Technical Reference MANUAL

W-4000 WEIGH SCALE MEASURING ASSEMBLY
A WeighArt Series 4000 System
Revision history

<table>
<thead>
<tr>
<th>Version</th>
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<tr>
<td>1.0</td>
<td>Initial release. Was part number 231446.</td>
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Explanation of symbols

The following symbols are used in this manual or on the instrument:

<table>
<thead>
<tr>
<th>In the manual</th>
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<tr>
<td>Radiation notice</td>
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<td></td>
<td><strong>Radiation notice</strong></td>
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<td></td>
<td>Information concerning radioactive materials or radiation</td>
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<td>safety information is found in the accompanying text.</td>
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<td>Caution</td>
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<td><strong>Caution</strong></td>
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<td>Warnings concerning potential damage to the equipment or</td>
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<table>
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<th>On the instrument</th>
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<td>AC current or voltage</td>
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<td></td>
<td><strong>AC current or voltage</strong></td>
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<tr>
<td></td>
<td>A terminal to which or from an alternating (sine wave) current</td>
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<td></td>
<td>or voltage may be applied or supplied.</td>
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<tr>
<td>DC current or voltage</td>
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<td></td>
<td><strong>DC current or voltage</strong></td>
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<td></td>
<td>A terminal to which or from which a direct current voltage may</td>
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<td></td>
<td>be applied or supplied.</td>
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<td>Potentially hazardous</td>
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<td>voltages</td>
<td><strong>Potentially hazardous voltages</strong></td>
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<td>A terminal on which potentially hazardous voltages exist.</td>
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Your comments

Ohmart/VEGA values your opinion! Please fill out this page so that we can continually improve our technical documentation.

Date: ______________

Customer Order Number: ______________
How we can contact you (optional if you prefer to remain anonymous):

<table>
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<td>Company:</td>
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Did you find errors in this manual? If so, specify the error and page number.

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Did you find this manual understandable, usable, and well organized? Please make suggestions for improvement.

____________________________________________________________________________
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Was information you needed or would find helpful not in this manual? Please specify.

____________________________________________________________________________
____________________________________________________________________________

Please send this page to:

Ohmart/VEGA Corporation
Director of Engineering
4241 Allendorf Drive
Cincinnati, OH 45209-1599 USA
Use of this set of manuals

Two manuals accompany this Ohmart/VEGA Equipment:

This manual covers the Measuring Assembly -- the specific source and sensor which Ohmart/VEGA developed for each application. In this manual are all of the sections which apply to the customized parts of the equipment. This includes Radiation Safety, Installation Drawings, and Factory Checkout Information.

If the Measuring Assembly is being supplied with an Ohmart/VEGA computer console or display, then a separate manual will cover the Computerized Electronics Console. The Console is used to receive, interpret and display information about the measurement. Since Ohmart/VEGA's digital electronics can fit a wide variety of applications, that manual does not address particular applications, but it explains how to calibrate the Gauge, set up outputs and alarms and a number of other topics.
Theory of gauging

A nuclear transmission gauge is designed to measure the density, level, or weight of a process material by directing a beam of gamma radiation from a source, through the process material to a detector assembly (sensor and amplifier) on the other side. Some of the radiation is absorbed during the passage through the material. This absorption is proportional to the mass of the material through which it passes. The amount of radiation which reaches the detector is measured and converted into electrical impulses which are then amplified.

This amplified signal is sent to a computerized electronic component. The computerized electronics has the function of converting the raw data into a useful format which can be displayed to the operator or be applied directly to the manufacturing process.

This principle is the basis of nuclear instrument measurement. A detector which is capable of measuring the amount of radiation can then be calibrated to measure the mass of the material. For example, in a density measurement, through a pipe of constant thickness (diameter), the mass of the material only changes by a change in the material's density. In a level measurement, such as yours, the gauge detects the absence or presence of material between the source of detector. In a weigh scale, such as yours, the gauge measures the mass of material on the belt.

![Diagram](image)

**Figure 1.1** Theory overview
System overview

The system is composed of two major parts -- the Measuring Assembly and the Computerized Electronics.

Measuring assembly

An Ionization Measuring Assembly consists of a Source and a Detector (or Sensor) which combine to collect raw data (measurements) about the product or process. The activity (or size) of the source and the sensitivity of the detector are selected by Ohmart/VEGA to fit each individual application.

Source

- Encapsulated radioactive material
- Source holder

Ion chamber detector

- Cell
- DF amplifier
- DPC power supply/temperature control

Computerized electronics

The computerized electronics console and/or display -- which is usually one of the SMART ELECTRONICS units -- processes the raw measurement data and converts the information into a usable display format.

The output format can also be tailored by Ohmart/VEGA for specific needs. The information can be displayed to the operator, or it can be applied directly to a Process Control Computer.

Details about the computer console/display is in a separate reference manual.
Application

Most nuclear gauges respond to the total mass of anything and everything between the source and the detector. This basic principle permits a great deal of flexibility in application. With minor variations in size, shape, and design, the basic sensor can be used to measure a variety of process conditions.

Density

Density gauges accurately indicate the specific gravity of liquids or percent solids of slurries in a process - in most cases in a pipe.

![Density measurement](image)

Figure 1.2  Density measurement

Weight

Weigh Scale gauges accurately weigh bulk materials on a belt, apron, drag or screw conveyor.

![Weight measurement](image)

Figure 1.3  Weight measurement
Level

Level gauges accurately indicate the level of liquids or bulk materials. Liquid level indications are either continuous throughout a range on vessels, reactors, or tanks - as shown at (1), or at a single point - as shown at (2).

Figure 1.4  Level measurement
Sample Smart Listing

The Smart Listing is a table of RAM addresses which lists the data that is stored at each address.

This listing contains the software settings that are used to configure each system for individual and unique applications. Under normal circumstances this list is not used, since all necessary information for normal operation is accessible through user-friendly screens.

The top line of the listing is labeled “Filename”. It gives the shop order name and number as well as the date and time the printout was created.

The first column down the left side is the base number representing the address. The first row across the top is the displacement from the base (i.e. the incremental value). Each address location is itemized by adding the displacement to the base.

\[
\text{Address location} = \text{base} + \text{displacement}
\]

For example, find “40” going down the first column, and follow it across to the “12” located in the top row. This represents address location “52” (40+12) and contains data “17196”.

The LOW process value used to calibrate the gauge at the factory is at address location 153 (140+13). In this sample, that data value is “8427”.

### Table: Sample Smart Listing

<table>
<thead>
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<th>1</th>
<th>2</th>
<th>3</th>
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</table>

**Figure 1.5** Example of a Smart Listing

**Note:** This example shows only a partial listing. The actual one extends to the right a full 20 digits, and will be considerably longer. Also, notice that the zeros (0) are represented here by a dot (.) to enhance readability.
Radiation safety

Ohmart/VEGA gauges contain a small amount of radioactive material (the source). This material emits radiation which is no different from the natural, or background, radiation which is always around us. Because of the concentration present in the source, however, several safety precautions are necessary. For safety purposes, the user should be aware of these precautions, as well as the licensing requirements of the U.S. Nuclear Regulatory Commission (U.S. NRC) or the appropriate Agreement State.

- Always be certain the source is in the OFF (shutter closed) position whenever working on the detector or whenever it is necessary to “clear” the measuring gap (i.e. between the source and detector).

When the source is ON (shutter open) and operating, users must limit the amount of time spent in the immediate area of the source--that is, within a one-foot (30 cm.) distance. The goal of radiation safety is to keep all exposures “As Low as Reasonably Achievable.”

- Also, be aware of the requirements to hold a license in order to operate a radioactive source. A license may be secured by one of two methods:
  
  - **General License** - Certain model gauges are available under the NRC's General License provisions. The execution of the purchase of one of these models, satisfies the requirements for obtaining a General License. A General License gives the holder permission only to mount the equipment in place. In order to turn it on, perform maintenance, or relocate it, however, on-site supervision must be secured from a specifically licensed person. (Consult the metal label mounted on the equipment, or contact Ohmart/VEGA for more details.)
  
  - **Specific License** - Most level gauges and weigh scales require a Specific License. Only those who have applied for and received an NRC or Agreement State Specific License are considered to be Specifically Licensed. Those people should refer to their own license in order to determine what operations they are permitted to perform.

- When in doubt about radiation safety procedures, check your regulations, or call the Ohmart/VEGA Corporation.

Note: Refer to the “Radiation Safety for U.S. General and Specific Licensees, Canadian and International Users” manual and the “Radiation Safety Manual References Addendum” CD for further information concerning radiation safety.
Unpacking the equipment

Many source holder models accept a lock. If the source holder has an ON/OFF operating handle, inspect each holder to be certain the handle is in the OFF position. In the event the handle is found to be in the ON position, place it in the OFF position immediately and secure it.

**Note:** Should the lock not be secured in the OFF position, call Ohmart/VEGA Field Service immediately for further instructions. 8:15 - 5:00 E.S.T., weekdays: (513) 272-0131
After hours: (513) 272-0135

If the detector is included as a separate package in the shipment, inspect the assembly for damage that may have occurred during shipment or storage.

If any part of the equipment is damaged during shipment, file a claim against the carrier, reporting the damage in detail.

**Caution:** Refer to the special instructions that came with your source holder. See “Radiation Safety for U.S. General and Specific Licensees, Canadian and International Users” manual and the “Radiation Safety Manual References Addendum” CD.
Storing the equipment

If it is necessary to store this equipment, do so in a clean, dry area which meets the Radiation Safety security criteria (a Restricted Area, as defined in the regulations).

Avoid storage at temperatures below freezing. For protection against mildew, mold and humidity, use appropriate sealed polyethylene bags with desiccant enclosed. Avoiding exposure to unnecessary dirt or moisture will prolong the life of the components.
Locating and mounting the equipment

Install the equipment according the detailed drawings which follow in this section of your manual.

Proper location of the Measuring Assembly can sometimes mean the difference between satisfactory and unsatisfactory operation.

**Note:** Try to locate the source holder in such a place that it will not become coated with process material, to ensure the continuing proper operation of the source ON/OFF mechanism. Many regulatory agencies (for example, the U.S. NRC) require periodic testing of the ON/OFF mechanism. Refer to Chapter 1: “Radiation safety” and the appropriate current regulations for details.

After a suitable location for the frame has been selected, it may be mounted around the conveyor or other process carrier. The frame outline drawing is located at the end of this section and shows the dimensions of the various sizes of frames. When special features are provided, appropriate information is shown on the outline drawing.

- The C-Frame is marked with a red stripe on the lower arm to indicate the center of the active measuring area. When positioning the C-Frame around the conveyor, this red stripe must coincide with the center of the conveyor.

- Additional information is provided about the tachometer in “Auxiliary and optional equipment” on page 2-5.

- Care must be taken when handling the Models 4000, 4100, 4200, and 4600 Weigh Scale Frames. These weigh scales are “top heavy” because the source holder is located on the top arm. The model 4000 requires straps to be placed around the upper arm and lifted into the desired location. The Models 4100, 4200 and 4600, have lifting eyes for use in handling. When mounting those models into place, keep the frame supported (to prevent it from falling over) until the mounting bolts are secured in the bottom tabs as shown in the outline drawing.

- Prevent process material or dirt from accumulating on the lower arm of the frame. Such accumulation can cause the gauge to indicate a higher weight than actual.
Wiring the equipment

The detailed Interconnect Drawing for your specific equipment is included with the Installation Drawings at the end of this section of the Measuring Assembly Manual. Follow the drawing notes and details for making the input and output connections.

**DO NOT APPLY POWER** until wiring is thoroughly checked.

Connect the sensor part of the Measuring Assembly to a voltage supply that cannot be turned off inadvertently. This should be a clean, transient-free supply such as a lighting panel. Power should be applied to the measuring assembly and console continuously. This will keep the equipment warm and dry. Radiation Measuring Assembly sensor warm-up time from a cold start can take up to 24 hours.

**Caution:** The DPC Power Supply is wired for only one voltage, either 115 Vac or 230 Vac, as shown on the label on top of the DPC. Do not apply a different voltage without changing the jumpers on the circuit board inside the DPC (Refer to the Power Supply Schematic Drawing.)
Auxiliary and optional equipment

Tachometer

A tachometer may be supplied with your gauge.

- The tachometer monitors the conveyor belt or screw speed, and is supplied when the belt or screw speed variation exceeds +/- 1%. It must be mounted correctly so that the proper speed can be maintained. The digital tachometer provides 1200 pulses per revolution. User's shaft revolutions per minute (rpm) must be between 5 and 1000 when line speed is maximum. If shaft rpm is not within this range, a step-up or step-down arrangement must be provided.

- The drive shaft (or idler roller) must have positive contact with the conveyor to insure accurate correlation of the speed. For accurate operation, select one of the four following locations on the conveyor for driving the tachometer:
  - On the Tail Pulley.
  - On the Idler take-up roller where the conveyor has adequate tension and wraparound to prevent slippage.
  - On the Idler roller where there is adequate contact with the conveyor, even when the conveyor is lightly loaded.
  - On the pulley in contact with the underside of the conveyor. However, such a pulley location should be used only if the first three recommended locations are inconvenient or impossible.

- Conveyor locations not recommended for the positioning of the tachometer include the following:
  - Do not use an Idler or Pulley that is in contact with the side of the conveyor handling material. Material build-up on the idler may cause a decrease in speed which introduces an error into the system.
  - Do not use a Head Pulley if there is any possibility of slippage. This slippage is prevalent on conveyors that are too long, inclined, or loaded heavily.
  - Make the mechanical connections from the idler to the tachometer carefully to prevent any eccentricity of the gears or couplings from causing output signal variations. A coupling adapter is supplied with each tachometer flexible coupling. The three holes used for mounting the adapter are intentionally oversized to permit adjustment to center it on the shaft.
  - When a tachometer is supplied, the dimensions of the tachometer and several methods of coupling it to the conveyor are included with the Installation Drawings which follow.
Installation drawings

Use any special installation drawings that came with your weigh scale. The following drawings may not be specific to your system.

Figure 2.1 Typical installation drawing of a W-4000 with SH-1 or SH-F1 source holder
Figure 2.2 Typical installation of W-4000 with adjustable barrier
Figure 2.3  Typical installation of W-4000 with barrier
Components of measuring assembly

Radioactive source

The standard types of radioactive sources used in a density measurement system are Cesium-137 and Cobalt-60. Cesium-137 has a half-life of 30 years and a low energy gamma radiation (0.66 MeV) which is readily absorbed. Hence, Cesium-137 is used where maximum instrument sensitivity is required. Cobalt-60 has a half-life of 5.3 years and much higher energy radiation (1.2 and 1.3 MeV); it is used for applications requiring greater penetration power.

The activity (measured in millicuries or becquerels) of the source is selected to fit the application. All sources commonly used are doubly sealed in welded stainless steel capsules. The diameter of the cylindrical-shaped source capsule is typically 1/2". The capsule is 3/4" or 1-1/2" long for point sources, depending upon the activity.

Source holder

Since radiation intensity drops in proportion to the square of the distance from the source, Ohmart/VEGA source holders are designed to provide radiation safety by providing a means of reducing the radiation intensity to a safe level for handling and servicing. Most source holder designs also provide a collimator, which directs the radiation beam directly through the process and toward the detector.

The holders are either steel weldments filled with lead or, in the case of fireproof models, solid cast-iron. Most source holder designs have provisions for shuttering, or moving the source to an “OFF” position, which completely encloses the source thereby providing an additional measure of safety for handling and servicing purposes.
Some applications require the source to be mounted in a source well within the vessel. In these cases, a lead and steel shipping and storage container is included to provide safe storage at any time the source must be removed from the source well. A source container which bolts directly to the source well flange may be provided to allow the source to be pulled directly into a shielding container during vessel maintenance.

A warning tag, showing the type and quantity of radioactive material, is affixed to the source holder.

**Note:** Abandonment or disposal prohibited unless transferred to persons specifically licensed by the NRC or an Agreement State.

Malfunction of the source holder should be reported to The Ohmart/VEGA Corporation for repair or replacement. Chapter 1: “Radiation safety” contains a summary of the proper handling and leak testing of radioactive sources. The “Maintenance” section contains detailed instruction for returning equipment to the Ohmart/VEGA Corporation.
**Ion chamber sensor**

The radiation sensor is an Ohmart/VEGA ionization detector. The ionization chamber (or cell) is a hollow metal tube filled with an inert pressurized gas (usually argon). As radiation strikes the ionization chamber, there is a partial ionization of the inert gas. The metal tube contains two electrodes: the anode, which is a positive electrode and the cathode, which is a negative electrode. A small bias voltage is applied to the cathode to enhance the attraction of ions.

When the gas is ionized, positive ions are attracted to the negative electrode, while negative ions are attracted to the positive electrode. Thus, a small electric current, in the picoamp range, is generated. (One picoamp = $1 \times 10^{-12}$ amp). As the amount of radiation reaching the sensor increases the current increases. As the current increases the detector’s output to the amplifier increases.

![Diagram of ion chamber sensor]

**Figure 3.1  Ion chamber sensor**

**Amplifier and power supply (DF / DPC)**

The DF / DPC assembly is mounted under the detector pipe cap above the ion chamber detector. The spare parts drawings in the back of Chapter 4: “Maintenance” show an exploded view of the detector housings for each model.

**DF amplifier**

The DF Amplifier receives the detector output picoamp current and converts it to a useable voltage level signal by using a hi-meg resistor. The DF is responsible for three major processing stages:

- Current to Voltage
- Voltage to Frequency
• Line Driver

![DF amplifier diagram]

Figure 3.2  DF amplifier

A schematic of the DF amplifier, drawing C-40447, can be found in the back of Chapter 4: “Maintenance”.

**Digital power and control - DPC**

The DPC has two major functions:

• Power Supply - of dc voltages for the DF amplifier and bias voltage for the ion chamber.

• Temperature Control - consists of heater blanket(s), thermistor, and safety control. This maintains the amplifier at a constant temperature. In some applications the ion chamber also requires a constant temperature.

  • Density and weigh scale ion chambers are sensitive to ambient temperature variations and are usually always heated.
  
  • Level ion chambers usually do not require heating.
Radiation transmission

As mentioned in “Theory of gauging” on page 1-2, the absorption of radiation is the basis of measurement of nuclear instruments: In this section and in “Signal processing” on page 3-8, we will use a density application example to illustrate the principle used to make measurements with radiation transmission.

• If the process material is very dense, more radiation will be absorbed by the material, and less will reach the detector. The output signal of the detector will be LOW which indicates HIGH density.

• If the process material is very light, less radiation will be absorbed by the material, and more will reach the detector. The detector output signal will thus be HIGH indicating a LOW density.
**Raw response curve**

The radiation transmission curve (raw data curve) below shows how the detector output changes with the process material's mass in a density application. Point A represents the light process and point B represents the heavy process.

![Raw Data Curve](image)

**Figure 3.3** Raw response data curve
Radiation transmission equation

The amount of absorbed radiation can be calculated by the radiation transmission equation:

\[ R = R_0 e^{-km} \]

Where:

- \( R \) = Radiation Intensity at the detector - after passing through the process material
- \( R_0 \) = Radiation Intensity at the source - before passing through the process material
- \( m \) = mass of the process material
- \( e \) = 2.718 (the exponential)
- \( k \) = constant depending on the physical configurations of the system.

In all applications, the change in transmitted radiation is caused by a change of mass between the source and the detector.

In a DENSITY application:

\[ \text{density} = \frac{\text{mass}}{\text{volume}} \]
\[ (\text{g/cm}^3) = \frac{\text{(g)}}{\text{(cm}^3)} \]
\[ \text{mass} = \text{density} \times \text{volume} \]
\[ (\text{g}) = (\text{g/cm}^3) \times (\text{cm}^3) \]

If volume is constant, then a change in the mass can only be due to a change in the density:

\[ \Delta \text{mass} = \Delta \text{density} \times \text{volume} \]

Example

On “Raw response curve” on page 3-6, the range of process is from 1 to 2 SpG. The range of counts is from 9700 to 2500. The “span” of counts is 7200 (9700-2500).

- Point A = 8100 counts = 1.1 SpG
- Point B = 6200 counts = 1.3 SpG
Signal processing

The detector output signal, shown as "counts" on the raw response curve, represents the process condition at a given point in time. Converting that signal to a usable measurement indication is known as signal processing.

Signal processing involves a number of modification procedures. Two of these modifications, normalization and linearization, are shown graphically on the following pages. Others involve spanning, averaging, source decay compensation, and converting to desired engineering units (customer units). All of this is performed through software in the computerized electronics.

Normalized curve

As explained, the raw signal from the detector is inversely proportional to the process condition, such that HIGH counts correspond to LOW process condition. A more useful format would be an end signal that is conveniently scaled, and which is proportional to the measured condition, that is, a LOW gauge reading which indicates a LOW density (or level) process and a HIGH gauge reading which indicates a HIGH density (or level) process. This "reversal" is accomplished through signal processing (normalization) at the Ohmart/VEGA supplied computerized electronics component.¹

Figure 3.4 Normalized response curve

1. Normalization is the data modification which reverses the relationship between detector counts and material mass such gauge that LOW gauge readings convey LOW process conditions and HIGH gauge readings convey HIGH process conditions. The raw data is proportionally fit into a predetermined range of 0 - 10,000 counts per second.
Linearized curve

From the Radiation Transmission Equation, the Raw Data Curve, and the Normalized Curve it is apparent that the transmitted radiation \( R \) is an exponential function of the mass \( m \) of the material. As an exponential function the relationship between the detector signal and material mass will be non-linear.

A linear output is preferred. Again, this data modification is accomplished through signal processing (linearization)\(^2\) at the computerized electronics component.

---

2. Linearization is the compensation applied to certain measurements that are inherently non-linear because of the exponential absorption of radiation.
Weigh scale application

It should be realized that while density application details are used as an example in the preceding explanation, the same discussion holds true for level and weigh scale process measurements. The shape and range of the curves may change, and certainly the “units” would change, but the same basic principles remain true.

If we refer back to the Raw Data Curve, the known density ranged from 1 to 2 SpG:

- Point A = 8100 counts = 1.1 SpG
- Point B = 6200 counts = 1.3 SpG

A typical weigh scale application would present a Raw Data Curve with a known loading from 0.0 to 300.0 lbs/ft. In that case, the same points may represent these approximate values:

- Point A = 8100 counts = 25.0 lbs/ft.
- Point B = 6200 counts = 60.0 lbs/ft.

In this case, a change in mass is due to a change in the weight of the process.
Calibration of the gauge

The term "calibration" is used rather loosely in the process measurement industry. The magnitude of the interpretation of the word may lead to some confusion and misunderstanding.

Additionally, the capacity to perform several different types of “calibration” is provided with the Ohmart/VEGA equipment. That may tend to further confuse the situation.

Calibration is a method of establishing reference point or points which relate the detector output to actual (or known) values of the process. Thinking of calibration of Ohmart/VEGA gauges in two separate categories may prove helpful.

Calibration is a full and complete calibration which is usually required only at the time of installation. It involves setting a span of measurement range and securing two reference points - a low and high reading.

Re-Cal, or Standardize, is a faster and easier method which is used at periodic intervals to RE-establish CALibration. It does not allow for change to the span, and it is done with only a one-point reading.

More information is provided on these subjects of Calibration and Re-Cal in the Electronics Console Reference.

- Before attempting calibration, the following operations should be completed:
  - Measuring Assembly completely installed.
  - Vessel empty and clean as possible. If measuring assembly is on a pipe - an empty pipe, a pipe filled with water, or a pipe filled with process of known density may be required.
  - Computerized electronics wired correctly and turned on.
  - Source shutter placed in the ON position by a person Specifically Licensed to do so.
- Consideration should be given to the following process parameters which may affect the initial calibration:
  - Vessel/pipe outside diameter
  - Vessel/pipe wall thickness
  - Vessel/pipe liner
  - Fluctuation in density, pressure, or temperature of process
  - Position of the source(s) on the vessel/pipe
  - Shape of vessel
  - Vessel/pipe/process structure supports, piping, etc. in the measurement path
  - Process material buildup on inside of vessel/pipe walls or on bottom arm of C-frame
• Moisture or other contamination of insulation in the measurement path

As a general rule, the gauge should be calibrated in the same conditions it is operated under. For instance, if there is usually insulation around the pipe between the source holder and detector, the gauge should be calibrated with the insulation present.

**Equivalent absorber**

After the calibration is complete, and while the conveyor belt is empty, the equivalent absorber (pieces of lead sheet fastened to a piece of sheet metal) should be placed in the radiation beam. The thickness of the absorber can be adjusted by adding or removing lead sheets so that it has approximately the same absorption of radiation as the process material on the conveyor. The reading of the absorber does not have to be exactly the same as the reading with process material. It should read between 75% and 100% of full scale. Record the percent of full scale reading of the absorber in a convenient location. The reading of the absorber can also be recorded for the totalizer counts. To do this, run the conveyor empty, reset the totalizer and record the number of counts for a six minute interval. Either of these numbers may be used, after standardization, as a check on the system.

**Re-Cal (Standardization)**

The information the sensor receives should be purely a function of the process material's composition. In reality, however, this measurement can also be affected by a number of other obstacles in the measurement path, such as vessel/pipe size and shape; fluctuating density of the material; and build up of process material on the wall of the pipe/vessel.

Care must be taken to compensate for these extraneous variables so that ongoing measurements will be accurate. In most instances, a full and complete calibration is not necessary, but rather a simple and fast “re-cal” will do. This is also known as “standardizing” the gauge, and should be performed at intervals determined by your own process conditions and plant maintenance procedures.

• All of the conditions listed below should be taken into consideration when determining a re-cal program:

  • Source Decay - The Ohmart/VEGA computerized electronics software will automatically compensate for source decay. This need not be of concern to the user.

  • Operator Confidence - Initially, you may want to re-cal at one month intervals (or less) so as to establish confidence in the new equipment.

  • Preventive Maintenance - Established plant maintenance procedures may require regularly scheduled preventive maintenance programs.

  • If using an Ohmart/VEGA Smart Electronics unit, the method used to re-cal will depend upon a number of factors:
• If the process conditions are such that the process can be emptied or can be flushed and replaced with a low absorber (such as water) then “Simple Re-cal on Low” is preferred.

• If conditions are such that neither of the above requirements can be met, then it will be necessary to use the “Re-Cal on Process” method.

**Equivalent absorber check**

After standardization, continue to run the conveyor empty and insert the equivalent absorber. Observe either the reading as a percentage of the normal process material reading or do a totalizer count for six minutes. Compare these numbers with those recorded at the time of initial calibration. If these numbers are inconsistent check for dirt or process build-up on either the absorber or the conveyor. If build-up is not evident, this may indicate electronic malfunction.
Product specification

Source
- Cesium 137 - half-life = 30 years, gamma radiation 0.66 MeV.
- Cobalt 60 - half-life = 5.3 years, gamma radiation 1.2 and 1.3 MeV.

Source holder
- Registered and approved by the U.S. Nuclear Regulatory Agency and by the Atomic Energy Control Board of Canada.

Ion chamber (cell)
- Typical bias voltage of -15Vdc applied to the cathode.
- Filled with inert pressurized gas (usually argon) to a typical pressure is 300 psig.
DF/DPC

The output of the voltage-to-frequency converter is a 0-10 kHz signal. The output TTL signal conforms to EIA Standard 422.

Table 4.1 DF voltage and current

<table>
<thead>
<tr>
<th>DF Voltage of:</th>
<th>Draws Current of:</th>
</tr>
</thead>
<tbody>
<tr>
<td>-15V</td>
<td>0.5 mA ±10%</td>
</tr>
<tr>
<td>+15V</td>
<td>9.0 mA ±10%</td>
</tr>
<tr>
<td>+5V</td>
<td>60.0 mA ±10%</td>
</tr>
</tbody>
</table>

Line driver enables the 5 Vdc, 30 mA, 50% duty cycle signal from the DF to be carried up to 5000 feet (1500 meters).

Input power = 115 or 230 Vac ±10%, 50 or 60 Hz, 525 watts, max.

Output power to heater = 500 watts, max.
Troubleshooting

The first step in troubleshooting is to determine if the problem is in the process and the gauge is indicating the true process condition, or if the trouble is a gauge malfunction.

If the problem is traced to the gauge, it is then necessary to determine if the Measuring Assembly, the Computerized Electronics (or other method being used to process the raw data), or the accessory equipment is at fault.

These four areas should be examined in an attempt to isolate the problem:

• The process being measured
• The Measuring Assembly
• The Computerized Electronics (or other method being used to process the raw data being gathered by the Measuring Assembly)
• Auxiliary and/or optional equipment
Process problems

It must be kept in mind that any and all material between the source and detector will affect the measurement. Changes to existing conditions should be suspected and examined as possible factors. Buildup of process material in the measuring gap will indicate a higher reading (greater density, higher level, or heavier weight) than what is actually the case. At the other extreme are changes that can indicate lower readings such as eroded pipe walls.

Factors to consider in a level application include:

- changes to pipe or vessel wall
- alterations to thermal insulation
- defective heating or cooling coils or jackets
- changes to dead air space
- build up of solids - gauge will indicate a higher density or level than actual air or gas bubbles in process - gauge will indicate a lower density or level than actual.

Air bubbles could be casued by:

- defective sealing glands on pumps
- defective gaskets on suction side of pump
- vortexing in head boxes or holding tanks
- mixing paddles or stirrers which are only partially submerged or which create a vortex.
- boiling or vaporization of the process material.

Source/holder

- “Source decay” produces an ongoing change in all radiation detectors. If the measuring assembly is being used with an Ohmart/VEGA Computerized Electronics, then source decay is compensated for through software adjustments and need be of no concern in the maintenance program.

- Periodic “leak testing” of the source holder and shutter ON/OFF operation check is required by NRC and Agreement States regulations. Refer to Chapter 1: “Radiation safety” for details.

Note: Proper operation of the source holder ON/OFF mechanism is very important to maintaining radiation safety. Take care that the source holder ON/OFF mechanism does not become coated with process material which may prevent its operation, and check the operation frequently. Refer to Chapter 1: “Radiation safety” and the appropriate current regulations (NRC or Agreement State) for details.
Ion chamber

- Gas leakage from the ion chamber will cause the detector to produce less current. This loss of sensitivity will be indicated by an upscale drift (greater density, higher level, or heavier weight).
- A shorted detector produces a shorted input to the amplifier. The amplifier output will be unaffected by changes in process or changes in current suppression. Other shorts can occur in the detector itself, the ceramic seals, or interconnections. If the ceramic seals are dirty or wet, clean with acetone and a stiff bristled brush; allow to air dry.

DPC power supply/temperature control

- The dc voltages, +15, -15 and +5 provide power to the DF amplifier circuit.
- The temperature sensor is a thermistor that is wrapped in the heater blanket. The thermistor has a resistance of 100,000 ohms at 25EC. At the temperature control point of 140EF (60EC) the thermistor has a resistance of 22,000 ohms.
- The safety thermostat is a bimetallic strip that opens and stops ac power to the heater blanket at 190EF (88EC). After opening, the thermostat recloses at 160EF (71EC).

DF amplifier

The model DF amplifier circuit consists of an electrometer amplifier, a V/F converter, and a line driver. The electrometer amplifier circuit consists of an operational amplifier which amplifies the current from the sensor through its feedback path. Drawing referenced is A-49253 and is located in the “Reference Drawing” section which follows.

Feedback resistor

The feedback resistor in the DF Amplifier is a very sensitive, “High-meg” glass resistor. It is especially prone to failure if exposed to dust contamination or oils from contact with skin. Although it is not recommended, if it is necessary to open the DF, be sure to do so in a clean environment, taking care not to touch the glass feedback resistor. If cleaning of the feedback resistor is necessary, acetone is recommended.

The feedback resistor (Rf) on the referenced drawing, and the gain resistors (R2 through R5), are selected to provide a range of 0 to +10Vdc at the output of the electrometer amplifier.
The value of the feedback resistor is determined by the formula:

\[ R_f = \frac{10V}{I_{\text{cal}}} \]

Where:

\[ R_f = \text{electrometer feedback resistor} \]
\[ I_{\text{cal}} = \text{the current from the sensor when the process is in the calibrate reference condition (i.e. empty vessel/pipe/belts, etc.)} \]

The actual Rf value is rounded off to the next lowest integer.

For example:

\[ R_f = \frac{10V}{1.9 \times 10^{-11}} = 5.26 \times 10^{11} \]

Therefore: Use 5 x \(10^{11}\) ohms

**Time constant capacitor**

The fastest sensor time possible is usually obtained with a time constant capacitor value of 10 pF. (C-9 on reference drawing)

**Gain resistors**

The gain resistors, (R2 through R5 on the drawing), are selected through W1 switch combinations. The W1 switches are closed when pushed in and open when pulled up. The chart illustrates the W1 switch combinations that result in a resistance and hence a gain. A gain is supplied to the signal to result in a electrometer amplifier output between 9.0 and 10.0 V when the process is in the calibrate reference condition. Initially, the gain of 1.0 is applied at factory test. Installation vessel/pipe/belt conditions different from design data may result in a different gain value being applied.
Auxiliary and optional equipment

Accessory recorder and display

The components used in a particular system are determined by the application and the output indications desired. Ohmart/VEGA output signals of 4-20mA, 0-20mA, or 0-100mV are compatible with most user-supplied recorders and digital or analog display. Ohmart/VEGA also offers recorders and digital and analog displays for purchase.
Troubleshooting flowchart

The flowchart which follows may help locate problems. It is modular in that it covers one topic. It consist of geometrically shaped boxes (usually diamonds and rectangles) which are interconnected by lines. Always start at the top with the "start" box and follow the connecting lines to the next box.

Diamond shaped boxes contain questions which are answered by either “Yes” or “No”. Answer the question and follow the appropriate line out of the box to the next box. The rectangle shaped boxes contain instructions or statements. In these cases, take the necessary action and follow the line to the next box.

If your sequence ends with a circled number or letter, such as (1), you must find where the matching number or letter flows back into a flowline and continue downward again from that point (even if you have already followed that particular route!)

Flowchart example

In the Measuring Assembly Flowchart the first diamond asks “Is Source On?”

- If your answer is “Yes” follow that line to the next diamond which asks “Is ac Power Applied to Detector Housing?”
- If your answer is “No” follow that line to the rectangle which instructs you to “Turn Source on.”

In the lower right side of the drawing, notice the circled numbers coming from the rectangles. These do not signify the end of the progression, but a continuation back into the “flow” up where the corresponding numbers point back into a flowline. If you go back in at (1) you will be just above the triangle “Is Frequency Stable and not Drifting?” You should continue downward from that point (even if you have already been through it.)
Figure 4.1 Troubleshooting chart for DF/DPC measuring assembly
Does digital tachometer work correctly?

Start

Is conveyor running?

No

Turn conveyor on.

Yes

Is power supply furnishing correct voltage to tach?

No

Check cabling and power supply. Replace if necessary.

Yes

Is tachometer connected to tail pulley?

No

Connect tach to tail pulley.

Yes

Is the shaft speed on tachometer between 5 and 1000 rpm?

No

Add sprockets and chains to tail pulley.

Yes

Are there pulses from tachometer output?

No

Replace tachometer.

Yes

Are there pulses at electronics console?

No

Check cabling. Replace if necessary.

Yes

Tachometer is working correctly.

Reference: C-46603

Figure 4.2 Troubleshooting chart for digital tachometer
Returning equipment for repair to Ohmart/VEGA

When calling Ohmart/VEGA to arrange repair service, be ready with the following information:

- ✔ Product model that is being returned for repair
- ✔ Description of the problem
- ✔ Ohmart/VEGA Customer Order (C.O.) Number
- ✔ Purchase order number for the repair service
- ✔ Shipping address
- ✔ Billing address
- ✔ Date needed
- ✔ Method of shipment
- ✔ Tax information

Returning equipment for repair

Procedure 4.1: Returning equipment for repair

1. Call Ohmart/VEGA Nuclear Products Repair: 513-272-0131
   8:00 a.m. to 5:00 p.m. Eastern U.S. time, Monday through Friday
2. Ohmart/VEGA will assign the job a material return authorization (MRA) number.
   Please note: Ohmart/VEGA reserves the right to refuse any shipment that has not been assigned an MRA.
3. Indicate the MRA on the repair service purchase order.
4. Clearly mark the shipping package with the MRA number.
5. Send the confirming purchase order and the equipment to:
   Ohmart/VEGA Corporation
   Attention: Repair Department
   4241 Allendorf Drive
   Cincinnati, OH 45209-1599 USA

Note: You must first contact Ohmart/VEGA and receive a material return authorization number (MRA) before returning any equipment to Ohmart/VEGA. Ohmart/VEGA reserves the right to refuse any shipment not marked with the MRA number.
## Spare parts

A recommended spare parts list for this unit is included following this page. Please use this list to determine the spares that you want to keep in stock. When ordering, use the part numbers indicated.

### Ordering spare parts

Following is the procedure to use for ordering spare parts:

**Procedure 4.2: Ordering spare parts**

<table>
<thead>
<tr>
<th>CALL:</th>
<th>• Ohmart/VEGA Customer Service: (513) 272-0131 (8:15 a.m. - 5:00 p.m. Eastern Time Weekdays)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ADVISE:</td>
<td>• Description of part(s) needed.</td>
</tr>
<tr>
<td></td>
<td>• Part number(s)</td>
</tr>
<tr>
<td></td>
<td>• Shop order number of original Ohmart/VEGA equipment</td>
</tr>
<tr>
<td></td>
<td>• Purchase Order Number</td>
</tr>
<tr>
<td></td>
<td>• Shipping address</td>
</tr>
<tr>
<td></td>
<td>• Billing address</td>
</tr>
<tr>
<td></td>
<td>• Date when needed</td>
</tr>
<tr>
<td></td>
<td>• Method of shipment</td>
</tr>
<tr>
<td></td>
<td>• Tax information</td>
</tr>
<tr>
<td>SEND:</td>
<td>• Confirming Purchase Order to: The Ohmart/VEGA Corporation</td>
</tr>
<tr>
<td></td>
<td>• 4241 Allendorf Drive</td>
</tr>
<tr>
<td></td>
<td>• Cincinnati, OH 45209 U.S.A.</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>
How To Find The Ohmart/VEGA Shop Order Number

In all correspondence with Ohmart/VEGA it is necessary to know the original Ohmart/VEGA Shop Order Number. This can be located by one of several ways:

- The number is usually registered at a specific address location in the Electronics Console/Display. Consult the Electronics Reference for details.
- The number is posted inside of the front cover of the original manual that is sent with the equipment.
- The number will also be on the metal source tag on the source holder part of the original equipment.
Reference Drawings

Following are several drawings which may help to identify Ohmart/VEGA equipment and parts.

Table 4.2  Maintenance reference drawings

<table>
<thead>
<tr>
<th>Drawing</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>A-49253</td>
<td>Configuration of DF Amp</td>
</tr>
<tr>
<td>C-40447</td>
<td>Schematic DF Amp</td>
</tr>
<tr>
<td>C-46097</td>
<td>Schematic DPC Power Supply</td>
</tr>
<tr>
<td>D-46713</td>
<td>DF/DPC with LJC</td>
</tr>
</tbody>
</table>
Figure 4.3  Configuration of DF amplifier
Figure 4.4 Schematic of digital amplifier - model DF
Figure 4.5  Digital power and control (DPC)
Figure 4.6  LJC detector with DF AMP and DPC - model RWC
Chapter 5

Glossary

**Absorption** - The reduction of energy in the form of electromagnetic radiation by a medium or by a reflecting surface. For example, this principle permits measurement of moisture content of paper since the amount of energy absorbed by the water can be compared to the amount of energy absorbed by the cellulose (paper).

**Accuracy** - Refers to the combined factors that can affect the correctness of the gauge reading. Initially, the accuracy is determined by the correctness of the gauge calibration (gauge reading vs. manual samples). The accuracy can be degraded by zero drift, source decay drift, and miscellaneous drift.

**AGC** - (Automatic Gain Control) - A process or means by which gain is automatically adjusted in a specified manner as a function of input or other specified parameters.

**Agreement State** - A state of the U.S.A. which has entered into an agreement with the NRC to control byproduct material within the state and, thus, relieve the NRC of the responsibility. The Agreement State regulations are, usually, about the same as the NRC regulations except that the states usually control radium and X-ray machines in addition to byproduct material.

**Alignment** - Refers to the placement of the source relative to the detector.

**Amplifier** - Device that amplifies, or magnifies, a current or voltage. May be one integral device or two separate devices - i.e., a preamplifier and the main amplifier.

**Anode** - The positive electrode in the ionization chamber detector.

**Attenuation** - 1) A decrease in signal magnitude between two points, or between two frequencies. 2) The reciprocal of gain.

**Backscatter Gauge** - Gauge where both the source and detector are on the same side of the process material. Also known as a Reflection gauge. Radiation strikes the material to be measured and some of the radiation is scattered back toward the detector. (See Transmission gauge).
**BIAS VOLTAGE** - The voltage applied to a detector to produce the electric field to sweep out the signal charge.

**BREAK POINT** - The junction of the extension of two confluent straight-line segments of a plotted curve.

**BYPRODUCT MATERIAL** - Radioactive material that is controlled by the Nuclear Regulatory Commission (NRC). Radium is a radioactive material but it is not controlled by the NRC. The word “byproduct” came into use because the material is a byproduct of a nuclear reaction.

**CALIBRATE** - To ascertain outputs of a device corresponding to a series of values of the quantity which the device is to measure.

**CALIBRATION** - Initial adjustment of the gauge controls to make the gauge reading correspond to the value of the process variable.

**CATHODE** - The negative electrode in the ionization chamber detector.

**COLLIMATOR** - Device made of shielding material used to restrict a beam of radiation and form the radiation into a “pencil-like” or “fan-shaped” beam. For gamma sources, the shielding material must be heavy lead or iron.

**CONSTANT TEMPERATURE HOUSING** - Housing for detector which has its temperature sensed by a thermistor and controlled by a heater. Thermal insulation is used between the detector and the housing.

**CURIE** - The quantity of radioactive material that decays at the rate of $3.7 \times 10^{10}$ disintegrations per second.

**DELTA I CURRENT** - Change in current, generated by the detector from the lowest to the highest point of interest - i.e., from low to high specific gravity for a density gauge; from zero to full for a level gauge; from lowest to highest specific gravity for an interface gauge; from empty belt to fully-loaded belt for a weigh scale.

**DELTA I PERCENT** - Ratio of **DELTA I CURRENT** to **RESIDUAL CURRENT**

Usually this value is high (50-100%) for level gauges; intermediate (10-50%) for weigh scales; and low (5-20%) for density and interface gauges.

**DEVICE** - An apparatus for performing a prescribed function.

**DOSE** - A general term for denoting the quantity of radiation or energy absorbed. Specific terms and their English and (SI) units are:

- exposure dose - roentgen, R (coulomb/kilogram, C/kg)
- absorbed dose - rad (gray, Gy)
biological dose equivalent - rem (sievert, Sv)

1 roentgen (R) = that amount of X-Ray or Gamma radiation that would produce one electrostatic unit of charge in one cm³ of dry air.
\[ 1 \text{ R} = 2.58 \times 10^{-4} \text{C/kgR} \]

1 rad = the absorbed radiation dose of 100 ergs/gram in any medium.
\[ 1 \text{ rad} = 0.01 \text{ Gy} \]

1 rem = absorbed dose in rads multiplied by the quality factor of the radiation in question.
\[ 1 \text{ rem} = 0.01 \text{ Sv} \]

**DOSIMETER** - Quartz fiber electrometer which is charged by a battery and discharges when exposed to radiation. Can be direct reading or indirect reading. Measures the total radiation dose received, in mrem, and is carried by a person who works with radiation.

**DRIFT** - Change in gauge reading when the process material is held constant. There are several kinds of drift. These are:

1. Zero Drift - Change in gauge reading caused by change in electronic components such as the MOSFET input transistors, power supply and other transistors, resistors, capacitors, etc. Zero drift does not include drift in the detector or the Rf resistor.

2. Source Decay Drift - As a radioactive source gives off radiation, it is used up. Thus, at the end of each succeeding interval of time there is less activity. Cs-137, the most popular radioactive source for density, level and weigh scale gauges, has a half-life of about 30 years - but the decay is logarithmic (not linear) according to the equation \( N = N_0 e^{-(4.03 \times 10^{-4})t} \) where \( t \) is the time in weeks. Thus, the source strength (activity) will be reduced about 0.04% per week. For a density gauge with a 5% Delta I, this will be observed as a drift of about 0.8% of span per week. Source decay drift is nullified by use of a source decay compensator software in the Smart electronics.

3. Miscellaneous Drift - There are other causes of drift such as: drift in the Rf resistor; erosion or corrosion of the pipe or vessel wall; build-up of material on the inside of the pipe. All of these drifts are nullified by going through the re-cal procedure.

**ELECTRODE** - A conducting element that performs one or more of the functions of emitting, collecting, or controlling by an electric field the movements of electrons or ions. A positive electrode is referred to as the anode, and the negative electrode is called the cathode. These two elements are located in the ion chamber (cell) of the ionization detector.

**ELECTRON VOLT (eV)** - A unit of energy equivalent to the energy gained by an electron in passing through a potential difference of one volt. Also, \( 1 \text{ eV} = 1.6 \times 10^{-12} \text{ erg} \).

**ENERGY LEVEL** - Refers to the penetrating power of a radiation. For example: Co-60 emits gamma radiation that has an energy level of 1.2 MeV (million electron volts) and is more penetrating than the gamma emitted from Cs-137, which has an energy level of 0.66
MeV. However, sources that emit different types of radiation (alpha, beta, gamma) cannot be compared by energy level because the behavior of each type is so different.

**EQUIVALENT ABSORBER, CALIBRATION** - Device placed between the source and sensor, when the pipe is empty, which has the same absorption of radiation as the process material at a given specific gravity. Usually constructed of steel and lead plates.

**FILM BADGE** - Small piece of film sensitive to radiation, placed in a light-tight holder and carried by a person who works with radiation. When the film is developed, the amount of darkening can be measured to determine the total radiation dose, in mrem. See also, TLD.


**GAP (MEASURING)** -

  Transmission gauge: the distance between opposing faces of the radiation emitting assembly and the detector assembly. The area in which the material being measured is located.

  Backscatter gauge: the distance from the nearest face of the emitting assembly or the detector assembly to the surface of the vessel containing the process being measured.

**GENERAL LICENSE** - A license issued by the NRC or an Agreement State to all persons in their jurisdiction to use byproduct material in devices approved by the NRC provided that the person uses the material in a specified manner. The General Licensee does not apply for a General License, nor does he receive a document or paper from the NRC or Agreement State.

**HALF VALUE LAYER (HVL)** - The thickness of a specified substance which, when introduced into the path of a given beam of radiation, reduces exposure rate by one-half.

**HALF-LIFE** - Time required for a source to decay to one-half its initial millicurie value. Typical values are: Cs-137: 30 years; Co-60: 5.3 years; Am-241: 433 years; Radium: 1600 years.

**HALF-LIFE, BIOLOGICAL** - The time required for the body to eliminate one-half of an administered dosage of any substance by regular processes of elimination. Approximately the same for both stable and radioactive isotopes of a particular element.

**HALF-LIFE, EFFECTIVE** - Time required for a radioactive element in an animal body to be diminished 50 percent as a result of the combined action of radioactive decay and biological elimination.

\[
\text{Effective Life} = \frac{\text{Biological half - life}}{\text{Radioactive half - life}} \times (\text{Radioactive half - life})
\]

**HARDWARE** - Physical equipment directly involved in performing industrial process measuring and controlling functions.
HAZARDOUS LOCATIONS - (As Defined by the National Electrical Code Handbook) - The degree of hazard is normally indicated by a three-part designation: Class, Division, and Group. Class I, Division 1, Group A denotes the most severely and continually hazardous condition.

Class I Locations - Those in which flammable gases or vapors are or may be present in the air in quantities sufficient to produce explosive or ignitable mixtures.

Class II Locations - Those which are hazardous because of the presence of combustible dust.

Class III Locations - Those which are hazardous because of the presence of easily ignitable fibers or flyings, but in which such fibers or flyings are not likely to be in suspension in air in quantities sufficient to produce ignitable mixtures.

Division 1 - Locations in which hazardous concentrations in the air exist continuously, intermittently, or periodically under normal operating conditions.

Division 2 - Locations in which hazardous concentrations are handled, processed, or used, but are normally confined within closed containers or closed systems from which they can escape only in case of accidental rupture or breakdown.

Group A - Atmospheres containing acetylene.

Group B - Atmospheres containing hydrogen, or gases or vapors of equivalent hazard, such as manufactured gas.

Group C - Atmospheres containing ethyl-ether vapors, ethylene, or cyclo propane.

Group D - Atmospheres containing gasoline, hexane, naphtha, benzine, butane, propane, alcohol, acetone, benzol, lacquer solvent vapors, or natural gas.

Group E - Atmospheres containing metal dust including aluminum, magnesium, and their commercial alloys, and other metals of similarly hazardous characteristics.

Group F - Atmospheres containing carbon black, coal or coke dust.

Group G - Atmospheres containing flour, starch, or grain dusts.

HIGH IMPEDANCE - Very large electrical resistance, in ohms. The input compartment of an amplifier has a high impedance section where the “Hi-Meg” resistor (Rf resistor), MOSFET transistor and high impedance insulators are mounted.

INTERFERENCE (ELECTROMAGNETIC) - Any spurious effect produced in the circuits or elements of a device by external electromagnetic fields.

IONIZATION - The process or the result of any process by which a neutral atom or molecule acquires either a positive or a negative charge.

IONIZATION CHAMBER DETECTOR - A “cell” that depends for its operation on the current of positive ions produced in the gas by electrons that are accelerated between two electrodes.

IONIZING RADIATION - Any radiation capable of producing ions in matter.
ISODOSE CURVE - A line connecting all points of equal radiation field intensity around a gauge. Usually drawn on an outline drawing of a gauge.

LEAK TEST - Test performed on a sealed source capsule to determine if there is a leakage of the radioactive material from the capsule. Test can be by immersion, wiping, etc.

LEAK TEST KIT - Contains materials to perform a leak test. The Ohmart/VEGA Leak Test Kit contains a swabstick in a plastic bag. The kit is shipped between the user and The Ohmart/VEGA Corporation. The Ohmart/VEGA Corporation analyzes the swabstick for the presence of radioactive material.

LINEARITY - The closeness to which a curve approximates a straight line.

LINEARIZER - The output of a density gauge is inherently non-linear because of the logarithmic absorption of radiation. For gauges with a narrow span, the non-linearity is not apparent because only a very small part of the logarithmic curve is displayed. Non-linearity starts to become observable about 10% Delta I - and the larger the Delta I percent, the larger the non-linearity. Unfortunately, due to various complicating factors, this curve is not truly logarithmic. Level gauges using point sources are, in general, always non-linear because the distance from the source to the bottom of the detector is usually much longer than the distance from the source to the top of the detector. The non-linearity effect is merely a distance phenomenon because the radiation field intensity decreases as a function of the square of the distance.

Ohmart/VEGA offers computer software curve generators, which handle both density, level and weigh scale gauge responses.

MASS FLOW gauge - Combination of a density gauge and a flowmeter (usually a magnetic flowmeter) to measure mass flow rate or the total weight of a product flowing in a pipe over a given period of time.

MEASURING ASSEMBLY - Ohmart/VEGA sensor which senses the change in radiation field intensity due to the change in process variable.

MEASURING GAP - The area between the source and the detector. This is the part through which the process passes as it is being measured. It may also be referred to as the “air gap”. Also see Gap, Measuring.

MILLICURIE - (abbreviated mCi) - One thousandth (0.001) of a curie.

MILLI-REM - (abbreviated mrem) - One thousandth (0.001) of a rem.

MILLIROENTGEN PER HOUR - (abbreviated mR/hr) - One thousandth (0.001) of a roentgen per hour.

MOUNTING BRACKET - Pieces that clamp on a pipe, bolt on a process vessel, or attach to process framework and to which the source holder and detector housing are attached. Usually made of sheet metal or fabricated steel pieces.

NEUTRON - An electrically neutral particle usually found in the nucleus of atoms. Neutrons can also exist freely when ejected from a nucleus by radioactivity or in a fission reaction.
**NEUTRON RADIATION** - The emission of a neutron from nucleus.

**NOISE** - An unwanted disturbance of a useful signal or variable. NOTE: It may be expressed in units of the output or in percent of output span.

**NOISE BAND (STATISTICAL NOISE)** - Noise Band is the signal random “jitter” or recorder pen “wipe” that is observed at the output of a nuclear gauge over a short period of time. It is caused by the random disintegration of the nuclear source as it gives off radiation. The observed noise band is a direct inverse function of Delta I percent; a square root inverse function of time constant; and a square root inverse function of source activity in mCi. Increasing the Delta I percent by 2 decreases the noise band to 1/2 of its original value; increasing the time constant by 2 decreases the noise band to 1/2 or 0.7 of its original value; increasing the activity of the source by 2 decreases the noise band to 1/2 or 0.7 of its original value.

**NORMALIZE** - Signal processing which reverses the relationship between detector counts and material mass such that LOW gauge readings convey LOW process conditions and HIGH gauge readings convey HIGH process conditions.

**PARAMETER** - A quantity or property treated as a constant but which may sometimes vary or be adjusted.

**POINT SOURCE** - Radioactive material approximately 1/4" diameter x 1/8" thick inside of a short sealed capsule. Capsule dimensions are approximately 1/2" diameter x 3/4" long.

**PROCESS** - Physical or chemical change of matter or conversion of energy; e.g., change in pressure, temperature, speed, electrical potential, etc.

**RADIATION** - The emission and propagation of energy through space or a material medium. The energy may be in the form of electromagnetic waves (gamma-rays and X-rays) or particles (beta particles, alpha particles, and neutrons).

**RADIATION SURVEY** - A measurement of the radiation field intensity in the vicinity of a gauge.

**RADIATION SURVEY FORM** - An outline drawing of a particular gauge with blank “fill-in” spaces for the entry of information pertaining to the intensity of radiation at specified points around the gauge.

**RANGE** - The region between the limits within which a quantity is measured, received, or transmitted, expressed by stating the lower and upper range-values.

**RE-CAL** - a technique of bringing a density, level, or weigh scale gauge back to its original calibration.

**REFLECTION gauge** - A gauge which houses the source and detector on the same side of the process. Also known as Backscatter gauge.

**REM** - (abbreviation means roentgen equivalent man) A measure of the dose to body tissue in terms of its estimated biological effect relative to a dose of one roentgen of X-rays.
rays. Thus, if a person is in a radiation field of one R/hr for one hour, the dose received is one rem.

REPEatability

1. Repeatability (Short Term) - Another word for noise band. Thus, for a given value of SpG the gauge reading will repeat its reading within the noise band.

2. Repeatability (Long Term) - This is the average of the pluses and minuses of the noise band over a period of time. Given an accurate calibration, this will constitute accuracy.

RESIDUAL CURRENT - Current generated by the detector when the process is at the lowest point of interest - i.e., zero level for a level gauge; lowest specific gravity for a density gauge; empty belt for weigh scale gauge; lowest specific gravity for an interface gauge; thinnest material for a beta gauge.

RESPONSE TIME (SPEED OR RESPONSE) - A “man-made” or “manufactured” definition which equals five time constants (in seconds).

ROENTGEN PER HOUR - (abbreviated R/hr) - A measure of radiation field intensity or dose rate. A roentgen is that quantity of X-radiation which will produce one electrostatic unit of ions in one cubic centimeter of air under standard conditions of temperature and pressure. This can also be expressed as $2.083 \times 10^9$ ion pairs per cc of air. Thus, a R/hr is a certain number of ions produced in air per unit of time.

SCINTILLATION - A flash of light occurring as a result of the ionization of a phosphor when struck by an energetic photon or particle.

SCINTILLATION DETECTOR - A device employing scintillation for detecting and measuring radioactivity.

SEALED SOURCE - Radioactive material encased in a capsule designed to prevent leakage or escape of the radioactive material.

SENSOR - A device directly responsive to the value of the measured quantity.

SHUTTER - The mechanism in the source holder which opens and closes access to the source. This effectively turns “ON” and “OFF” the source radiation.

SIGNAL, DIGITAL - Representation of information by a set of discrete values in accordance with a prescribed law. These values are represented by numbers.

SIGNAL PROCESSING - Conversion of the raw data output signal from the detector to a usable measuring indication. This data manipulation usually involves a computerized component.

SOURCE - Radioactive material encased in a capsule. Ohmart/VEGA uses only sealed sources.

SOURCE DECAY - Depletion of radioactive material as the atoms of the material disintegrate and produce radiation. The decay is logarithmic.
**SOURCE HOLDER** - Device to contain the sealed source. Provides shielding to reduce radiation field strength except in desired direction of use. Usually constructed of a heavy, dense material, such as iron, steel, lead, tungsten alloy, or combination of these materials - i.e., steel shell and lead inside. Usually equipped with a shutter to turn radiation off and on.

**SPAN** - The algebraic difference between the upper and lower range-values.

**SPECIFIC LICENSE** - A license issued by the NRC or AGREEMENT STATE to a specified company or person for a specified type and quantity of byproduct material, for a specified use. The company, or person, must apply to the NRC on Form NRC-313 and will receive the Specific License on Form NRC-374, or to the AGREEMENT STATE on that state’s appropriate form. If a company applies for a license, it must name an individual as the “user” of the byproduct material.

**STABILITY** - Refers to the long term (days or weeks) ability to get a correct gauge reading. The short term variation (noise) is not considered when speaking of stability.

**STRIP SOURCE** - Radioactive material inside of the sealed capsule is stretched out to form a strip. Dimensions of radioactive material are approximately 1/4" diameter x length required. Maximum length possible: about 6’.

**SURVEY METER** - Portable device which measures radiation field strength in mR/hr. Used to make a radiation survey.

**TACHOMETER** - Device coupled to a conveyor to sense belt speed. Output is TTL pulses.

**TEMPERATURE, AMBIENT** - The temperature of the medium surrounding a device.

**TEMPERATURE COMPENSATION SYSTEM** - Electronic components which automatically provide a density gauge with a signal to indicate changes in process specific gravity due to changes in process temperature. Temperature compensation is used primarily with gauges that measure chemical streams or petroleum products where the SpG must be referred back to a reference temperature. Its use depends on the process temperature excursion and the span (percent Delta I). For example: given a process material temperature coefficient of 0.00025 SpG/EF and a process temperature excursion of 40EF, the change in SpG, due to the temperature change is 0.01. If the span is 0.05 the change in gauge readout is 0.01/0.05 or 20% of span; if the span is 0.10, the change is 10% of span; if the span is 1.0, the change is 1% of span. Thus, temperature compensation is normally used only on narrow span gauges.

**TEMPERATURE, PROCESS** - The temperature of the process medium at the sensing element.

**THERMOLUMINESCENT DOSIMETER (TLD)** - A radiation detector used for personnel monitoring, similar to a film badge. The TLD contains crystalline materials that, after absorbing radiation, will emit light when heated. The amount of light emitted is proportional to the radiation absorbed. The material in the TLD is made to have an energy response similar to that of tissue, and so can indicate how much radiation an individual wearing the TLD absorbed.
TIME CONSTANT - Mathematically defined as the time, in seconds, for the gauge reading to achieve 63.2% of the final steady state reading when a step change is introduced at the input. The gauge will achieve a reading of about 98% of the final value in four time constants and about 99.4% in five time constants.

TRANSMISSION GAUGE - gauge where the source is on one side of the process and the sensor is on the other side of the process. (Contrast with Reflection gauge).

WIPE TEST - A leak test performed by wiping the surface of a sealed source capsule or the outside surface of a source holder with an absorbent material and analyzing the absorbent material for the presence of radioactive substances.
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