PUBLIC

KRAFT Kraft Foods

030-11485

September 25, 1996

United States Nuclear Regulatory Commission
Region 3
801 Warrenville Rd.
Lisle, IL 60532-4351
Attn.: Mike Weber

RE: Additional information for previously requested amendments to NRC License No. 12-16690-01

Dear Mr. Weber:

Attached is the additional information you requested regarding the license amendments that I submitted on June 19, 1996 (license No. 12-16690-01). This information concerns personnel training at the Wausau, WI, Kraft, Inc. location.

If you have any questions please call me at 847-646-2127.

Yours truly,

Richard Pico

Richard Pico

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SEP 30 1996
REGION III

PM: 9-27-96

SEP 30 1996

NUCLEAR RADIATION SAFETY TRAINING

Presented by Raymond Parsons of Kay-Ray/Sensall

Attendees Name (print)	Initials	Date
ALAN D. SCHILLING	ADS	7/30/96
Michael J. L[illegible]	[illegible]	[illegible]
Mike Joyce	MJ	7-30-96
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Gene Beine	GB	7-30-96
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RANDY KETTUNEN	RK	7-31-96
Vicki Andreas	VA	7-31-96
Judith Nienaber	JN	7-31-96
Joel Brandt	JRB	7-31-96
Jim Maly	JLM	7-31-96
Bobbie Kuszewski	BK	7-31-96
Chad Riegle	CR	7-30-96

(PRESENTED BY RAY PARSC KAY-RAY/SENSALL

OUTLINE

3½ Hour Seminar With Time For "Question and Answer" Period

A. What is radiation?

1. Where does it come from?
2. Different types (Basic)
   a. Alpha
   b. Beta
   c. Gamma
   d. Neutrons

3. Penetration Characteristics

4. Particulate and Electromagnetic

B. Terms used in radiation

1. Curie (Millicurie)
2. Roentgens (Milliroentgens)
3. RAD (Acronym) Radiation Absorbed Dose
4. REM (Acronym) Roentgens equivalent man
5. Dose & Dose Rate (MR/hr)

C. Exposure

1. Natural & Others
2. Medical X-Ray
3. Health Risks

D. Safety Regulations

D. Conclusion

INDUSTRIAL GAMMA RADIATION SAFETY

ABSTRACT

Gamma radiation instruments have many features which make them attractive to the process instrument engineer. This paper will address the safety and application aspects of nuclear gauges in a typical process environment. The methodology will be to explain radiation basics including comparisons of radiation levels at the equipment to exposure from medical x-rays, air travel, etc.

INTRODUCTION

Among the many types of density, level, and weigh scale measurement systems available to the instrument and control engineer, the gamma-radiation-based sensor is unique because it is completely non-contacting. No load cells, probes, or diaphragms come in contact with the measured liquid or solid; installation and maintenance can be performed without process downtime.

Thus, the gamma-based sensor can be used to solve some of the most difficult process measurement problems - - those that involve corrosive, abrasive, very hot, highly pressurized, or viscous materials.

Since gamma-based sensors use a technology not understood by many people, this paper has been written first to acquaint the reader with the many different types of radiation - then to define more specifically gamma radiation and its safe use in industry.

CLASSIFICATIONS OF RADIATION

There are many different types of radiation. Each type has its own characteristics and industrial uses. For purposes of this discussion, we have segmented radiation into two classifications.

Particulate And Electromagnetic Radiation

Particulate radiation encompasses emissions that have a definable mass; some of these are listed below.

Particulate Radiation

Alpha particles (symbolized by α)

Beta particles (symbolized by β)

Neutrons (symbolized by η)

Alpha and Beta particles are often used in industry to measure the thickness of strips and webs. Neutrons are used to measure moisture in bulk materials.

Electromagnetic radiation is characterized by emissions that have observable wavelike behavior and no detectable mass.

Radio waves, microwaves, light, and x-rays are electromagnetic radiation that are familiar to almost everyone. The spectrum in Figure 1 relates the wave lengths of these and other electromagnetic emissions.

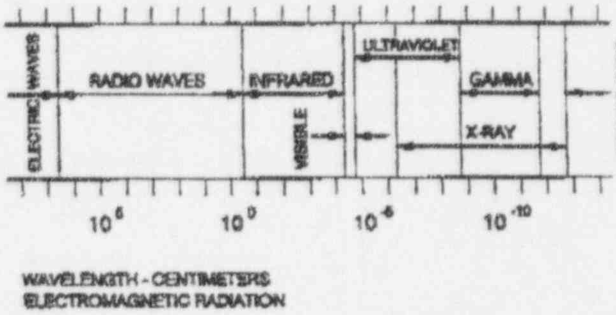


Figure 1

Gamma radiation (symbolized by γ) wave lengths are within the x-ray portion of the spectrum. The difference is that x-rays are emitted from a man-made machine while gamma radiation is emitted by natural or man-made radioactive source materials. The radioactive source materials used in industry emit specific wave lengths of gamma radiation; some of the most common of these are given in Figure 2.

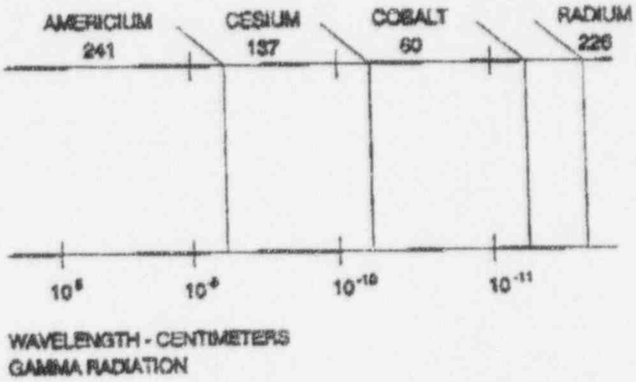


Figure 2

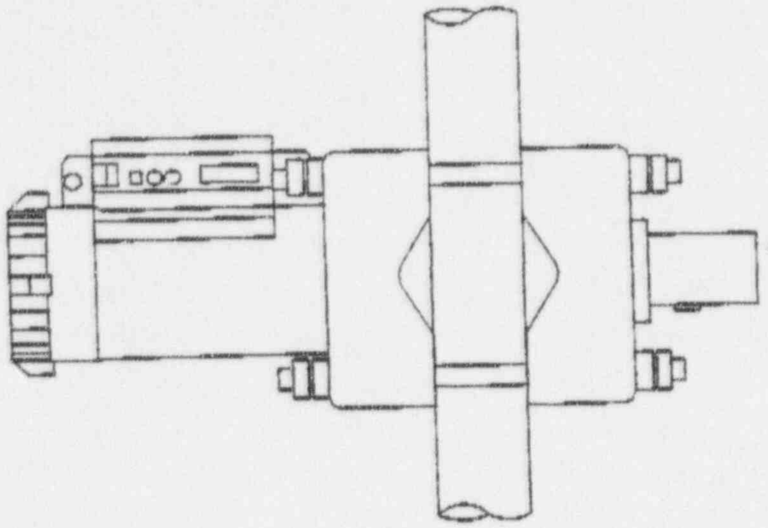


Figure 3

The *KAY-RAY®* density sensor, shown in Figure 3, is typical of an industrial gamma radiation measurement system.

The source housing and detector are mounted on opposite sides of a process pipe. The source housing is made of steel and lead to contain the gamma radiation emitted by the double encapsulated source material in the center. A movable steel and lead shutter controls the gamma beam. When closed the beam is contained - when opened the finely defined beam passes through the pipe to the detector and finally to the lead cap where it stops. The potential gamma radiation exposure of a density sensor installation is easily determined. Table 2 relates the potential exposure levels from this device with those the average human being receives in one year from other sources. Note the amount of time and distance one must be from the density sensor to receive the amounts listed.

Table 2

Source	REM/Year
Cosmic rays from the sun at sea level (external)	0.034
Natural radium in water (ingestable)	0.040
Natural radioactivity in soil (external)	0.060
Natural K40 in body (ingestable)	0.020
Chest x-rays (external)	0.100
Natural radioactivity in wooden house (external)	0.010
Natural radioactivity in brick house (external)	0.040
*2 feet from typical Kay-Ray density sensor (external)	0.318 max. pot. exp.
*3 feet from typical Kay-Ray density sensor (external)	0.154 max. pot. exp.
*4 feet from typical Kay-Ray density sensor (external)	0.091 max. pot. exp.
*8 feet from typical Kay-Ray density sensor (external)	0.031 max. pot. exp.
Allowable NRC annual occupational exposure limit (external)	5.000

*Individual stays at stated distance 8 hours/day for 50 weeks.

GAMMA INDUSTRIAL GAUGING

NON-CONTACTING MEASUREMENT AND CONTROL

Among the many types of density, level, and weigh scale systems available to the instrument and control engineer, the gamma system is unique in that it is completely non-contacting. No probes or interface windows come in contact with the measured liquid or solid. Thus, gamma radiation-based systems can be used on the most difficult process materials; those that are corrosive, abrasive, very hot, viscous, or under high pressure. Not only are these systems non-contacting, they are completely external to the vessel on which they are used, so installation and maintenance can be performed without process downtime.

RADIATION BASICS

This paper will review simple radiation principles and the basic operating theories of gamma density, level, and weigh scale systems, and their corresponding application in various process industries.

Types of Radiation

Radioactive isotopes, either natural or man-made, emit radiation in the form of particles or electromagnetic waves (photons) as they go through the process of decay. The three most common types of nuclear radiation are:

1. Alpha (α) - Emitted particle consists of two protons and two neutrons - same as a helium nucleus.
2. Beta (β) - Electron or positron.
3. Gamma (γ) - High energy electromagnetic waves similar to x-rays.

Because of their low penetrating power, alpha particles are rarely used for industrial gauging. Beta particles are frequently used for thickness measurement in processes such as plastic film, paper, and metal strip. For non-contacting industrial density, level, and weigh scale gauging, gamma radiation is used almost exclusively because its penetrating power is ideal for the relatively thick-walled pipes and vessels used in industrial processes. Some commonly used gamma emitters are:

ISOTOPE	ENERGY (Mev)	HALF-LIFE (Years)
1. Americium (Am-241)	0.060	455
2. Cesium (Cs-137)	0.662	30
3. Cobalt (Co-60)	1.250 avg.	5.3
4. Radium (Ra-226)	1.500 avg.	1602

Cesium-137 has reasonable penetrating power and a useful half-life, making it the most commonly used isotope for industrial density, level, and weigh scale gauges.

Activity

In addition to energy, radioactive isotopes are rated according to their activity (source size). The basic unit of activity is the curie (Ci) after Madame Curie, the Polish-born French scientist who discovered radium. A more convenient unit of measure is the millicurie (mCi), one thousandth of a curie, the amount of radioactive material needed to produce 3.70×10^7 disintegrations per second. Note that activity is independent of energy. For most industrial applications, practical source activities range from 1 to 10,000 millicuries. Since activity is independent of environmental effects, gamma sources are an extremely predictable tool for industrial gauging.

Half-Life and Source Decay

As a radioactive isotope decays, it decreases in activity according to a precise exponential formula. Half-life is the length of time required for a source to decay to half of its original activity. For example, Cs 137 has a half-life of 30 years, so a 100 mCi Cs 137 source will have an activity of 50 mCi in 30 years, and after 60 years its activity will be 25 mCi.

Radiation Field

The radiation field, the intensity of radiation at any given distance from a source, is a function of its activity, its energy, and the thickness and type of material between the source and target. This field is measured in Roentgens (R) after Wilhelm Roentgen, the German scientist who discovered x-rays in 1895. A milliroentgen (mR), one thousandth of a Roentgen, is the radiation field needed to produce 2.08×10^6 ion pairs in one cubic centimeter of air under standard conditions. The Roentgen is used only for measuring gamma and x-ray fields.

Radiation Dose

Dose is a measure of the effect that radiation has on the tissue with which it reacts. Dose, expressed in REM (Roentgen Equivalent Man) is the biological effect produced on a person by a field of one Roentgen. Again, a more convenient unit of measure for our purposes is the millirem, one thousandth of a REM. Although commonly abbreviated mREM, mRem, or mrem, millirem should be spelled out so as not to confuse it with milliroentgen (mR). When dealing with gamma and x-radiation, millirem and mR are

RADIATION DETECTORS

Three types of radiation detectors are commonly used with industrial gauges: G-M tubes, ionization chambers, and scintillation detectors.

G-M Tubes

The G-M (Geiger-Mueller) tube consists of a small diameter (about 15 to 20 mm) of thin-walled metal tube filled with an inert gas, such as argon, at a pressure of about 10 cm Hg. The center electrode is a very thin wire that carries a high electric potential so that any incident beta particle or gamma photon producing a single ion pair within the gas can initiate an avalanche of electrons by gas-multiplication. This avalanche produces a current pulse that can be counted or measured by suitable electronics. G-M tubes can be connected in parallel for improved sensitivity. The G-M tube has the advantage of relative small size and low cost, but can be adversely affected by vibration and generally has a maximum temperature rating of 120°C.

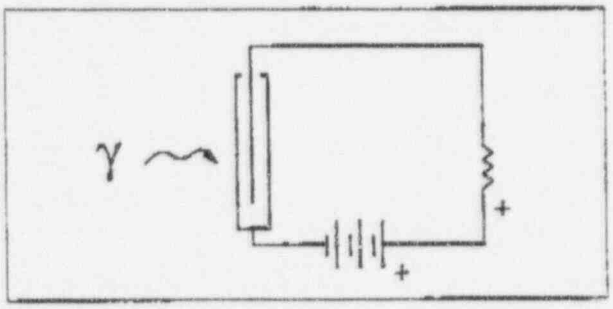


Figure 2A - GM Tubes

Ionization Chamber

The ionization chamber (ion chamber) consists of a relatively large diameter sealed steel chamber with a sturdy center electrode. This arrangement is much more rugged than either the G-M tube or the scintillation detector. It is filled with a heavy, inert gas such as argon at a pressure of several atmospheres. A heavy gas under pressure increases the chances of a collision between an incident gamma photon and a gas molecule. As radiation strikes the chamber, the gas becomes ionized, the resulting current output is continuous and proportional to the intensity of the incident radiation. The ion chamber operates at a lower voltage than the G-M tube and the output is relatively independent of power supply fluctuations. It is less temperature sensitive than the scintillation detector, withstanding ambient temperatures up to 150°C. and high vibration without permanent damage.

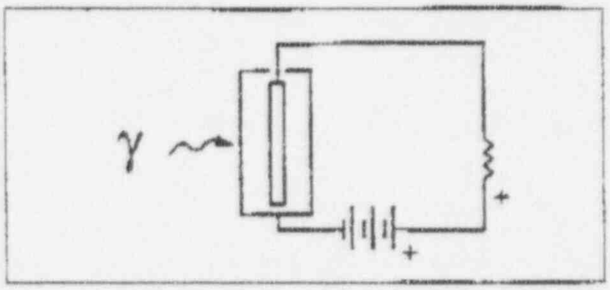


Figure 2B - Ion Chamber

Scintillation Detector

The scintillation detector (more precisely the scintillation photomultiplier detector) makes use of the phenomenon that when gamma photons strike certain crystals, such as sodium iodide (NaI), visible light photons are produced. These light photons can then be made to strike the cathode of a photomultiplier (PM) tube producing photoelectrons, those photons are attracted to the positively charged dynodes and, in turn, produce even more electrons due to the phenomenon of secondary emission. The scintillation detector is capable of very high amplification so it can be used with much smaller activity sources than the ion chamber. It is generally more sensitive to electrical and environmental disturbances than the ion chamber, however this is a drawback that Kay-Ray/Sensall, Inc. has been able to overcome.

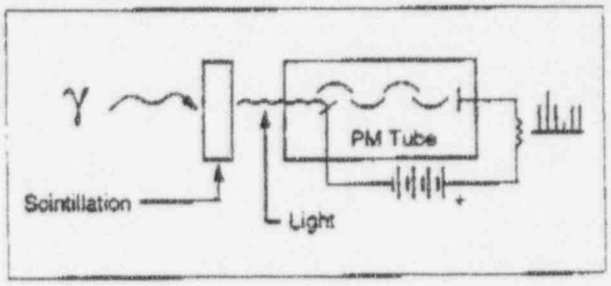


Figure 2C - Scintillation

Application Considerations

The following factors must be carefully considered when applying gamma level systems:

1. **Source Activity.** Selecting the correct source activity is a function of the distance between the source and detector, the number of half-values of material between the source and detector, and the detector sensitivity.

2. **Ambient Temperature.** Gamma level systems are commonly used on very hot processes where contacting level gauges will not work. All gamma detectors can operate in ambient temperatures up to approximately 60°C. Above this temperature, with the exception of the ion chamber which can operate in ambients up to 150°C, water cooling is necessary. The source housing can withstand ambient temperatures up to the melting point of lead, approximately 300°C.

3. **Falling Material.** Excessive amounts of falling material can create false high level indications. In most applications, an increased source activity will compensate for the extra absorbtion caused by the falling material.

4. **Material Buildup.** Material buildup on vessel walls, if large enough, may cause false triggering. In this case, it is necessary to estimate the maximum buildup and increase the source activity accordingly.

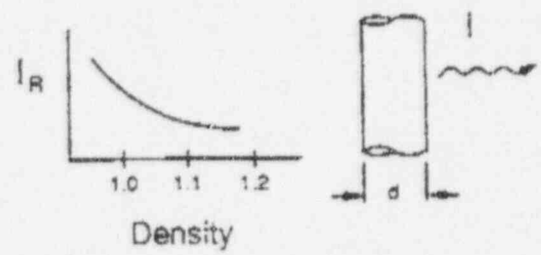
5. **Linearization.** With large continuous level ranges, the gauge output is non-linear due to the differences in radiation path length and effective wall thickness from top to bottom. These differences can be compensated for by using a multiple-segment linearizer.

Typical Applications

Chemical:	Reactors, surge tanks, fluidized beds, storage tanks; product interfaces, foam level detection, molten polyester.
Mining:	Crushers, storage hoppers, sumps, sand beds.
Metals:	Continuous casters, cupolas, storage bins, blast furnaces; powdered metals, molten metal.
Pollution:	Incinerators, fly ash hoppers, sludge tanks.
Power:	Coal gasifiers; ash lock, coal lock, and fly ash hoppers; plug and void conditions in feed chutes.
Paper:	Chip bins, chip chutes, batch digesters; plug and void detection in feed and discharge chutes of TMP and M&D digesters.
Glass:	Molten glass level in furnaces.

DENSITY SYSTEMS

Basic radiation principles can be applied to measure the density of material in a pipe. Since radiation is absorbed in proportion to the amount of mass through which it travels, varying density of a material flowing through a pipe will result in a varying output from the detector. Refer to Figure 5. The mass absorbtion coefficient (μ) is a characteristic of the process material, diameter (d) is a constant, and (ρ) is the variable to be measured. In most cases, (μ) can be calculated and combined with a known (d) and (ρ) range to predict the resultant radiation change. With Cs-137 as the radiation source, (μ) does not change greatly with different process materials.



$$I = I_R e^{-\mu\rho d}$$

I - Radiation intensity at ρ density
I_R - Radiation intensity at reference density
μ - Mass absorption coefficient
ρ - Density of process material
d - Inside diameter of pipe

Figure 5 - Density vs. Radiation at Detector

Application Considerations

Installation. A few simple guidelines will ensure a successful installation:

1. Clamp the source housing and detector on a vertical pipe with the flow upward (refer to Figure 6). This assures a full pipe and no stratified material between source and detector. If a horizontal pipe must be used, then mount the source and detector in a vertical plane to average the stratified material.

2. A sample valve should be installed near the source and detector for initial calibration and subsequent periodic calibration checks.

WEIGH SCALES

The gamma weigh scale operates on a principle similar to the gamma density system. In this case, a fan-shaped radiation beam spreads across the entire width of a conveyor from above, and the detector is positioned below. As material passes between the source and detector, the amount of radiation reaching the detector is inversely proportional to the mass of material per unit area on the conveyor. Typically, the conveyor loading is multiplied by the conveyor speed to produce a mass flow rate. This rate can be integrated over time to give a totalized flow. Refer to Figure 8.

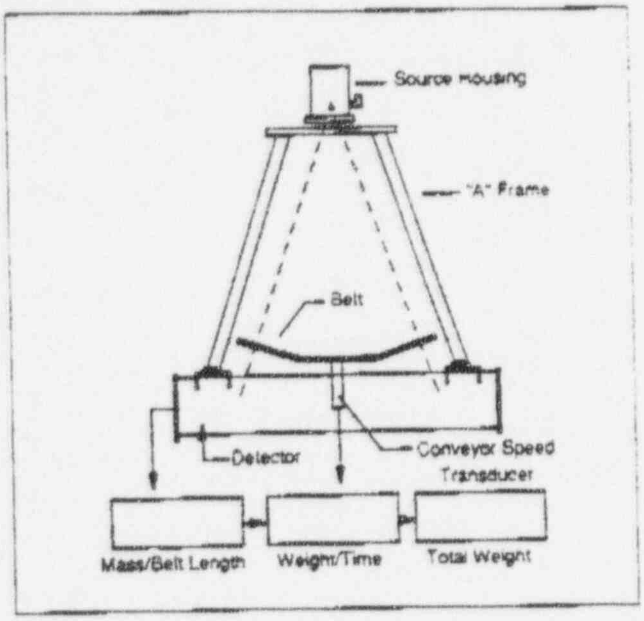


Figure 8 - Weigh Scale on Belt Conveyor

Installation and Calibration

The gamma weigh scale is specifically designed for easy installation on any conveyor. It slips easily under any existing belt conveyor without requiring modification to stringers or idlers. Calibration is established simply by zeroing the electronics based on an empty conveyor reading and setting the span on a known full load reading.

Application Considerations

1. **Repeatability.** Basic repeatability is ±0.5% of full scale where conveyor speed and loading geometry are repeatable and loading is maintained between 70% and 100% of full scale.

2. **Loading.** Belt conveyor loading is calculated by the following formula:

$$\text{Conveyor Belt Loading}(\#/ft^2) = \frac{\text{maximum throughput } (\#/min)}{\text{Belt speed } (ft/min) \times \text{Belt width } (ft)}$$

The minimum full scale belt loading is 2.7 lbs/ft^2. There is no maximum loading limit on a nuclear weigh scale.

3. **Linearization.** When a significantly large loading span is encountered, the radiation change may be enough to require linearization. Generally, a linearizer is not required for full scale loadings less than 10 lbs/ft^2.

4. **Particle Size.** Particle size has no significant effect unless inc ·idual particles are larger than 15% of belt width.

5. **Conveyor Speed Transducer.** If belt speed variations are more than ±25%, a speed/weight multiplier option should be included in the system to maintain basic accuracy. This option includes a conveyor speed transducer and computer card to calculate weight per unit of time.

6. **Density and Moisture Variations.** Product density and moisture variations of less than 10% will have minimal effect on accuracy. Kay-Ray/Sensall weigh scales have been used on screw, apron, dragchain, and bucket conveyors.

Typical Applications

Chemical:	Fertilizer, phosphates, charcoal, cement.
Mining:	Foundry sand, ores, limestone, potash, gravel.
Metals:	Coal, ores, pellets, sinter, metal concentrates.
Pollution:	Sludge filter cake, dewatered sludge.
Cement:	Kiln feed, clinkers.
Power:	Coal flow.
Paper:	Wood chips, sawdust, bark.
Food:	Grain, fruit, potatoes, bagasse.
Misc.:	Rubber, gypsum.

SUMMARY

When proper attention to application evaluation, component selection and installation is given, non-contacting density, level, and weigh scale systems ideal for numerous applications in almost every process industry.