(Form Template)		
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IR-TRACC Length Calibration Procedure Tube In-Out

1 Introduction

Scope: Calibration of IR-TRACCs
Equipment: Cal fixture part # TE-3700-IRTKIT (or TE-3600)
Software: IR-TRACC Calibration Template official document nr here
The issue of Tube In-Out error is being addressed with this calibration method.

This document describes the procedure for length calibration of IR-TRACCs. The procedure is performed on the existing calibration fixture. In this procedure calibration data are obtained in two conditions at each calibration interval: with IR-TRACC tubes fully compressed in and fully extended out (Tube In-Out). The spreadsheet calculates the optimized linearization exponent and linear sensitivity based on the input data, taking into account data from both tube conditions at each length interval. The spreadsheet calculates the maximum non linearity error per calibration interval and the total span of error per calibration interval.

2 Length calibration Tube In-Out

This part follows the standard IR-TRACC calibration procedure on Calibration Fixture part# TE-3700-IRKIT (or TE-3600).

Step 1.0

- Open the calibration template and save it under a new file name according the test data base file naming conventions.
- On tab 'Tube In-Out INPUT' complete all relevant cells in the orange fields in upper portion of the data collection sheet.
- See Figure 1

IRTRACC - CALIBRATION SHEET

Advanced In-Out Calibration Procedure

Test No.	101614DS3170	**Date**	16-Oct-14
Model No.	IF-367-R2S7	**Last Calibrated**	
Serial No.	DS3170	**Technician**	B.Chadwick
Cal. Range [mm]	80	**Temp (C)**	23.8
Diffuser?	Yes	**Hum. (%)**	47.5
Customer		**Calibration Standard**	DTC-CLP029
Order number		**Excitation**	5

Figure 1 Calibration Identification fields

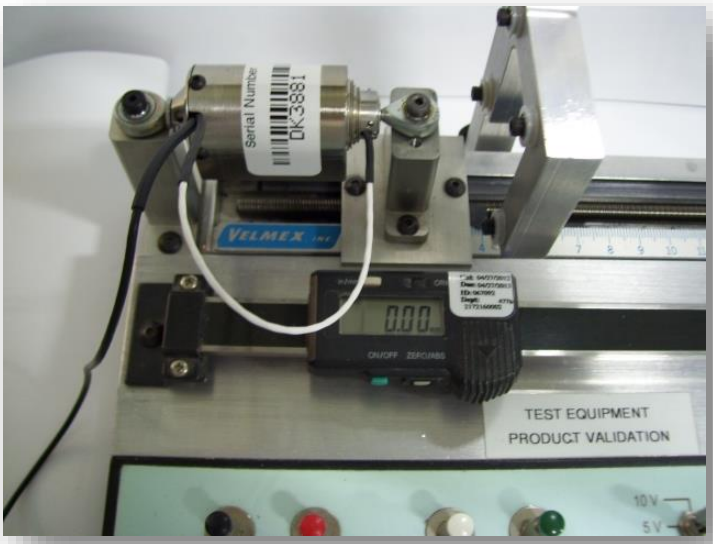

Figure 2: IR-TRACC fully collapsed. Note: wire loop from big end to small end is on the same side

Step 1.1

- Check IR-TRACC and the cal. fixture for any mechanical play, like loose screws, loose mechanical components, loose ball joint, etc. and fix as necessary.
- Secure IR-TRACC to fixture as shown. Fasten until secure. Make sure the wire loop from the big end to the small end are facing the same side.
- Collapse IR-TRACC completely as shown in Figure 2. Make sure not to exert excessive force, as this will bend the pillars of the fixture.
- Zero the caliper.

Step 1.2

- Establish the zero position of the extended IR-TRACC calibration range as follows, according values given in Table 1 forTable 1 Starting point, zero position, calibration range and intervals per model number:
  - Example (IF-367):
  - From fully compressed, expand 85-86mm outward; see column A
  - to remove backlash compress back to 82mm and zero the caliper; see column B
  - Calibrate 5mm increments until 80mm compression; see column C

Table 1 Starting point, zero position, calibration range and intervals per model number

	Column A	Column B	Column C
Model number	Starting point: expand outwards from fully compressed … [mm]	Remove backlash, compress to … [mm] and zero caliper	Calibration range, compress in 5mm intervals to …[mm]
IF-362	85 - 86	82.00	80.00
IF-363			
IF-364			
IF-366			
IF-367			
IF-368			
IF-372			
472-3550/-60 3640-00-CR3			
472-3570/-80 3640-00-CR4			
6110			
8830			
IF-369	70-71	67.00	65.00
IF-371			
6510	63-64	62.00	60.00
9810			
9910, 9915	119-120	117.00	115.00
10180	24-25	23.50	22.50; 2.5mm increments

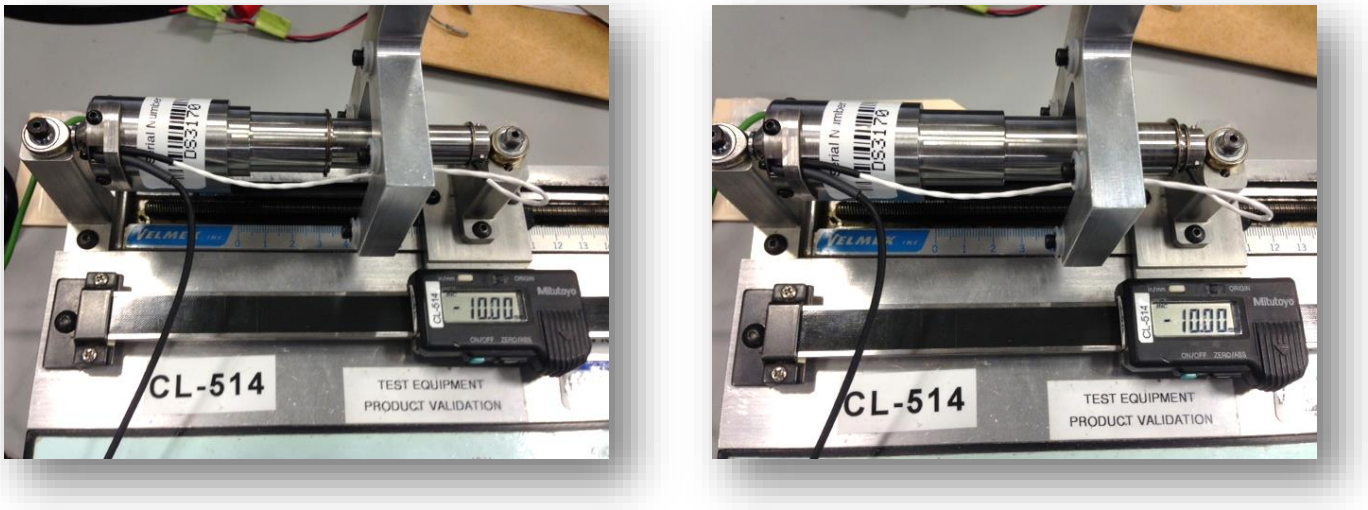

Figure 3: IRTRACC tubes-in shown left and tube-out shown right

Step 1.3

- 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 and enter the measured voltage in calibration sheet.
- Connect the voltmeter to measure the IR-TRACC output.
- Enter IR-TRACC specific calibration range on the certification sheet cell B14 “Cal. Range [mm]” at the top of the certification sheet (for example 80mm, see column C). This will set the calibration range of the spreadsheet and removes lines that are not used.

Table 2: wire color assignments

Wire Color	**Function**
Red	+EXC
White	-SIG
Black	-EXC
Green	+SIG
Orange	ID
Shield	GND, Return ID

Step 1.4

- At the zero position check lateral play with ballast of 0.45kg (~1 lbs.).

- Load IR-TRACC in four different directions as shown in Figure 4. Tubes are fully out.
- *Note: Wire loop around IR-TRACC should be in line with fixture pulleys.
- Enter the four voltage readings (4 digits) in the certification sheet in the orange "Lateral Displacement Measurement" fields (Figure 5).
- Remove the lateral play ballast
- Save the file.

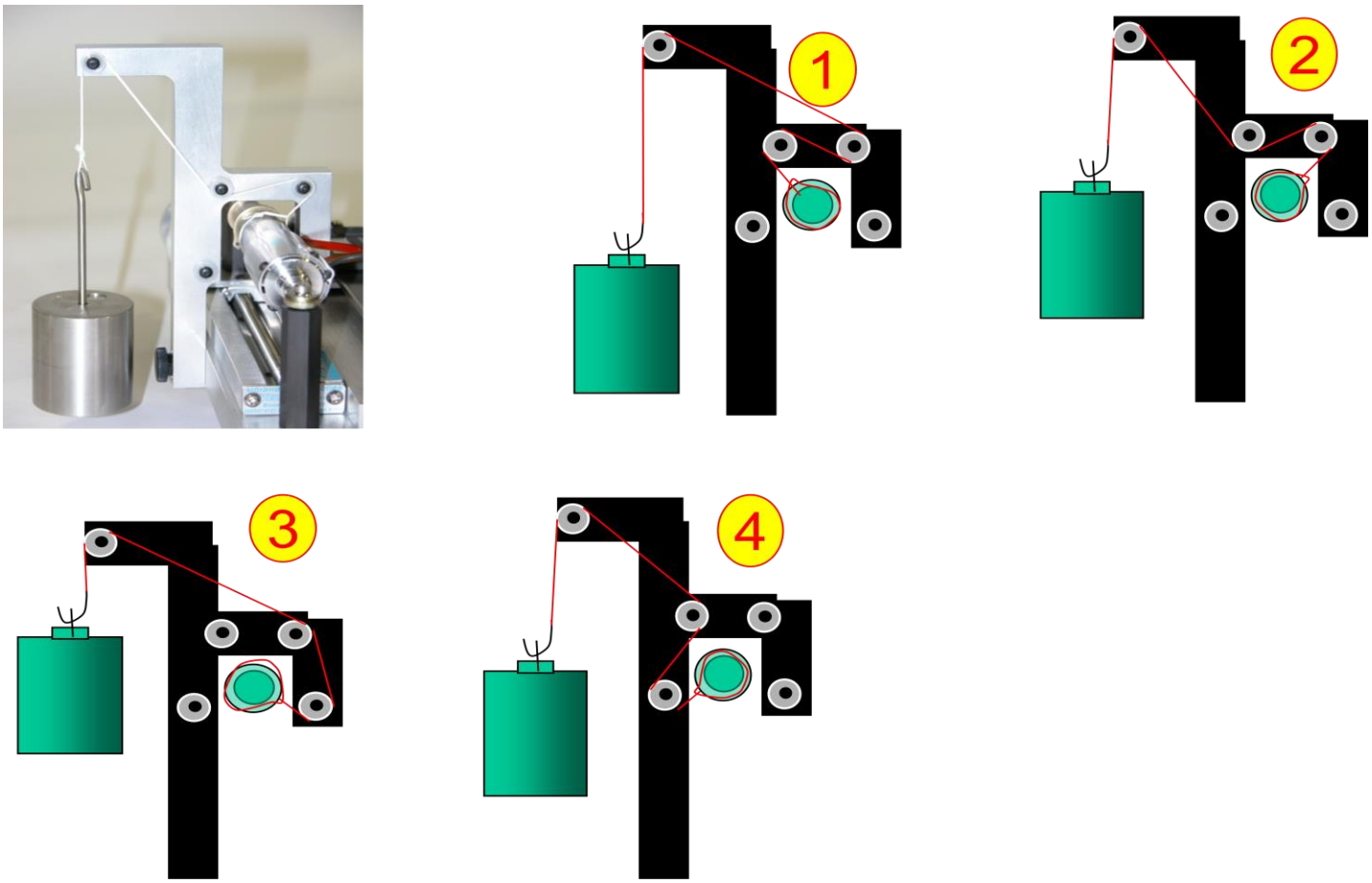

Figure 4: IRTRACC lateral displacement setup

Lateral Displacement Measurement			
Output # @ Disp = 0	**Measured Output (V)**	**Linearized Output (V)**	**Calculated Displacement (mm)**
1	0.0540	3.945	-0.57
2	0.0543	3.935	-0.28
3	0.0546	3.924	0.01
4	0.0544	3.931	-0.18
Max. Variance	0.0006	0.020	0.57
		Max. % F.S.:	**0.72**
		Pass/Fail:	Pass

Figure 5 Lateral displacement input fields in orange

Step 1.5

- In this step data is taken of the tubes-in and tubes-out condition. It is mandatory to obtain data of tube-in at each length interval first, then go back beyond 0mm and repeat all length intervals tube-out. Important: only take data in one direction pushing IN to the next calibration interval.[1]
- Make sure the caliper is at 0.00mm
- Slide all floating IR-TRACC tubes IN to the big end (to the left in Figure 3)
- Enter voltage reading [V] at 0mm in orange column tubes IN (Figure 6)
- Subsequently collapse IR-TRACC in 5mm increments, pushing all tubes to the IN position and take voltage readings at each calibration point
  *Note: for consistent results, take reading from only one direction (collapsing). If 5mm movement is exceeded, bring scale back beyond last target point and reposition
- Enter voltage reading in orange column tubes IN (column I)
- When last IN data point is entered at full calibration range return the calibration head beyond 0mm (between -1, -2mm); slide all floating IR-TRACC tubes OUT to the small end (to the right in Figure 3);
- Move calibration head back to 0.00mm
- Enter voltage reading at 0mm in orange column tubes OUT (column J)
- Subsequently collapse IR-TRACC in 5mm increments, keeping all tubes to the OUT position and take voltage readings at each calibration point
- Repeat until the IR-TRACC reaches the maximum calibration range and the orange cells are completed.

[1] It is possible to take IN and OUT data at each calibration interval, which would save positioning twice at each interval. However, this is not recommended as it has two major disadvantages: 1) while manipulating the tubes IN to OUT one could inadvertently push the IR-TRACC end out of position, thereby invalidating the calibration length; 2) When tubes are IN, it is nearly impossible to get the tubes to the OUT position when the IR-TRACC is around fully compressed. It is easier to keep the tubes in the out position during collapse, when moving the calibration head in to the next calibration point.

Displacement	Sensor Output	Optimized Exponent			Calculated Variation Tubes IN - OUT			IN	OUT
(mm)	Average Tube IN-OUT V_{sensor}	V_{linear}	Calculated Displacement (mm)	Nominal Linearity Error	Deviation IN [mm]	Deviation OUT (mm)	Maximum Variation [mm]	V_{sensor}	V_{sensor}
0	0.0550	3.9126	0.3374	0.42%	0.66	0.01	0.66	0.0553	0.0546
5	0.0605	3.7410	5.1464	0.18%	0.51	-0.22	0.73	0.0609	0.0600
10	0.0669	3.5681	9.9912	-0.01%	0.24	-0.26	0.49	0.0672	0.0665
15	0.0745	3.3909	14.9573	-0.05%	0.08	-0.16	0.24	0.0747	0.0743
20	0.0835	3.2148	19.8931	-0.13%	-0.03	-0.18	0.15	0.0836	0.0833
25	0.0943	3.0360	24.9033	-0.12%	-0.03	-0.16	0.13	0.0944	0.0941
30	0.1073	2.8564	29.9355	-0.08%	-0.03	-0.10	0.07	0.1074	0.1072
35	0.1232	2.6767	34.9705	-0.04%	0.00	-0.06	0.06	0.1233	0.1231
40	0.1429	2.4964	40.0236	0.03%	0.05	0.00	0.05	0.1430	0.1428
45	0.1672	2.3190	44.9938	-0.01%	0.00	-0.02	0.02	0.1672	0.1671
50	0.1988	2.1374	50.0819	0.10%	0.10	0.07	0.03	0.1989	0.1987
55	0.2395	1.9582	55.1040	0.13%	0.10	0.10	0.00	0.2395	0.2395
60	0.2932	1.7805	60.0829	0.10%	0.09	0.07	0.02	0.2933	0.2931
65	0.3672	1.6018	65.0898	0.11%	0.09	0.09	-0.01	0.3671	0.3672
70	0.4699	1.4263	70.0066	0.01%	0.00	0.01	-0.02	0.4697	0.4701
75	0.6229	1.2493	74.9664	-0.04%	-0.04	-0.03	-0.01	0.6227	0.6230
80	0.8576	1.0749	79.8536	-0.18%	-0.15	-0.15	0.00	0.8575	0.8576
			Non-Lin. Max:	**0.18%**	**0.51**	**0.26**	**0.73**		

Figure 6 Orange columns to enter calibration data tubes In and tubes Out

Step 1.6

- After all data points are entered, click the "Solve it" button to run the optimization routine and produce pass/fail results (Figure 7).
- Check if the IR-TRACC passes calibration criteria for nominal and maximum linearity error, maximum variation and forced lateral displacement.

Optimized Exponent (Max Error 0.18%)	
Calibration Factor mm/volt	**28.0213**
Linearization exponent:	**-0.47020**
Inverse Calibration Factor V/mm	-0.035687
**Calculate displacement using the formula:*	
*mm = (Vsensor ^ -0.4702) * -28.0213+109.9746*	
**These values are unique to this IR-TRACC*	

!Solve It!

Solved

Figure 7: Click the 'Solve it' button

Step 1.7

- The Length Calibration is now **completed**. Save the file in the appropriate manner in the test data base. Print calibration sheet on paper or PDF as required.

Test No.	101614DS3170		**Date**	16-Oct-14	
Model No.	IF-367-R2S7		**Last Calibrated**		
Serial No.	DS3170		**Technician**	B.Chadwick	
Cal. Range [mm]	80		**Temp (C)**	23.8	
Diffuser?	Yes		**Hum. (%)**	47.5	
Customer			**Calibration Standard**	DTC-CLP029	
Order number			**Excitation**	5	Volt

Displacement	Sensor Output	Optimized Exponent			Calculated Variation Tubes In-Out			IN	OUT
[mm]	Average Tube In-Out V_{sensor} [V]	V_{linear} [V]	Calculated Displacement [mm]	Nominal Linearity Error [%]	Deviation IN [mm]	Deviation OUT [mm]	Maximum Variation [mm]	V_{sensor} [V]	V_{sensor} [V]
0	0.0708	3.2987	0.1032	0.13%	0.17	0.03	0.14	0.0709	0.0707
5	0.0783	3.1523	5.0708	0.09%	0.13	0.01	0.12	0.0784	0.0782
10	0.0869	3.0077	9.9802	-0.02%	-0.02	-0.02	0.00	0.0869	0.0869
15	0.0973	2.8583	15.0512	0.06%	0.23	-0.13	0.36	0.0977	0.0969
20	0.1092	2.7134	19.9675	-0.04%	0.04	-0.11	0.15	0.1094	0.1090
25	0.1236	2.5661	24.9685	-0.04%	0.03	-0.10	0.13	0.1238	0.1234
30	0.1410	2.4182	29.9885	-0.01%	0.09	-0.12	0.21	0.1414	0.1406
35	0.1618	2.2727	34.9243	-0.09%	-0.03	-0.12	0.09	0.1620	0.1616
40	0.1880	2.1243	39.9612	-0.05%	0.00	-0.08	0.09	0.1882	0.1877
45	0.2207	1.9760	44.9969	0.00%	0.01	-0.02	0.03	0.2208	0.2206
50	0.2620	1.8291	49.9816	-0.02%	0.03	-0.07	0.10	0.2624	0.2615
55	0.3161	1.6805	55.0231	0.03%	0.03	0.01	0.02	0.3162	0.3160
60	0.3875	1.5332	60.0229	0.03%	0.03	0.02	0.01	0.3875	0.3874
65	0.4856	1.3849	65.0586	0.07%	0.08	0.04	0.03	0.4860	0.4852
70	0.6233	1.2375	70.0609	0.08%	0.06	0.06	-0.01	0.6232	0.6234
75	0.8237	1.0914	75.0194	0.02%	0.00	0.04	-0.05	0.8225	0.8248
80	1.1288	0.9469	79.9243	-0.09%	-0.07	-0.08	0.01	1.1292	1.1283
			Non-Lin. Max:	0.09%	0.23	0.13	0.36		

Nominal Linearity Error <2% Calibration Range	Humanetics Acceptance Specification	Pass
Maximum variation <2% Calibration Range		Pass
Maximum Linearity error <2% Calibration Range		Pass

Maximum Error

Optimized Exponent (Max Error 0.09%)		
Calibration Factor mm/volt		33.9403
Linearization exponent:		-0.45074
Intercept Voltage [V] & Inverse Sensitivity [V/mm]	3.3017	-0.0294635

**Calculate displacement using the formula:*
*mm = (Vsensor ^ -0.4507) * -33.9403+112.0614*
**These values are unique to this IR-TRACC*

Solved

Lateral Displacement Measurement			
Output # @ Disp = 0	Measured Output (V)	Linearized Output (V)	Calculated Displacement (mm)
1	0.0691	3.335	-1.13
2	0.0724	3.266	1.23
3	0.0715	3.284	0.60
4	0.0700	3.316	-0.47
Max. Variance	0.0033	0.069	2.36
		Max. % F.S.:	2.94
		Pass/Fail:	Pass

Humanetics Acceptance Specifications	
Max. variation tubes in-out [mm]	1.6
Max. Linearity Error [%]	2% F.S.

Wire Color Codes	
Wire Color	Function
Red	+ Exc
Black	- Exc
Green	+ Sig

Figure 8 Completed Tubes In-Out calibration sheet