DRYER MASTER

DRYER MASTER INC

2220 Series Moisture Sensor Guide

115 Ardelt Ave. Building 2
Kitchener, Ontario
N2C 2E1
Canada
Tel 519 725-4700
Fax 519 885-4300

2220 series Moisture Sensor Guide

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General Specifications

Moisture Sensor Principles of Operation

The Dryer Master Moisture sensor detects moisture content by measuring the dielectric properties (capacitance) in the materials adjacent to the detector fin. Most grains have a base dielectric in the 2 to 5 range, water has a dielectric of 80 at 20°C. Water has a significant impact on the dielectric properties and is the largest variable in natural grains or grain derived manufactured products.

Maintenance and Calibration Sampling Static Cautions

The moisture sensor in the Fin-style design configuration needs to be handled with caution regarding static transmission to the fin when maintenance or calibration sampling is done. Normal safety precautions for opening a live product stream must be taken.

Caution:

Contact with the sensor fin must only be made with an object (hand or cleaning tool) that is first grounded to the sensor case or assembly which houses the sensor BEFORE contacting the sensor fin. This will route any static charge to ground, protecting the sensor electronics.

Moisture Sensor Installation

The moisture sensor, typically a Fin-style design, needs to be installed in a bypass chute or pipe, never in the full product stream.

1) The product flow is mechanically metered to a constant flow rate of less than 2.5 CM (1 inch) per second.
2) The exact dimension of the pipe is not critical, provided a good flow cross section is achieved. This pipe is completely full of compacted product during operation. Typically, the Fin sensor is mounted in a 15 to 20 cm (6 to 8 inch) square or round pipe into which a portion of the product stream is diverted.

3) The product is metered out of this pipe with either a screw conveyor or a rotary valve. The speed of the conveyor or rotary valve is such that the flow past the sensor is at less than 2.5 cm (1 inch) per second.
4) In continuous operation with highly abrasive products, or less than 1000kg (2200 lbs.) per hour flow, it is recommended that the flow rate be further reduced to 1 cm (0.4 inches) per second or less.
5) The sensor must be mounted within 5° of vertical to ensure proper product flow.

Product flow rates are approximate but should be no faster than 5 cm (2 inches) per second for best performance and sensor life. Flow rates must be constant; change in the speed of flow will affect moisture sensor accuracy and performance. Speed of flow affects product moisture readings.

Moisture Range & Temperature range.

The sensors have a very wide operating temperature range.

1) The electronics has typical operating temperature range is –40 degrees Celsius (-40 degrees Fahrenheit) to 70 degrees Celsius (150 degrees Fahrenheit).
2) Product temperature can range from –40 to 95 degrees Celsius (-40 to 200 degrees Fahrenheit) although verification of the actual product moisture at the temperature extremes becomes nearly impossible.
3) Moisture accuracy and repeatability is dependent on absolute product moisture and moisture gradient. Product density and product temperature also influence the sensor's accuracy. Typical accuracy is +/-0.2% moisture or 2% of scale.
4) Surface moisture on product can skew the sensor's performance especially at higher moistures. The sensor reads water first.

The Moisture Range is a function of the product density and product temperature. Sensors are available to cover moisture ranges from 2% to 45%, product densities from 0.15 g/cm^3 (10 lbs./foot^3) to 1.5 g/cm^3 (95 lbs./foot^3), and product temperatures from –40 to 95 degrees Celsius (-40 to 200 degrees Fahrenheit).

Sensor signal conversion

The dielectric conversion formula is a function of the sensor and the specific product. For most products a linear conversion serves the narrow moisture range typically seen by the user. This formula will provide a starting place for converting the dielectric voltage signal to an actual moisture value.

1) The temperature conversion formula:

- For degrees Celsius (Volts * 40) – 60 = ^{o} C
- For degrees Fahrenheit (Volts * 72) – 76 = ^{o} F

2) The Moisture conversion formula:
   Much work has gone into developing a good base calibration. However installation, product and other conditions will affect the moisture readings. The basic formula is as follows.
   - **(Offset) + (Volts * Slope) + (Temperature * T Slope) = Moisture %**

   Although temperature correction is shown in the formula it need not be incorporated in most applications.

3) Base 'Offset' and 'Slope' numbers for a range of products:
   These numbers are for 2220-11-BTC-RB sensor model.

Material	(lb/ft^3)		lbs/bu		(kg/m^3)		recommended	recommended
	from	to	from	to	from	to	starting **slope**	starting **offset**
Peanuts, unshelled	15	24	18.67	29.87	240.28	384.44	*8*	
Sunflower, unshelled	18	26	22.40	32.36	288.33	416.48		-2
Cat food	20	25	24.89	31.11	320.37	400.46		
Coffee bean, roasted	22	30	27.38	37.33	352.41	480.56	*7*	
Beans, coffee	22	40	27.38	49.78	352.41	640.74		
Oats	25	35	31.11	43.56	400.46	560.65		-2
Dog food, IAMS minichunk	26		32.36		416.48			
Corn, gluten	26	33	32.36	41.07	416.48	528.61	*6.5*	
Sesame seed	27	37	33.60	46.05	432.50	592.68		
Distillars grain	30		37.33		480.56			
Corn, ground	30	35	37.33	43.56	480.56	560.65	*6*	
Corn, meal	32	40	39.82	49.78	512.59	640.74		
Coffee bean, green	32	45	39.82	56.00	512.59	720.83		
Peanuts, shelled	35	45	43.56	56.00	560.65	720.83		
Fullers earth	35	45	43.56	56.00	560.65	720.83		
Barley, kernal	35	40	43.56	49.78	560.65	640.74		0
Sunflower seed	36		44.80		576.67		*5.5*	
Flax seed	40	45	49.78	56.00	640.74	720.83		
Wood pellets	40	41	49.78	51.02	640.74	656.76		
Corn, grits	40	45	49.78	56.00	640.74	720.83		
Sorghum seed	42	50	52.27	62.22	672.78	800.93	*5.25*	2
Rye	44		54.76		704.81			
Corn, whole kernel	45		56.00		720.83			0
Wheat, whole kernel	45	55	56.00	68.45	720.83	881.02		
Rape seed	45	50	56.00	62.22	720.83	800.93		0
Rice	45	50	56.00	62.22	720.83	800.93		
Popcorn, shelled	45	50	56.00	62.22	720.83	800.93	5	
Peas, dry	45	50	56.00	62.22	720.83	800.93		
Mustard seed	45		56.00		720.83			
Beans, lima	45		56.00		720.83			2
Beans, soy	45	48	56.00	59.73	720.83	768.89		2
Soybean, whole	47		58.49		752.87			
Navy beans, dry	48		59.73		768.89		*4.5*	
Millet seed	48		59.73		768.89			
Beans, navy	48		59.73		768.89			

Figure 1. Moisture Sensor Calibration values (Slope & Offset)

- The slope is density dependent. The values listed are the best values derived from years of actual operation. These values should not change.
- The sensor has internally applied compensation for products in the 40 to 50lbs ft^3, 50 to 60lbs/bu, or 600 to 800 kg/m^3 range. For products outside that range test the affect and apply correction if needed.

- Hot corn, Sunflower and Oats temperature correction has not been verified. Suffice to say all present applications required no additional temperature correction. It is permissible to leave out the temperature correction portion of the equation.
- **The offset is the only value adjusted to calibrate the moisture reading.**

4) The Moisture sensor empty voltage is between 0.5 and 0.8 volts. Therefore provisions must be made to display 0% moisture as the voltage transitions below a threshold voltage of 0.9 volts (recommended). Wire length and installation can affect the empty voltage.

5) Applying the formula, the theoretical minimum moistures are as follow:
   - Corn, offset = 2, slope = 5 2+ (0.9*5.0) +(30*0.0) = 6.5 minimum = 6.5%
   - Beans, offset = 3, slope = 4.5 3+ (0.9*4.5) +(30*0.0) = 7.05 minimum = 7.05%
   - Sunflower, off = -2, slope = 8 -2+ (0.9*8.0) +(30*0.0) = 5.2 minimum = 5.2%

Actual product temperature and other factors, including installation will influence the readings and modify the required offset value. Changes in product density may shift the offset value as well. These factors will shift the theoretical minimum moisture.

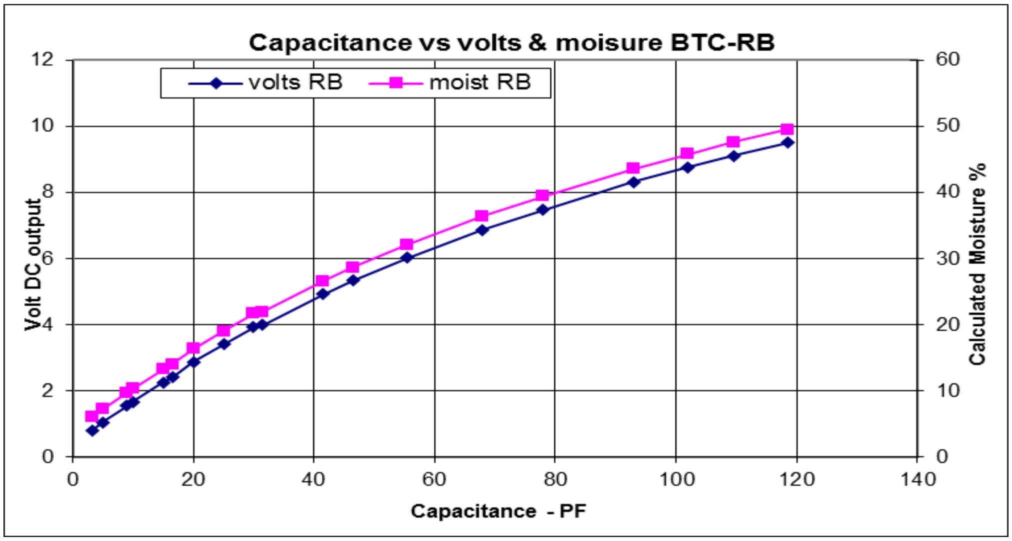


Figure 2. RB Moisture Sensor response min to max moisture

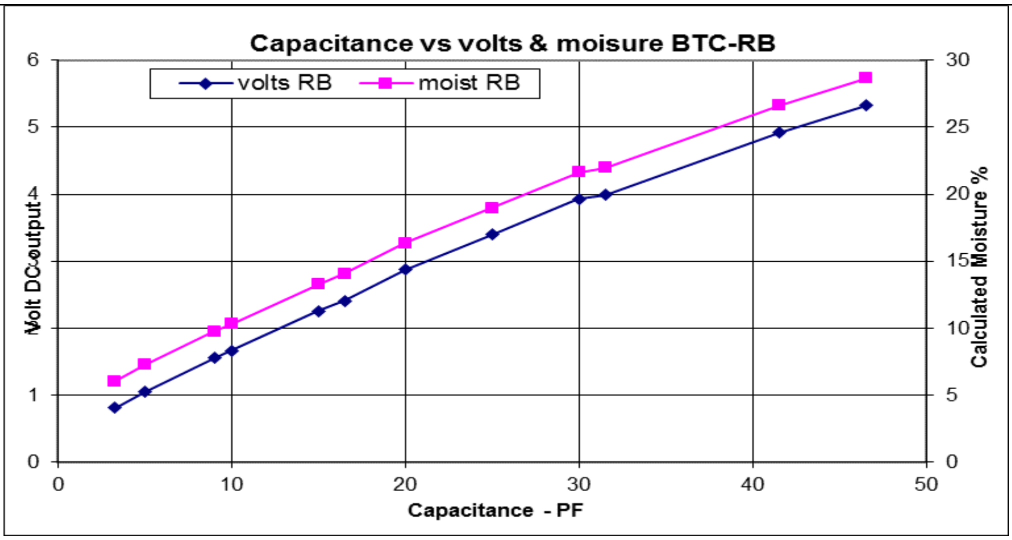


Figure 3. RB Moisture Sensor, typical operating range.

2200-11 series, Small Fin Sensor

Figure 4. Moisture Sensor

Caution:

Do not cut holes in the sensor. Use only the existing wire entry location. Entry at any other location voids the warranty.

The Moisture sensor electronics are sensitive to the electromagnetic energy from nearby welding. To reduce the risks of damage remove the sensor before welding in the immediate area and observe the 'Maintenance and Calibration Sampling Static Cautions' notes listed on page 3. Under no circumstances may the sensor housing or connecting bolts be used as a ground for welding.

Electrical Requirements, Specifications and Connections

Power & Wire

The sensor requires 18 to 28 volts DC at less than 20 mA. Two output signals in the 0 to 10 volt range provide the temperature and a measure of dielectric properties of the material in the sensor. The sensor power requirements are low enough to permit locating the sensor in class 2 and class 3 environments using Intrinsic Safety Barrier protection.
Any 4 wire shielded instrumentation cable such as Belden 8723, 0.326mm^2, 22AWG, overall shield is suitable for distances to 100 meters, 325 feet. Larger gauges are acceptable though not necessary.

Note that a separate grounding wire at least 18GA (or meeting the local electrical code requirement) must be connected from the green sensor chassis ground wire to the reading equipment earthing point (i.e., the point where the sensor is interfaced to the display or control system)

PARK Jumper

The sensor is shipped with a PARK jumper installed. This jumper must be removed **after installation**. The jumpers purpose is to short the fin to ground for shipping and handling.

Connection

Due to the inhospitable environment typically associated with the sensor location Dryer Master has opted for field connections with silicone grease filled crimps.

1) Strip lead wires to 12mm, ½ inch and twist leads together.

2) Slide supplied silicone grease filled crimp over the twisted together leads

3) Flatten the crimp with a combination plier. **Do not use a barrel crimper**.

4) Twist on wire connectors can be used if silicone grease filled crimps are not available. ***DO NOT*** use telephone style insulation displacement crimps, these cut the stranded wires which will lead to connection failures in time.

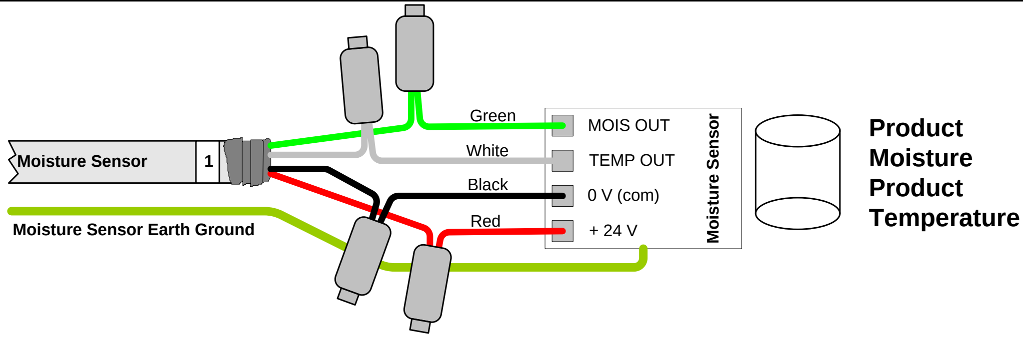


Figure 5. Crimping power and signal connections

Grounding

The sensors require a good ground to function dependably. Run a ground wire from each sensor chassis ground to the signal-processing Panel. The sensor chassis must be at the same ground potential as the signal grounds. Large ground potential differences may contribute to erratic operation of the sensor.

Signal Output

The sensor output is 0 – 10 Volts, 2 signals, dielectric (moisture) and product temperature. Minimum recommended load resistance is 10k ohm for each output. The outputs are protected from shorts to ground and supply.
The output signal is a voltage to permit locating the sensor in class 2 and class 3 environments using Intrinsic Safety Barrier protection.

Sensor setup & diagnostics

Note: The sensor has been prepared to operate within the specification range of the product. The Sensor setup & diagnostics sheet serves as a diagnostics tool to verify the sensors operation and functionality and provide electrical connection locations. There is no need to calibrate a new sensor. It is permissible to note the signals by stepping through the calibration procedure. This will provide a base for comparison should the sensors function come into question at some time in the future. Adjusting the hardware calibration will negate the software calibration adjustments that have taken place over time. Hardware recalibration should only be attempted if the sensor no longer functions and should only be performed after stabilizing the unit at 22°C, 72°F.

Diagnostics LED's

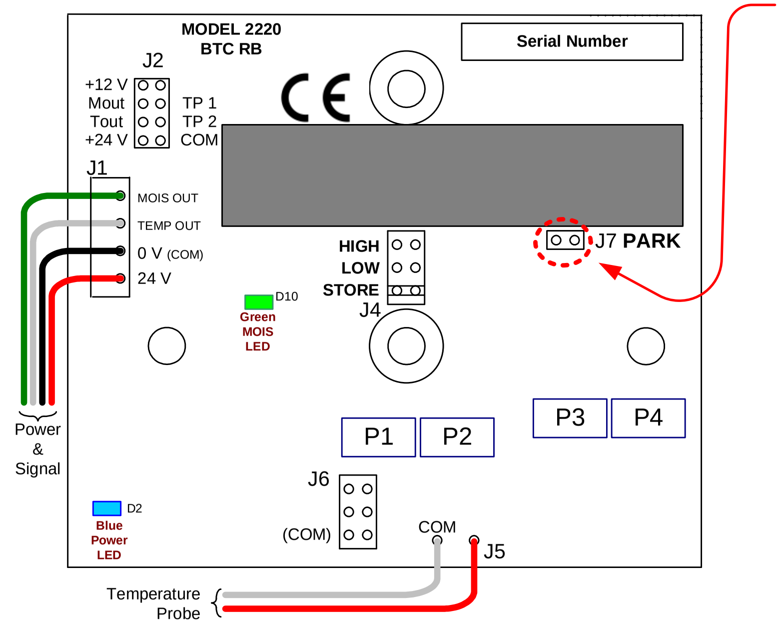
The 2220 series sensor board is equipped with diagnostics LED's.

1) +24V Blue Power ON LED
2) MOIS Green Moisture in detectable range LED.

The BLUE power LED is designed to confirm that DC power is supplied to board. No BLUE LED means no +24Vdc is present at the RED and BLACK leads or the onboard power supply diagnostic circuitry has failed.

The GREEN moisture OK led will only illuminate if product is present at the fin and it is in the acceptable moisture range. The LED on is equivalent to greater than 0.9 volts and less than 9.5 volts' dc measured between the "green and black" signal leads.
If there is no product present the functionality of the green LED can be verified by placing a static-drained* hand on the fin. If there is product present and the LED is not illuminated it is either too dry (below the minimum moisture threshold) or too wet (above the maximum moisture usually greater than 50%).
**refer to calibration maintenance section for instructions on how to prevent static damage to sensor.*

Moisture Sensor Model 2220 series



Note:
The Dryer Master Capacitance Moisture sensor Field Test and set up procedure.

INSPECT & TEST

1) Remove PARK jumper J7

2) Inspect unit for physical damage. Broken off Fin, worn out temperature sensor requires the unit to be returned for service. There are no field serviceable components.

3) Test sensor power. 18-28Vdc at location "24 V and 0 V (com)". Blue +24V power LED is illuminated. If voltage is present at "24 V and 0 V (com)" and Blue LED is not illuminated. Device has failed and must be returned for service.

4) Signal levels above 5 Vdc at location MOIS OUT and 0 V (com) with the sensor empty and J4 jumper in the store position. Device has failed and must be returned for service.

5) Signal levels at 0.5 to 0.8 Vdc at location MOIS OUT and 0 V (com) with the sensor empty and J4 jumper in the LOW or HIGH position. Device has failed and must be returned for service.

SETUP Note values will differ at different temperatures.

1) With J4 jumper in the STORE position and sensor empty. Signal levels at 0.5 to 0.8 Vdc at location MOIS OUT and 0 V (com).

2) With J4 jumper in the LOW position and sensor empty. Signal levels at 0.95 to 1.05 Vdc at location MOIS OUT and 0 V (com). (adjust P3 if required) **Adjust only At 22°C, 72°F.**

3) With J4 jumper in the HIGH position and sensor empty. Signal levels at 4.95 to 5.05 Vdc at location MOIS OUT and 0 V (com). (adjust P4 if required). **Adjust only At 22°C, 72°F**.

4) P3 and P4 are interactive. Repeat SETUP steps 2 and 3 as required. Return jumper to the STORE position when complete

5) Signal levels at location TEMP OUT and 0 V (com).
V*40 – 60 = °C, thus 2.00 Vdc *40 – 60 = 20°C
V*72 – 76 = °F, thus 2.00 Vdc *72 – 76 = 68°F
(adjust P1 if required)

Legend:

MOIS OUT	(green)	DC Voltage signal, 0-10Vdc (dielectric)
TEMP OUT	(white)	DC Voltage signal, 0-10Vdc (temperature)
24 V	(red)	DC Voltage, 18-28Vdc, 20mA max, Sensor Power
0 V (COM)	(black)	Common point for all power and signal
P1		Temperature offset adjustment Potentiometer
P2		Temperature gain adjustment Potentiometer
P3		Dielectric gain adjustment Potentiometer
P4		Dielectric offset adjustment Potentiometer
J1		Field connections
J2		Test points
J4		Calibration setup reference jumper block
J5		Temperature sensor connections
J6		Initial setup test block
J7		Sensor PARK jumper. ***Must be removed for operation.***
D2		Power LED, **Blue** when power is applied.
D10		Product detector LED, **Green** when sensor is detecting product.

Drawn by: WKS	Date: 06/07/14	DRYER MASTER
Revised: WKS	Date: 06/22/15	
Revised: WKS	Date: 01/18/17	Model 2220 Field test points
CHKD: JR	Date: 01/19/17	
Approved:	Date:	2220test..vsd

Figure 6. Sensor setup & diagnostics

Sensor Not Reading Empty with no product present or behaving erratically.

With the sensor powered +18 to 28 volts DC at the Moisture Sensor "Red" power lead to Moisture Sensor "Black" lead. In order for the sensor to operate properly it must show "Empty", signal voltage less than 0.85 volts and greater than 0.5 volts when no product is present, "Green Lead to Black". If the sensor does not show empty you will need to take the following corrective measures:

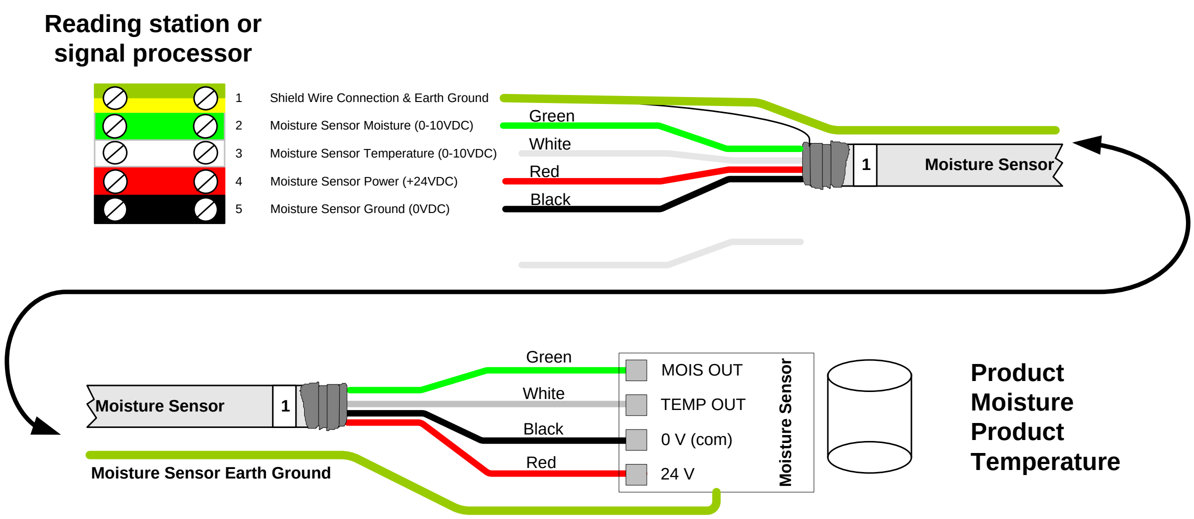


Figure 7. typical connection

If the value is greater than 0.9 volts DC at the reading station, measured "Green wire to Black", with the sensor empty:

1) The distance between the sensor and the display unit is too large for the wire size used.
2) There is a ground potential difference which is interfering with the operation. This may cause intermittent dramatic changes in the reading or cause a higher than expected empty reading.
3) There is potentially high energy electrical noise radiating into the signal wiring. This may cause intermittent dramatic changes in the reading.

1) The distance between the sensor and the display unit.

If the issue is due to the distance between the sensor and the display

Try doubling up on the black signal return lead. Use the shield as an additional conductor to bring the signal down (this may lead to interference and should only be done as a temporary fix).

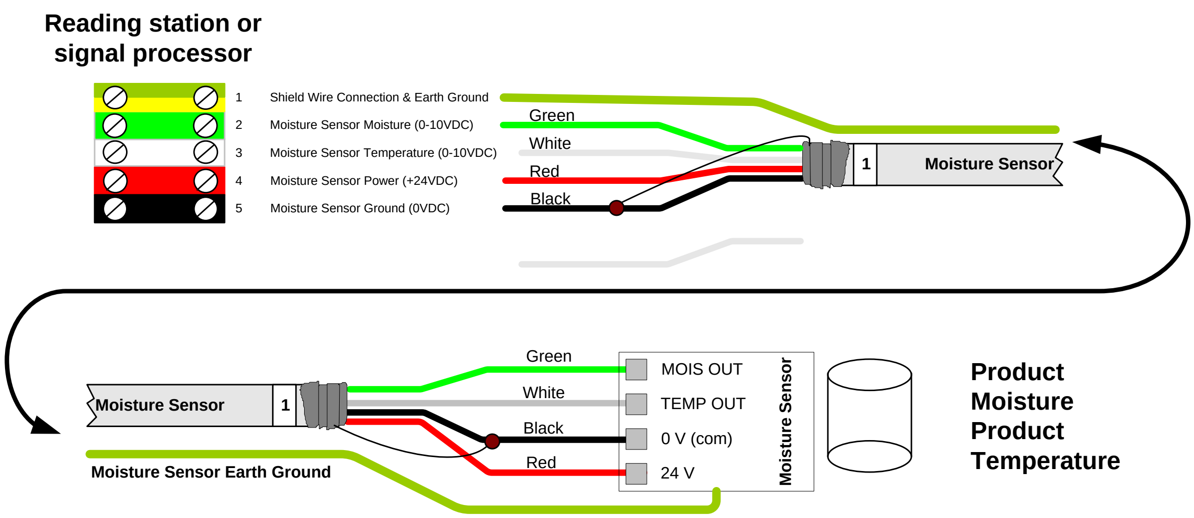


Figure 8. distance, to signal processor, using shield as ground return,

2) For sensors where there is a ground potential difference.

This may cause intermittent dramatic changes in the reading or cause a higher than expected empty reading. Join the “Black” signal & power return lead in the moisture senor enclosure to the earth ground lead leaving the existing connections intact. This in effect grounds the Moisture sensor electronics to the case and also grounds the display to the moisture sensor. In 90% of the cases the problem will be eliminated.

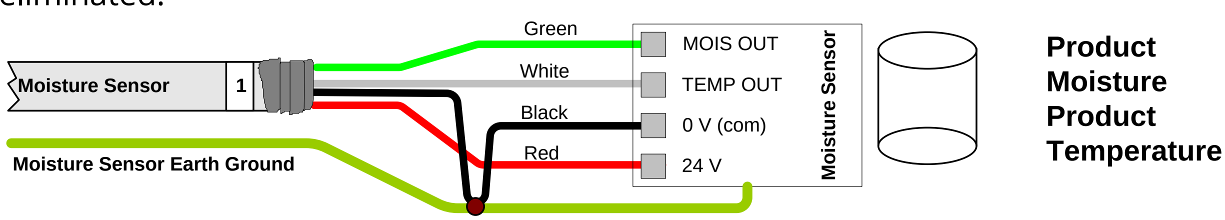


Figure 9. grounding sensor electronics connection

3) There is potentially high energy electrical noise radiating into the signal wiring

In normal practice, the shield on instrumentation cable is only grounded at the reading station or signal receiver. There are situations where performance is better with the shield connected at the instrument end. This needs to be determined experimentally should an electrical interference situation arise.

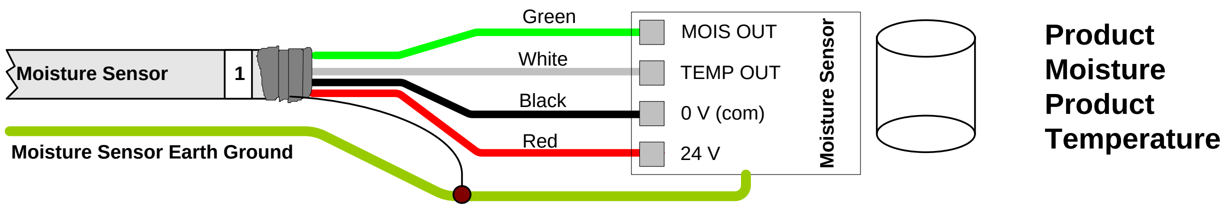


Figure 10. grounding shield at the sensor connection

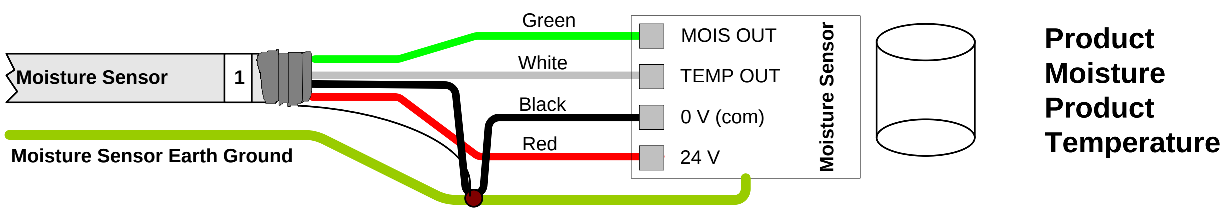


Figure 11. grounding shield at the sensor with the return also grounded connection

Installation Requirements & Specifications

The moisture sensor is installed in a bypass section into which a portion of the product is directed. The product is metered out of the chute with a small rotary feeder, rotary valve or conveyor. Make the necessary changes to the conveying system so that there is room for the moisture sensor chute installation

Install the chute so that there will be a continuous flow of product and the chute will remain full.

Ensure that the product flowing through the chute is a good representative sample of the product flow.

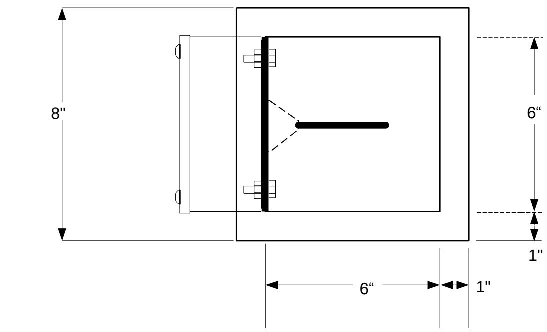
Locate the sensor so it can be **safely** accessed for cleaning and taking product samples.

Caution:

Contact with the sensor fin must only be made with an object (hand or cleaning tool) that is first grounded to the sensor case or assembly which houses the sensor BEFORE contacting the sensor fin. This will route any static charge to ground, protecting the sensor electronics.

Install bars across the opening to the sensor in the direction of product flow. This will prevent large objects from entering the sensor chute.

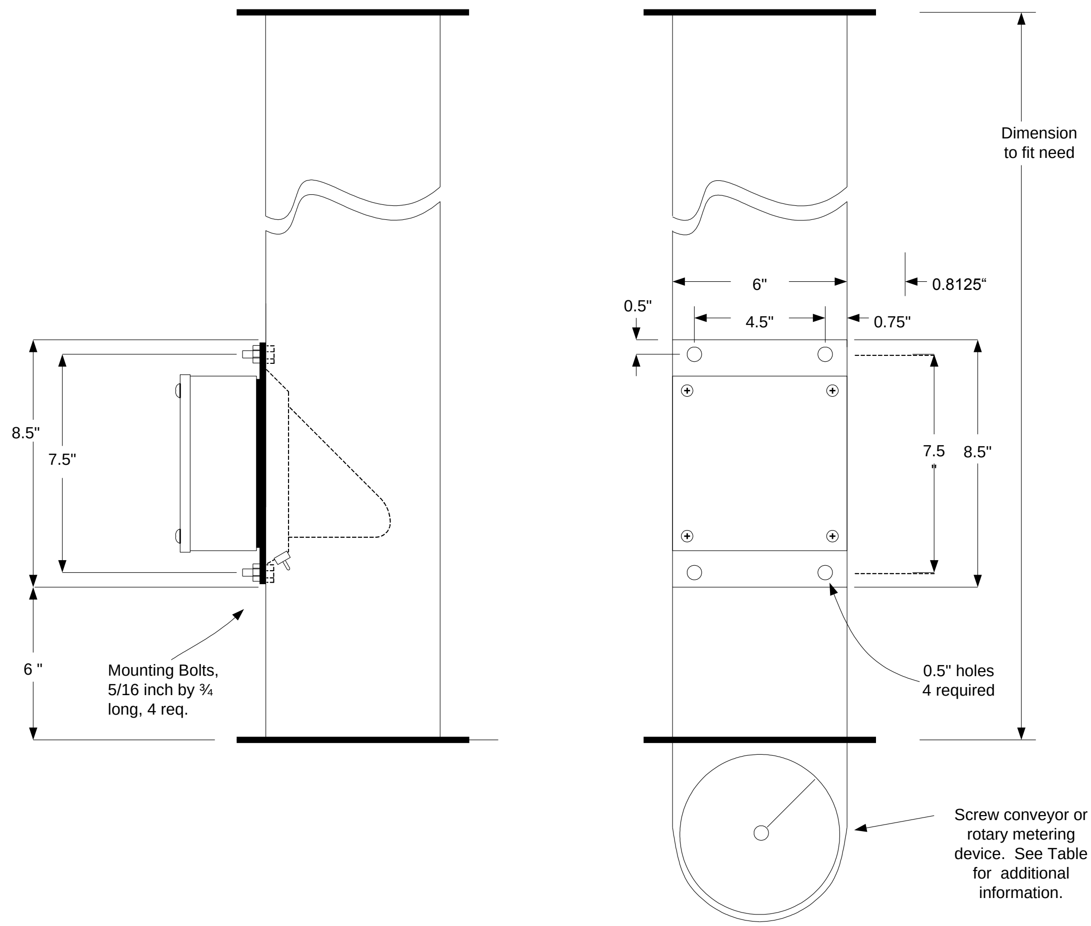
If needed install a shut off slide gate above the sensor to shut off the flow to the sensor to allow cleaning out and or servicing the sensor.



Note:

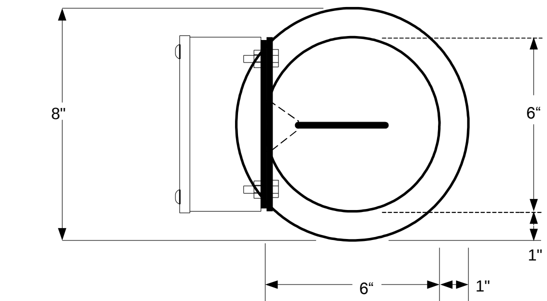
This chute design accommodates the standard 2200 series, small fin style moisture sensors in a standard 6" by 6" chute. This smaller dimension chute will improve product flow by not requiring the hopper bottom of the standard 10 inch square chute to return the product to the metering device.

The 6" space between the bottom of the sensor and the metering device (screw conveyor or rotary valve) ensures a more even flow up at the sensor location. In the event that this space needs to be reduced orient the sensor so that the predominant flow is at the base of the fin.



Revision History	Who	Date:	
created	**WKS**	**07/17/02**	
			Small Fin Sensor chute
Checked:			Small_Fin_chute.vsd
Approved:			Page 1 of 1

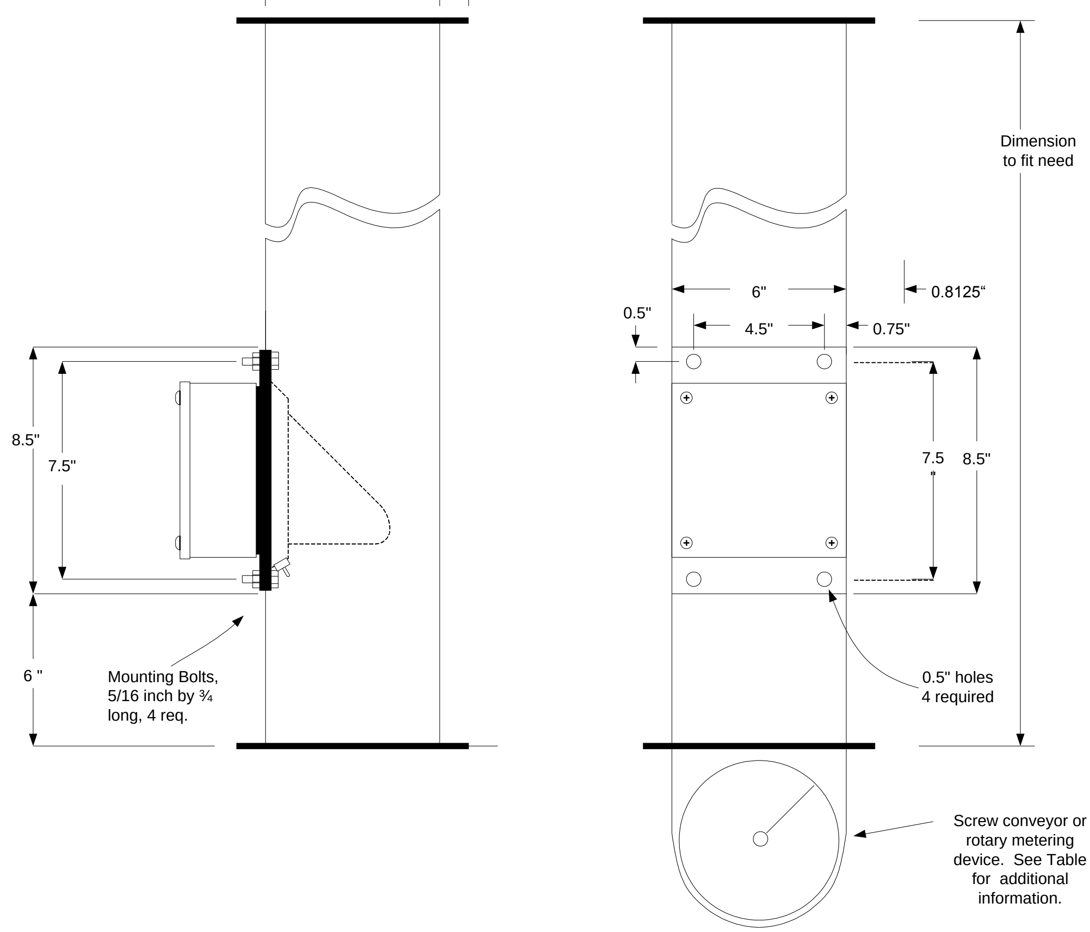
Figure 12. Bypass Chute design #1 square pipe



Note:

This chute design accommodates the standard 2200 series, small fin style moisture sensors in a standard 6" diameter pipe chute. This smaller dimension chute will improve product flow by not requiring the hopper bottom of the standard 10 inch square chute to return the product to the metering device.

The 6" space between the bottom of the sensor and the metering device (screw conveyor or rotary valve) ensures a more even flow up at the sensor location. In the event that this space needs to be reduced orient the sensor so that the predominant flow is at the base of the fin.



Revision History	Who	Date:
created	WKS	07/17/02
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Small Fin Sensor chute

Small_Fin_chute.vsd

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Figure 13. Bypass Chute design #2 round pipe

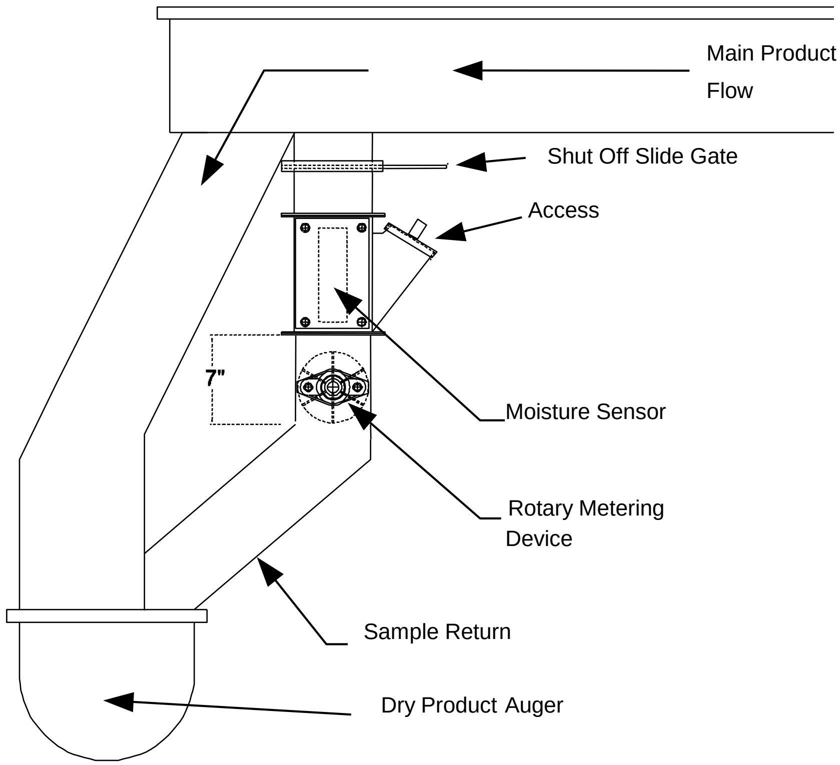


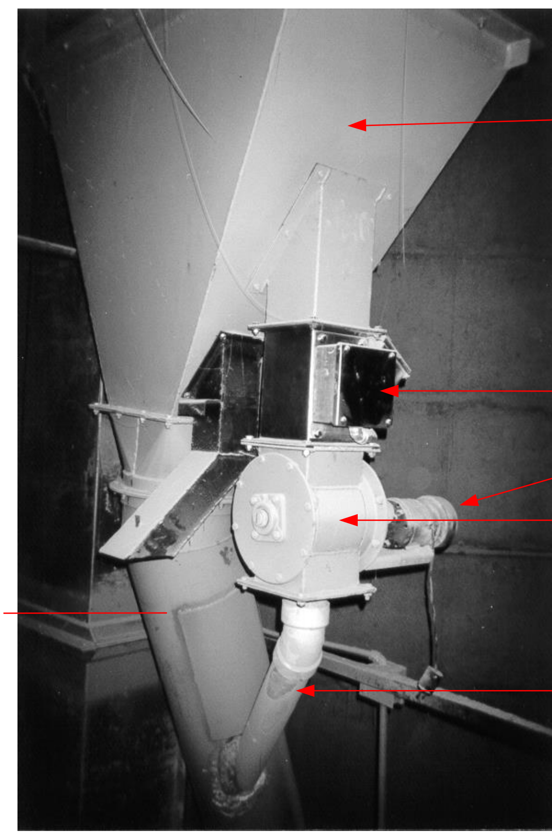
Figure 14. Sample Bypass Installation

Verify the flow and gear box required. The table is an approximate guideline.

Metering Device	***Approximat e rpm.***	***Gear Reduction for 1750 rpm Motor***
6" Rotary valve or metering device	6	280:1
5" Rotary valve or metering device	9	192:1
4" Rotary valve or metering device	14	120:1

Figure 15. Metering valve table

Figure 16. By-pass Chute Installation sample pictures



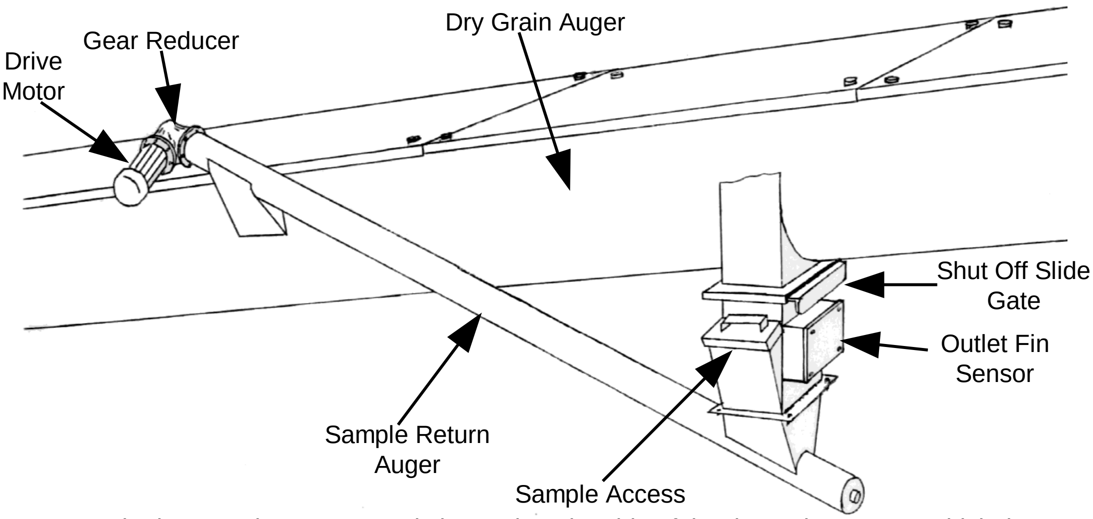
The moisture sensor is installed in a by-pass whereby a portion of the product is directed through the bypass and then back into the system. This method of installation is only recommended in systems where the product flow through the sensor is less than 10% of the total product flow. In this method a screw conveyor is used to meter the product through the moisture sensor instead of the rotary feeder or rotary valve. A four-inch sampling conveyor is recommended. Several other options are available; see figure below. All gear reductions given are based on a chute that is six inches by six inches. For the best flow characteristics it is recommended that the auger be opened to the full width of the chute. This will also reduce transition complexity. Verify the conveyor flow and gear box required. The table is an approximate guideline.

Metering Device	***Approximate rpm.***	***Gear Reduction for 1750 rpm Motor***
6” screw conveyor standard pitch	6.5	270:1
6” screw conveyor ½ pitch	13	135:1
4” screw conveyor standard pitch	20	88:1
4” screw conveyor ½ pitch	40	44:1
4” flex screw conveyor	20	88:1

Figure 17. Metering screw table

Note: When using a screw conveyor as the product-metering device it is recommended that the screw section under the moisture sensor chute be made ½ pitch. This ensures the conveyor is only ½ full once the screw returns to normal pitch this reduces mechanical wear, product damage and motor/gearbox load requirements.

Placing the sensor in a location where it will not get the full flow may cause an excess of fines or trash to pass through the sensor and will contribute to errors or false readings.



Note: The bypass chute entrance is located on the side of the dry grain auger to which the dry grain is pushed.

Figure 18. Screw conveyor metering feeding back on itself.

Installation where it is not possible to meter the product passing through the sensor and pass it further down the product stream it is permissible discharge the metered product back to the incoming product stream. In this type of installation should only be considered if the returned product is less than 20% of the total product stream.