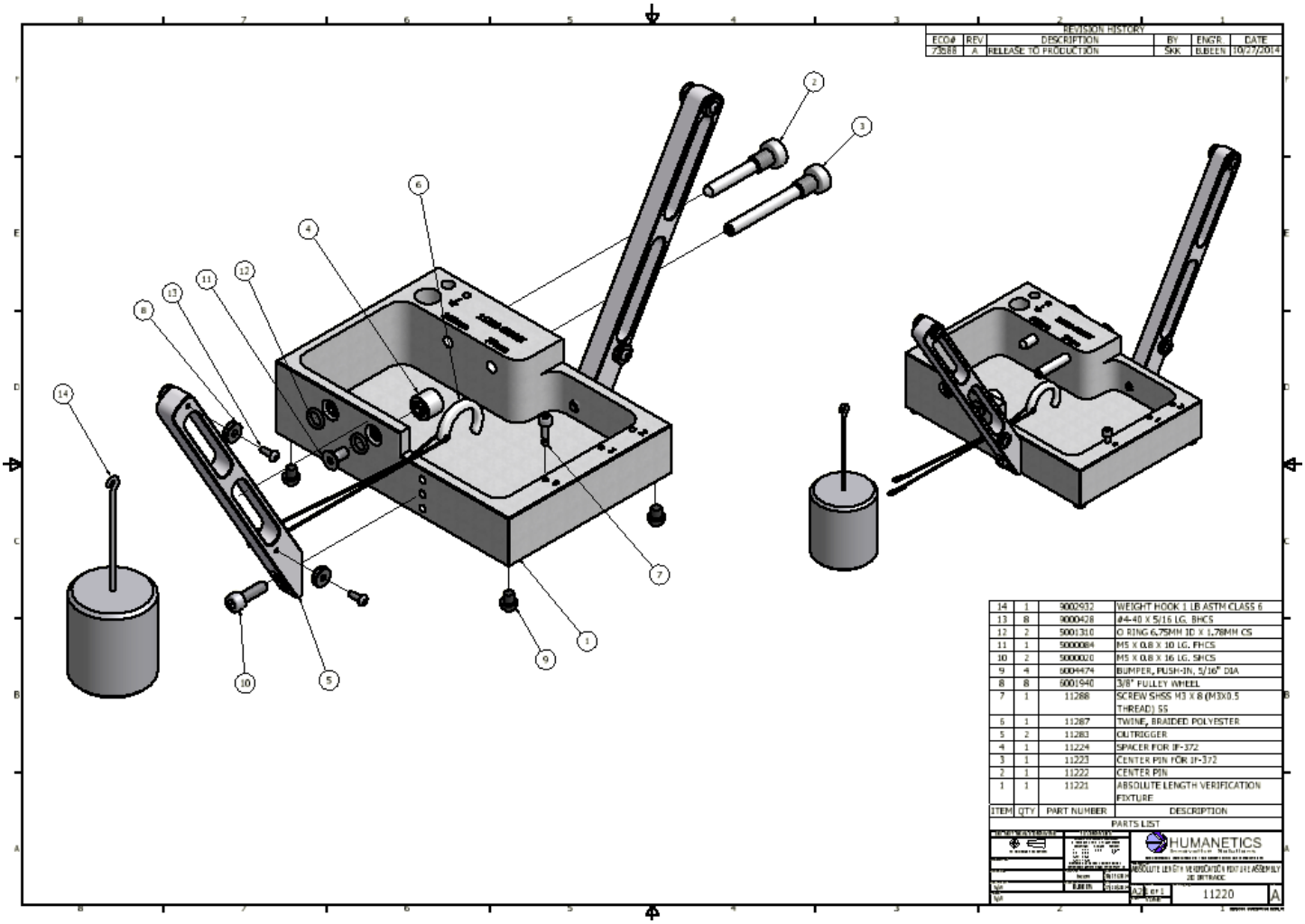


Figure 1 Reference Fixture part# 11220

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 verification template tab '2D-ABSOLUTE INPUT'. The results of Tubes In-Out Length Calibration can be found in the IRTRACC calibration certificate.

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 part# 11222 (Figure 2 Left).
- Push the pivot screw head inside the hole on the near side wall 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 part# 11224 and the long Centre Pin part# 11223 (Figure 2 Right). Secure the spacer with an M6x10 Flat Head Countersunk Screw. Push the IRTRACC 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 rod end bearing in Pos0 (Table 3) with the 3mm screw part# 11288 (Figure 1, item 7) and fasten until secure.

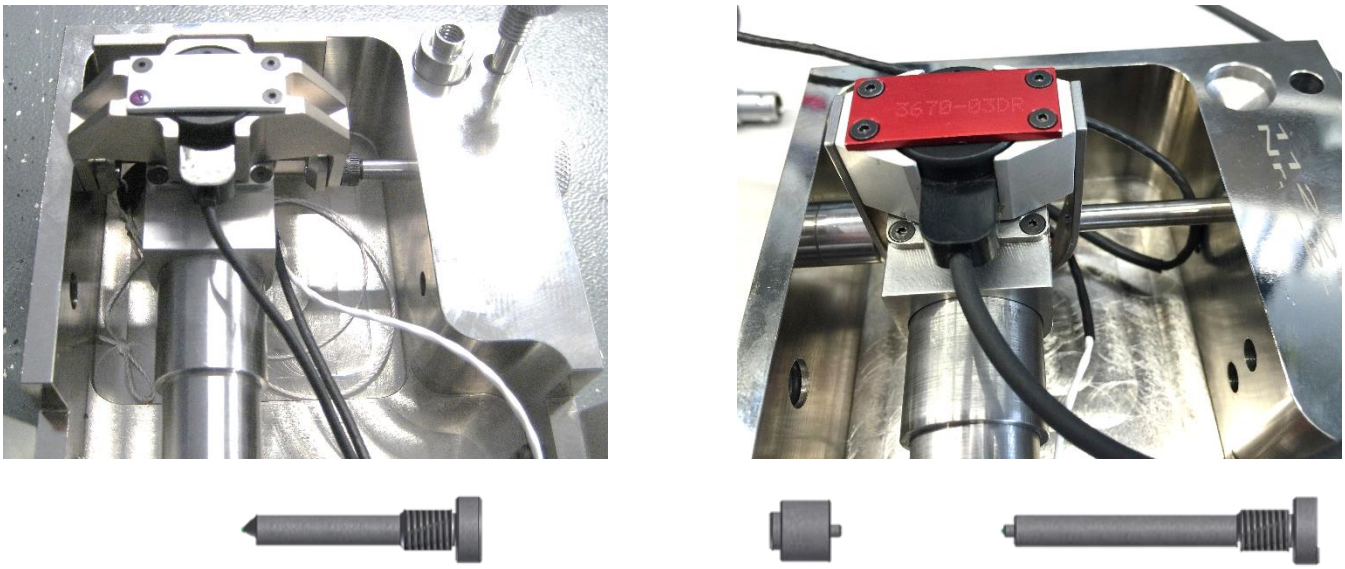


Figure 2 IF-367, IF-368, IF-371: use short Centre Pin *IF-372: use Spacer and long Centre Pin*

Step 2.1

- Open the 2D-IRTRACC Verification Template; Save the file to a new name according data base file naming conventions. Go to the 2D-ABSOLUTE INPUT tab. Note that cells to enter data are colored light orange. Also note that when you hover with the mouse over a cell a comment pops up with brief instructions.
- In cells G10-G13 enter test date (press ctrl;), test number, Technician name, humidity and temperature;
- Get the pertaining IR-TRACC calibration certificate for the serial nr that you are about to verify for absolute length. Check that Tubes In-Out Length calibration was carried out. If not, carry out Tubes In-Out Length Calibration.
- In cells B11-B14 copy the IRTRACC certification information in the verification template: test number, model number, serial nr and calibration range.
- In cells J11-J13 copy the IRTRACC certification parameters in the verification template: Tubes in-out Intercept, Linearization exponent and Calibration factor;
- Get the calibration sheet of the angle sensor for the relevant serial number applied in the 2D IR-TRACC

assembly. In the cells DE11- DE12 copy angle sensor calibration test number, model number and serial number;

- Enter angle sensor calibration factor in cell D13 in $Volt_{sen}/Volt_{exc}$/degree unit. Please note that the unit is important. Sometimes the calibration certificate shows degree/mV, sometimes 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.
- Save the file.

2D IR-TRACC ASSEMBLY- ABSOLUTE LENGTH VERIFICATION SHEET Applies for Right Hand Side IR-TRACC Orientation							#DIV/0!		
IR-TRACC		**Angle Sensor**			**Date**		**Tubes In-Out Intercept [mm]**		**110.00**
Test No.	0	**Test Nr.**			**TEST No.**		**Linearization exponent**		**-0.4600**
Model No.	0	**Model / SN**	3670-11s		**Technician**	your name	**Calibration Factor [mm/V]**		**33.000**
Serial No.	0	**Ang cal/polarity**	**-0.002000**	**V_{sen}/V_{exc}/deg**	**Temp / Hum**	23.2 / 45	**Absolute Intercept [mm]**		**#DIV/0!**
Calibration Range [mm]	80	**Excitation [V]**	**5.0000**	90	**REF Length [mm]**	**105**	#DIV/0!	InvCF [V/mm] 0.0303	#DIV/0!
V_{REF} Length [V]	**0.0000**	**V_{REF} Angle [V]**	**0.0000**	**φ0ffset$_{Sensor}$ [deg]**	**0.00**	**φ_{IRT} [deg]**	**R [mm]**	**x [mm]**	**y [mm]**
V_{REF} Tubes In [V]	0.0000	V_{REF} far [V]	0.0000	**φ_{REF} RIGHT**	**-90.00**	90.0	#DIV/0!	#DIV/0!	#DIV/0!
V_{REF} Tubes Out [V]	0.0000	V_{REF} near [V]	0.0000	**Ang cal/polarity**	**-0.002000**	90.0	#DIV/0!	#DIV/0!	#DIV/0!
IR-TRACC pos1 [V]	0.0000	**Ang pos1 [V]**	0.0000	**φ_{REF} LEFT**	**90.00**	90.0	#DIV/0!	#DIV/0!	#DIV/0!
IR-TRACC pos2 [V]	0.0000	**Ang pos2 [V]**	0.0000	**φ_{REF} FRONT**	**0.00**	90.0	#DIV/0!	#DIV/0!	#DIV/0!

Figure 3 the verification template in MS Excel

Calibration Factor [mm/V]		**33.8666**
Linearization exponent:		**-0.45142**
Inverse Cal.Factor [V/mm] & Intercept Voltage [V]	Inv CF [V/mm] -0.029528	Intercept [V] 3.3067
**Calculate displacement using the formula:* *mm = (Vsensor ^ -0.4514) * -33.8666+111.99*		

Figure 4 IRTRACC calibration parameters given in the cal certificate. The Tubes In-Out Intercept is given in the formula (circled).

Step 2.2

- Connect the IR-TRACC to an adjustable power supply and a calibrated digital voltmeter with a resolution of 5 decimal places (Example: 1.23456V), see Table 1. Make sure to run a grounding cable from the verification 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 5.000V.
- Connect the voltmeter to measure the IR-TRACC output, see Table 1 Wire colors and functions.
- In orange field G14 select from the drop down list the reference length from step 2.0 (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 rod end bearing 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 verification got to Step 2.4, as the rotation is limited to ±20° (skip position 2).
- Reposition the rod end bearing 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.
- Reposition the rod end bearing of the IR-TRACC back to Position 0 on the Reference Fixture (Table 3 middle row). Fasten 3mm screw until secure.
- Save the file.

Step 2.4

- Connect the angle sensor to the 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).
- For long range IRTRACCS (model nrs IF-367, IF-368, IF-372) see Figure 5, for short range IRTRACC IF-371, see Figure 6.
- **Slide all tubes out**, clip the nylon twine (part# 11287) 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) part# 9002932 ballast on the end loop of the longer twine (Figure 5, 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 shorter twine to the near side (Figure 5 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 outside 88.6-91.4 degrees, check Table 2 Fault tree.

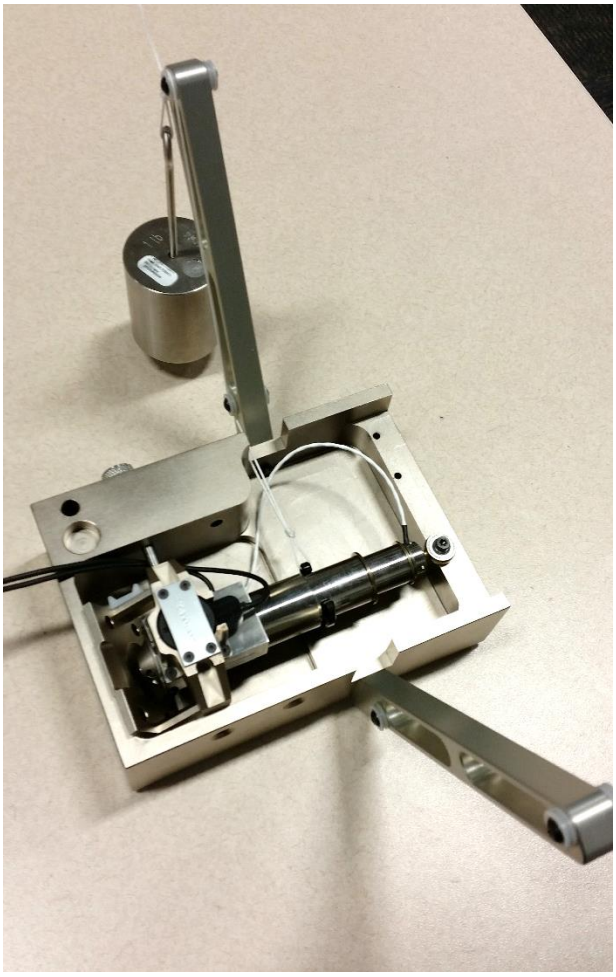
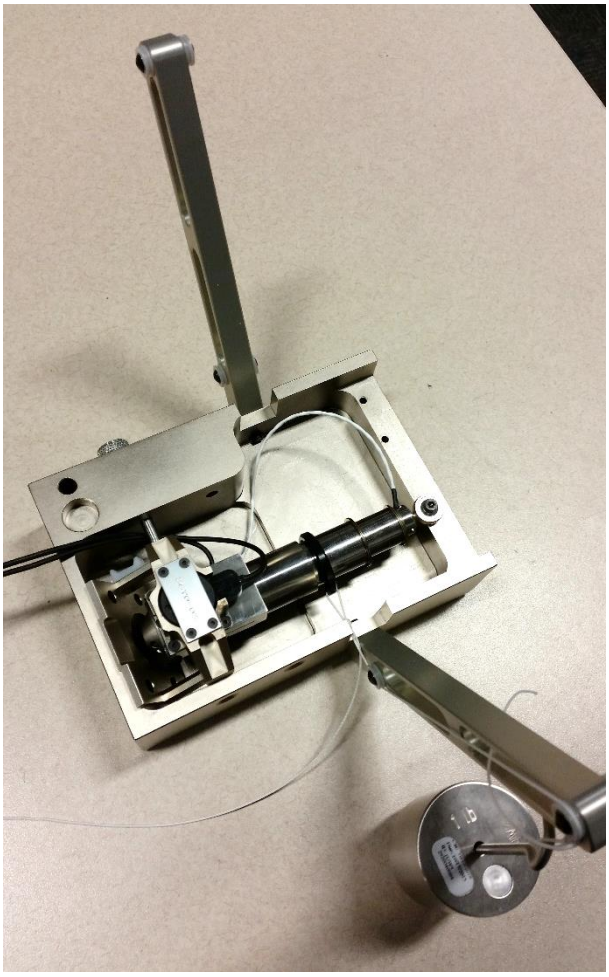


*Figure 5 Ballast on **Far** side **long** range*



*Ballast on **Near** side **long** range*

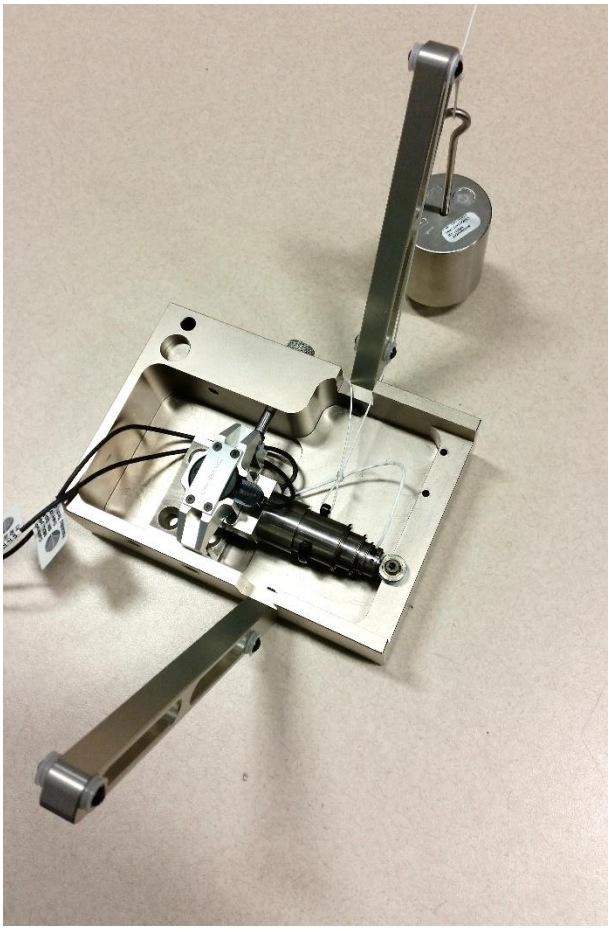
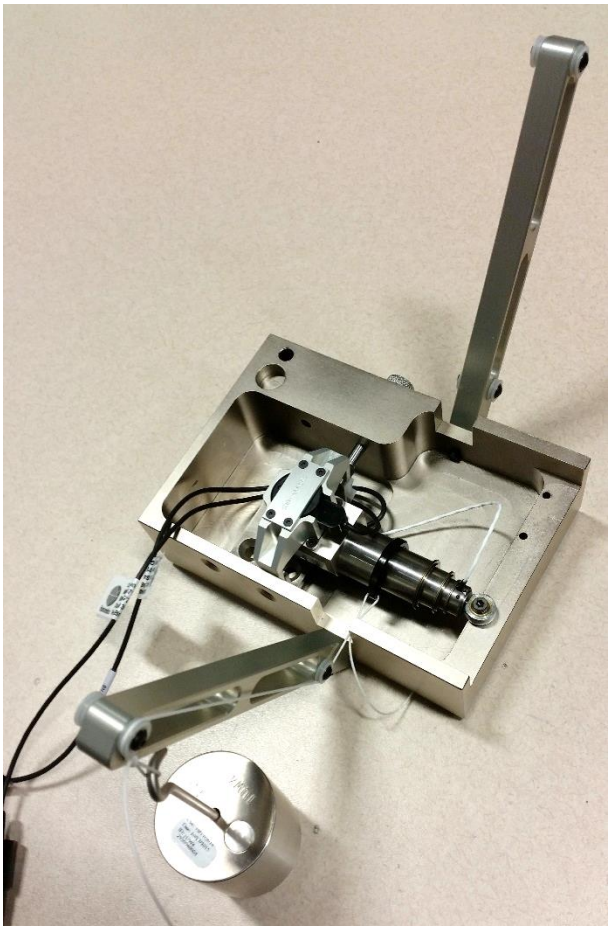


*Figure 6 Ballast on **Far** side **Short** range*



*Ballast on **Near** side **Short** range*

Step 2.5

- Reposition the rod end bearing 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 5 decimals: i.e. -0.00312, make sure to enter the correct sign).
- For IF-372 skip position 2.
- Reposition the rod end bearing 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 5 decimals: i.e. -0.00312, make sure to enter the correct sign).
- The fields under φ_{IRT}, L, x and y should now be all green. Cells are colored red when the 3% tolerance of the assembly specification is exceeded. If cells are red, go back to step 2.1 and re-verify consecutive steps make corrections as necessary. Consult Table 2 Fault tree for further assistance.
- Save the file.

Step 2.6

- The Absolute Length Verification is now completed. Save the file in the appropriate manner in the test data base. Print or PDF. File and distribute as laboratory procedure specify.

Table 2 Fault tree

Possible cause of error	**Check action**
Error in calibration parameters	Recheck all calibration parameter are copied over correctly from the certification sheet.
A common mistake is the wrong sign of the angle voltages (forgot to type -).	Check and correct the angle sensor voltages at the relevant position(s).
Reference length wrong	Check you have entered the correct Ref Length (105 or 77mm) pertaining to the model number and mounting position
Wrong sign or value of angle calibration factor.	Cross check with angle calibration sheet. Check if unit is converted correctly.
Calibration range sets the amount of tolerance on x and y parameters.	Check that the correct calibration range is entered.
Voltage readings of the IR-TRACC are entered in the angle cells.	Make sure that the angle sensor is connected to the voltmeter.
Excitation voltage measured or entered wrong	Recheck the excitation voltage.
The IR-TRACC assembly may have simultaneous occurrence of a tube in-out error and lateral play close to the limits.	Check the verification sheet δR-in and δR-out errors of the absolute verification point closest to 105mm (or 77mm).
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).	Deflect the middle of the tube for large play. If there is no angle sensor voltage response, this indicates play in the angle sensor shaft. See further instructions below.
If the errors persists, the angle sensor could be bad.	Unscrew the rod end bearing screw (Figure 1, Item 7) and rotate the IRTRACC. 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 replace the angle sensor.
The verification template functionality is lost as some cells have been overwritten accidentally. (Cells are not protected).	Re-open the template and start over.
Enter errors found here to expand knowledge base as we progress	Enter check and remedy here! Refer to website for latest version.

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Document nr xx **Revision** **23-Feb-15**

2D IR-TRACC ASSEMBLY- ABSOLUTE LENGTH VERIFICATION SHEET

Applies for Right Hand Side IR-TRACC Orientation

Calculate IRTRACC Radius using formula: R = (Vsensor ^ -0.4514) * 33.87+11.62

IR-TRACC		Angle Sensor			Date		Tubes In-Out Intercept [mm]		111.19
Test No.	101614DS3170	Test Nr.	10162014DQ5978		TEST No.		Linearization exponent		-0.4514
Model No.	IF-367-R2S7	Model / SN	3670-11s		Technician	Bonny Chadwick	Calibration Factor [mm/V]		33.867
Serial No.	DS3170	Ang cal/polarity	-0.003169	V_{sen}/V_{exc}/deg	Temp / Hum	23.2 / 45	Absolute Intercept [mm]		11.62
Calibration Range [mm]	80	Excitation [V]	5.0060	90	REF Length [mm]	105	122.81	InvCF [V/mm] 0.02953	Abs.Interc[V] 0.3433
V_{REF} Length [V]	0.1058	V_{REF} Angle [V]	-0.0504	φ0Offset$_{Sensor}$ [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} RIGHT	-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	36.6	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

Calibration Equipment Used

Manufacturer Report No. Cal Date Cal Due Model No. Serial No.

Verification by: _____

signature

Figure 7 Completed Absolute Length Verification Sheet with verification parameters (purple), validation (green) and error results

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

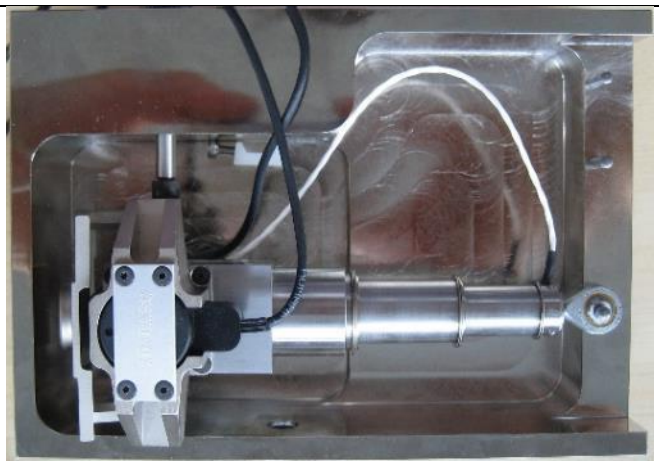
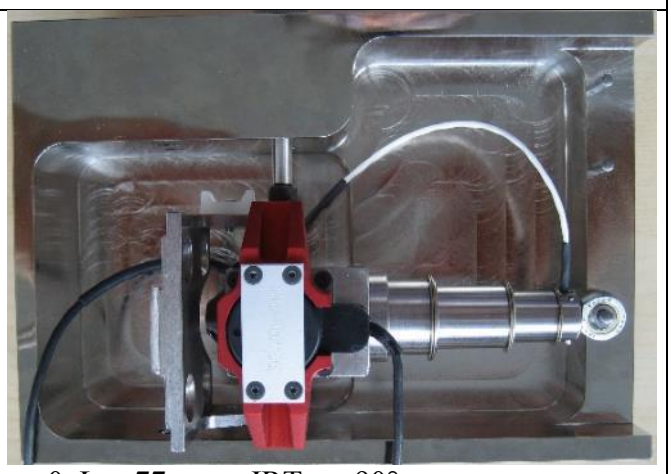
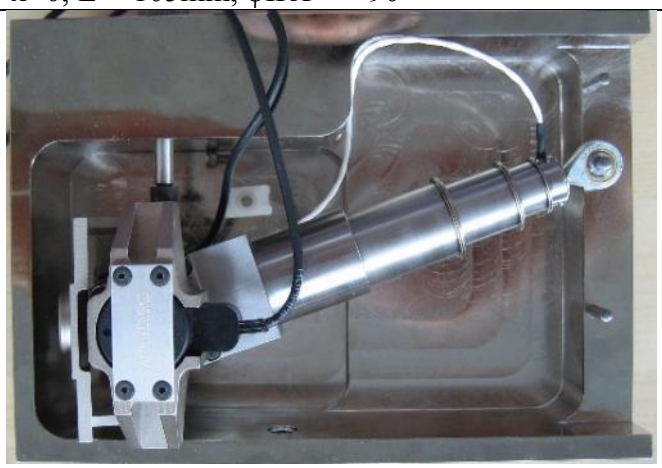
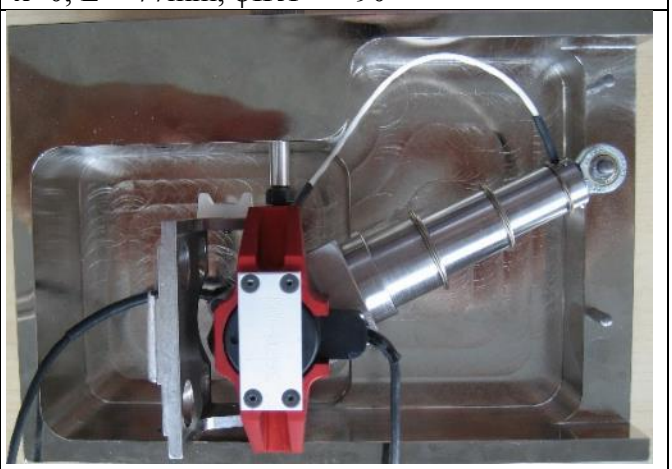
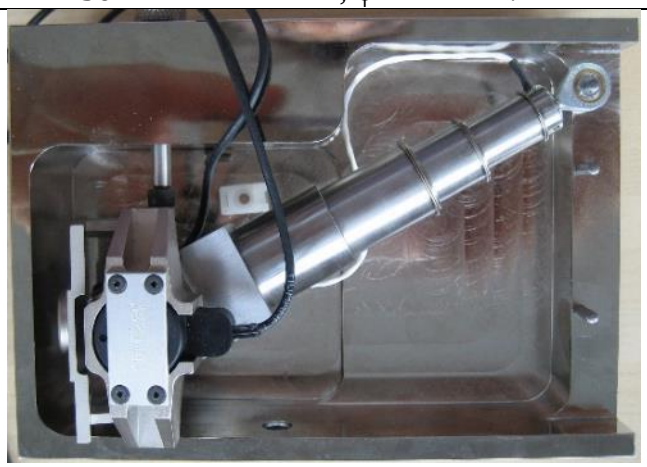
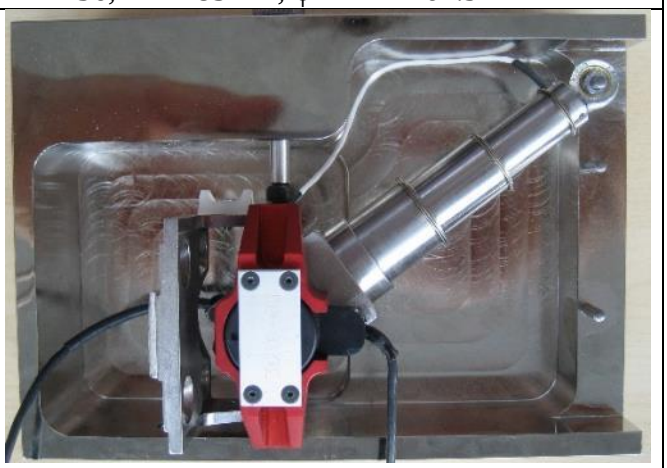
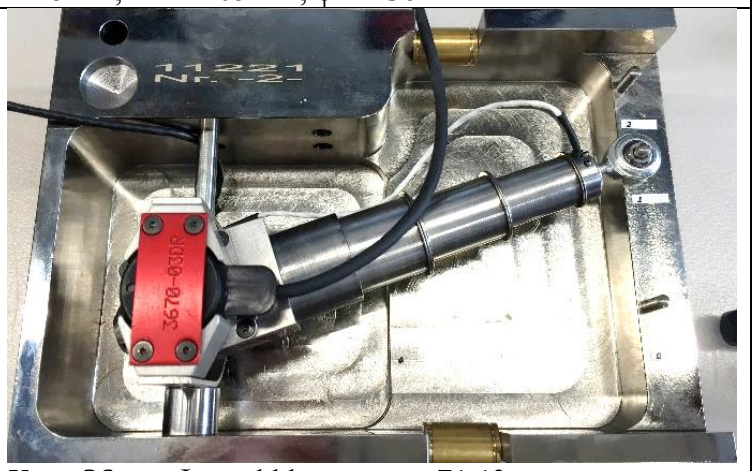
Position	**IF-367 & IF-368: y = 105mm**	**IF-371: y = 77mm**
Pos0	 x=0, L=+105mm, φIRT = +90°	 x=0, L=+77mm, φIRT = +90°
Pos1 X=36	 X = +36mm L = +111mm, φIRT = +71.1°	 X =+36, L = +85mm, φIRT = +64.9°
Pos2 X=56	 X=+56mm, L = +119mm, φ = +61.9°	 X=+56mm L = +95.2mm, φ = +54°

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.