This report was prepared as a part of the account of Government-sponsored work. Neither the United States, nor the Commission, nor any person acting on behalf of the Commission makes any warranty or representation, express or implied, with respect to the accuracy, completeness, or usefulness of the information contained in this report, or that the use of any information, apparatus, method, or process disclosed in this report may not infringe privately owned rights. The Commission assumes no liability with respect to the use of, or from damages resulting from the use of, any information, apparatus, method, or process disclosed in this report.

(A-6.465.1)

AECD-4082

CLINTON ENGINEER WORKS
TENNESSEE EASTMAN CORPORATION

BETA DEVELOPMENT GROUP
Dr. R. S. Livingston - Supt.

PROCESS MONITOR ANALYSIS

VICTORREX MODEL 350

Photostat Price \$	4.80
Microfilm Price \$	9.70
Available from the Office of Technical Services Department of Commerce Washington 25, D. C.	

ABSTRACT

An analysis of the improved Model Number 350 Process Monitor was made so that it could be determined if this instrument would fulfill the need for gamma radiation detection instruments in the production buildings of Y-12. The results of these tests indicated the possibility of marked improvement in the monitor characteristics with minor redesigns. After these improvements have been made, this instrument will be a satisfactory monitor for this area.

J. A. Harter
E. L. Olson

Oak Ridge, Tennessee
May 1, 1947

1213

CONTENTS

Introduction	1
Experimental	2
Procedure	2
Results	4
Discussion of Results	7
Weaknesses and Suggested Improvements .	7
Acknowledgements	9

2812

PROCESS MONITOR ANALYSISVICTOREEN MODEL 350INTRODUCTION

The process monitors now in use in the production buildings at Y-12 have not been entirely satisfactory in the past. It was thought that a new improved model would be very desirable for future operations. With this thought in mind, a new circuit for an improved process monitor was designed. The Victoreen Instrument Company of Cleveland, Ohio was given an order to build several of these improved instruments. The first instrument to be constructed according to this new design has been received and tested. The details and results of these tests are given in this report. Also, some suggestions for further improving the monitor have been given.

EXPERIMENTAL

Procedure

It was necessary to make numerous tests to determine the stability and reliability factors such as voltage regulation, zero and sensitivity drift, temperature dependency, effect of supply voltage fluctuations, response to spurious signals (line voltage radio frequency transients, light, beta particles, vibration, and power failure), resolving time errors, component failure, directional discrimination, and linearity.

The voltage regulation was checked on the high and low voltage supply by varying the line voltage from 90 to 135 volts by means of a Variac.

The zero and sensitivity drift was obtained by placing a recording milliammeter in series with the alarm relay and the drift measured. Zero setting and sensitivity were checked at the beginning, middle, and end of tests with an audio oscillator, square wave generator, 6:1 ratio pulse generator, and an oscilloscope.

In order to obtain the temperature dependency, the entire monitor was placed in a temperature-controlled oven. The signal was supplied by the oscillator and pulse generator. The variation of the count rate with temperature was recorded.

Supply voltage transients were effected manually by means of a variac, power switches, and momentary interruptions.

The monitor response to spurious signals was noted for line voltage radio frequency transients due to motor commutation,

4/8/53

arc welders, high voltage supply sparking, etc. A 30,000 counts per minute beta particle source of 1.8 Mev energy was placed directly on the Geiger-Müller tube shield to check the beta response. The power switch on the monitor was used to simulate a power failure. The effects of illumination from a 100 watt bulb and mechanical vibration were noted.

The circuit response was noted from 20 to 200,000 pulses per second using an oscillator, pulse generator, and an oscilloscope. The circuit was tested as received and also with a change in the value of resistor R7 to lower the 6SN7 tube grid bias to rated value of minus three volts. "Blanking out" effect was made with a 4.77 milligram radium source laid directly on the Geiger-Müller tube, slowly and also suddenly.

Component failure was simulated and the results noted. The Monitor angular sensitivity in the horizontal and vertical plane was checked using a 1.1 milligram radium source. All possible back-scattering and reflection possibilities were eliminated and the readings averaged over an extended period of time.

The rate meter linearity was checked using an oscillator, pulse generator, and a square wave generator.

5813

Results

Voltage regulation with selected tubes, as received was superior to regulation when VR tubes selected at random from stock were substituted, as would occur in periodic servicing of the instrument. Even so, regulation of Geiger-Müller tube high voltage supply did not exceed ± 20 volts for ± 10 percent variation in line voltage (see figure 1) and may be considered within satisfactory limits though such a variation is not desirable. The low voltage supply regulation (see figure 2) is poor at reduced line voltages, limiting the range of the rate meter (see figure 3), even with twin-triode balanced bridge circuit. The high voltage potentiometer adjustment is excessively critical, minute changes in contact resistance causing appreciable drift in high voltage over extended periods of time.

Constant readjustment of high voltage setting was necessary to maintain constant Geiger-Müller tube voltage and obtain reproducible test data. With such attention, overall stability was excellent and zero drift negligible over a period of weeks. Tube change produced a need for bias adjustment control for pulse equalizer tube, V3. Readjustment to proper operating values after such change gave stable operation.

Figure 4 shows the relatively constant counting rate of the Geiger-Müller tube with temperature change. Figure 5 shows temperature dependency of the Geiger-Müller tube and

monitor under similar conditions. Since probable range of temperature fluctuation is limited, small error in count will be introduced.

Figure 3 shows undesirable transient response; sudden decrease of ten percent in line voltage in less than 0.5 second and greater than 0.05 second cause momentary closure of the alarm relay, giving spurious alarm. This effect was not noted on transients of greater length than 0.5 second.

The monitor is insensitive to line transients of extremely short time duration, such as radio frequencies, as might be expected from figure 6 which shows attenuation at frequencies above thirty kilocycles. Incandescent and ultra-violet light on the Geiger-Müller tube produced no false response. The instrument is remarkably free from microphonic signals from mechanical vibration. Beta particle response is also absent.

Power failure almost invariably produces the alarm relay closure. Capacitor C13, added to the circuit to prevent relay closure when the monitor supply is energized, causes alarm on power failure.

As may be seen on figure 6, input pulse sensitivity is attenuated above 30,000 pulses per second. Complete "blanking out" with pulse generator occurred at 130,000 pulses per second (alarm value is 2500 pulses per second). The strongest available radium source (4.77 milligram) failed to "saturate"; pulses only eight microseconds apart were resolved as separate counts.

The instrument is vulnerable to component failure; failure of almost any component either produces a false alarm or renders the instrument inoperative without warning. Unfortunately, this was inherent in the Chicago design, and major redesign was not attempted. Components are conservatively rated except for the 7B4 high voltage supply regulator tube.

The angular response and the directional sensitivity of the Geiger-Muller tube in the plane of the coaxial wire was approximately constant (see figures 7 and 8). Constant sensitivity in the plane perpendicular to the wire may be safely assumed. The Directional sensitivity and angular response curves of both horizontal (see figures 9 and 10) and vertical planes (figures 11 and 12) of the monitor show "blind spots" with sensitivity reduced by a factor of five due to shielding of the Geiger-Muller tube by transformers, chokes, etc. Comparison curves made on present monitors (Chicago Mark 10, model 20; see figures 13 and 14) show the same objectionable directional attenuation.

Figure 15 shows the linear relationship between the indicated pulse rate and the input pulse frequency. The count rate meter scale is also approximately linear.

8/8/13

DISCUSSION OF RESULTS

These data indicate the possibility of marked improvement in the monitor characteristics with relatively minor redesigns.

Weaknesses and Suggested Improvements.

Poor Low Voltage Supply Regulation.-Proper design for good regulation would improve instrument characteristics as a whole.

Directional Discrimination.-Relocation of the Geiger-Müller tube is comparatively easy: exact placement depends upon geometrical solid angle to be monitored. For this particular plant, placement of the Geiger-Müller tube above chassis behind and parallel to the front panel would be a comparatively simple change and satisfactory for monitoring a 2π solid angle (vertical hemisphere) in front of the monitor.

High Voltage Drift.-Reduction in value of R36 high voltage adjustment potentiometer for reduced sensitivity of adjustment would improve the High Voltage Setting stability, even though such change might necessitate using selected 6AG5 amplifier tubes.

False Alarm on Power Failure.-The alarm on power failure may be eliminated by removing the grid capacitor (C13) from the circuit. Proper selection of the 6SN7 (V5) tube eliminates the need for this capacitor. Unless the 6SN7 tubes are selected, unequal heating of the cathodes can cause enough unbalance to trigger the alarm circuit momentarily when the circuit is first turned on. Even though the tubes must be selected, this is a

small disadvantage compared to the improved characteristics of the balanced pair vacuum tube voltmeter circuit. Also, the degeneration inherent in cathode follower circuits permits the use of approximately two-thirds of the tubes picked at random for this purpose.

Tube Replacement Discrimination.-In addition to the necessity for selected tubes for V5, it seems advisable to change fixed resistor R7 to an adjustable potentiometer. The grid bias of tube V3, second section, is relatively critical; and readjustment for desired sensitivity (see figure 6) is necessary in the majority of tube replacements.

Miscellaneous.-Good engineering practice would advocate use of substitute tube type for the voltage regulator tube, V3 (78L); the maximum plate voltage rating is now exceeded three hundred percent.

More rigid mechanical support of the relay and the Geiger-Müller tube shields is suggested.

Replacement of the high voltage transformer, T1, (shorted secondary winding) and the high voltage pilot lamp transformer (open primary winding) was necessary. These may be considered specific cases, since accepted quality of these parts is good. Failure occurred in routine testing without particular abuse.

CONFIDENTIAL

9.

ACKNOWLEDGMENTS

Many useful suggestions and helpful criticisms have been received from Dr. E. D. Shipley and R. L. Quinn.

J. A. Harter
J. A. Harter

E. L. Olson
E. L. Olson

APPROVED: W. D. Lavers
W. D. Lavers

DISTRIBUTION:

- 1.-12. Mr. J. C. Robinson
- 13. Mr. W. D. Lavers
- 14. Dr. R. S. Livingston
- 15.-18. Mr. J. C. Bowles
- 19. Dr. E. D. Shipley
- 20. Mr. E. L. Olson

CONFIDENTIAL

11/8/3

Figure 1

20 X 20 PER INCH

EUGENE DIEZEL CO.
PRINTED IN U. S. A.

Figure 2

10 X 10 PER INCH

SECURITY DISTRICT CO
MADE IN U.S.A.

Figure 3

20 X 20 PER INCH

PRINTED IN U. S. A.

Figure 4

NO. 35010 DIETZEN GRAPH PAPER
10 X 10 PER INCH

EUGENE DIETZEN CO
MADE IN U.S.A.

Figure 5

4 CYCLES X 10 DIVISIONS PER INCH

MADE IN U.S.A.

Figure 6

18816

Figure 7

Figure 8

20, 812

Figure 9

Figure 10 ,

228" Figure 11

23460

Figure 12

EUGENE DIEZGEN CO.
SERIAL NO. 124
NO. 340-P DIEZGEN GRAPH PAPER
POLAR CO-ORDINATE

24813160

Figure 13

Figure 14

258¹³

268/11 Figure 15 -

REPORT NO. 3

ENGR. AABERG

DATE 1-13-47

RATE METER CIRCUIT PROCESS MONITOR MODEL 350 SER. I

THE VICTOREEN INSTRUMENT CO
CLEVELAND OHIO

PLATE

1

27813

REPORT NO. 3
 ENGR. A. ABERG
 DATE 1-13-47

POWER SUPPLY CIRCUIT
 PROCESS MONITOR MODEL 350 SER. I
 THE VICTOREEN INSTRUMENT CO.
 CLEVELAND, OHIO

PLATE
 2

22813