



Designation: F 111 – 96 (Reapproved 2002)

## Standard Practice for Determining Barium Yield, Getter Gas Content, and Getter Sorption Capacity for Barium Flash Getters<sup>1</sup>

This standard is issued under the fixed designation F 111; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon ( $\epsilon$ ) indicates an editorial change since the last revision or reapproval.

### 1. Scope

1.1 This practice describes techniques for the determination of evaporated barium yield, getter gas content, and getter carbon monoxide sorption capacity for barium flash getters used in electron devices. Test conditions are chosen to approximate use conditions.

1.2 Auxiliary procedures for cleaning, for determining vacuum system leak-up rates, for flashing getters, and for determining barium content in both getter fill and films are also given.

1.3 The various tests described are destructive in nature. In general the tests are semiquantitative but they can be expected to yield comparative information on a single-laboratory basis to the precision indicated. No information relative to multi-laboratory reproducibility is available.

#### 1.4 List of Methods Described:

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1.5 This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of whoever uses this standard to consult and establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use. Specific hazard statements are given in Section 4.

### 2. Referenced Documents

#### 2.1 ASTM Standards:

D 1193 Specification for Reagent Water<sup>2</sup>

### 3. Terminology

#### 3.1 Definitions of Terms Specific to this Standard:

3.1.1 *barium flash getters*—used to remove residual gases present after exhaust or generated during device operation by sorption with a barium film produced by heating the getter.

3.1.2 *barium yield, M*—the weight of barium in milligrams evaporated when a getter is flashed. Flash conditions are specified in terms of start time and total time.

3.1.2.1 *start time,  $t_s$* —the interval in seconds between the application of heating power and the onset of barium evaporation. This value depends on the power applied.

3.1.2.2 *total time,  $t_t$* —the full interval in seconds during which heating power is applied to the getter.

3.1.3 *carbon monoxide sorption capacity, C*—the quantity of CO sorbed at room temperature (25°C) measured in millitorr-litres until the terminal gettering rate is reached.

3.1.4 *conductance, F*—of a system for a given gas or vapor is the ratio of throughput of gas,  $Q$ , to the partial pressure difference across the system,  $P_2 - P_1$ , in the steady state. It is measured in liters per second, and given by  $F = Q/(P_2 - P_1)$  where  $P_2$  is the upstream pressure, and  $P_1$  is the downstream pressure.

3.1.5 *flashing*—the evaporation of barium, contained within a getter, as a consequence of induction or resistance heating of the getter.

#### 3.1.6 Gas Content:

3.1.6.1 *preflash gas content, PGC*—the quantity of gas in millitorr-litres reported as nitrogen equivalent evolved at flashing after it has been degassed at 350°C for 15 min under kinetic vacuum conditions.

3.1.6.2 *total gas content, TGC*—of a getter is the quantity of gas in millitorr-litres reported as nitrogen equivalent evolved at flashing when a getter is heated from room temperature.

<sup>1</sup> This practice is under the jurisdiction of ASTM Committee F01 on Electronics and is the direct responsibility of Subcommittee F01.03 on Metallic Materials.

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<sup>2</sup> Annual Book of ASTM Standards, Vol 11.01.

3.1.7 *getter mount*—a mechanical device used to secure the getter and its integral support leg (if any) at the specified position in the getter test bulb.

3.1.8 *gettering rate, G*—defined as the volume of gas sorbed in 1 s and is measured in litres per second.

3.1.8.1 *terminal getter rate*—reached when the gettering rate decreases to 1 L/s for large (TV) getters or 0.1 L/s for small (receiving tube) getters. It is used to define the end point of the CO sorption capacity test.

3.1.9 *getter test bulb*—that portion of the apparatus in which the getter is flashed (see Table 1 and Table 2).

3.1.10 *mass throughput, Q*—the quantity of gas flowing through a given plane in unit time and is measured in millitorr-litres per second.

3.1.11 *molecular flow region*—that pressure region where gases or vapors flow under conditions such that the largest internal dimension of a transverse section of the vessel is smaller than the mean free path. Under these conditions the rate of flow is limited not by collisions between molecules but by collisions of molecules with the walls.

3.1.12 *sorption by a getter*—the process of removing gases and vapors by adsorption and absorption phenomena.

3.1.12.1 *Absorption*, deals with gas interactions in the bulk of the getter film and is dependent on diffusion rates, solubility, and chemical reactions.

3.1.12.2 *adsorption*—describes gas interactions at the surface of the getter film.

3.1.12.3 Quantities of sorbed gas are measured in millitorr-litres.

TABLE 1 Suggested Bulb and Coil Dimensions

NOTE 1—The getters are centered in both coaxial and tangential coils.

Getter Type	Bulb			
	Number	Outside Diameter, mm	Length, mm	Height, <sup>A</sup> mm
Coaxial Flashing:				
Receiving tube	A	20	100	35
TV black and white	B	35	250	150
TV color	C	60	320	140
Tangential Flashing (optional):				
TV color	D	80	320 <sup>B</sup>	90 <sup>C</sup>

Getter Type	Coil			
	Number	Inside Diameter, mm	Height, mm	Tuns
Coaxial Flashing:				
Receiving tube	E	23	16	3.5
TV black and white	F	51	22	5.5
TV color	G	70	22	5.5
Tangential Flashing (optional):				
TV color	H	51	15	6.0 <sup>D</sup>

<sup>A</sup> Measured from bottom of getter to dome of bulb.

<sup>B</sup> Bulb axis inclined 30° from the vertical.

<sup>C</sup> Measured from center of getter to dome of bulb.

<sup>D</sup> A two-layer coil with three turns per layer.

TABLE 2 Bulbs and Coils for Determination of CO Sorption Characteristics

Getter Type	Test Bulb	Test Bulb Dimensions	Coil
Receiving tube (all)	spherical bulb	100-cm <sup>3</sup> spherical flask (OD 60 mm)	F
OD 12–13 mm TV	standard TV bulb	12-in., 110° neck, OD 20 mm	E
OD 18–19 mm TV	standard TV bulb	19-in., 114° neck, OD 28.5 mm	F
OD 25–26 mm TV	standard TV bulb	23-in., 92° neck, OD 36.5 mm	F H <sup>A</sup>

<sup>A</sup> Used for antenna-mounted getters.

4. Safety Hazards

4.1 Eye protection is mandatory in the presence of large evacuated glass vessels or picture-tube bulbs, which should also be surrounded by suitable mechanical protection against implosion.

5. Test Specimens

5.1 The test specimens are commercial barium floss getters used in electron devices. The major components of a getter are: the fill, the container, and the support.

5.1.1 *The Getter Fill* is based on barium alloy, BaAl<sub>4</sub>, to minimize the reactions of barium with the atmosphere.

5.1.1.1 An endothermic getter fill uses the BaAl<sub>4</sub> alloy alone and requires continued heating above 1050°C to liberate and evaporate the barium.

5.1.1.2 An exothermic getter fill is produced by intimately mixing about four moles of nickel with one mole of the barium alloy. On heating to about 800°C, the nickel reacts exothermally with the alloy, liberating and evaporating 10 to 30 % of the barium. Continued heating is required to evaporate most of the remaining barium.

5.1.1.3 The getter may be gas doped. Hydrogen may be added to the fill for reported beneficial effects on electron emission. Nitrogen may be added to influence the distribution and to produce a more porous film and thereby increase the gas sorption capacity as measured below.

5.1.2 *The Getter Container* form depends on the method of supplying heating power for flashing.

5.1.2.1 If resistance heating is to be used it should have an open geometry, more or less rectilinear.

5.1.2.2 If induction heating is to be used it should have the form of a closed loop. The present trend is to employ a ring-shaped channel. In such cases the getter-channel cross section may be varied to influence, to a certain extent, the getter film-deposition pattern.

5.1.3 *A Getter Support* is used for mounting and positioning the getter in electron devices. It may or may not be an integral part of the getter.

5.2 Nominal getter sizes which are currently available are listed in Appendix X1.

5.3 *Getter Description*—The getter manufacturer shall furnish on request the following data:

5.3.1 Type of fill (endothermic or exothermic).

5.3.2 Recommended yield, start, and total times.

5.3.3 If gas doped or not. If doped, then with which gas; and the maximum temperature time condition which causes no loss of doping.

5.3.4 Container size (outside diameter in millimetres for ring getters; length times width, each in millimetres, for loop getters; and length, in millimetres for resistance-heated getters).

5.3.5 Container (channel) shape (ring with high inside wall, ring with high outside wall, ring with equal height walls, getter tubing, and so forth).

5.3.6 If magnetic or antimagnetic.

5.3.7 Shape of support (ribbon, wire, tab).

5.3.8 Special features such as ceramic spacers, etc., if any.

5.4 *Getter Lot Number*—To any getter production batch a lot number is assigned and the production date is given. From the lot number, date, and the internal manufacturer's control charts it shall be possible to trace back all the production cycles up to the incoming raw materials.

5.5 *Specimen Handling*:

5.5.1 Handle getters only with clean tools, lint free gloves, or finger cots, never with bare hands.

5.5.2 For long term storage, store the getters in a phosphorus pentoxide air desiccator or equivalent. As soon as the getter can be opened, place getters to be tested in a conventional silica gel desiccator. Initiate all measurement between 24 and 48 h after placing the getters in the conventional silica gel desiccator.

## 6. Cleaning Procedures

6.1 *Scope*—The following cleaning procedures shall be used for getter mounts and getter test bulbs used in Sections 10, 11, and 12.

6.2 *Significance*—Cleaning procedures are necessary not only to ready the mount and bulb for the tests but also to minimize possible errors. A residue of barium can cause errors in the barium yield determination when chemical methods are used. Oils and greases can adversely effect the vacuum.

6.3 *Materials and Reagents*:

6.3.1 *Hydrochloric Acid* (1 + 17)—add 1 part of concentrated HCl (sp gr 1.19) to 17 parts of deionized water.

6.3.2 *Deionized Water (DIW)*—At least 2-M $\Omega$  resistivity.

6.3.3 *Acetone*, cp.

6.3.4 *Cleaning Solution*—Add 2 volumes of concentrated HF (sp gr 1.15), 33 volumes of concentrated HNO<sub>3</sub> (sp gr 1.42), and 2 volumes of surface active agent to 100 volumes of DIW.

6.3.5 Alkylaryl polyether alcohol (OPE—7 to 8) is a liquid, nonionic surface active (wetting) agent. It is listed as an industrial detergent and emulsifier, effective in aqueous mineral acids with good hard (glass) surface detergency and low foam. Any such agent, without filler, ionic or nonionic that meets the properties listed above is acceptable.

6.4 *Mount Cleaning*:

6.4.1 Wash with HCl (1 + 17).

6.4.2 Rinse with DIW.

6.4.3 Dry with acetone.

6.4.4 Handle only with clean tools, lint free gloves, or finger cots.

6.5 *Getter Test Bulb Cleaning*:

6.5.1 Wash twice with HCl (1 + 17) to dissolve barium.

6.5.2 Rinse with tap water.

6.5.3 Rinse with acetone to eliminate oils and greases.

NOTE 1—The acetone may be replaced by the more active cleaning solution of 6.3.4. Use solution at room temperature.

6.5.4 Rinse twice with DIW.

6.5.5 Drain.

6.5.6 Dry using a clean oil-free air blast, or better: vacuum dry, with or without bake, using a trapped mechanical pump to minimize hydrocarbon contamination.

## 7. Leak-Up Rates

7.1 *Significance*—The leak-up rate gives a measure of the cleanliness and freedom from leaks of vacuum system.

7.2 *Summary*—The vacuum test chamber which contains a pressure gage is isolated from the vacuum pumps by a suitable valve and the changes in pressure with time are recorded to obtain the data needed to calculate leak-up rates. A gas burst may be observed initially on closing the valve due to the liberation of sorbed gases in the valve, but the pressure will reach a steady-state value within several seconds. The pressure may then continue to rise in a manner controlled by any real leaks and relatively high vapor pressure contaminants within the vacuum chamber. The pressure may decrease with time indicating a clean leak-free system and pressure-gage pumping.

7.3 *Procedure*:

7.3.1 Measure the leak-up rate during the determinations of gas content (11.4.4) and sorption capacity (12.4.7). The apparatus used is described in these sections. At the appropriate stage of these determinations, indicated in the relevant text, valve off the test chamber from the vacuum pumps and record the initial pressure  $P_i$ . After a time,  $t$ , record the final pressure  $P_f$ .

7.3.2 The value of  $P_f$  and  $P_i$  should be such that there is a reasonable difference between them. Allow a change of at least a factor of 2 in pressure unless the leak-up rate is extremely low.

7.4 *Calculations*—Calculate the system leak-up rate,  $Q_L$ , in millitorr-litres per second using the following equation:

$$Q_L = V(P_f - P_i)/t$$

where:

$V$  = system volume, litres,

$P_f$  = final pressure, mtorr, in the valved-off test chamber,

$P_i$  = initial pressure, mtorr, in the valved-off chamber, and

$t$  = time of pressure rise, s.

7.5 *Sensitivity*—Using commercial Bayert-Alpert design ionization gages and controls (10.10<sup>-9</sup> torr most sensitive full-scale range) and a 1-L volume leak-up rates of 1.10<sup>-8</sup> mtorr-litres/s are readily measurable.

## 8. Getter Flashing

8.1 *Summary of Procedure*—Getters are flashed by induction or resistance heating using the required power to achieve the specified start time. This power is applied for the specified total time. The quantity of barium evaporated can then be determined using the analytic methods given in Section 9.

8.2 *Significance*—The barium yield of a getter when flashed at the manufacturer's recommended start and total times is one of the factors considered in selecting a particular getter for a specific application. The variation in barium yield caused by changes in start and total times are of interest to define the effects of application and production variables.

8.2.1 It should be noted that induction heating is not a simple phenomenon. The generator design, the frequency used, the reflected load, flashing techniques and procedures, etc. can influence the yield.

8.3 *Apparatus:*

8.3.1 *Induction Heater* (frequency must be between 250 and 450 kHz) or resistance heating apparatus.

8.3.2 *Bulb and Work Coils* (Table 1).

8.3.3 *Stop Watch.*

8.3.4 *Preset Timer.*

8.4 *Procedure:*

8.4.1 Position work coils as specified in the footnote to Table 1, and with reference to Table 3.

8.4.2 Set power input into heater for desired start time.

8.4.3 Start heating and timing.

8.4.4 Measure start time to an accuracy of 0.5 s or better using the stop watch.

8.4.4.1 The onset of barium evaporation is indicated for endothermic getters by the appearance of a film on the bulb.

8.4.4.2 The onset of barium evaporation is indicated for exothermic getters by the sudden temperature increase visually observable on the surface of the fill.

8.4.4.3 In both cases a sudden pressure drop will be observed.

8.4.5 Control total time by a preset timer to an accuracy of 0.5 s or better.

8.4.6 During the getter flash cycle watch the getter for uniformity of heating, evidence of loose particles, and type of gas discharge, if any.

8.4.7 Use resistance heating for getters that are not of closed shape, for example wire getters. Connect the ends of the getter to an alternating- or direct-current source via a suitable ballast resistor. The ballast resistor must have a resistance 20 to 30 times greater than that of the cold getter and have a power rating sufficiently large to support the current required to flash the getter. The resistance of the current feedthrough, legs, and mounting support shall be small compared to the rest of the circuit. Connect an ammeter in series with the getter and use it

to determine the power supplied. Connect a voltmeter in parallel with the current feedthroughs to evaluate the variation of getter resistance.

**9. Barium Determination**

9.1 *Scope*—Chemical and physical analytical procedures are given for the determination of barium in the getter-alloy fill and in the evaporated barium film. The procedures to be described are listed in Table 4. Composite apparatus, materials, and reagent lists are given. Summaries, procedure, calculation and accuracy are given under each method.

9.2 *Reagents and Materials (General Recommendations):*

9.2.1 *Purity of Reagents*—Reagent grade chemicals will be used in all tests. Unless otherwise indicated, it is intended that all reagents shall conform to the specifications of the Committee on Analytical Reagents of the American Chemical Society or other recognized institution where such specifications are available.<sup>3</sup> Other grades may be used provided it is first ascertained that the reagent is of sufficiently high purity to permit its use without lessening the accuracy of the determination.

9.2.2 *Purity of Water*—Unless otherwise indicated, reference to water shall be understood to mean reagent water conforming to Specifications D 1193.

9.3 *Weight Difference:*

9.3.1 *Principle of Method*—The getter and its support leg is weighed before and after getter flash. The weight difference is the quantity of barium evaporated. This method is a very rapid, accurate, and simple method for determining the yield if the getter is not overflashed. It is the recommended method for barium yields greater than about 10 mg.

9.3.2 *Apparatus:*

9.3.2.1 *Analytical Balance*, 0.1 mg sensitivity or better.

9.3.2.2 *Apparatus for Getter Flash*, as described in 8.3.

9.3.3 *Procedure*—Weigh the getter accurately to the nearest 0.1 mg. Mount the getter, flash, and reweigh. The flashed getter should be reweighed within 15 min after exposure to air. Overflashing, as evidenced by channel burn and loose particles, can affect the measurement.

9.3.4 *Calculations*—The weight difference before and after flash is the amount of barium evaporated.

9.3.5 *Accuracy*—The method is accurate to  $\pm 0.5\%$ .

**TABLE 3 Getter Positions**

Getter Type	Test Bulb	Getter Position
Receiving tube (all)	spherical bulb	at the neck position with its plane tangential to the projected spherical surface of the bulb
OD 12–13 mm TV	standard TV bulb	27.0 mm from <i>YRL</i> coaxial with neck
OD 18–19 mm TV	standard TV bulb	27.0 mm from <i>YRL</i> coaxial with neck
OD 25–26 mm neck-mounted	standard TV bulb	41.3 mm from <i>YRL</i> coaxial with neck
OD 25–26 mm antenna-mounted TV	standard TV bulb	The center of the getter is 22 mm from <i>YRL</i> . The plane of the getter is parallel to the surface of the funnel.

**TABLE 4 Methods for Determination of Barium**

Method	For Barium in		Mass of Barium, mg
	Fill	Film	
Weight difference (9.3)		x	>2
Gravimetric (9.4)	x		>50
Spectrophotometric (9.5)	x	x	all

<sup>3</sup> *Reagent Chemicals, American Chemical Society Specifications*, American Chemical Society, Washington, DC. For suggestions on the testing of reagents not listed by the American Chemical Society, see *Analar Standards for Laboratory Chemicals*, BDH Ltd., Poole, Dorset, U.K., and the *United States Pharmacopoeia and National Formulary*, U.S. Pharmacopoeial Convention, Inc. (USPC), Rockville, MD.



#### 9.4 Gravimetric Determination of Barium in the Fill:

9.4.1 *Summary of Method*—Barium is precipitated from solution as barium sulphate and a direct weighing of the precipitate is made.

##### 9.4.2 Reagents and Materials:

9.4.2.1 *Hydrochloric Acid (1 + 1)*—Mix equal volumes of concentrated HCl and water.

9.4.2.2 *Sulfuric Acid (1 + 200)*—Add 5 mL of concentrated H<sub>2</sub>SO<sub>4</sub> (density 1.82 g/mL) to 11 of deionized water.

##### 9.4.2.3 Litmus Paper.

9.4.3 *Procedure*—Dissolve 250 mg of endothermic or 500 mg of exothermic-getter alloy from one or more getters in the smallest possible amount of HCl (1 + 1). Evaporate nearly to dryness and then dilute with water to between 200 and 300 mL. Heat the slightly acid (HCl) solution of BaCl<sub>2</sub> to boiling and add a slight excess of H<sub>2</sub>SO<sub>4</sub>(1 + 200). Settle the precipitate on the water bath and decant the clear solution through a weighed Gooch crucible or through an ashless filter paper. Transfer the precipitate to the crucible (or paper) and wash twice with H<sub>2</sub>SO<sub>4</sub>(1 + 200), and finally with hot water until free of acid. Dry and ignite the precipitate at first gently and then over a good flame to a cherry-red heat, for 30 min. Weight the residue as barium sulphate, BaSO<sub>4</sub>, to the nearest 0.1 mg.

9.4.4 *Calculations*—Calculate the weight of barium as follows:

$$\text{Barium, mg} = 0.586 A$$

where:

A = weight of BaSO<sub>4</sub> in mg.

9.4.5 *Accuracy*—This method is accurate to ±0.5 %.

#### 9.5 Spectrophotometric Method:

9.5.1 *Principle of Method*—The powder extracted from the getter container is dissolved in HCl and the barium concentration is determined by means of an atomic absorption spectrophotometer.

##### 9.5.2 Apparatus:

9.5.2.1 *Analytical Balance*, 0.1 mg sensitivity or better.

9.5.2.2 *Atomic Absorption Spectrophotometer*.

9.5.2.3 *Microburet*.

##### 9.5.3 Reagents and Materials:

9.5.3.1 *Barium Solution*, certified standard, 10 000 ppm.

9.5.3.2 *Lanthanum Chloride*.

9.5.3.3 *Hydrochloric Acid (1 + 1)*—Mix equal volumes of concentrated HCl and water.

##### 9.5.4 Procedure:

9.5.4.1 *Preparation of 10 % Lanthanum Chloride Solution*—Weight 100 g of lanthanum chloride and dissolve in 11 of deionized water.

9.5.4.2 *Preparation of Barium Standards*—Draw aliquots of 0.0, 0.5, 1.0, 1.5, 2.0, 2.5 and 3.0 mL from the 10 000 ppm barium standard solution and decant them in 100-mL volumetric flasks. Add 2.5 mL of HCl (1 + 1) and 5 mL of lanthanum chloride 10 % solution to any flask. Make up the volume with deionized water and shake. The standard solutions thus prepared have a barium concentration respectively of 0 (blank), 50, 100, 150, 200, 250, 300 ppm.

9.5.4.3 *Preparation of the Sample Solution:*

(1) Weight the powder extracted from the getter container to the nearest 0.1 mg and pour it in a 250-cm<sup>3</sup> flask. Slowly add 30 mL of HCl (1 + 1) and then heat moderately until all the sample has been dissolved. Continue heating to concentrate the solution down to about 10 mL for samples of more than 200 mg and nearly to dryness for samples of less than 200 mg.

(2) Cool to room temperature and decant the liquid into suitable volumetric flask and make up the volume with the wash water and water, ensuring a complete transfer of the sample.

(3) Prepare a final solution, eventually through successive dilution, so as to obtain a barium concentration ranging from 100 to 200 ppm.

(4) Before filling the final volumetric flask, add the 10 % lanthanum solution and HCl (1 + 1) to the drawn aliquots. The volumes to be added are respectively of 5 mL and 2 mL, referring to a final volume of 100 mL. When adding HCl take into account the eventual residual volume of the sample after drying.

##### 9.5.4.4 Measurement:

(a) Set the atomic absorption spectrophotometer to the following conditions:

(1) Wavelength: 553.6 nm,

(2) Slit Aperture: 0.14 nm,

(3) Flame: air/acetylene, in slightly reducing conditions.

(b) Set burner and lamp current according to the directions of the manufacturer.

(c) Suggested reading time is 7 s. Number of readings to be averaged should be three.

(d) Set zero by means of the blank solution and read the standard solutions twice. Ensure deionized water is admitted in the atomic absorption spectrophotometer for a sufficient time before analyzing a new standard.

(e) Perform analyses on the samples.

(f) Repeat analyses on the standard solutions and compare the results with the previous ones.

(g) The measurements on the actual samples can be considered acceptable if the readings on the standard solutions, before and after the measurements on the samples, do not differ of more than 1 %.

##### 9.5.5 Calculations:

9.5.5.1 Calculate the amount of barium as follows:

$$\text{Barium, mg} = \frac{A \cdot B \cdot 100}{1000}$$

where:

A = ppm of barium, and

B = dilution factor.

9.5.5.2 Calculate the percentage of barium as follows:

$$\text{Barium, \%} = \frac{\frac{A \cdot B \cdot 100}{1000}}{W} \times 100$$

where:

A = ppm of barium,

B = dilution factor, and

W = weight of the sample in mg.

9.5.6 *Accuracy*—This method is accurate to ±0.2 %.

### 10. Determination of Barium Yield

10.1 *Summary*—Flash getters when heated to a sufficiently high temperature evaporate a quantity of barium that is a function of the start time and the total time. To describe the barium yield properties for each type of getter one or more yield curves are plotted which give the mass of barium evaporated as a function of the start time with the total time as a parameter.

10.2 *Significance*—One of the factors in selecting a barium flash getter is the available barium yield for specified start and total times. Since these times vary in use due to the specific application and process variables, the changes in yield with these parameters is evaluated. The barium yield may be compared to the total amount of barium in the getter-alloy fill.

#### 10.3 Apparatus:

10.3.1 The test apparatus is shown schematically in Fig. 1.

10.3.2 The pumping system must have the following characteristics:

10.3.2.1 An ultimate vacuum of less than  $5.10^{-4}$  Torr and

10.3.2.2 Adequate pumping speed so that the maximum pressure during flashing is less than 0.1 Torr.

10.3.3 Suggested cylindrical bulb dimensions, getter mounting position (from the base of the getter to the dome of the bulb), and work coil dimensions are given in Table 1. The getter is centered in both the cylindrical and tangential coils. Normally the getters are flashed with a coaxial coil in the horizontal position with the flash directed toward the dome of the bulb. For antenna mounted color TV getters, a tangential coil may be used to cause flashing towards the opposite wall. In this case, the getter mount should be at an angle of at least  $30^\circ$  to the vertical to prevent motion of the getter during flash. The getter must be placed at a suitable distance from major metal parts to prevent rf losses. The use of a spoiler strip to prevent rf losses due to the continuous barium film is optional.

10.3.3.1 A typical apparatus for wire getters is shown in Fig. 2. The wire getter is parallel to the axis of the tube and should flash towards the nearest wall.

10.3.4 The pressure gage,  $G_1$ , must measure pressures ranging from  $5.10^{-4}$  to 0.1 Torr.

#### 10.4 Procedure:

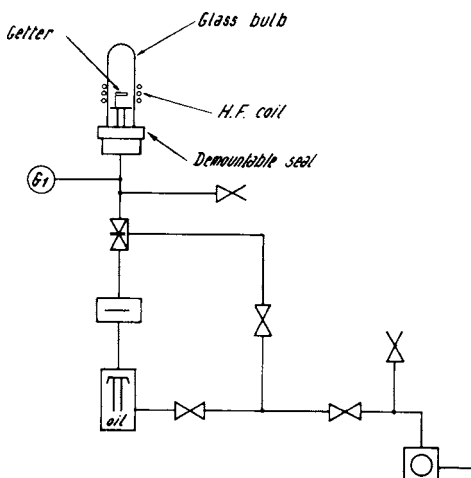


FIG. 1 Schematic of Barium Yield Determination Apparatus

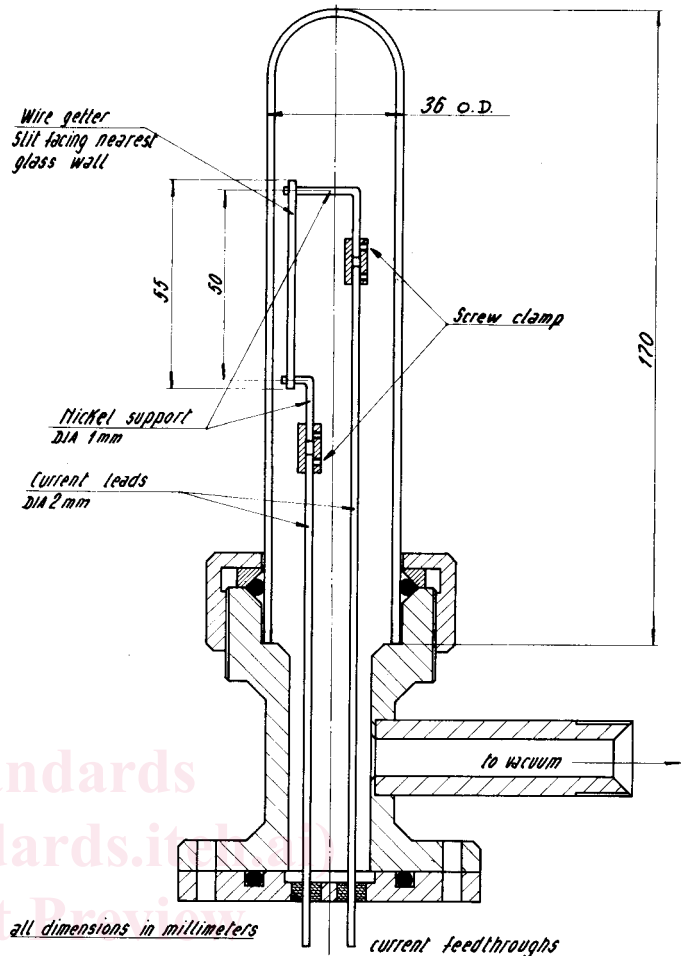


FIG. 2 Getter Mounting for Yield Determination: Wire Getters

10.4.1 Observe the clean handling techniques of 5.5.1 for both getter and mount.

10.4.2 Weigh the getter with its integral support. Sections 10.4 and 12.4 describe only the use of the weight difference method of determining the barium yield. Any of the chemical methods, given in Section 9, can be used. In these cases, the weighing of the getter before and after flash is not required and the yield calculations are those of the relevant part of Section 9.

10.4.3 Attach test getter to its appropriate cleaned mount.

10.4.4 Secure the mounted getter in the test apparatus.

10.4.5 Evacuate the system to  $5.10^{-4}$  Torr or less.

10.4.6 Flash the getter by applying the necessary heating power. Record both the start and total times.

10.4.7 Admit air into the system; remove the glass bulb and the getter with its integral support. Check that there is no fusion of the getter container.

10.4.8 Weight the getter with support.

10.4.9 Determine the average weight,  $\bar{M}_p$ , in milligrams of barium in the fill using the procedures given in 9.4 or 9.7 and a minimum sample of ten getters.

10.4.10 Flash  $n$  getters, where  $n$  is greater than 9, in sequence at constant total time and constant applied power. The power and the total times are such that the manufacturer's