

Evaluation of Ionization Chamber Design

Type 100A

Performed for:

Fyrnetics Inc.  
1021 Davis Road  
Elgin, Illinois 60120

Performed by:

Gerald D. Rork  
Radiological Consultant  
P.O. Box 142  
West Dundee, IL 60118  
(312) 428-4409

#### General Description

The Type 100A ionization chamber is a variant of the type presently licensed for distribution by the U. S. Nuclear Regulatory Commission under the provisions of license no. 12-10000-01A.

As, in that type, the radioactive material, Americium 241 maximum quantity 1 uCi, is encased in noble metal foil. The complete foil is manufactured by either of two vendors:

Rad Division of Mark IV Industries  
2937 Alt Boulevard  
Grand Island, NY 14072

Amersham Corporation  
2037 Clearbrook Drive  
Arlington Heights, IL 60005

The foil is retained between two stainless steel plates secured together by two rivets. These plates clasp the plastic insulator which forms a common wall between the smoke sensing and reference chambers. The outer electrode of both chambers are made of stainless steel drawn into the form of a flanged cup. The outer electrode of the smoke sensing chamber is slotted to allow smoke entry.

The two cup shaped electrodes are fastened to the insulator by means of two ultrasonically deformed pegs molded on the insulator. In addition, two tamper resistant bolts pass through both electrodes and the insulator and are secured to the detector mounting base with recessed nuts.

#### Chamber Type Comparison

Since the Type 100A ionization chamber is a variant of the type presently licensed, most of the construction details are identical to those used in the presently licensed chambers.

#### 1. Radioactive Material

The foil containing the radioactive material in the Type 100A ionization chamber is identical to that used in the presently licensed chambers.

#### 2. Type 100A Retention

The method of retention by sandwiching the foil between the two stainless steel plates in the type 100A chamber is identical to that used in presently licensed chambers.

#### 3. Insulator

The insulator used to separate the sensing chamber from the reference chamber in the type 100A ionization chamber is identical to that used in presently licensed chambers.

#### 4. Outer Electrodes

The cup shaped electrode used to form the outer surface of the reference chamber is identical to that used in presently licensed chambers. The cup shaped electrode used to form the outer surface of the sensing chamber is slotted for smoke entry. These slots are different from those used in presently licensed chambers. The radiological aspects of this difference will be discussed below.

#### 5. Chamber Fastening Method

The outer two cup shaped electrodes of the Type 100A ionization chamber are fastened to the insulator in four places. Two of the fasteners consist of ultrasonically deformed pins molded as part of the insulator. The remaining two fasteners are tamper resistant bolts with nuts which pass through both electrodes and the insulator. These bolts are also used to fasten the type 100A chamber to the detector base. The nuts are recessed in cavities in the base. This method of fastening the electrodes to the insulator and the chamber to the detector base is identical to that used in presently licensed ionization chambers.

As noted in the foregoing, the only difference between the Type 100A ionization chamber and those presently licensed consists of differences in the smoke entry slots in the cup shaped electrode which form the outer surface of the sensing chamber.

In this discussion of the differences between the two types of electrodes used to form the outer surface of the sensing chamber, reference should be made to the drawings enclosed which show the construction details of these electrodes.

In presently licensed chambers, there were eight openings in the sensing chamber which allowed smoke entry as shown on Tyndetics drawing 2. These openings were formed by pushing out a 0.25 inch portion of the cup wall a distance of 0.170 inches.

The electrode used to form the outer surface of the sensing chamber used in the Type 100A ionization chamber has 36 slots to allow smoke entry. These slots are  $0.04 \pm 0.004$  inches in width by  $0.41 \pm 0.005$  inches in length. This is shown on Management Investment & Technology Co. Ltd's drawing 52060090.

The only two radiological aspects of this design change concern the amount of exposure to the public from the radioactive source and any change in the ease of access to the source during normal use of smoke detectors containing this ionization chamber.

Appendix 1 to this report shows the results of measurements of the exposure at the surface and at 5 and 25 centimeters from four samples of the Type 100A ionization chamber assembled into detectors. As will be noted, the maximum exposures measured were: 4.56  $\mu\text{R/hr}$  surface, 2.61  $\mu\text{R/hr}$  at 5cm and 0.12  $\mu\text{R/hr}$  at 25cm. These exposures are not considered significant and are well below any required limits.

Access to the radioactive source without disassembling the ionization chamber is only possible through the smoke entry slots. These slots are only 0.04 inches wide. Thus, any contact with the source is not possible during normal operation of a smoke detector containing the Type 100A ionization chamber.



# Gerald D. Rork Consultant

LIABILITY LITIGATION  
PRODUCT SAFETY  
RADIATION LICENSING  
RADIATION PROTECTION  
TECHNICAL EXPERT

## EXHIBIT 1

### MEASUREMENT OF EXTERNAL RADIATION EXPOSURE

#### Syrnatics Type 100A Ionization Chamber

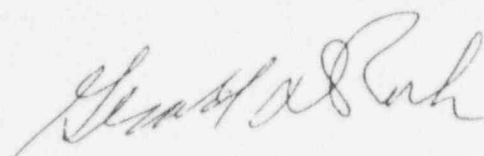
Method: Four samples of the Type 100A ionization chamber installed in detectors were measured for external radiation exposure. The samples were numbered 1-4. Measurements were made using a Nuclear Chicago counter. The detector was a 50mm x 50mm diameter NaI scintillation crystal with associated photomultiplier. All measurements were performed inside a 2 inch thick lead shield to reduce background. Prior to and after the measurements, the instrumental set up was calibrated using a certified source.

Measurements were performed in three orientations of each of the four samples. These orientations were: top of ionization chamber, bottom of ionization chamber outside the detector mounting base and the side closest to the outside of the detector mounting base. The exposure was measured at three distances: surface, 5 centimeters and 25 centimeters. All measurements were made without the detector cover being present.

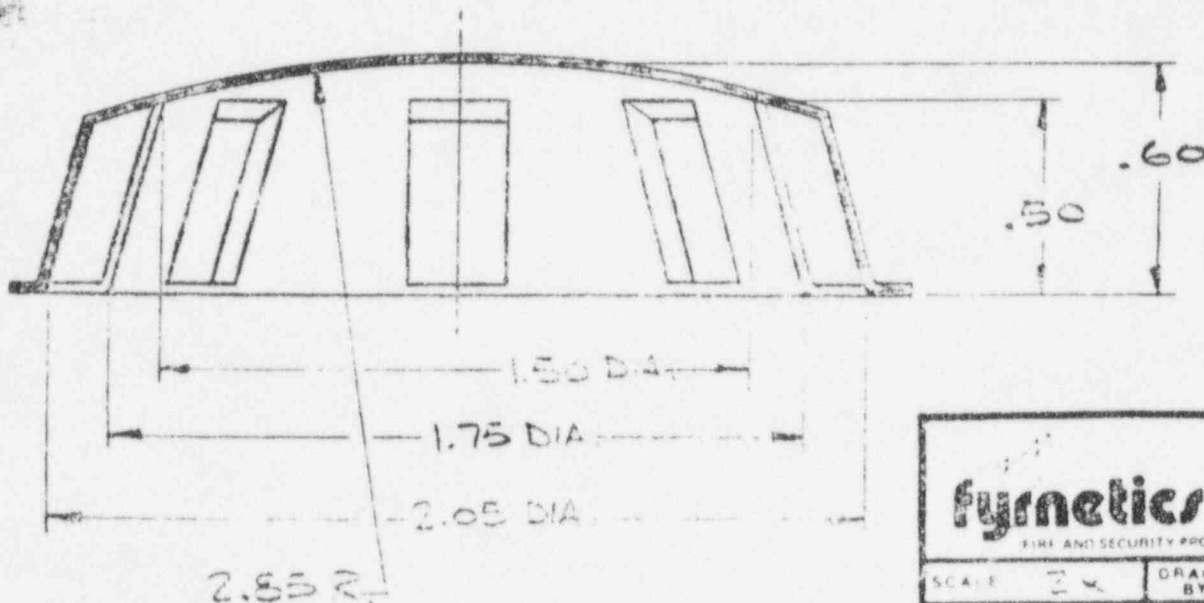
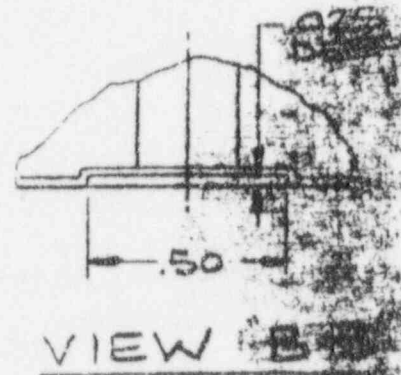
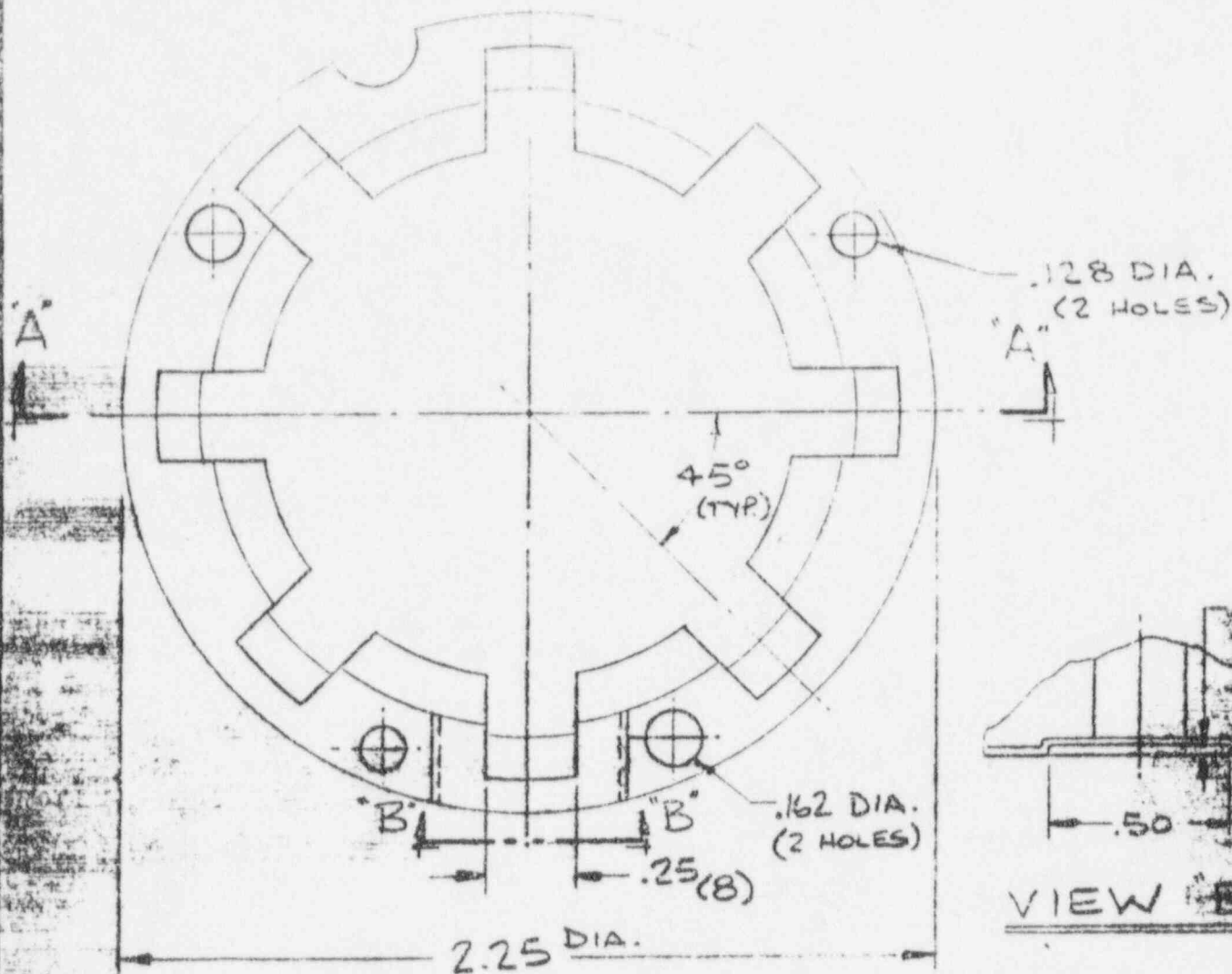
The following results in  $\mu\text{R}/\text{hour}$  were measured:

Sample no.	1	2	3	4
Orientation				
Top	0.80 surface 0.22 @ 5cm 0.02 @ 25cm	0.83 surface 0.22 @ 5cm 0.02 @ 25cm	0.76 surface 0.22 @ 5cm 0.02 @ 25cm	0.79 surface 0.22 @ 5cm 0.02 @ 25cm
Bottom	0.76 surface 0.20 @ 5cm 0.02 @ 25cm	0.80 surface 0.20 @ 5cm 0.02 @ 25cm	0.73 surface 0.20 @ 5cm 0.02 @ 25cm	0.75 surface 0.20 @ 5cm 0.02 @ 25cm
Side	4.38 surface 2.06 @ 5cm 0.12 @ 25cm	4.56 surface 2.01 @ 5cm 0.12 @ 25cm	4.33 surface 2.05 @ 5cm 0.10 @ 25cm	4.41 surface 2.03 @ 5cm 0.12 @ 25cm

Measurements performed by: G. D. Rork  
Date: January 16, 1966







MAT'L

.020 STAINLESS STEEL  
DEGREE

SECTION

**fyrnetics inc.**

FIRE AND SECURITY PRODUCTS

SCALE 3X

DRAWN BY

PER. SE-SE

DWG  
NO

SECTION

REVISIONS

SYM	DESCRIPTION	DATE	APPR.
PR	FIRST RELEASED EN-608/85	14-12-85	

R 0.93 ± 0.008"

BREAK LINE  
(TTL: 28 PCS)

Ø 0.162  
4 HOLES

Ø 1.75  
INSIDE

R 2.85 (INSIDE)

SLOT

0.0010 ± 0.0004

REMARK: 1 SAMPLE MUST BE API 0.0010  
2 THE COMPONENT MUST BE (YP: 2)  
3 ALL DIMS IN INCH.

GEMENT INVESTMENT & TECHNOLOGY CO., LTD.

1 SENSE (BUG SCREEN)

1

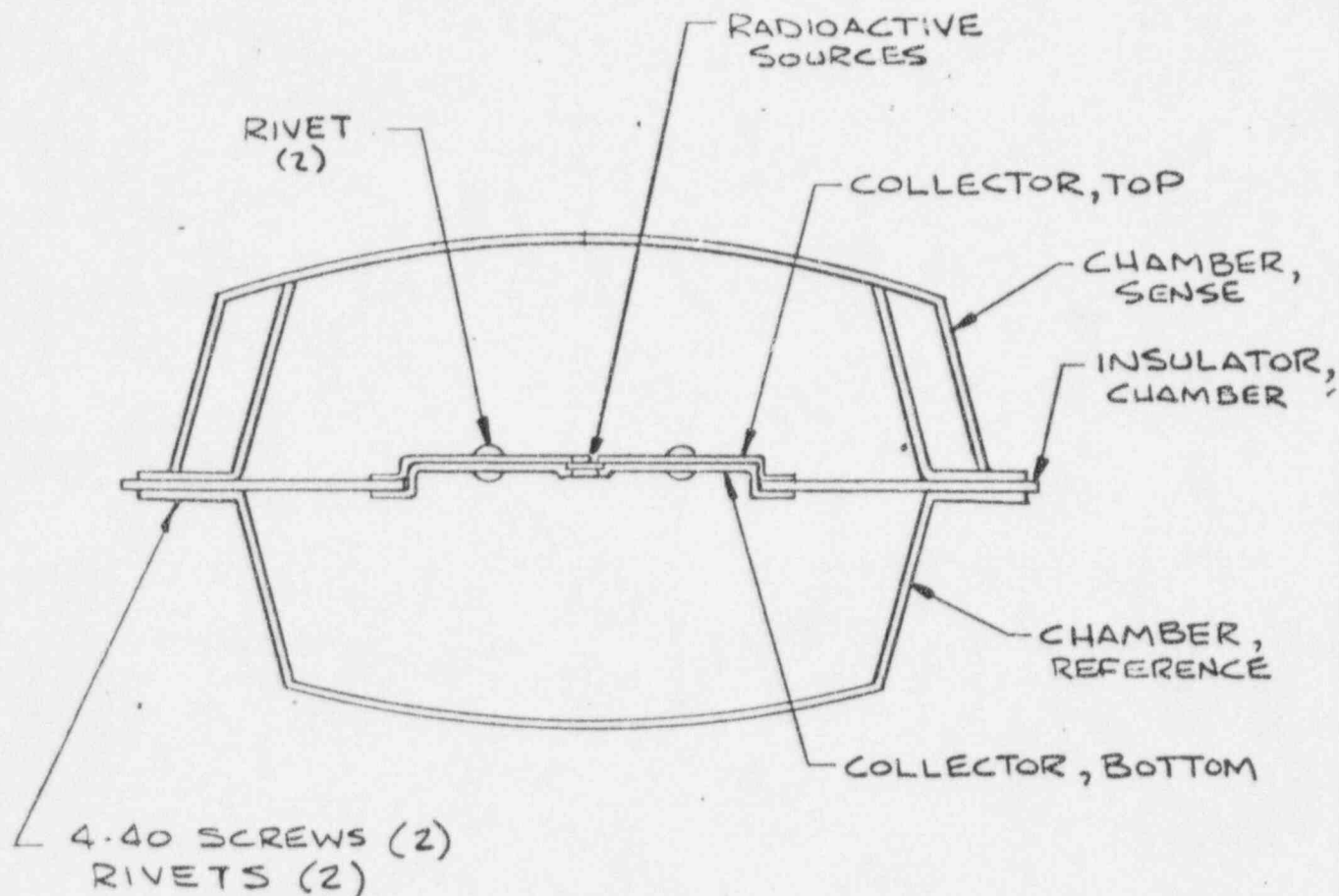
DWG  
SIZE  
D

520E0090


REV

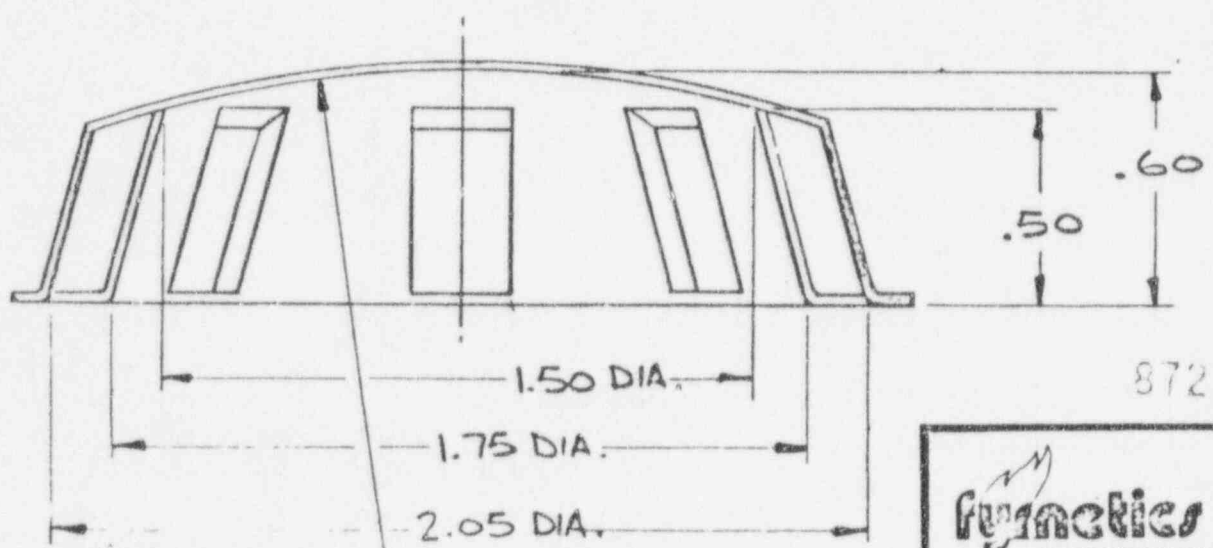
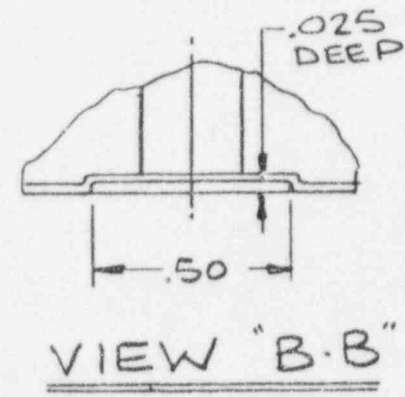
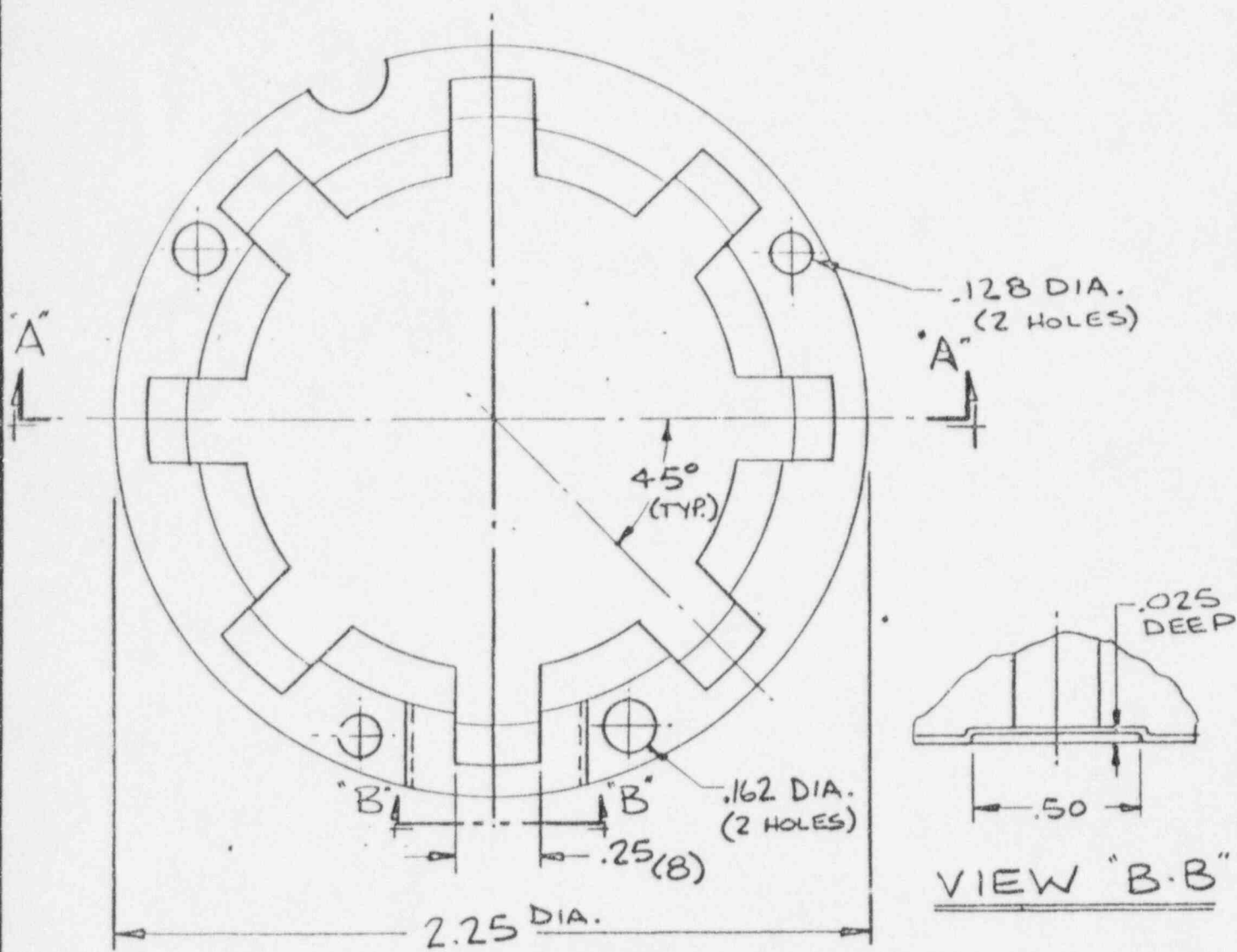
PR





87274

 <b>fumetec inc.</b> <small>FIRE AND SECURITY PRODUCTS</small>	
SCALE 2x	DRAWN BY <i>MD</i>
TYPE 500A IONIZATION SMOKE DETECTOR ASSY	
DWG NO.	1



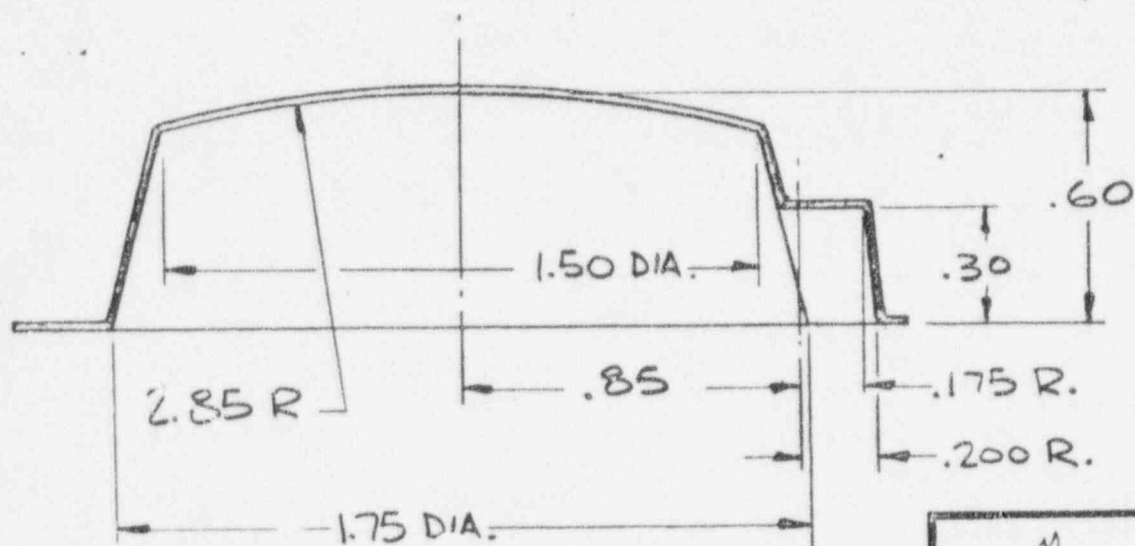
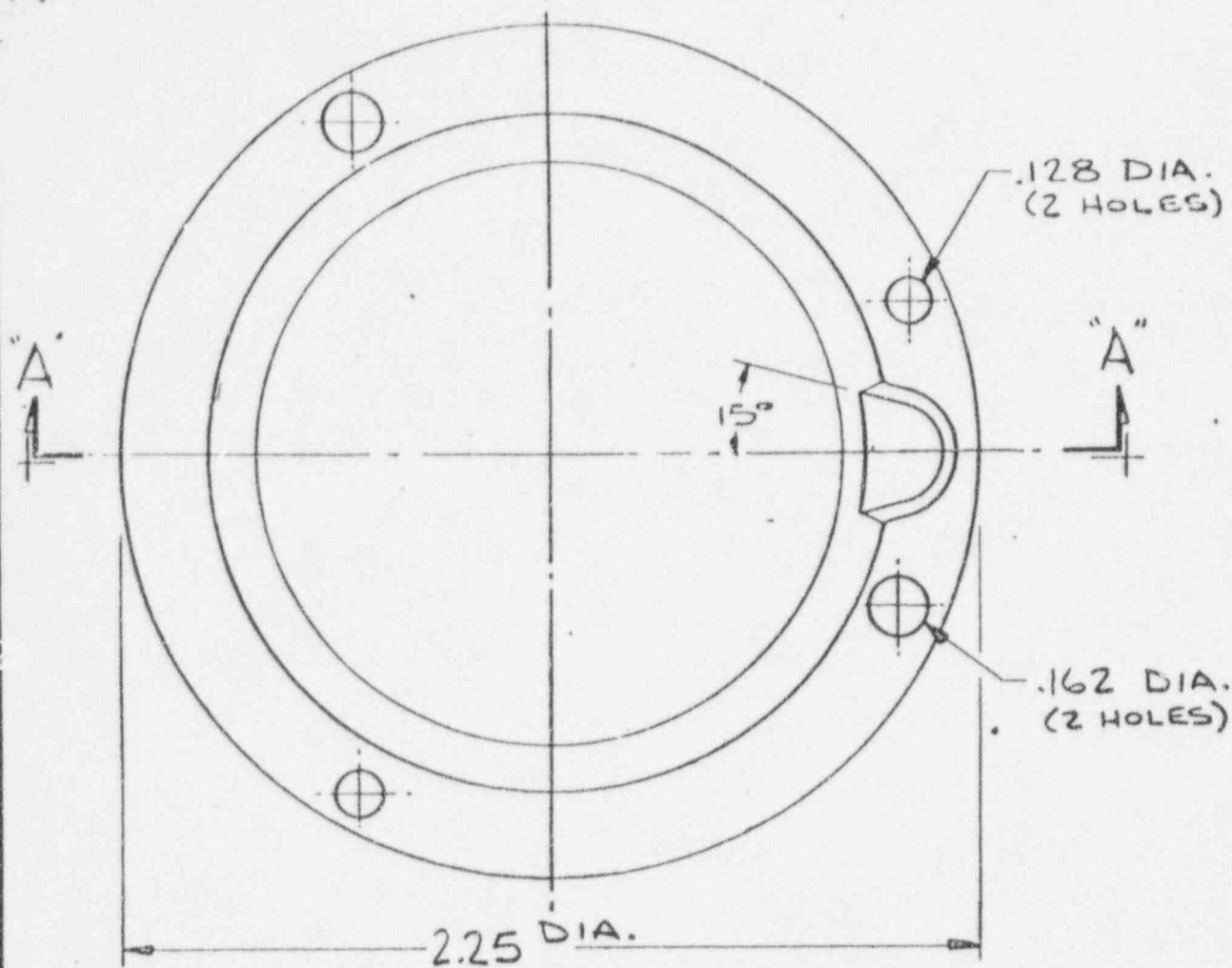
87274

T'L  
SECTION "A-A"

STAINLESS STEEL (302 OR 304)  
DEGREASED

REF. 101002-002

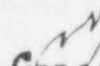
 FYNETICS inc.	
SCALE 2x	DRAWN BY <i>MD</i>
CHAMBER, SENSE	
DWG NO.	2

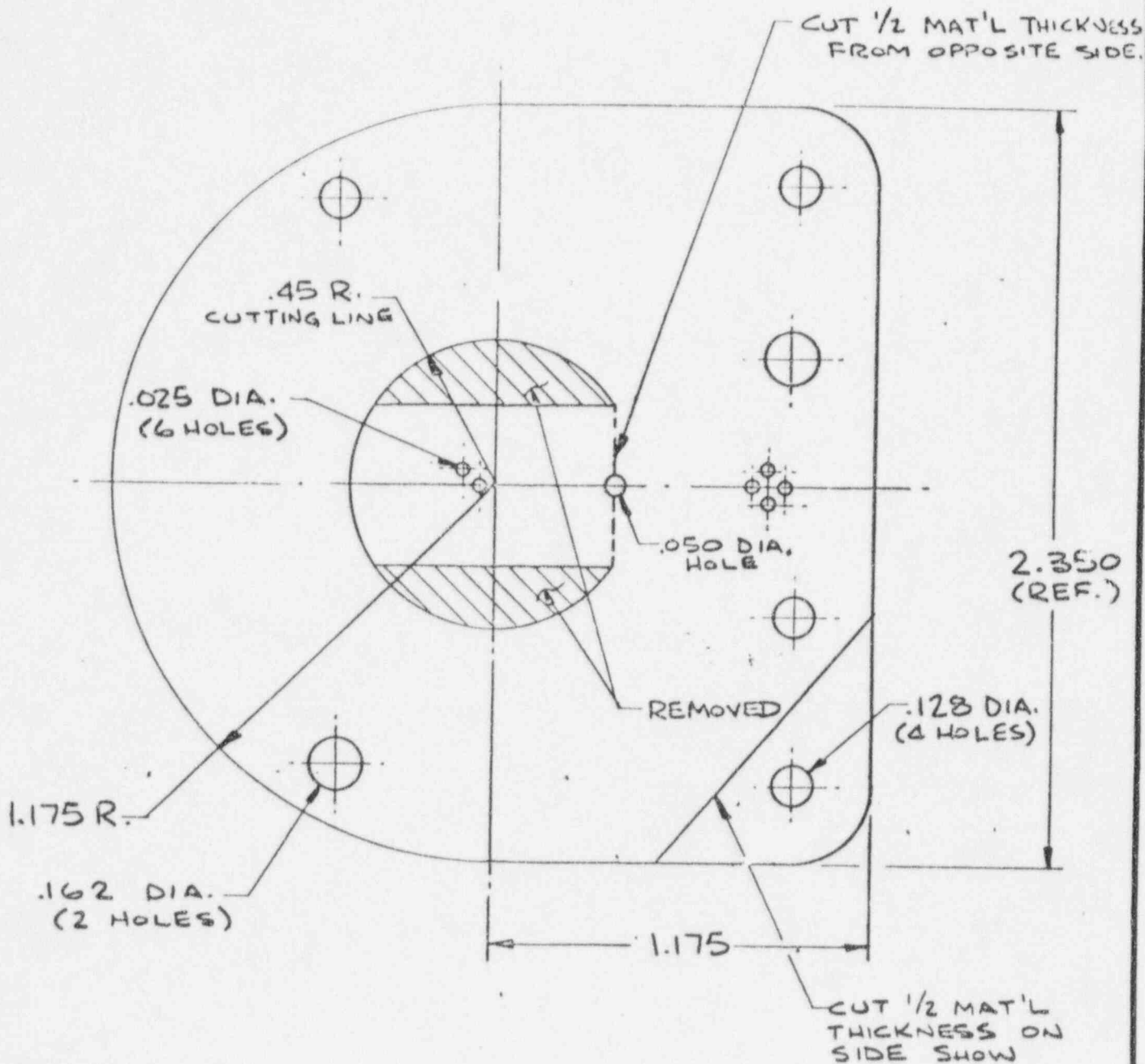


### SECTION 'A-A'

MAT'L

.020 STAINLESS STEEL (302 or 304)  
DEGREASED


 <b>fymetics inc.</b> <small>FIRE AND SECURITY PRODUCTS</small>	
SCALE 2X	DRAWN BY <i>110</i>
CHAMBER, REFERENCE	
DWG NO.	3

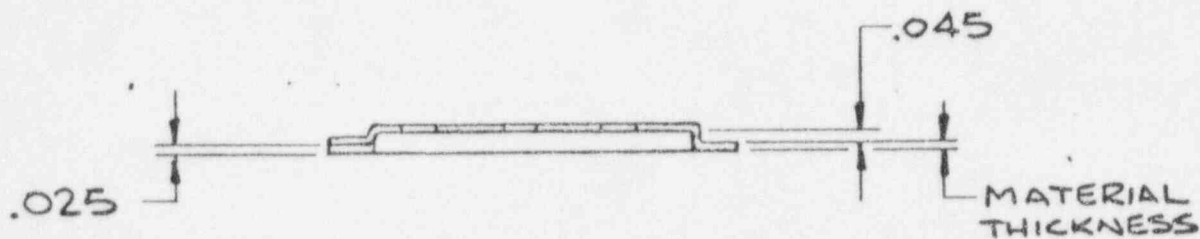
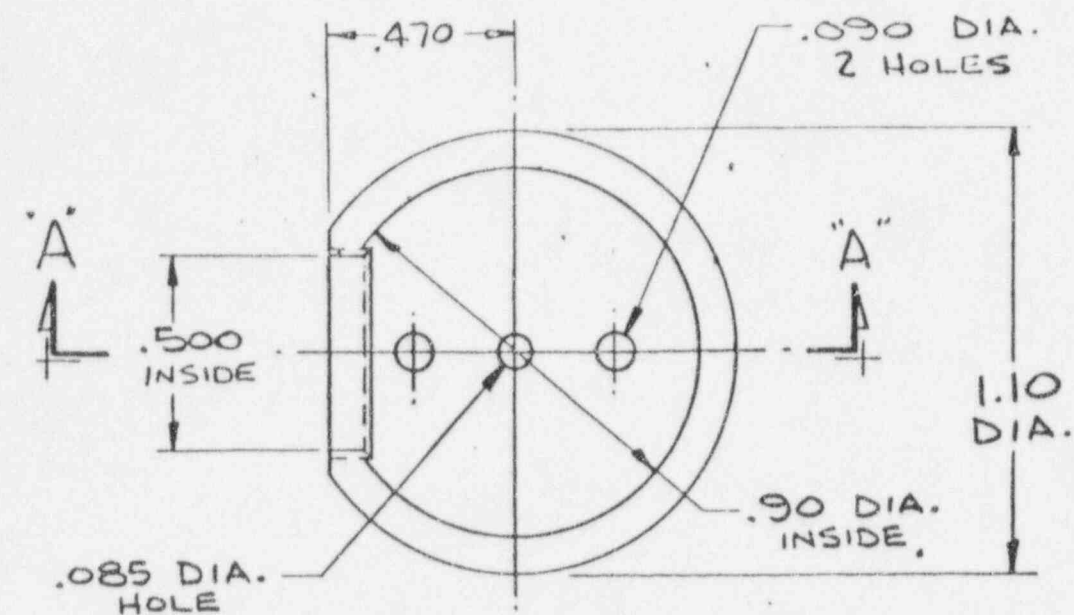


MAT'L

.025 THK TEFLON SHEET

87274

 <b>fymetics inc.</b> <small>FIRE AND SECURITY PRODUCTS</small>	
SCALE 2x	DRAWN BY YMD
INSULATOR, CHAMBER	
DWG NO.	4



## SECTION A-A

### MAT'L

.020 STAINLESS STEEL  
(302 OR 304)

DEGREASED

87274

**fymetics inc.**

FIRE AND SECURITY PRODUCTS

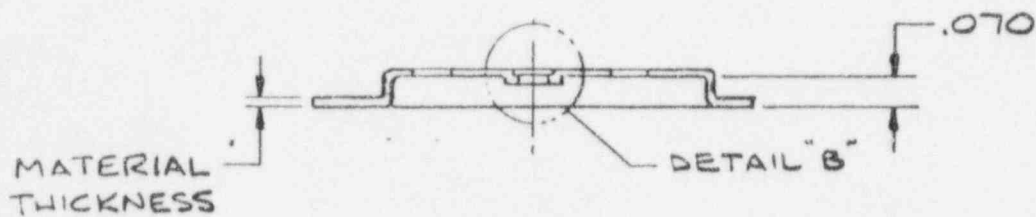
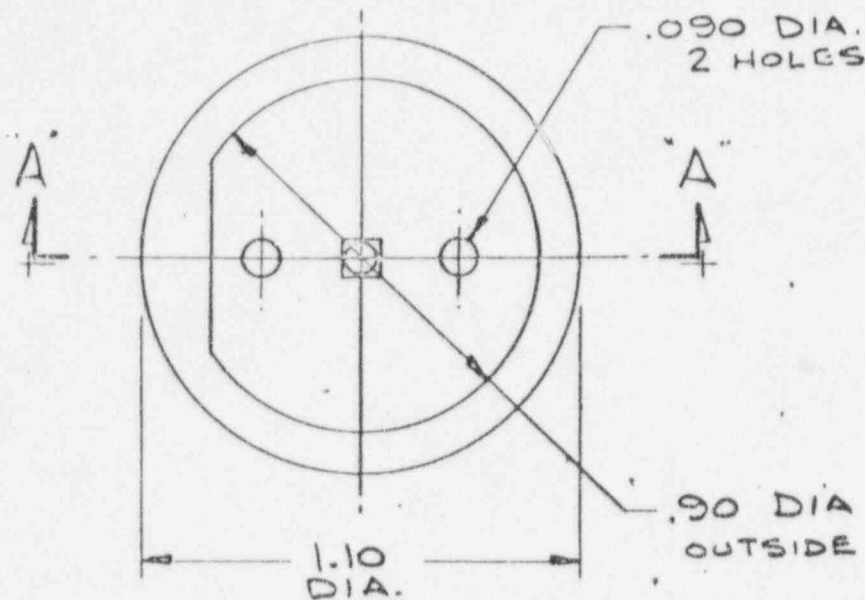
SCALE 2x

DRAWN BY MD

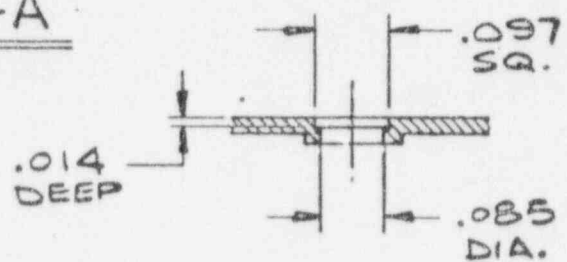
COLLECTOR, TOP

DWG  
NO.

5



## SECTION "A-A"



## DETAIL "B"

SCALE: 4X 87274

## MAT'L

.020 STAINLESS STEEL  
(302 OR 304)

DEGREASED

**functics inc.**  
FIRE AND SECURITY PRODUCTS

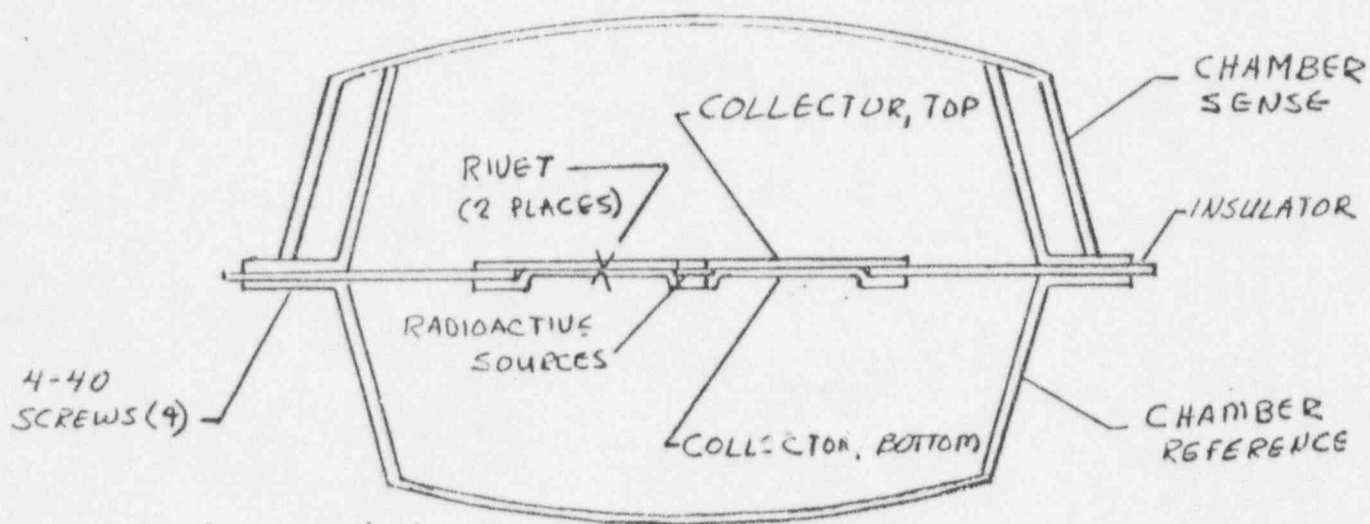
SCALE 2X

DRAWN BY *MD*

COLLECTOR, BOTTOM

DWG  
NO.

6



FyrNETICS INC.

SCALE: 2X

APPROVED BY:

DRAWN BY LDL

DATE:

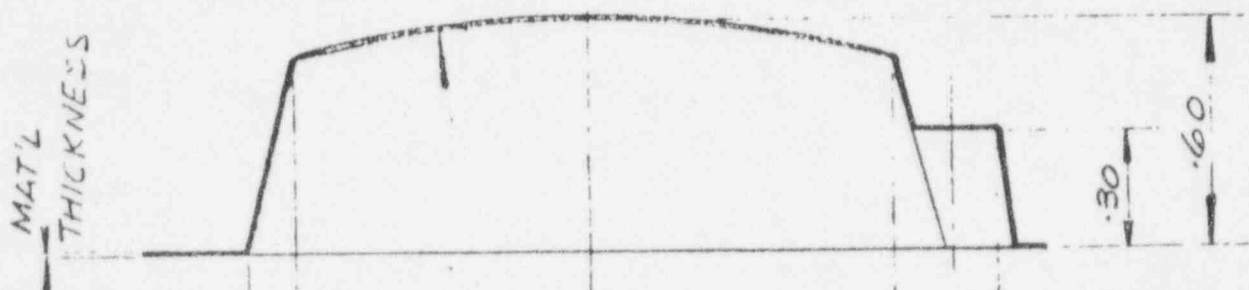
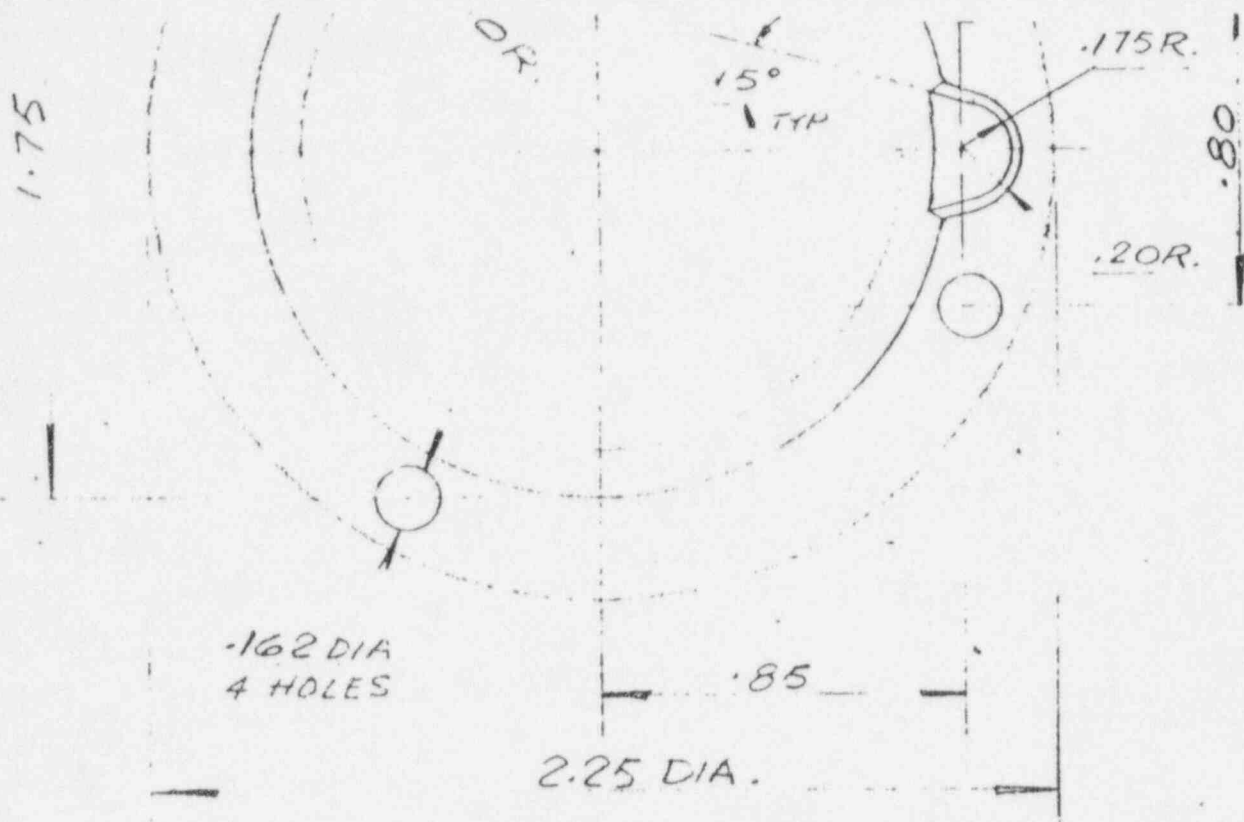
REVISED

TYPE 500 ION. SMOKE DETECTOR ASSY

DRAWING NUMBER

IL-1000

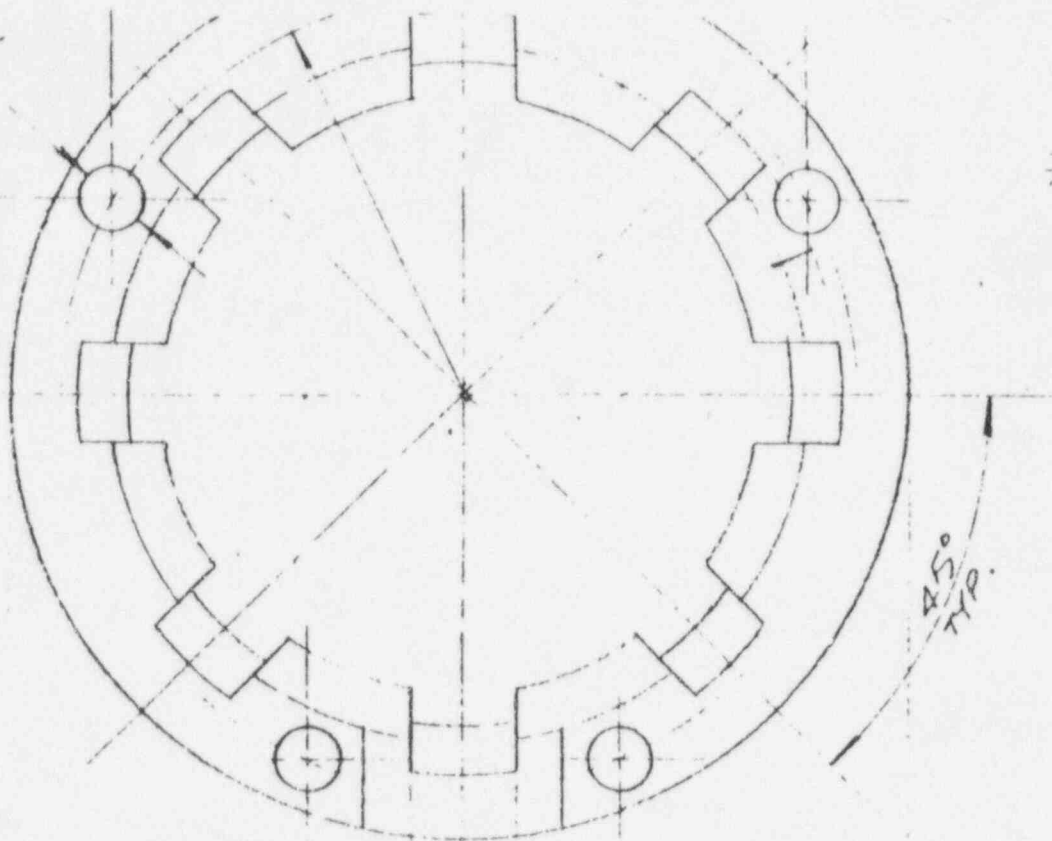




FYRNETICS INC.		67274
SCALE: 2X	APPROVED BY:	DRAWN BY LDL
DATE:		REVISED
CHAMBER, REFERENCE		
		DRAWING NUMBER IL-1001

.162 DIA.  
4 HOLES

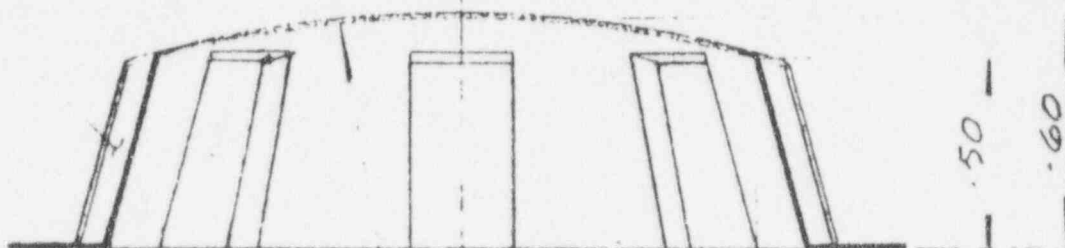
.95 R.  
TYP.



.25 TYP

.80

2.25 DIA.



.50

.60

FYRNETICS INC.

8-274

SCALE: 2X

APPROVED BY:

DRAWN BY LDL

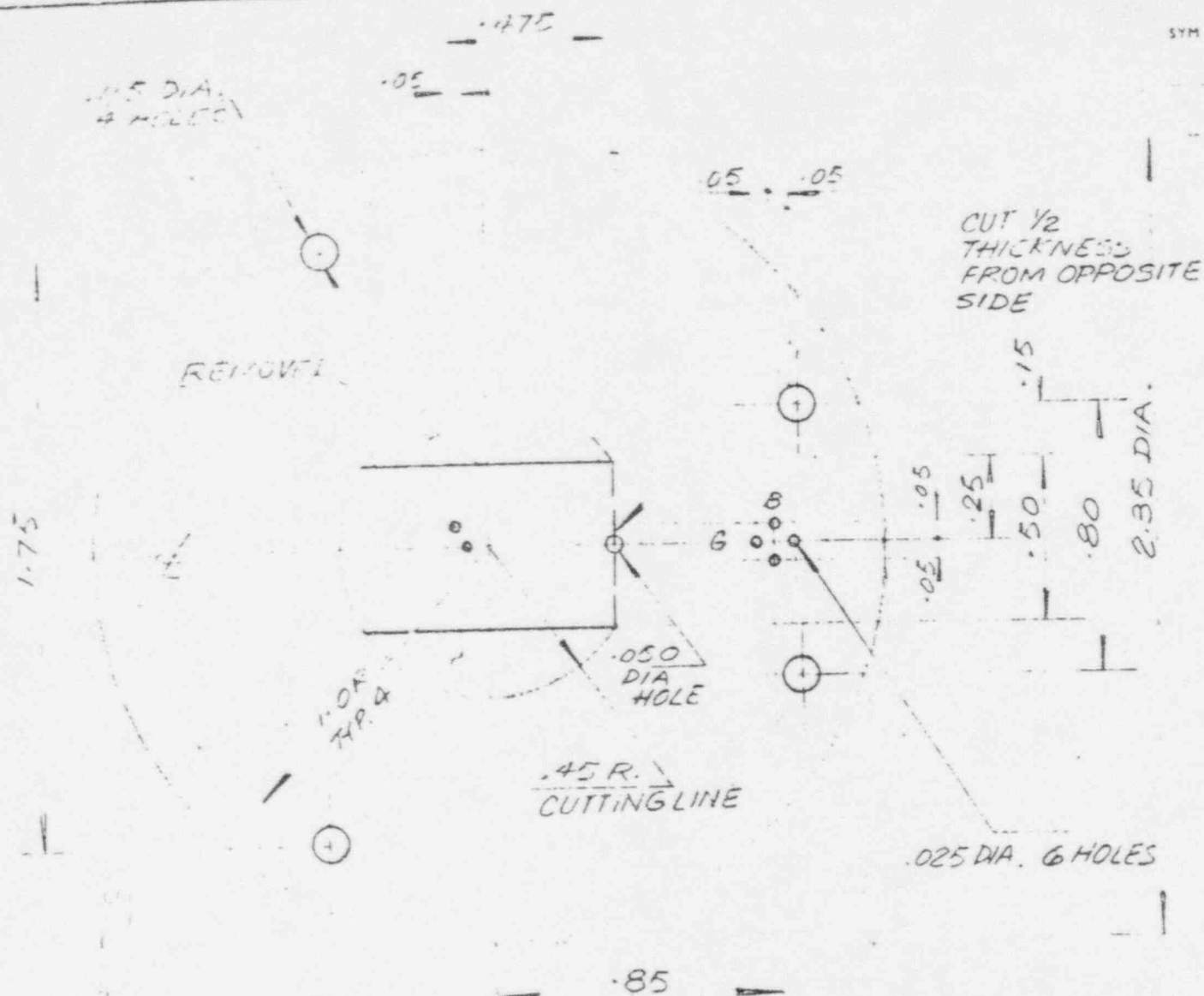
DATE:

REVISED

CHAMBER, SENSE

DRAWING NUMBER

IL-1002



UNLESS OTHERWISE SPECIFIED  
ALL DIMENSIONS ARE IN INCHES

TOLERANCES ON

FRACTIONS  $\pm 1/64$

DECIMALS  $\pm .005$ 

ANGLES  $\pm 1/2^\circ$

DRAFT.

CH.

ENG.

PROD.

APPROVED  
ONLY  
FOR

PILOT

SAMPLE

## QUOTE

MATERIAL: 0.05 THICK TEFLON SHEET

FINISH:

INSULATOR, CHAMBER

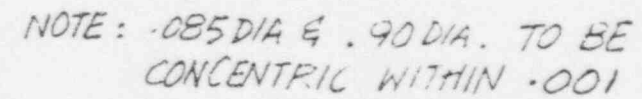
SIZE	DWG.
A	NO.

DW  
NO

101604

REV.

SCALE: 2 = 1 SHEET / OF / DATE



SCALE: 2: / SHEET / OF / DATE

REVISIONS

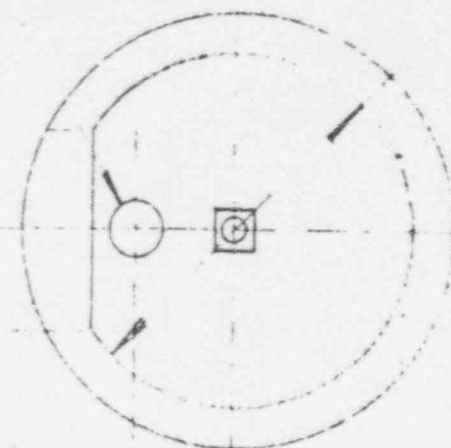
SYM DESCRIPTION DATE APPR.

.090 DIA  
HOLE

.90 DIA.  $\pm .000$   
- .002  
(OUTSIDE)

A

$\pm .000$   
- .005



A

NOTE: .085 DIA., .90 DIA.  
AND .094 SQ. TO BE  
CONCENTRIC WITHIN .001

MAT'L THICKNESS

.25

1.1 DIA.

.200  $\pm .002$   
- .050

DETAIL 'B'

.002 MAX RADIUS

SECTION 'A-A'

SHARP CORNER

.094 SQ.

.014  $\pm .001$   
DEEP

.085  $\pm .001$   
DIA.

DETAIL 'B'

UNLESS OTHERWISE SPECIFIED

ALL DIMENSIONS ARE IN INCHES

TOLERANCES ON

FRACTIONS  $\pm 1/64$

DECIMALS  $\pm .005$

ANGLES  $\pm 1/2^\circ$

NOT APPROVED FOR PRODUCTION

DRAFT.

C.

EN'G.

PROD.

APPROVED  
ONLY  
FOR



PILOT

SAMPLE

QUOTE

MATERIAL: 0.5MM STAINLESS STEEL 302 OR 304

FINISH: DEGRADED

COLLECTOR, BOTTOM

SIZE

A

DWG.

NO.

101006

REV.

-

SCALE: 2:1 SHEET 1 OF 1 DATE

Evaluation of Ionization Chamber Design

Fyrnetics, Inc. Type 200

Performed for:

FYRNETICS, INC.  
1021 Davis Road  
Elgin, Illinois 60120

Performed by:

Gerald D. Rork  
Smoke Detector Consultant  
P.O. Box 142  
Dundee, IL 60118  
(708) 428-4409

7610180224 SPP

Arnetics, Inc. Type 200 Ionization Chamber

1. General Description

The Type 200 ionization chamber is a totally new design from those previously licensed by the U.S.N.R.C. See the enclosed assembly drawing (Drawing 0910-9501) for construction details.

As in previous designs, the radioactive material, Americium 241, maximum quantity 1 uCi, is encased in noble metal foil. The type of foil containing the radioactive material in the Type 200 ionization chamber is identical to that used in presently licensed ionization chambers. The foil meets the requirements for a sealed source as defined in ISO Standard 1677.

The complete foil is manufactured by either of two fully licensed vendors:

NRD, Incorporated  
2937 Alt Boulevard  
Grand Island, NY 14072

Amersham Corporation  
2637 Clearbrook Drive  
Arlington Heights, IL 60005

Details of the method of foil construction and licenses of these vendors are on file with the U.S. Nuclear Regulatory Commission.

The foil (Drawing 0905-4109), in the form of a 2.4 mm diameter disk, is retained in a stainless steel source holder (Drawing 0910-4103) by swaging three areas of the source holder. These swaged areas are 120 degrees apart and retain the foil in the source holder. Details of the swaging and the quality assurance procedures to be followed to insure retention of the foil in the source holder are enclosed as Appendix 1 to this report.

A portion of the source holder passes through the plastic chamber housing (Drawing 0910-2106) and source plate (Drawing 0910-4102). The source holder is fastened to the source plate by three swaged areas of the source holder. This assembly clasps the plastic chamber housing between the source holder and the source plate and the swaged areas secure all the parts together.

The plastic chamber housing serves as an insulator which holds the reference plate (Drawing 0910-4101) in the correct position. The reference plate is fastened to the insulator by three pegs deformed by heat staking.



General Description (cont.)

The source holder, source plate, reference plate and plastic chamber housing form the reference chamber. The assembled reference chamber is secured to the printed wiring board by three barbed legs that are inserted into slots in the board. The assembly is further secured by a leg of the source plate that is soldered to the printed wiring board. In addition, a leg of the reference plate is soldered to the integrated circuit which further secures the assembly in place.

The reference plate, together with the sense chamber (Drawing 0910-4106) form the smoke sensing chamber. This sense chamber has two tabs which pass through slots in the printed wiring board and are soldered to the board.

The printed wiring board, with attached ionization chamber and associated electronic components, is attached to the detector base by snap over barbs molded into the plastic base.

The plastic detector cover is fastened to the base by three molded barbs which snap into three molded retainers in the base.

2. Radiological Safety Features

Radioactive Material Containment

The type of foil containing the radioactive material in the Type 200 ionization chamber is identical to that used in ionization chambers presently licensed for distribution by Fyrnetics.

The foil is retained in a stainless steel source holder by three swaged portions of the holder. This method of foil retention is being used in detectors presently distributed under license by other manufacturers with excellent results.

Appendix 2 to this report contains the results of vibration and drop testing of samples of smoke detectors containing the type 200 ionization chambers. After the testing, only insignificant levels of removable contamination were found. There was no reduction in integrity of any of the ionization chambers and all foils were retained in the source holder following the tests.

The quality assurance procedures to be followed to insure retention of the radioactive foil in the source holder are enclosed as Appendix 1 to this report. In addition, if a foil were to come loose from the source holder after the ionization chamber were assembled and installed in a smoke detector, the detector would not operate properly. This would be discovered during the 100% functional checking performed during the production process.

B. Access to Radioactive Material

Direct access to the radioactive material contained in a Type 200 ionization chamber is not normally possible. Such access would only be possible by intentional disassembly of the smoke detector containing the ionization chamber and the chamber itself. Such disassembly would first require removal of the plastic cover from the base. This removal would require the use of tools to release the barbed fittings which hold the cover to the base or a severe impact.

After removal of the cover, only the external surfaces of the ionization chamber are accessible. These are formed by the sense chamber and the printed wiring board. The sense chamber is formed from 0.3mm thick stainless steel. The printed wiring board is made of 1.6 mm thick epoxy impregnated fiberglass. Both of these materials are very strong and durable and the probability is negligible that they could degrade sufficiently to provide access to the radioactive material.

There are no openings in the printed wiring board which could provide access to the radioactive material. The sense chamber is slotted to allow smoke entry. The slots are formed by punching in a portion of the chamber to form louvered openings. These openings are such that no line-of-sight path to the foil containing the radioactive material exists. The slots are only 0.8 mm wide by 10 mm long and thus entry into the chamber is impossible for any part of the human body.

Access to the radioactive material would require removal of the sense chamber. This would require either un-soldering of the two tabs which hold the chamber to the printed wiring board or cutting of the chamber or board. This does not constitute normal use or wear of a smoke detector.

Based on the above discussion, it may be concluded that it is unlikely that there will be a significant reduction in the effectiveness of the containment or other safety features of the detectors during normal wear or abuse.

C. Radioactive Material Shielding


Appendix 3 to this report shows the results of measurements of the exposure at 5 and 25 centimeters from four samples of this type chamber assembled into smoke detectors. As will be noted, the maximum exposures measured were: 0.741 uR/hr at 5 cm and 0.083 uR/hr at 25 cm. Based on these exposures, it can be concluded that any dose or dose commitment will not exceed the criteria set forth in 32.27 10 CFR.

Exposure to the Public

Use of the type 200 ionization chamber in smoke detectors, rather than the types of chambers presently licensed, will not change the quantity of radioactive material in each detector. Also, it will not change the number of smoke detectors distributed to the public. Consequently, there will be no change in the already low risk of exposure to the public.

4. Conclusions

Based on the foregoing, it may be concluded that use of the Type 200 ionization chamber in smoke detectors will not result in any significant radiation exposure to the public. In my professional opinion, the type 200 ionization chamber meets the criteria for licensing as set forth in 32.26 and 32.27 10 CFR.



Gerald D. Rork  
Smoke Detector Consultant