Fisher Controls International, LLC

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Level-Trol Input Simulation Configuration Page			
Device Model	DLC3010		
Operator Initials	CLL		1. Follow Instructions in green fields.
Ship Site	088		Enter Sensor Data in yellow fields.
Serial Number	F001334117		Computed values are returned in blue fields.
Tag	LT-441A		
Sensor Type	249B		
	Driver Rod Length (in)	8.006	
249V(special)Length		in	If the sensor is a 249V with a non-standard driver rod length, enter actual driver length here
Torque Tube Wall	STD		
Displacer Length	14.00	in	
Displacer Volume	99.00	in3	
Displacer Weight	4.75	lb	Note: Effective displacer weight includes the stem weight and half the driver rod weight.
Theoretical max Unbuoyed Weight for torque tube (lb):		5.0	(It is permissible for displacer to exceed this limit for an interface or density application.)
Theoretical minimum *displacer* water level required to insure that driver rod is off stop during calibration (in):		0.00	2. If possible, **mark coupling point** at zero buoyancy and **run a straight Level Calibration** with SG=1.00: If the **"Min level required"** at right is **not zero**, use a **two point calibration** at Min level and 100% Level
			If the "Min level required" is greater than the displacer length, the calibration must be done with weights.
Method Used:	Water Column		**a.** Enter Input Simulation Method Used:
Coupling point mark at:	Zero Buoyancy		**b.** Record the condition at which the coupling point is marked
Measured TT Rate:	9.372	lbf*in/deg	3. Enter Torque Tube Rate read from Instrument **after ambient calibration**:
Temperature Units:	Fahrenheit		**a.** Select Temperature Units: (here and in instrument)
Process Temperature:	150.0		**b.** Enter Normal **Operating** Process Temperature from requisition:
	Deg C	65.6	(here and in instrument)
	Deg F	150.0	
Torque Tube Material:	K-Monel, Ni/Cu (N05500)		**c.** Select torque tube alloy from drop-down list:
	Compensation Factor:	0.9953	to lookup temperature compensation factor
Compensated TT Rate:	lbf*in/deg	9.328	**d.** Send the compensated torque tube rate value back to instrument:
Actual Application:	Level		**e.** Select application measurement type from requisition (Level, Interface, or Density):
SG Entry:	Single-Point	Application SGs	**f.** Select "Single-Point" here & enter liquid SGs @ Normal Operating Process Temperature,
SG of Upper Fluid:	0.0000	0.00000	or select "Steam Tables" to use table-look-up of steam/water SG at Process temperature.
SG of Lower Fluid:	0.8000	0.80000	For a level application, set SG of Upper Fluid = 0.00.
			For density, set: SG Lower to maximum, SG Upper to minimum, (of range to be measured).
4. Configure the DLC measurement mode (Level, Interface, or Density)			If application is **density** and displacer is **overweight**, use Interface Mode with weight input method.
PV is =	Level		See Instructions here
	For an **interface** application with **overweight displacer**, mark the coupling point at zero differential buoyancy, (lowest process condition),		
	Delta SG	0.8000	Use Level Measurement Mode, and enter **Delta SG** in the instrument configuration.
	If the application is a **saturated steam / saturated water interface** measurement, and you elected to use the SG tables for Steam/Water,		
	Sat. Steam SG	0.00095	enter the tables into the instrument to allow it to compute SG based on digital process temperature.
	Sat. Water SG	0.97925	The default steam table is on the SG Table sheet. **Print it out for the customer if used.**
	SG of Upper Fluid		These are the SG values that the instrument is using for calculations.
	SG of Lower Fluid	0.80000	
Zero reference for PV	Bottom of Displacer	(@ min process cond.)	5. Now record the final PV Setup used in the *instrument:*
Level Offset:	0.000	0.003	(in) - to trim PV to match simulated input condition, (blue is theoretical for DispBot@MinProc)
Action:	Direct		(For Reverse Action, make LRV greater than URV)
URV:	14.00	in	6. If test input is water, go to Water worksheet for application requested.
LRV:	0.00	in	If test input is weight, go to Weight worksheet for application requested.

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2/13/2017 1:13 PM

Level-Trol Worksheet: **Simulating Level or Interface Level at process conditions using only water levels at room temperature.**

Within certain constraints, we can compute a *cage* water level at ambient temperature that will produce a load equivalent to a given cage interface level at Process Temperature. This document is not a certificate, but does aid in validation of the calibration procedure.

$L(h\%) = L(Fbmin) + (dHc / dHd)\_a * [Wdisplacer - W(h\%) - Fbmin] / [WaterDensity * Vdisplacer]$

Where: $L(Fbmin) = DispLength * Fbmin / Fbmax\_h2o$

$(dHc / dHd)\_a = (AvlblDispLength + RiseMax(ambient)) / AvlblDispLength$

$$W(h\%) = \frac{Wdisplacer - WaterDensity * Vdisplacer * [SGmin + (\%hDsimulated/100\%) * (SGmax - SGmin)]}{TempFactor}$$

hDsimulated = simulated interface level on displacer

= hsim_cage0 + (dHd / dHc)_p * (hsim_cage - hsim_cage0)

(dHd / dHc)_p = DisplacerLength / (DisplacerLength + AppDeltaDisplacerRise)

hsim_Cage0 = cage level at which interface contacts displacer.

(dHc/dHd)_a =	1.030	Serial	F001334117
(dHd/dHc)_a =	0.970	Tag	LT-441A
(dHd/dHc)_p =	0.976	Type	249B
(dHc/dHd)_p =	1.024	Driver Rod (in)	8.006
		TT Material	K-Monel, Ni/Cu (N05500)
		TT Wall	STD
		TT Rate	(lbf*in/deg)
		ambient	9.372
		compensated	9.328
		URV (in)	14.000
		LRV (in)	0.000
		Range(In)	14.000
		hsim_Cage0 (in)	0.000

SG of Upper	0.0000
SG of Lower	0.8000
Displ. Length (in)	14.00
Displ. Vol (in3)	99.00
Displ. Wt (lb)	4.75
Process Temp (F)	150.0
TempFactor	0.9953
Max unbuoyed Wt (lb)	5.00
Fbmax_h20 (lb)	3.5739
Max Usable SG for Displacer	1.1892
Lowest usable Input (in)	0.00
Fbmin (lb)	0
Max Displacer Rise (amb)	3.047%

At lowest process condition, the actual position of the bottom of the displacer will have shifted from the ambient zero buoyancy location by:

-0.003 (in) -0.07 (mm) Due to displacer rise and temperature zero shift effects.

Normal factory practice is to trim the calculated PV to zero at this condition, since interface levels lower than this are unobservable.

Process Condition Simulated *			Wd - Fbmin - W(h%)	Desired Current Output (DLC3010)	Actual Water Level $ Input Required	
(in)	(mm)	(% Range)	(lbs)	(mA)	(in)	(mm)
0.00	0.0	0%	-0.02	4.000	-0.09	-2.3
3.50	88.9	25%	0.68	8.000	2.74	69.6
7.00	177.8	50%	1.38	12.000	5.57	141.4
10.50	266.7	75%	2.08	16.000	8.40	213.3
14.00	355.6	100%	2.78	20.000	11.23	285.2

$ Cage levels measured from ambient temperature zero-buoyancy reference.

If the message "Out of Range" appears here, an assumption **Out of Range!** has been violated. Use the "alternate approach" below:

* These values assume that PV is trimmed to zero at intitial minimum buoyancy and process temperature.

ALTERNATE APPROACH: We can compute the "theoretical" normalized levels at process temperature that are simulated by the usable water levels at ambient temperature:

$Hdisp\_eq = L(Fbmin) + (dHd / dHc)\_a * (Lc\_used - L(Fbmin))$

$Sgapp\_sim = TempFactor * Hdisp\_eq + (1 - TempFactor) * (Wdisplacer) / (WaterDensity * Vdisplacer)$

$Lc\_sim(Lc\_used) = (dHc / dHd)\_p * (Sgapp\_sim - Sgmin) / (SGmax - SGmin)$

where: Lc_sim and Lc_used are normalized to actual displacer length.

$ Cage levels measured from ambient temperature zero-buoyancy reference.

	Water Level Input Used $		Expected DLC Reading Process Condition Simulated *			Current Output (DLC3010)
	(in)	(mm)	(in)	(mm)	(% Range)	(mA)
Min	0.000	0.00	0.113	2.87	0.81%	4.129
User Choice:	0.00	0.00	0.113	2.87	0.81%	4.129
	2.74	69.56	3.500	88.90	25.00%	8.000
	5.57	141.43	7.000	177.80	50.00%	12.000
	8.40	213.31	10.500	266.70	75.00%	16.000
	11.23	285.18	14.000	355.60	100.00%	20.000
Max useful	14.427	366.44	17.957	456.10	128.26%	20.500

* These values assume that instrument is calibrated to read zero at simulation of intitial minimum buoyancy and process temperature.

Calibration Information: **Fisher Controls International, LLC** 2/13/2017 1:13 PM

Type	249B	DLC3010
Tag	LT-441A	
Serial No.	F001334117	
Date	13-Feb-17	
Ship Site:	088	
Operator:	CLL	

Torque Tube:				
Material	K-Monel, Ni/Cu (N05500)			
Wall Thickness	STD			
Driver Rod Length	8.006	(in)	203.4	(mm)
Displacer:				
Length	14.00	(in)	355.6	(mm)
Volume	99.00	(in3)	1622.3	(mL)
Weight	4.75	(lb)	2.15	(kg)

Target Process Condition:				
Process Temperature:	150.0	(deg F)	65.6	(deg C)

Actual Measurement Application:					
Level	X	Interface Level		Density	
Fluid SG	0.80000	Upper Fluid SG		Lowest SG	
		Lower Fluid SG		Highest SG	

Torque Tube Rate Calibration:				
Input Simulation Method Used:	Water Column			
Measured torque tube rate at 70 F (21.1C):	9.372	(lbf*in/deg)	1.0589	(N*m/deg)
Temperature Compensation Factor:	0.9953	@ Listed process temperature		
Compensated TT Rate:	9.328	(lbf*in/deg)	1.0539	(N*m/deg)

Note: The instrument was precompensated for operation at the process temperature listed, and may not read correctly at a different temperature.

Configuration Values Used in Instrument				
Instrument Measurement Mode used:	Level			
Reference coupling point mark at:	Zero Buoyancy			
SG entry:	Single-Point	(If Steam Tables used, print SG Tables sheet)		
SG of Upper Fluid:	N/A	(SGU)		
SG of Lower Fluid:	0.80000	(SGU)		
Zero Reference:	Bottom of Displacer			
Level Offset Required to Trim PV to simulated input condition:	0.000	(in)	0.0	(mm)
Output Action:	Direct			
Upper Range Value:	14.000	(in)	355.6	(mm)
Lower Range Value:	0.000	(in)	0.0	(mm)

Test Equipment Documentation:						
Input Measurement Accuracy:					Last Calibration:	Calibration Due:
force accuracy		(lb)		(N)		
weight accuracy		(lb)		(kg)		
water column height accuracy	0.1	(in)		(mm)		N/A
Output Measurement Accuracy:						
current accuracy	0.1	(mA)				

Test site should fill in the accuracy and calibration data for relevant test equipment and save. Update per plant calibration schedule.

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Level-Trol Input Simulation Configuration Page			
Device Model	DLC3010		
Operator Initials:	DRM		1. Follow Instructions in green fields.
Ship Site	088		Enter Sensor Data in yellow fields.
Serial Number	F001334118		Computed values are returned in blue fields.
Tag	LT-441B		
Sensor Type	249B		
	Driver Rod Length (in)	8.006	
249V(special)Length		in	If the sensor is a 249V with a non-standard driver rod length, enter actual driver length here
Torque Tube Wall	STD		
Displacer Length	14.00	in	
Displacer Volume	99.00	in3	
Displacer Weight	4.75	lb	Note: Effective displacer weight includes the stem weight and half the driver rod weight.
Theoretical max Unbuoyed Weight for torque tube (lb):		5.0	(It is permissible for displacer to exceed this limit for an interface or density application.)
Theoretical minimum *displacer* water level required to insure that driver rod is off stop during calibration (in):		0.00	2. If possible, **mark coupling point** at zero buoyancy and **run a straight Level Calibration** with SG=1.00: If the "**Min level required**" at right is **not zero**, use a **two point calibration** at Min level and 100% Level
			If the "Min level required" is greater than the displacer length, the calibration must be done with weights.
Method Used:	Water Column		**a.** Enter Input Simulation Method Used:
Coupling point mark at:	Zero Buoyancy		**b.** Record the condition at which the coupling point is marked
Measured TT Rate:	9.434	lbf*in/deg	3. Enter Torque Tube Rate read from Instrument **after ambient calibration**:
Temperature Units:	Fahrenheit		**a.** Select Temperature Units: (here and in instrument)
Process Temperature:	150.0		**b.** Enter Normal **Operating** Process Temperature from requisition:
	Deg C	65.6	(here and in instrument)
	Deg F	150.0	
Torque Tube Material:	K-Monel, Ni/Cu (N05500)		**c.** Select torque tube alloy from drop-down list:
	Compensation Factor:	0.9953	to lookup temperature compensation factor
Compensated TT Rate:	lbf*in/deg	9.389	**d.** Send the compensated torque tube rate value back to instrument:
Actual Application:	Level		**e.** Select application measurement type from requisition (Level, Interface, or Density):
SG Entry:	Single-Point	Application SGs	**f.** Select "Single-Point" here & enter liquid SGs @ Normal Operating Process Temperature,
SG of Upper Fluid:	0.0000	0.00000	or select "Steam Tables" to use table-look-up of steam/water SG at Process temperature.
SG of Lower Fluid:	0.8000	0.80000	For a level application, set SG of Upper Fluid = 0.00.
			For density, set: SG Lower to maximum, SG Upper to minimum, (of range to be measured).
4. Configure the DLC measurement mode (Level, Interface, or Density)			If application is **density** and displacer is **overweight**, use Interface Mode with weight input method.
PV is =	Level		See Instructions here
	For an **interface** application with **overweight displacer**, mark the coupling point at zero differential buoyancy, (lowest process condition),		
	Delta SG	0.8000	Use Level Measurement Mode, and enter **Delta SG** in the instrument configuration.
	If the application is a **saturated steam / saturated water interface** measurement, and you elected to use the SG tables for Steam/Water,		
	Sat. Steam SG	0.00095	enter the tables into the instrument to allow it to compute SG based on digital process temperature.
	Sat. Water SG	0.97925	The default steam table is on the SG Table sheet. **Print it out for the customer if used.**
	SG of Upper Fluid		These are the SG values that the instrument is using for calculations.
	SG of Lower Fluid	0.80000	
Zero reference for PV	Bottom of Displacer	(@ min process cond.)	5. Now record the final PV Setup used in the *instrument:*
Level Offset:		0.003	(in) - to trim PV to match simulated input condition, (blue is theoretical for DispBot@MinProc)
Action:	Direct		(For Reverse Action, make LRV greater than URV)
URV:	14.00	in	6. If test input is water, go to Water worksheet for application requested.
LRV:	0.00	in	If test input is weight, go to Weight worksheet for application requested.

Calibration Information: **Fisher Controls International, LLC** 2/14/2017 12:54 PM

Type	249B	DLC3010
Tag	LT-441B	
Serial No.	F001334118	
Date	14-Feb-17	
Ship Site:	088	
Operator:	DRM	

Torque Tube:				
Material	K-Monel, Ni/Cu (N05500)			
Wall Thickness	STD			
Driver Rod Length	8.006	(in)	203.4	(mm)
Displacer:				
Length	14.00	(in)	355.6	(mm)
Volume	99.00	(in3)	1622.3	(mL)
Weight	4.75	(lb)	2.15	(kg)

Target Process Condition:				
Process Temperature:	150.0	(deg F)	65.6	(deg C)

Actual Measurement Application:					
Level	X	Interface Level		Density	
Fluid SG	0.80000	Upper Fluid SG		Lowest SG	
		Lower Fluid SG		Highest SG	

Torque Tube Rate Calibration:				
Input Simulation Method Used:	Water Column			
Measured torque tube rate at 70 F (21.1C):	9.434	(lbf*in/deg)	1.0659	(N*m/deg)
Temperature Compensation Factor:	0.9953	@ Listed process temperature		
Compensated TT Rate:	9.389	(lbf*in/deg)	1.0609	(N*m/deg)

Note: The instrument was precompensated for operation at the process temperature listed, and may not read correctly at a different temperature.

Configuration Values Used in Instrument				
Instrument Measurement Mode used:	Level			
Reference coupling point mark at:	Zero Buoyancy			
SG entry:	Single-Point	(If Steam Tables used, print SG Tables sheet)		
SG of Upper Fluid:	N/A	(SGU)		
SG of Lower Fluid:	0.80000	(SGU)		
Zero Reference:	Bottom of Displacer			
Level Offset Required to Trim PV to simulated input condition:	0.000	(in)	0.0	(mm)
Output Action:	Direct			
Upper Range Value:	14.000	(in)	355.6	(mm)
Lower Range Value:	0.000	(in)	0.0	(mm)

Test Equipment Documentation:						
Input Measurement Accuracy:					Last Calibration:	Calibration Due:
force accuracy		(lb)		(N)		
weight accuracy		(lb)		(kg)		
water column height accuracy	0.1	(in)		(mm)		N/A
Output Measurement Accuracy:						
current accuracy	0.1	(mA)				

Test site should fill in the accuracy and calibration data for relevant test equipment and save. Update per plant calibration schedule.

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Level-Trol Worksheet: **Simulating Level or Interface Level at process conditions using only water levels at room temperature.**

Within certain constraints, we can compute a *cage* water level at ambient temperature that will produce a load equivalent to a given cage interface level at Process Temperature. This document is not a certificate, but does aid in validation of the calibration procedure.

L(h%) = L(Fbmin)+(dHc / dHd)_a * [Wdisplacer - W(h%) - Fbmin] / [WaterDensity * Vdisplacer]

Where: L(Fbmin) = DispLength * Fbmin / Fbmax_h2o

(dHc / dHd)_a = (AviblDispLength + RiseMax(ambient)) / AviblDispLength

W(h%) = (Wdisplacer - WaterDensity * Vdisplacer* [SGmin + (%hDsimulated/100%)* (SGmax - SGmin)]) / TempFactor

hDsimulated = simulated interface level on displacer = hsim_cage0 + (dHd / dHc)_p * (hsim_cage - hsim_cage0)

(dHd / dHc)_p = DisplacerLength / (DisplacerLength + AppDeltaDisplacerRise)

hsim_Cage0 = cage level at which interface contacts displacer.

(dHc/dHd)_a =	1.030	Serial	F001334118
(dHd/dHc)_a =	0.971	Tag	LT-441B
(dHd/dHc)_p =	0.976	Type	249B
(dHc/dHd)_p =	1.024	Driver Rod (in)	8.006
		TT Material	K-Monel, Ni/Cu (N05500)
		TT Wall	STD
		TT Rate	(lbf*in/deg)
		ambient	9.434
		compensated	9.389
		URV (in)	14.000
		LRV (in)	0.000
		Range(in)	14.000
		hsim_Cage0 (in)	0.000

SG of Upper	0.0000
SG of Lower	0.8000
Displ. Length (in)	14.00
Displ. Vol (in3)	99.00
Displ. Wt (lb)	4.75
Process Temp (F)	150.0
TempFactor	0.9953
Max unbuoyed Wt (lb)	5.00
Fbmax_h20 (lb)	3.5739
Max Usable SG for Displacer	1.1892
Lowest usable Input (in)	0.00
Fbmin (lb)	0
Max Displacer Rise (amb)	3.027%

At lowest process condition, the actual position of the bottom of the displacer will have shifted from the ambient zero buoyancy location by:

-0.003 (in) -0.07 (mm) Due to displacer rise and temperature zero shift effects.

Normal factory practice is to trim the calculated PV to zero at this condition, since interface levels lower than this are unobservable.

Process Condition Simulated *			Wd - Fbmin - W(h%)	Desired Current Output (DLC3010)	Actual Water Level $ Input Required	
(in)	(mm)	(% Range)	(lbs)	(mA)	(in)	(mm)
0.00	0.0	0%	-0.02	4.000	-0.09	-2.3
3.50	88.9	25%	0.68	8.000	2.74	69.6
7.00	177.8	50%	1.38	12.000	5.57	141.4
10.50	266.7	75%	2.08	16.000	8.40	213.3
14.00	355.6	100%	2.78	20.000	11.23	285.2

$ Cage levels measured from ambient temperature zero-buoyancy reference.

If the message "Out of Range" appears here, an assumption **Out of Range!** has been violated. Use the "alternate approach" below:

* These values assume that PV is trimmed to zero at intitial minimum buoyancy and process temperature.

ALTERNATE APPROACH: We can compute the "theoretical" normalized levels at process temperature that are simulated by the usable water levels at ambient temperature:

Hdisp_eq = L(Fbmin) +(dHd / dHc)_a * (Lc_used - L(Fbmin))

Sgapp_sim = TempFactor*Hdisp_eq +(1-TempFactor)*(Wdisplacer)/(WaterDensity*Vdisplacer)

Lc_sim(Lc_used) = (dHc / dHd)_p* (Sgapp_sim -Sgmin) / (SGmax-SGmin)

where: Lc_sim and Lc_used are normalized to actual displacer length.

$ Cage levels measured from ambient temperature zero-buoyancy reference.

	Water Level Input Used $		Expected DLC Reading Process Condition Simulated *			Current Output (DLC3010)
	(in)	(mm)	(in)	(mm)	(% Range)	(mA)
Min	0.000	0.00	0.113	2.86	0.81%	4.129
User Choice:	0.00	0.00	0.113	2.86	0.81%	4.129
	2.74	69.56	3.500	88.90	25.00%	8.000
	5.57	141.43	7.000	177.80	50.00%	12.000
	8.40	213.30	10.500	266.70	75.00%	16.000
	11.23	285.17	14.000	355.60	100.00%	20.000
Max useful	14.424	366.36	17.954	456.02	128.24%	20.500

* These values assume that instrument is calibrated to read zero at simulation of intitial minimum buoyancy and process temperature.

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Level-Trol Input Simulation Configuration Page

Device Model:	DLC3010		
Operator Initials:	DRM		1. Follow Instructions in green fields.
Ship Site:	088		Enter Sensor Data in yellow fields.
Serial Number:	F001334119		Computed values are returned in blue fields.
Tag:	LT-447		
Sensor Type:	249B		
	Driver Rod Length (in)	8.006	
249V(special)Length:		in	If the sensor is a 249V with a non-standard driver rod length, enter actual driver length here
Torque Tube Wall:	STD		
Displacer Length:	14.00	in	
Displacer Volume:	99.00	in3	
Displacer Weight:	4.75	lb	Note: Effective displacer weight includes the stem weight and half the driver rod weight.
Theoretical max Unbuoyed Weight for torque tube (lb):		5.0	(It is permissible for displacer to exceed this limit for an interface or density application.)
Theoretical minimum *displacer* water level required to insure that driver rod is off stop during calibration (in):		0.00	2. If possible, **mark coupling point** at zero buoyancy and **run a straight Level Calibration** with SG=1.00: If the "**Min level required**" at right is **not zero**, use a **two point calibration** at Min level and 100% Level
			If the "Min level required" is greater than the displacer length, the calibration must be done with weights.
Method Used:	Water Column		a. Enter Input Simulation Method Used:
Coupling point mark at:	Zero Buoyancy		b. Record the condition at which the coupling point is marked
Measured TT Rate:	9.524	lbf*in/deg	3. Enter Torque Tube Rate read from Instrument **after ambient calibration**:
Temperature Units:	Fahrenheit		a. Select Temperature Units: (here and in instrument)
Process Temperature:	150.0		b. Enter Normal **Operating** Process Temperature from requisition:
	Deg C	65.6	(here and in instrument)
	Deg F	150.0	
Torque Tube Material:	K-Monel, Ni/Cu (N05500)		c. Select torque tube alloy from drop-down list:
	Compensation Factor:	0.9953	to lookup temperature compensation factor
Compensated TT Rate:	lbf*in/deg	9.479	d. Send the compensated torque tube rate value back to instrument:
Actual Application:	Level		e. Select application measurement type from requisition (Level, Interface, or Density):
SG Entry:	Single-Point	Application SGs	f. Select "Single-Point" here & enter liquid SGs @ Normal Operating Process Temperature,
SG of Upper Fluid:	0.0000	0.00000	or select "Steam Tables" to use table-look-up of steam/water SG at Process temperature.
SG of Lower Fluid:	0.8000	0.80000	For a level application, set SG of Upper Fluid = 0.00.
			For density, set: SG Lower to maximum, SG Upper to minimum, (of range to be measured).
4. Configure the DLC measurement mode (Level, Interface, or Density)			If application is **density** and displacer is **overweight**, use Interface Mode with weight input method.
PV is =	Level		See Instructions here
	For an **interface** application with **overweight displacer**, mark the coupling point at zero differential buoyancy, (lowest process condition),		
	Delta SG	0.8000	Use Level Measurement Mode, and enter **Delta SG** in the instrument configuration.
	If the application is a **saturated steam / saturated water interface** measurement, and you elected to use the SG tables for Steam/Water,		
	Sat. Steam SG	0.00095	enter the tables into the instrument to allow it to compute SG based on digital process temperature.
	Sat. Water SG	0.97925	The default steam table is on the SG Table sheet. **Print it out for the customer if used.**
	SG of Upper Fluid		These are the SG values that the instrument is using for calculations.
	SG of Lower Fluid	0.80000	
Zero reference for PV	Bottom of Displacer	(@ min process cond.)	5. Now record the final PV Setup used in the *instrument:*
Level Offset:		0.003	(in) - to trim PV to match simulated input condition, (blue is theoretical for DispBot@MinProc)
Action:	Direct		(For Reverse Action, make LRV greater than URV)
URV:	14.00	in	6. If test input is water, go to Water worksheet for application requested.
LRV:	0.00	in	If test input is weight, go to Weight worksheet for application requested.

Calibration Information: **Fisher Controls International, LLC** 2/14/2017 2:20 PM

Type	249B	DLC3010	Torque Tube:				
Tag	LT-447		Material	K-Monel, Ni/Cu (N05500)			
Serial No:	F001334119		Wall Thickness	STD			
Date	14-Feb-17		Driver Rod Length	8.006	(in)	203.4	(mm)
Ship Site:	088		Displacer:				
Operator:	DRM		Length	14.00	(in)	355.6	(mm)
			Volume	99.00	(in3)	1622.3	(mL)
			Weight	4.75	(lb)	2.15	(kg)

Target Process Condition:				
Process Temperature:	150.0	(deg F)	65.6	(deg C)

Actual Measurement Application:					
Level	X	Interface Level		Density	
Fluid SG	0.80000	Upper Fluid SG		Lowest SG	
		Lower Fluid SG		Highest SG	

Torque Tube Rate Calibration:				
Input Simulation Method Used:	Water Column			
Measured torque tube rate at 70 F (21.1C):	9.524	(lbf*in/deg)	1.0761	(N*m/deg)
Temperature Compensation Factor:	0.9953	@ Listed process temperature		
Compensated TT Rate:	9.479	(lbf*in/deg)	1.0710	(N*m/deg)

Note: The instrument was precompensated for operation at the process temperature listed, and may not read correctly at a different temperature.

Configuration Values Used in Instrument				
Instrument Measurement Mode used:	Level			
Reference coupling point mark at:	Zero Buoyancy			
SG entry:	Single-Point	(If Steam Tables used, print SG Tables sheet)		
SG of Upper Fluid:	N/A	(SGU)		
SG of Lower Fluid:	0.80000	(SGU)		
Zero Reference:	Bottom of Displacer			
Level Offset Required to Trim PV to simulated input condition:	0.000	(in)	0.0	(mm)
Output Action:	Direct			
Upper Range Value:	14.000	(in)	355.6	(mm)
Lower Range Value:	0.000	(in)	0.0	(mm)

Test Equipment Documentation:						
Input Measurement Accuracy:					Last Calibration:	Calibration Due:
force accuracy		(lb)		(N)		
weight accuracy		(lb)		(kg)		
water column height accuracy	0.1	(in)		(mm)		N/A
Output Measurement Accuracy:						
current accuracy	0.1	(mA)				

Test site should fill in the accuracy and calibration data for relevant test equipment and save. Update per plant calibration schedule.

Fisher Controls International, LLC

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Level-Trol Worksheet: **Simulating Level or Interface Level at process conditions using only water levels at room temperature.**

Within certain constraints, we can compute a *cage* water level at ambient temperature that will produce a load equivalent to a given cage interface level at Process Temperature. This document is not a certificate, but does aid in validation of the calibration procedure.

$L(h\%) = L(Fbmin)+(dHc / dHd)\_a * [Wdisplacer - W(h\%) - Fbmin] / [WaterDensity * Vdisplacer]$

Where: $L(Fbmin) = DispLength * Fbmin / Fbmax\_h2o$

$(dHc / dHd)\_a = (AvlblDispLength + RiseMax(ambient)) / AvlblDispLength$

$W(h\%) = \frac{Wdisplacer - WaterDensity * Vdisplacer * [SGmin + (\%hDsimulated/100\%) * (SGmax - SGmin)]}{TempFactor}$

hDsimulated = simulated interface level on displacer

= hsim_cage0 + (dHd / dHc)_p * (hsim_cage - hsim_cage0)

$(dHd / dHc)\_p = DisplacerLength / (DisplacerLength + AppDeltaDisplacerRise)$

hsim_Cage0 = cage level at which interface contacts displacer.

(dHc/dHd)_a =	1.030
(dHd/dHc)_a =	0.971
(dHd/dHc)_p =	0.976
(dHc/dHd)_p =	1.024

Serial	F001334119	SG of Upper	0.0000
Tag	LT-447	SG of Lower	0.8000
Type	249B	Displ. Length (in)	14.00
Driver Rod (in)	8.006	Displ. Vol (in3)	99.00
TT Material	K-Monel, Ni/Cu (N05500)	Displ. Wt (lb)	4.75
TT Wall	STD	Process Temp (F)	150.0
TT Rate	(lbf*in/deg)	TempFactor	0.9953
ambient	9.524	Max unbuoyed Wt (lb)	5.00
compensated	9.479	Fbmax_h20 (lb)	3.5739
URV (in)	14.000	Max Usable SG for Displacer	1.1892
LRV (in)	0.000	Lowest usable input (in)	0.00
Range(in)	14.000	Fbmin (lb)	0
hsim_Cage0 (in)	0.000	Max Displacer Rise (amb)	2.998%

At lowest process condition, the actual position of the bottom of the displacer will have shifted from the ambient zero buoyancy location by:

-0.003 (in) -0.07 (mm) Due to displacer rise and temperature zero shift effects.

Normal factory practice is to trim the calculated PV to zero at this condition, since interface levels lower than this are unobservable.

Process Condition Simulated *			Wd - Fbmin - W(h%)	Desired Current Output (DLC3010)	Actual Water Level $ Input Required	
(in)	(mm)	(% Range)	(lbs)	(mA)	(in)	(mm)
0.00	0.0	0%	-0.02	4.000	-0.09	-2.3
3.50	88.9	25%	0.68	8.000	2.74	69.6
7.00	177.8	50%	1.38	12.000	5.57	141.4
10.50	266.7	75%	2.08	16.000	8.40	213.3
14.00	355.6	100%	2.78	20.000	11.23	285.2

$ Cage levels measured from ambient temperature zero-buoyancy reference.

If the message "Out of Range" appears here, an assumption **Out of Range!** has been violated. Use the "alternate approach" below:

* These values assume that PV is trimmed to zero at intitial minimum buoyancy and process temperature.

ALTERNATE APPROACH: We can compute the "theoretical" normalized levels at process temperature that are simulated by the usable water levels at ambient temperature:

$Hdisp\_eq = L(Fbmin) +(dHd / dHc)\_a * (Lc\_used - L(Fbmin))$

$Sgapp\_sim = TempFactor*Hdisp\_eq +(1-TempFactor)*(Wdisplacer)/(WaterDensity*Vdisplacer)$

$Lc\_sim(Lc\_used) = (dHc / dHd)\_p* (Sgapp\_sim -Sgmin) / (SGmax-SGmin)$

where: Lc_sim and Lc_used are normalized to actual displacer length.

$ Cage levels measured from ambient temperature zero-buoyancy reference.

	Water Level Input Used $		Expected DLC Reading Process Condition Simulated *			Current Output (DLC3010)
	(in)	(mm)	(in)	(mm)	(% Range)	(mA)
Min	0.000	0.00	0.113	2.86	0.81%	4.129
User Choice:	0.00	0.00	0.113	2.86	0.81%	4.129
	2.74	69.55	3.500	88.90	25.00%	8.000
	5.57	141.42	7.000	177.80	50.00%	12.000
	8.40	213.29	10.500	266.70	75.00%	16.000
	11.23	285.16	14.000	355.60	100.00%	20.000
Max useful	14.420	366.26	17.950	455.92	128.21%	20.500

* These values assume that instrument is calibrated to read zero at simulation of intitial minimum buoyancy and process temperature.