



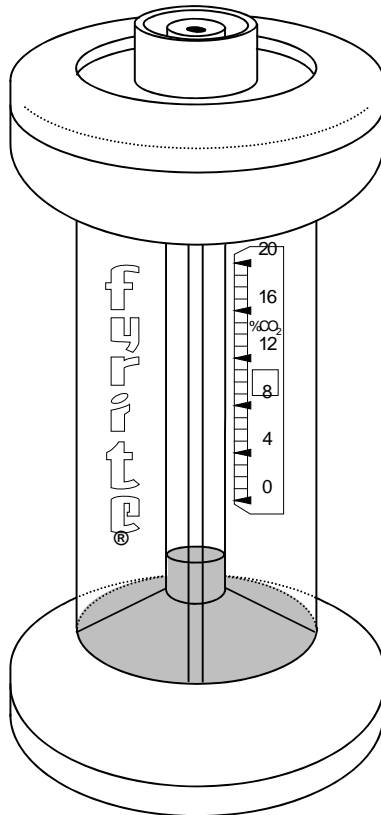
INSTRUCTION 0011-9026

FYRITE® Gas Analyzer

CO₂ and O₂ Indicators

Operation/Maintenance

Rev. 12 – December 2012



WARRANTY

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NOTE: *Gaskets are considered consumable items and are excluded from the terms of this warranty.*

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CAUTION

***Corrosive fluid is contained inside this unit.
These instructions should be thoroughly
read before operation is attempted.***

FYRITE SAFETY PRECAUTIONS

The operator (s) of this instrument should thoroughly familiarize themselves with the applicable safety precautions before handling or using the FYRITE for gas analysis.

Review Figures 1a, 1b, 1c and 1d on this page. Make certain to follow the steps outlined below and read the fluid handling precautions for your personal safety.

- 1) Always use protective equipment such as safety goggles, gloves, and protective clothing as illustrated in Figure 1a.
- 2) Read the instruction manual thoroughly. When filling the FYRITE with the applicable fluid charge, use safety equipment and perform the operation in the vicinity of running tap water (Figure 1b).
- 3) The FYRITE fluid should always be in the bottom reservoir before and during sample introduction to the FYRITE. When venting the FYRITE to atmosphere, hold the instrument in the vertical position and at a location away from your face (Figure 1c).
- 4) **NEVER** vent FYRITE in the inverted position (with the plunger facing downward). This will cause fluid to spill, which is corrosive and contains harmful elements (Figure 1d).

NOTE: *In the event of fluid spill - refer to Section 2.2 (FYRITE Handling Precautions). For Maintenance - refer to Section 6.0.*

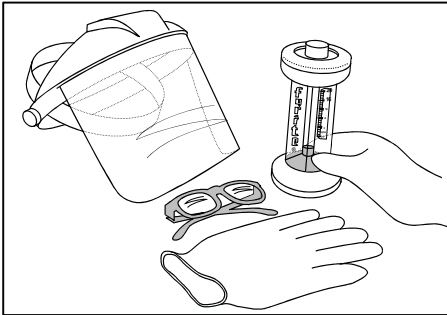


Figure 1a. Protective equipment required before attempting gas analysis.

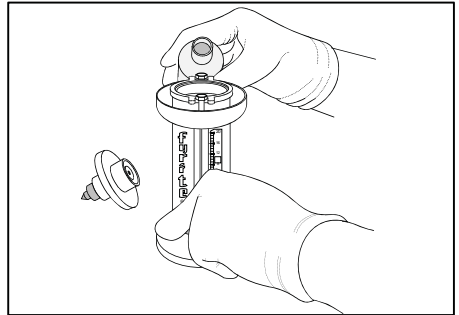


Figure 1b. Preparing to fill FYRITE using recommended protective safety equipment.

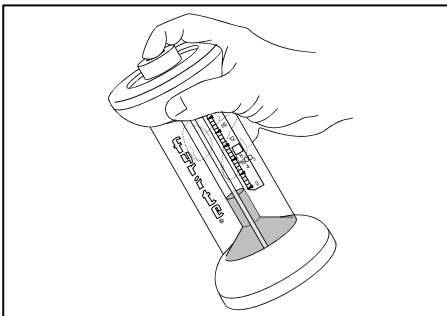


Figure 1c. Venting FYRITE to atmosphere at 45° angle.



Figure 1d. NEVER vent FYRITE in the inverted position, which will cause fluid to spill.

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INSTRUCTIONS 0011-9026
OPERATION/MAINTENANCE
BACHARACH FYRITE MODELS
CO₂ and O₂ INDICATORS

1.0 DESCRIPTION (Refer to Figure 1)

The FYRITE employs the well-known "Orsat" method of volumetric analysis involving chemical absorption of a sample gas, such as carbon dioxide or oxygen. The reagent used to absorb carbon dioxide (CO₂) is potassium hydroxide (dyed red), and chromous chloride (blue) is the absorbent for oxygen (O₂). The unique feature of the FYRITE is that the absorbing fluid is also used as the indicating fluid so that one vessel takes the place of both measuring burette and absorption pipette.

The body of the FYRITE is molded of clear high-strength plastic, comprises top and bottom reservoirs and a center tube connecting the two reservoirs. The bottom of the lower reservoir is sealed off by a synthetic rubber diaphragm that rests on a perforated metal plate. The upper reservoir is covered by a molded plastic cap that contains a double-seated plunger valve. A spring holds this valve against a carefully finished seat in the top cap providing a perfect seal which makes the instrument spill-proof in any position. When the valve is partially depressed, the entire instrument is open to the atmosphere and the instrument is, of course, is no longer spill-proof.

The bottom reservoir is filled with the absorbing fluid, which extends about 1/4 inch into the bore of the center tube when the instrument is held upright. The scale position, mounted to one side of the center tube, is adjustable.

2.0 FYRITE INSPECTION BEFORE AND DURING TEST

CAUTION

Corrosive fluid is contained inside unit, instructions should be thoroughly read before operation is attempted.

2.1 Pre-Operational Check

To ensure proper FYRITE operation and reliable results, check the following:

- (a) With FYRITE vented and in a vertical position, it should be possible to adjust scale zero to the top of the fluid column. Refer to FYRITE Operation for proper setup (Section 3.0 Steps 1 through 5). If this is not possible, add or remove a small amount of fluid per Section 6.1.

(b) FYRITE Fluid Strength

To check fluid strength.

NOTE: *When repeating procedures as outlined in Section 3.0 Steps 7 through 9 (absorbing and reading percent O₂ and absorbing and reading percent CO₂) and before venting FYRITE to atmosphere for next sample, if the reading increases by more than 1/2 percent for either CO₂ or O₂, replace the fluid.*

It is often desirable to check fluid strength before taking the FYRITE to a location where it will be used. It can be tested on sample atmospheric air (which contains 20.9% O₂). Be certain to wet Filter Saturator when checking atmospheric air for maximum accuracy. (See Section 6.9)

O₂ (Oxygen) Fluid - Fresh FYRITE fluid will absorb all O₂ from approximately 100 samples containing 10% O₂.

CO₂ (Carbon Dioxide) Fluid - Fresh FYRITE Fluid will absorb all CO₂ from approximately 350 samples containing 10% CO₂.

(c) FYRITE Sampling Assembly - Always check sampling assembly for proper (leak-free) operation as outlined in Section 6.7 before proceeding with test.

(d) Make certain wool in Filter Saturator Tube is moistened with water if using either O₂ or CO₂ FYRITE in a noncombustible application where the gas sample is not fully saturated with water vapor. Examples where filter-saturator must be wetted include measuring CO₂ or O₂ in ambient air or from compressed gas samples. Refer to Section 6.9 when replacing or moistening saturator (wool) filter is required.

FYRITE OPERATION PRECAUTION: *To prevent fluid spill, never depress Plunger Valve to vent FYRITE when unit is in the inverted or any other non-upright position. When depressing Plunger Valve in the upright position to vent FYRITE, hold at a slight angle away from the operator's face.*

2.2 FYRITE FLUID HANDLING PRECAUTIONS

CAUTION

FYRITE fluids used in the CO₂ and O₂ analyzers are corrosive and contain poisonous elements which must not be taken internally. In the event of a spill or accidental body contact with FYRITE fluid, read the following carefully.

HAZARDS

Corrosive liquid causes burns. May cause blindness if splashed in eyes. Vapors are irritating and may be harmful.

PRECAUTIONS

Prevent contact with eyes, skin and clothing. Wear eye protection and gloves. Do not vent instrument until fluid has drained from top well. Do not vent instrument (FYRITE) in inverted position.

FIRST AID

For contact with eyes: Immediately flush eyes with water 20 minutes. Get immediate medical attention.

For contact with skin: Immediately flush skin with water 20 minutes. Get immediate medical attention.

For inhalation overexposure: If irritation develops, move victim to fresh air.

For swallowing: Do not induce vomiting. Give two glasses of water or milk if conscious and not convulsing. Get immediate medical attention.

Refer to the material safety data sheet for further information.

3.0 BASIC FYRITE OPERATION PERCENT CO₂ AND O₂

Four basic steps are required when making an analysis, many being common to both the CO₂ and O₂ FYRITE.

FYRITE MODEL CO₂ (Red Fluid)

- (a) Vent and adjust scale zero.
- (b) Pump sample into FYRITE.
- (c) Absorb CO₂ from sample.
- (d) Read % CO₂ on scale.

FYRITE MODEL O₂ (Blue Fluid)

- (a) Vent and adjust scale zero.
- (b) Pump sample into FYRITE.
- (c) Absorb O₂ from sample.
- (d) Read % O₂ on scale.

NOTE: *To prevent warming of FYRITE fluid during analysis, hold FYRITE by the fins only.*

CO₂ FYRITE OPERATION (RED FLUID)

1. Hold upright (Fig. 1) and away from face. Depress Plunger Valve (momentarily) to vent FYRITE, and release.

2. Invert FYRITE (Fig. 2). Hold at slight angle to drain fluid into top reservoir.

3. Turn upright. Hold FYRITE at 45° angle (Fig. 3) momentarily to allow fluid droplet drainage into bottom reservoir.

4. Hold FYRITE in upright (Fig. 4) position and away from face. Depress Plunger Valve (momentarily) and release.

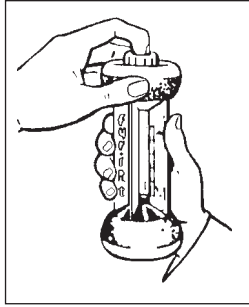


Figure 1

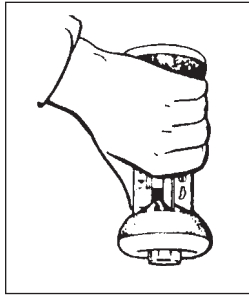


Figure 2

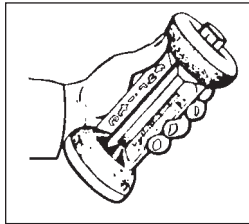


Figure 3

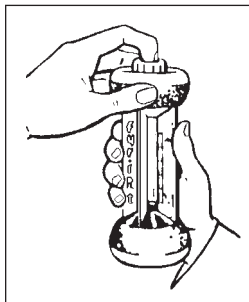


Figure 4

O₂ FYRITE OPERATION (BLUE FLUID)

1. Hold upright (Fig. 1) and away from face. Depress Plunger Valve (momentarily) to vent FYRITE, and release.

2. Invert FYRITE (Fig. 2) to absorb O₂ drawn into FYRITE whenever Plunger Valve is depressed). Hold at slight angle to drain fluid into top reservoir.

3. Turn upright. Hold FYRITE at 45° angle to drain fluid into bottom reservoir. Turn upright. Repeat sequence of Steps 1, 2, and 3 twice until fluid level does not drop more than 1/2% when Plunger Valve is depressed. Turn upright. Hold FYRITE at 45° angle (Fig. 3) momentarily until excess fluid droplets have been drained from inside surfaces.

4. Hold FYRITE in upright (Fig. 4) position and away from face. Note fluid level in column. Depress Plunger Valve (momentarily), and release.

CO₂ FYRITE OPERATION (RED FLUID)

5. Holding FYRITE upright (Fig. 5), loosen locknut at rear of scale. Slide scale (Fig. 5a) until top of fluid column lines up with zero line on scale (Fig. 5b). Tighten scale locknut.

NOTE: When setting scale zero, hold FYRITE vertically as shown and level with eyes while sighting across scale to top of fluid column.

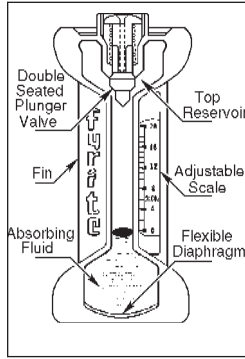


Figure 5

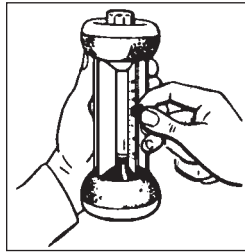


Figure 5a

6. To pump gas sample into FYRITE (Fig. 6), insert open end of metal sampling tube into area bearing gas for analysis. Hold FYRITE in upright position and place sampling assembly rubber connector tip over the Plunger Valve.

Depress Plunger Valve firmly with connector tip.

Pump sample by squeezing and releasing aspirator bulb 18 times. During 18th bulb squeeze (with bulb held deflated) release connector tip and Plunger Valve.

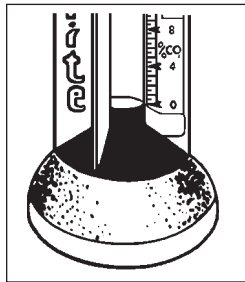


Figure 5b

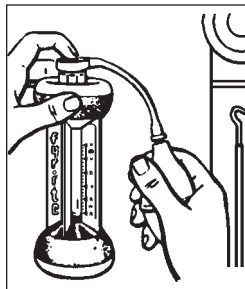


Figure 6

O₂ FYRITE OPERATION (BLUE FLUID)

5. Holding FYRITE upright (Fig. 5), loosen locknut at rear of scale. Slide scale (Fig. 5a) until top of fluid column lines up with zero line on scale (Fig. 5b). Tighten scale locknut.

NOTE: When setting scale zero, hold FYRITE vertically as shown and level with eyes while sighting across scale to top of fluid column.

6. To pump gas sample into FYRITE (Fig. 6), insert open end of metal sampling tube into area bearing gas for analysis. Hold FYRITE in upright position and place sampling assembly rubber connector tip over the Plunger Valve.

Depress Plunger Valve firmly with connector tip.

Pump sample by squeezing and releasing aspirator bulb 18 times. During 18th bulb squeeze (with bulb held deflated) release connector tip and Plunger Valve.

CO₂ FYRITE OPERATION (RED FLUID)

7. Absorb sample gas into FYRITE by inverting until fluid drains into top reservoir (Fig. 7). Then turn upright (Fig. 8) to drain fluid into bottom reservoir. Repeat this step once.

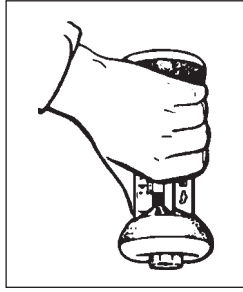


Figure 7

8. Hold FYRITE at 45° angle (Fig. 9) momentarily to allow fluid droplets to drain into the bottom reservoir.

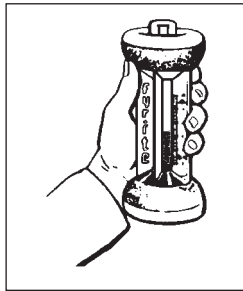


Figure 8

9. With FYRITE held upright (Fig. 10), permit fluid in column to stabilize a few seconds, then immediately read % carbon dioxide on scale at the point corresponding to top of the fluid column.

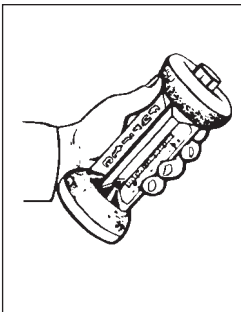


Figure 9

O₂ FYRITE OPERATION (BLUE FLUID)

7. Absorb sample gas into FYRITE by inverting until fluid drains into top reservoir (Fig. 7). Then turn upright (Fig. 8) to drain fluid into bottom reservoir. Repeat this step three (3) more times (four complete inversions total).

8. Hold FYRITE at 45° angle (Fig. 9) momentarily to allow fluid droplets to drain into the bottom reservoir.

9. With FYRITE held upright (Fig. 10), permit fluid in column to stabilize a few seconds, then immediately read % oxygen on scale at the point corresponding to top of the fluid column.

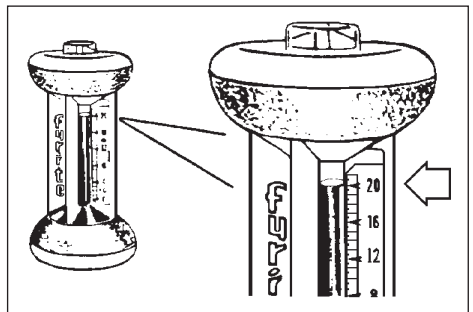


Figure 10

10. This step completes CO₂ or O₂ FYRITE gas sample analysis. A few points to remember when reading the FYRITE:
- (a) FYRITE accuracy is within $\pm 1/2\%$ CO₂ or O₂ compared to actual value.
 - (b) Always handle FYRITE by fins to ensure body heat is not absorbed by fluid.
 - (c) A delay in reading of 5 or 10 seconds may decrease accuracy of reading slightly but longer delays may cause substantial error.
 - (d) The FYRITE is calibrated to indicate on a “dry” basis for flue gas samples, which are normally fully saturated with moisture. Failure to artificially moisten wool packing in Filter Saturator Tube when actual sample is not fully saturated will cause FYRITE to read slightly low.

Therefore, make certain wool packing in Filter Saturator Tube is sufficiently moistened with water for accurate results on non-flue gases. Avoid excessive moisture which can be drawn into the Aspirator Bulb and forced into the FYRITE during sampling.

CAUTION

Never depress plunger valve to vent FYRITE in the inverted position. This will cause fluid to spill, which is corrosive and contains poisonous elements. In the event of a spill, read Instructions in Section 2.2 FYRITE fluid handling precautions.

3.1 Determining CO₂ and O₂ FYRITE Fluid Strength

FYRITE Fluid strength can be conveniently checked immediately after the first sample reading. Without venting, repeat the absorbing operations (Steps 7 through 9) by inverting FYRITE again and positioning upright until all fluid drains to the bottom reservoir. Observe scale reading. An increase of more than $1/2\%$ CO₂ or O₂ in the second reading as compared to the first indicates a need for fluid replacement.

3.2 Operating Precautions to Ensure Maximum Accuracy

Locate top of fluid column (refer to Fig. 11). The surface at the top of the fluid column (meniscus) in the small, center bore will be dish-shaped as shown in Figure 11. Either the high or low point of this dish-shaped surface may be used to locate top of fluid column providing the same point is always used both for setting scale zero and reading percent CO₂ or O₂. Obviously, using high point for one operation and low point for the other will cause an error.

Best practice is to use high point of this fluid surface just at the small center bore wall. In setting scale zero or reading percent CO₂ or O₂, hold FYRITE vertically and level with eyes and sight across scale to top of fluid column.

3.2.1 Draining Fluid Droplets

For maximum accuracy, it is important to form the habit of following a standard procedure in this operation and to use the same procedure both before adjusting scale zero and before reading percent CO₂ or O₂ .

3.3 FYRITE Temperature

The FYRITE temperature should be at or close to the temperature of the working environment where the analysis is being made and should not be subject to sudden temperature changes. If FYRITE is carried from cooler to warmer location or vice versa, expose FYRITE to new temperature condition to permit uniform temperature stabilization. Usually 15 or 20 minutes will suffice, except when extreme temperature variations are involved. Temperature stabilization can also be accelerated by inverting FYRITE frequently.

3.3.1 Temperature of Gas Sample

The gas sample as it enters FYRITE should be cooled (or warmed if sampling cool gases) to same (ambient) temperature as the FYRITE.

Capacity of Standard Aspirator Bulb and Sampling Assembly (Part # 11-7029) to cool the gas sample is sufficient if the temperature of gas being sampled does not exceed 850°F (454°C), even where a large number of consecutive samples are required if there is an interval of not less than 5 minutes between samples.

FYRITE indicators operate over a wide temperature range. They may be exposed to ambient temperatures from -30° to 150°F (-34° to 66° C). Gases up to 850° F (454° C) may be tested with Standard Aspirator Sampling Assembly (11-7029).

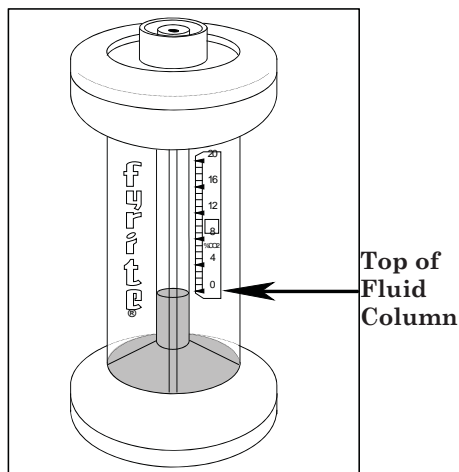


Figure 11. Locating Top of Fluid Column.

4.0 PRINCIPLE OF OPERATION

(Refer to Figures 12, 13, and 14)

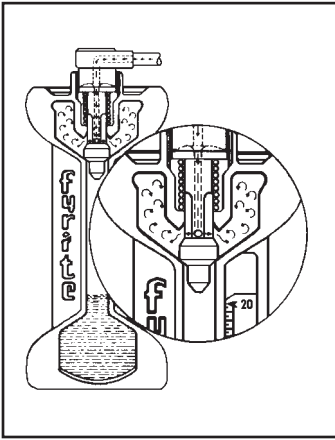


Figure 12. When plunger valve is depressed, a gas sample is pumped through top reservoir with center bore is sealed off.

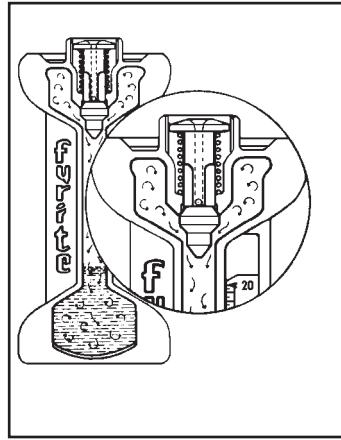


Figure 13. When plunger valve is released, the gas sample is locked into FY-RITE and the top reservoir is opened to center bore so that gas sample can pass through absorbing fluid.

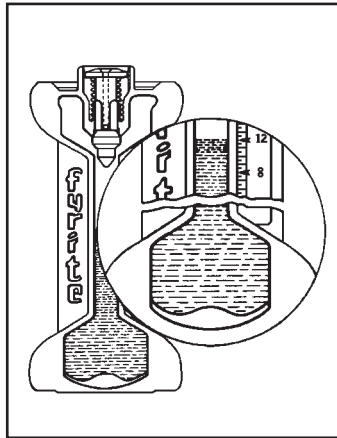


Figure 14. Absorption of gas sample by fluid creates suction, which causes diaphragm to flex up and fluid to rise in center bore to replace gas absorbed.

To make a test with the FYRITE, the metal Sampling Tube at one end of Sampling Assembly Hose is inserted into the gas to be analyzed. The rubber Connector Plug at the other end of the Rubber Hose is then firmly pressed down on the spring-loaded Valve of the instrument (See Figure 12). This simultaneously opens a passage into the Top Reservoir and seals off the center bore.

Next, a sample of the gas is pumped into the Top Reservoir by squeezing the rubber Aspirator Bulb. At least 18 bulb squeezes are required to assure that the rubber Sampling Hose and the Top Reservoir of the FYRITE are thoroughly purged of the previously analyzed sample. During the 18th Aspirator Bulb squeeze and immediately before releasing Bulb, the finger is lifted from the Connector Plug, which automatically returns the Plunger Valve to upper position against its top seat.

Refer to Figure 13. With the Valve in this position, the final 60 cc of the gas sample is locked into the FYRITE and the Top Reservoir is opened to the center bore so that the gas sample can pass to the absorbing fluid. The FYRITE is then inverted, forcing the gas sample to bubble through the absorbing solution which absorbs either CO₂ or O₂ depending on the type FYRITE in use.

Refer to Figure 14. The instrument is then turned and held upright. Absorption of the CO₂ or O₂ by the absorbing fluid creates a suction, which causes the Diaphragm at the bottom to flex upward permitting the level of the absorbing fluid to rise in the center tube an amount proportional to the gas absorbed. The scale indication corresponding to the top of the fluid column is then read as a percentage of gas absorbed by the FYRITE fluid.

5.0 APPLICATION INFORMATION

FYRITE Analyzers are available for either Carbon Dioxide or Oxygen analysis, and each of these models is made in the three scale ranges shown in Section 5.3. All six instruments are similar in appearance and size, but they differ in important construction details, as well as in absorbing fluids.

5.1 FYRITE Absorbing Fluid

FYRITE absorbing fluid is selective in the chemical absorption of carbon dioxide or oxygen respectively. Therefore, the FYRITE's accuracy is well within the range required for industrial and professional applications, and does not depend upon complicated sequential test procedures. Furthermore, the FYRITE readings are unaffected by the presence of most background gases in the sample.

The appearance of a dark red fluid floating on top of CO₂ FYRITE solution is entirely normal. The darker fluid consists of a small amount of material added to prevent excessive foaming at the meniscus and improves readability.

5.1.1 FYRITE Refill Fluid (Storage Life, etc.)

FYRITE refill bottles should be stored at room temperature (70° F [21° C]) in the carton provided, and placed in use within one year.

NOTE: *Before opening refill bottle, read the label and make certain to observe all precautions.*

FYRITE CO₂ refill fluid may develop a white insoluble precipitate upon aging. The precipitate does not affect fluid performance in any way, but if present, should be filtered out to prevent adherence to internal surfaces of the FYRITE.

To filter, place a clean piece of thin cloth or netting loosely over the open CO₂ FYRITE and slowly pour refill contents into top reservoir. Before disposing of cloth, rinse thoroughly with water. FYRITE fluid is corrosive!

FYRITE O₂ refill fluid reacts very rapidly with oxygen in air. Oxidation of absorbent can be prevented by purging the FYRITE body with Nitrogen, natural gas or other oxygen-free gas, just before filling, and by maintaining a stream of this gas around mouth of the bottle (see Figure 21) while its contents are emptied into the FYRITE.

Another method for refilling the O₂ FYRITE (and still limiting the oxidation of the absorbent) is to invert the unit and place it over the 60 cc bottle of fluid. Then invert both so that the FYRITE is now upright and the O₂ fluid is filling the instrument (see Figure 21a). Immediately install plastic Top Cap Ring without delay. This method helps to minimize oxidation and improve the life of the fluid.

5.2 FYRITE Operating Temperature Range

The FYRITE indicators operate over a wide temperature range, and may be exposed to ambient temperatures from -30° to 150° F. (-34° to 66°C). Gases up to 850° F (454° C) may be tested with standard aspirator sampling equipment (11-7029).

***NOTE:** Remember, for most accurate results, the FYRITE must be at temperature equilibrium with its surroundings (ambient temperature) and the incoming gas sample at the same temperature as the FYRITE.*

5.3 Typical FYRITE Applications

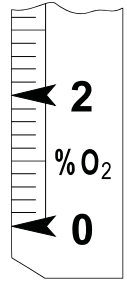
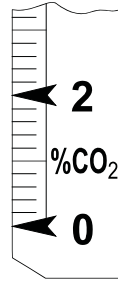
Listed below are six models of FYRITE Indicators and two Aspirator Sampling Assemblies with part numbers identifying their application.

	Bacharach Part Numbers				
For Testing	Scale Range	FY-RITE	Aspirator Sampling Assy.	Fluid	Complete Kit with Case
Carbon Dioxide	0 - 7.6%	11-7042	11-7029	10-5100	10-5053
	0 - 20%	11-7032	11-7029	10-5057	10-5000
	0 - 60%	11-7034	11-7029	10-5057	10-5032
Oxygen	0 - 21%	11-7036	11-7029	10-5060	10-5011
	0 - 60%	11-7038	11-7029	10-5060	10-5046

TYPICAL APPLICATIONS WITH FULL SIZE SECTIONS OF FYRITE SCALES

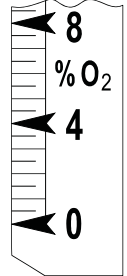
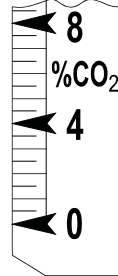
0-7.6% CO₂ or O₂

CO₂ tests of controlled atmospheres in fruit, vegetable, and meat storage rooms. Oxygen determination in flammable gases. Oxygen tests to check atmospheres made inert with nitrogen (silos, fuel tanks, etc.)



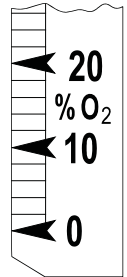
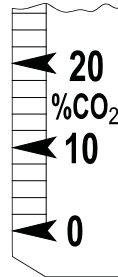
0-20% CO₂ or 0-21% O₂

Flue gas combustion tests, oxygen deficiency tests, and CO₂ tests of heat treating atmospheres. Checking oxygen concentrations in hydrogen-cooled generators and oil-sealed inert-gas transformers.



0-60% CO₂ or O₂

Checking CO₂ in inert gas blankets in tankers and barges carrying gasoline and other combustibles. CO₂ tests on lime kilns. Checking CO₂ in sewage plant digesters. Oxygen tests in connection with oxygen and gas anesthesiology.



5.4 CO₂ FYRITE Only Combustion Testing

5.4.1 Percent CO₂ Shows Volume of Excess Air (Refer to Figure 15)

For any given fuel, theoretical maximum percent CO₂ (Ultimate CO₂) would be produced when exactly enough air (but no excess air whatsoever) is supplied to burn all of the fuel. As increasing amounts of excess air are supplied, percentage CO₂ naturally decreases from theoretical Ultimate CO₂ due to the diluting effect of excess air.

Thus, measuring percent CO₂ is also a method of indicating excess air to ensure that enough is supplied to permit clean combustion without adding so much that combustion efficiency is unnecessarily decreased.

5.4.2 Too Much Excess Air Means Inefficient Combustion

Excess combustion air is heated and carries some of this heat to the flue where it is wasted. The FYRITE CO₂ Analyzer is used to adjust combustion excess air to a minimum (maximum CO₂), which will permit clean efficient combustion.

Calculation of combustion efficiency is possible (assuming complete combustion) if percentage of CO₂ and net temperature of combustion products are known.

5.4.3 What is Proper CO₂ Value?

Proper CO₂ is that which will ensure complete, clean combustion with some safety margin for variations in fuel, draft, atmospheric conditions, and mechanical wear.

Consult manufacturer of heating equipment for specific recommendations. Generally accepted values for good combustion practice in residential furnaces and boilers when firing the following fuels are:

Natural Gas8 to 9.5% CO₂

No.2 Oil10 to 12.5% CO₂

These are only guidelines, however, and in all cases recommendations of the equipment or fuel supplier would also include recommendations for allowable smoke (oil firing) or combustibles (gas firing), which are undesirable combustion by-products. Testing for smoke, CO, or combustibles is important since in extreme fuel rich firing, high CO₂ values also occur (see Figure 16).

5.4.4 How To Calculate Combustion Efficiency

Measure percent CO₂ in flue gases with FYRITE. Then measure flue gas temperature with a suitable thermometer (e.g., TEMPOINT) at the same sampling point. Deduct temperature of basement or combustion air supplied from measured flue gas temperature to obtain net flue gas temperature. Use a Bacharach FIRE EFFICIENCY FINDER to calculate combustion efficiency. Instructions for using the FIRE EFFICIENCY FINDER are printed on the face of this slide rule calculator.

5.5 O₂ FYRITE Only Combustion Testing

5.5.1 Percent O₂ Shows Volume of Excess Combustion Air (Refer to Fig. 15)

All fuels require some excess air (in addition to air theoretically required to burn the fuel) to ensure clean, complete combustion. As the amount of this excess air increases, the percentage of O₂ in combustion products increase.

5.5.2 Too Much Excess Air Means Inefficient Combustion

Excess combustion air is heated and carries some of this heat to the flue where it is wasted. The FYRITE O₂ analyzer is used when adjusting combustion air to minimum excess air (minimum O₂) which will permit clean, efficient combustion.

5.5.3 What is Proper O₂ Value?

Proper O₂ content for any fuel fired is the lowest O₂ value that will ensure complete, clean combustion with adequate safety margin for variations in fuel, draft, atmospheric conditions, and mechanical wear. Consult manufacturer of heating equipment or local authorities for specific recommendations. Figure 15 illustrates the relationship between CO₂, excess air and oxygen for gas and oil.

For guidance, it should be added that modern boilers are capable of 80% or greater combustion efficiency. Rough guidelines for setting conventional power burners are 10-15% excess air for natural gas and 15-20% excess air for oil, with little or no smoke and carbon monoxide formation.

5.5.4 Measuring O₂ in Addition to CO₂

Figure 16 illustrates why it is good practice to measure oxygen, in addition to carbon dioxide, when firing gaseous fuels. Note that the same CO₂ reading can be obtained on both sides of the stoichiometric (or perfect) mixture. Carbon dioxide alone cannot define proper excess air operation for gaseous fuels.

A check must also be made for the presence of oxygen, which confirms operation with excess air. Gaseous fuels should also be checked for presence of carbon monoxide (CO) in the flue gases and adjusted for either “no CO” or to conform to applicable safety regulations.

5.5.5 Where is Percent CO₂ or O₂ Measured? (Refer to Figure 17)

For residential and most commercial and industrial combustion units, percent CO₂ or O₂ is measured by analyzing gas sample obtained through a 1/4-inch diameter hole located between the flue outlet (breeching) and any mechanical opening in the flue such as the barometric draft regulator or draft diverter. Best practice is to locate sampling hole at least six inches upstream from such flue openings. The metal FYRITE Sampling Tube should extend at least 2-1/2 inches into the flue gases.

For larger installations, consult manufacturer of combustion equipment for special instructions regarding sampling point, special sampling tube required, or advice on averaging readings.

Residential gas furnaces with built-in draft diverter (gas designed) will require the FYRITE metal Sampling Tube to be inserted as illustrated in Figure 17 to avoid dilution of flue gas sample.

Additional information on residential furnace combustion testing may be obtained from the following Bacharach publication:

Bulletin 4097 - Technical Combustion Brochure

5.6 Background Gases Affecting FYRITE Readings

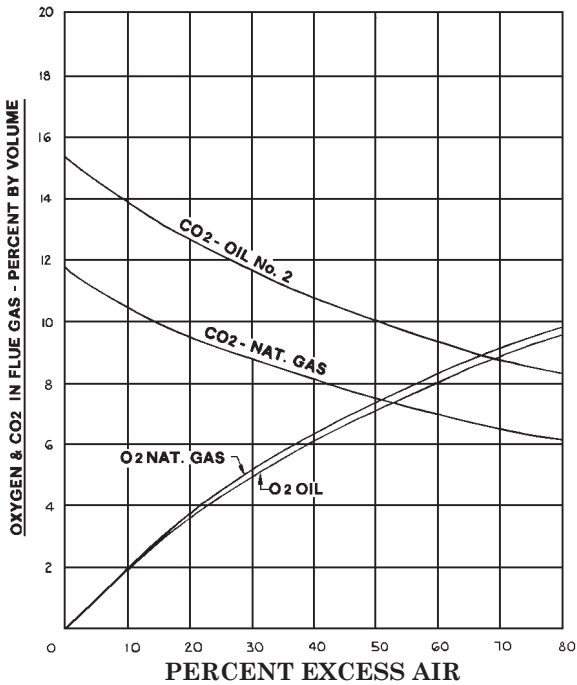


Figure 15. Relation between Oxygen, CO₂ and excess air in flue gases for Natural Gas and Fuel Oil.

THEORETICAL EXCESS AIR CURVE

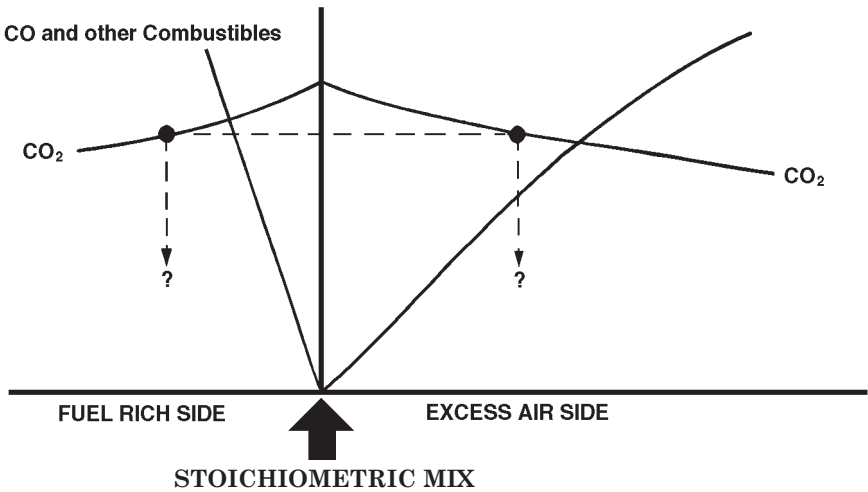


Figure 16. CO₂ measurements alone do not determine combustion air setting when firing gaseous fuels.

As a rule of thumb, background gases/vapors may be present in concentrations up to 1/2% by volume (5000 ppm) before they present a significant interference problem to the CO₂ or O₂ FYRITE (20/21% ranges).

An exception exists with the action of ammonia on Oxygen FYRITE Fluid. Ammonia neutralizes the acidic solution of chromous chloride, and therefore use of the O₂ FYRITE with even trace amounts of ammonia in the backgrounds is not advised unless suitable filters are used.

Inert gases, even in concentrations approaching 100% by volume, do not interfere with either the CO₂ or O₂ FYRITE. In general, interferences can be of a chemical (chemical reaction initiated) or a mechanical nature, with resultant error, but are also given up by the solution when the sample no longer contains the interfering substance. They can therefore be compensated for by saturating the FYRITE solution with samples containing the mechanical interferant as long as the background stays reasonably constant. Usually 3 or 4 tests are sufficient to saturate FYRITE solution with the mechanical interferant in question.

TYPICAL INTERFERENCE (CO₂ FYRITE)

All Acid Gases (SO₂, H₂S, Hydrocyanic Acid, Cyanogen, etc.).

TYPE OF INTERFERENCE

Chemical

APPROXIMATE EFFECT

1:1

TYPICAL INTERFERENCE (O₂ FYRITE)

Acetone
Acetylene and other unsaturated hydrocarbons

TYPE OF INTERFERENCE

Chemical
Chemical

APPROXIMATE EFFECT

1:1
1:1

CO₂

Mechanical, 20% CO₂ background can be zeroed out in 3 to 4 tests if background remains constant.

Can be zeroed out up to approximately 30% CO₂ background.

Ammonia

Chemical

Ammonia neutralizes O₂ FYRITE solution and instrument use on this background is not advised unless suitable filters are used.

Nitrous Oxide (N₂O)

Mechanical

- - -

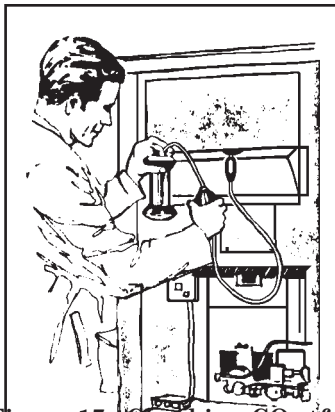


Figure 17. Checking CO₂ of gas designed furnace (sampling tube inserted through draft diverter; flue gas temperature test can be made at same point).

5.7 General FYRITE Applications

It is only possible to specify a few general rules for such applications. Where possible, sample should be obtained at a point where the gases are well mixed to a uniform composition. Where this is impossible; it will be necessary to average a number of measurements taken at different locations to obtain representative average. Where gases being sampled are not saturated with moisture (many non-combustion applications), it is very important to maintain the wool packing of Filter Saturator Tube in a moist condition.

NOTE: *The FYRITE is calibrated to analyze gases which are normally saturated with moisture. Failure to moisten wool packing in filter saturator tube with water will cause FYRITE to indicate slightly lower than actual gas concentration.*

Where special length sampling lines are required, add one more bulb squeeze to the 18 required with standard Sampling Assembly for each additional 3 cubic inches (50cc) volume of special sampling line.

EXAMPLE: *For each 9 ft. of 3/16 inch (I.D.) additional length of sampling line, add one more bulb squeeze.*

If it is necessary to trap a sample over water for later analysis, a minimum of 900 cc of sample will be required. If sample is trapped over water, it is good practice to use 10 to 15% NaCl (table salt) in the water to minimize absorption of CO₂ or O₂ by water.

Trapping a sample over mercury will eliminate any possible error due to absorption of CO₂ or O₂.

5.8 Altitude Correction Table

The gas concentration read on the FYRITE is directly dependent upon the mass of air in the sample. The aspirator bulb used in the FYRITE is a constant-volume pump, not a constant-mass pump. Altitude, therefore, affects the FYRITE reading due to the air's density changing with altitude, thus requiring higher CO₂ or O₂ concentrations to reach the same mark on the scale.

Use the following table to find the altitude correction (e.g., add the correction to the reading to get the correct concentration).

TABLE 5-1. ALTITUDE CORRECTION TABLE

Altitude Ft. (Meters)		Correction %		
		20% CO ₂	21% O ₂	7% O ₂ or CO ₂
1000	(305)	0.0	0.0	0.0
2000	(610)	0.0	0.0	0.0
3000	(914)	0.1	0.1	0.0
4000	(1575)	0.1	0.2	0.1
5000	(1219)	0.2	0.2	0.2
6000	(1829)	0.2	0.3	0.2
7000	(2134)	0.3	0.3	0.3
8000	(2438)	0.4	0.4	0.3
9000	(2743)	0.4	0.5	0.4
10,000	(3048)	0.5	0.6	0.5
11,000	(3353)	0.6	0.7	0.5
12,000	(3658)	0.7	0.8	0.6
13,000	(3962)	0.7	0.8	0.6
14,000	(4267)	0.8	0.9	0.7

6.0 FYRITE MAINTENANCE

NOTE: *With FYRITE vented and in a vertical position, it should be possible to adjust scale zero to the top of the fluid column. Refer to FYRITE Operation (Section 3.0) Steps 1 through 4 (for CO₂) or Steps 1 through 5 (for O₂) for proper setup. If this is not possible, add or remove a small amount of fluid as described below.*

6.1 Increasing FYRITE Fluid To Proper Level

Refer to Figure 18. Hold FYRITE upright and cover hole in center of Plunger Valve with finger. Add clean water, a few drops at a time (dripping water faucet is convenient) into space around Plunger Valve. Work Plunger Valve up and down several times. Repeat process until fluid is at proper level.

6.1.1 Decreasing FYRITE Fluid to Proper Level

Refer to Figure 19. To remove excess fluid, insert small diameter glass tube into FYRITE fluid through the small center FYRITE bore (with Top Cap Assembly removed). Seal open end of glass tube with finger and dip out fluid with glass tube until FYRITE fluid is at proper level. Avoid unnecessary exposure of O_2 fluid to air since it will rapidly absorb O_2 and become exhausted.

6.2 Checking FYRITE Fluid Strength

6.2.1 CO_2 FYRITE Fluid Only

Fresh FYRITE fluid will absorb all CO_2 from more than 350 samples containing 10% CO_2 . Where it is desirable to check fluid strength before taking FYRITE to the test location to be used, or when a questionable (low) FYRITE reading is obtained the instrument may be tested on any sample of CO_2 . Exhaled breath (containing approximately 4% CO_2) is often most convenient.

Disconnect the rubber bushing and Sampling Hose Assembly from the Filter Saturator Tube. Place the rubber connector tip over the Plunger Valve and depress Plunger Valve down firmly with rubber connector tip. Take a deep breath, hold for 3 or 4 seconds and exhale at a steady rate into the rubber bushing end of the Sampling Hose Assembly. Simultaneously squeeze the Aspirator Bulb several times while exhaling breath. Release rubber connector tip from Plunger Valve while still exhaling breath. Perform steps outlined below to absorb exhaled breath into FYRITE fluid.

1. Absorb sample gas into FYRITE by inverting until fluid drains into top reservoir, then turn upright to drain fluid into bottom reservoir. Repeat this step once more (two complete inversions total).
2. Hold FYRITE at 45° angle momentarily to allow fluid droplets to drain into bottom reservoir.
3. With FYRITE held upright, permit fluid in column to stabilize a few seconds, then immediately read % carbon dioxide on scale at point corresponding to top of fluid column.

To check CO_2 FYRITE fluid strength - DO NOT VENT FYRITE but reabsorb sample gas by inverting and turning upright. Repeat this step once more (two complete inversions total). If reading increases by more than 1/2 percent CO_2 as compared to initial reading; replace fluid.

Formation of a frothy, persistent foam on FYRITE fluid also indicates need for fluid replacement. A few "beads" or small air bubbles floating near the small center bore wall is not considered foaming. FYRITE fluid may be colored for ease in readings. Color has no bearing on fluid strength or ability to absorb CO_2 .

Cloudy fluid or small flakes of solid material in fluid do not necessarily mean CO_2 fluid is exhausted. Precipitate may form in CO_2 Refill Bottles due to extended storage, and can be filtered through cheese cloth or other screen like material when refilling FYRITE.

NOTE: *If compressed gas standards are used to check FYRITE*

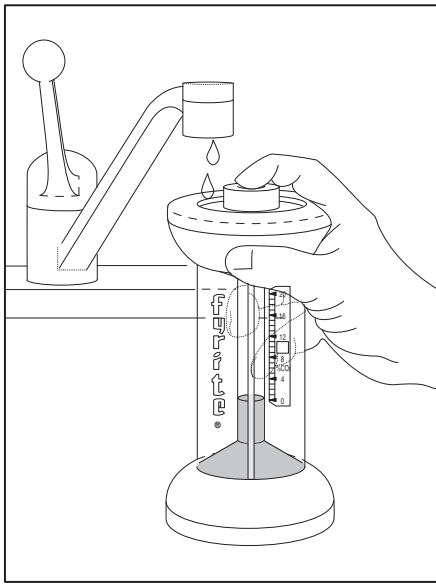


Figure 18. Increasing FYRITE fluid to proper level.

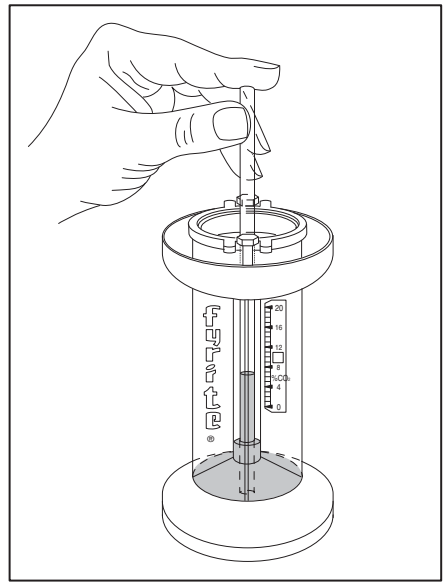


Figure 19. Decreasing FYRITE fluid to proper level

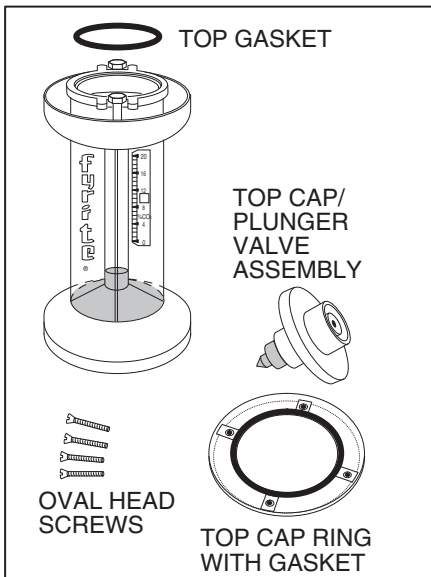


Figure 20. Removing top gasket.

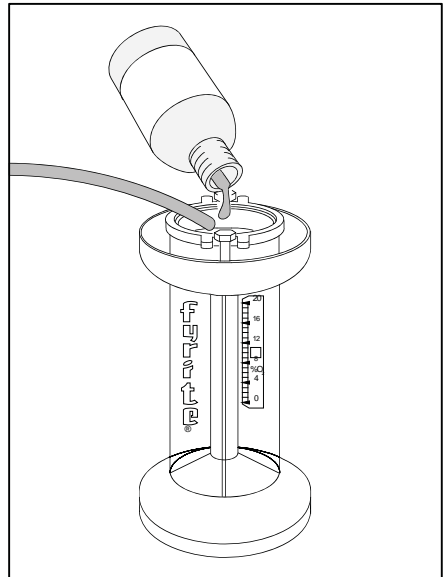


Figure 21. Flushing FYRITE with a stream of O₂ free, inert gas (Also see Fig. 21a for alternate method).

accuracy don't forget to saturate filter saturator wool packing as such gas standards are usually supplied "bone dry".

6.2.2 O₂ FYRITE Fluid Only

Fresh FYRITE fluid will absorb all O₂ from approximately 100 samples containing 10% O₂. After completing test (as outlined in Section 3.0 Steps 1 through 9) O₂ FYRITE Fluid strength can be checked by performing steps outlined below:

1. DO NOT VENT FYRITE, but reabsorb sample gas into FYRITE by inverting until fluid drains into top reservoir, then turn upright to drain fluid into bottom reservoir. Repeat this step three (3) more times (four complete inversions total).
2. Hold FYRITE at 45° angle momentarily to allow fluid droplets to drain into bottom reservoir.
3. With FYRITE held upright, permit fluid in column to stabilize a few seconds, then immediately read % oxygen on scale at the point corresponding to top of fluid column. If reading increases by more than 1/2 percent O₂ as compared to the initial reading, replace fluid.

When it is desirable to check fluid strength before taking the FYRITE to a location where it will be used, it can be conveniently tested on a sample of atmospheric air which contains 20.9% O₂.

NOTE: *Make certain wool in filter saturator tube is moistened with water when using FYRITE in a non-combustible application where the gas sample is not fully saturated with water vapor.*

Formation of a frothy, persistent foam on FYRITE fluid also indicates need for fluid replacement. A few "beads" or small air bubbles floating near the small center bore wall is not considered foaming. Color of FYRITE O₂ (blue) fluid is not an index of ability to absorb oxygen although towards the end of fluid life, a greenish cast can be detected.

NOTE: *If compressed gas standards are used to check FYRITE accuracy, don't forget to saturate filter saturator wool packing as such gas standards are usually supplied "bone dry".*

6.3 Replacing FYRITE Fluid (Refer to Figs 20, 21, and 22)

CAUTION

Because of the corrosive effect of the FYRITE fluid, always change FYRITE fluid in immediate vicinity of a sink with running water available as shown in Figure 18.

Remove 4 screws, metal Top Cap Ring, plastic Top Cap Assembly and Top Gasket.

Drain old fluid from FYRITE and rinse all parts in clean, lukewarm water.

NOTE: *FYRITE fluid is corrosive to skin, clothing, some metals, and painted or lacquered surfaces. Dispose of these fluids in accordance with Local, State and Federal Laws. If draining into a porcelain sink is permitted, keep water faucet turned on while draining and flush for at least 1/2 minute afterwards.*

NOTE: *Examine top gasket for warpage, if distorted as shown in Figure 22, replace gasket with part # 11-0143 before proceeding.*

Drain all parts of excess water. Stand FYRITE Body upright to center replacement Top Gasket in recess provided in top flange of body.

O₂ FYRITE Only: Before adding fluid, flush FYRITE with a stream of O₂ - free, inert gas (Figure 21) or be prompt in reassembling Top Cap to prevent excessive fluid contact with air.

Uncap FYRITE fluid bottle, invert FYRITE and place over the bottle. Invert both FYRITE and bottle (Figure 21a) so that FYRITE comes to an upright position and the fluid is filling the unit. Immediately install plastic Top Cap Assembly and metal Top Cap Ring without delay.

CO₂ FYRITE Only: Uncap CO₂ Refill Bottle and pour entire contents into FYRITE. Reinstall plastic Top Cap Assembly and metal Top Cap Ring.

CO₂ / O₂ FYRITEs: Make certain that Top Cap Ring Gasket (11-0109, Figure 33) is in place between metal Top Cap Ring and plastic Top Cap. Draw the 4 machine screws down with light screwdriver force.

Then, going from one screw to the next, draw down 1/4 turn until all are firmly tightened. Avoid excessive force in tightening which may damage plastic parts.

6.4 Inspection of FYRITE for Fluid Leakage

Gradual loss of fluid, moisture or dried encrustation around Plunger Valve does not indicate fluid leakage. Gas enters and leaves unit during sampling with considerable velocity and some fluid vapor is carried out during normal sampling. To check Top Assembly for fluid leakage in upright position, depress Plunger Valve and release.

Note the scale reading at top of fluid column, and then stand FYRITE upside down overnight in glass or porcelain test dish (See Figure 23). Then, return FYRITE to upright position and, after allowing 5 minutes for drainage, depress and release Plunger Valve. Leakage will be evidenced by lower scale reading. Extreme leakage will be apparent by presence of fluid in test dish.

Follow the same procedure to check fluid leakage from Bottom Cap Assembly with FYRITE stood overnight in the upright position.

When leakage is proven, examine plastic and rubber parts for deterioration to deter-

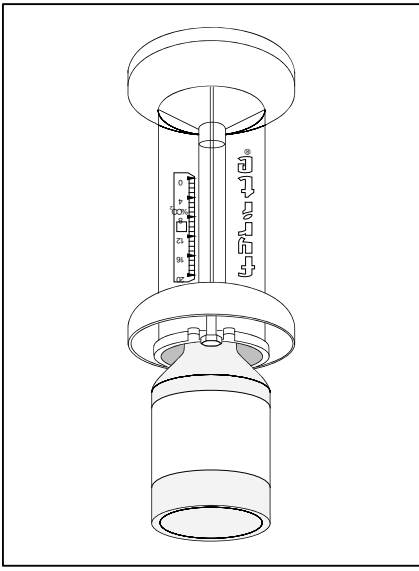


Figure 21a. Alternate filling method. Invert FYRITE (with bottle in place) to upright position.

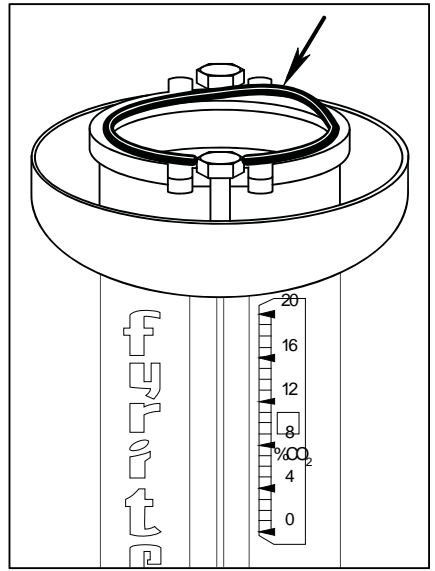


Figure 22. Examining top gasket for warpage.

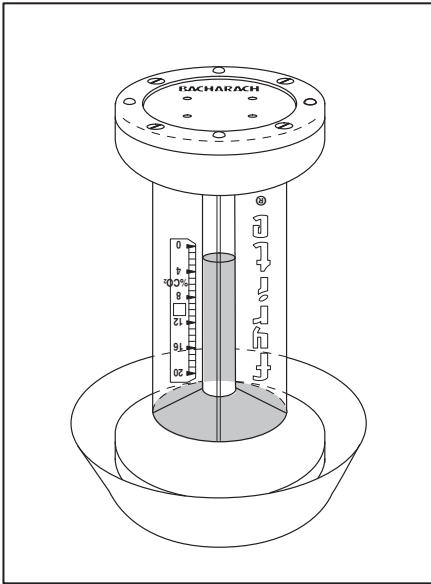


Figure 23. FYRITE inverted in test dish (overnight) for leakage test.

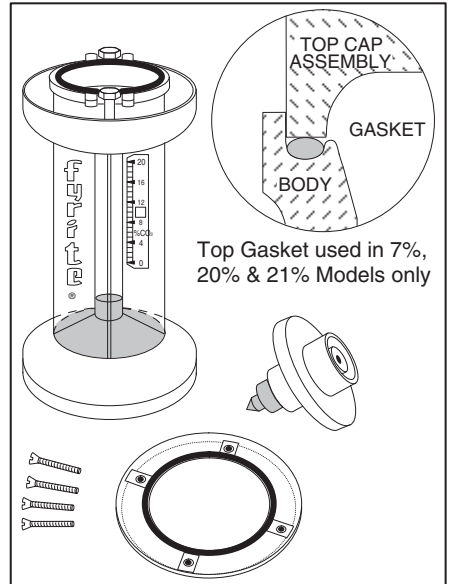


Figure 24. Top gasket properly centered in top flange of body.

mine replacement parts necessary for repair, or drain instrument and return if factory service or repair is desired.

6.5 Cleaning FYRITE

Use only soapy lukewarm water if cleaning is required (lukewarm water is usually sufficient).

NOTE: *Use of gasoline, naphtha, carbon tetrachloride or any other organic solvent or oil will destroy plastic and rubber parts.*

6.6 Replacing FYRITE Plastic and Rubber Parts (Refer to Illustrated Parts List FYRITE CO₂/O₂ [Section 7.0 and Fig. 33])

Replace plastic parts when cracked or crazed in location exposed to fluid and rubber parts when badly swollen, warped or showing other evidence of deterioration.

In replacing Top Gasket, make certain it is properly centered in the recess provided in top flange of FYRITE Body (See Figure 24). When installing plastic Top Cap Assembly, be sure that assembly is centered on Top Gasket.

To remove Top Cap Assembly or replace Top Cap, Plunger Valve, or Plunger Tip Gasket, use the procedure as outlined in Section 6.3.

When replacing Plunger Tip Gasket, simply depress Plunger Valve against its spring limit and strip old Gasket from the end of Plunger Valve.

Before assembling new Gasket, wet inside surface of Tip Gasket, then force it over the end of Plunger Valve (after depressing Plunger Valve against the spring limit).

Make certain that new Tip Gasket is seated uniformly against the mating surface in plastic Top Cap.

To replace Diaphragm, stand FYRITE upside down, remove 4 screws and metal Bottom Cap.

Refer to Figure 25a. Remove old Diaphragm and center new replacement with the lettering facing you, so that after the FYRITE Bottom Cap is installed the letters will face up into its recess. Center Bottom Cap Assembly in Body Recess and reinstall 4 screws, observing same precautions in tightening as outlined in Section 6.3.

To replace Body, remove the 4 hex head Bezel screws and 4 Bezels. Install Bezels on new Body.

NOTE: *Make certain the rubber bezel gaskets are properly seated and clamped between bezel and body as shown in Figure 25.*

6.7 Aspirator Bulb - Sampling Assembly (Refer to Figs. 26, 27, & 28)

Defective Check Valves or a leaking Sampling Assembly can result in sample loss, or sample dilution with resultant loss of accuracy.

To inspect Sampling Assembly, seal hole in the center of rubber Connector Tip firmly

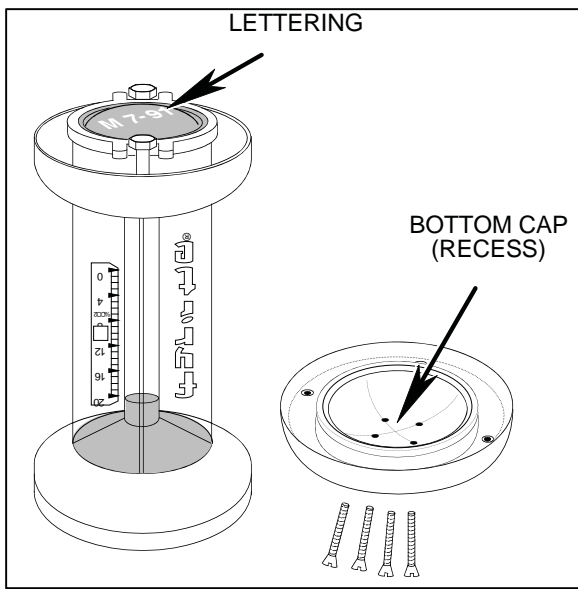


Figure 25a. Replacement Diaphragm properly installed.

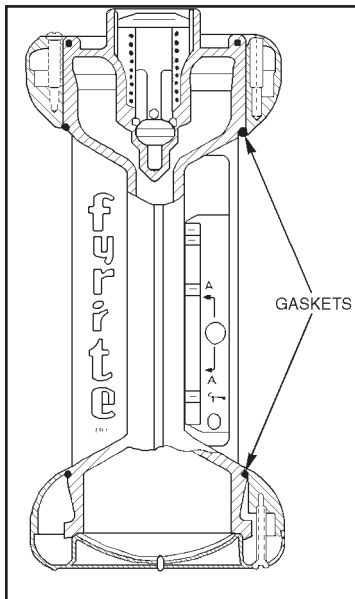


Figure 25. Locating Bezel Rubber Gaskets.

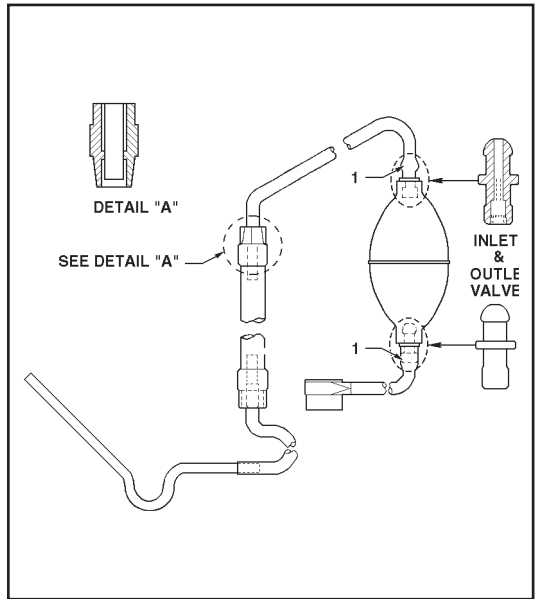


Figure 26. FYRITE Sampling Assembly; Locating Inlet/Outlet Check Valves.

with finger and squeeze Aspirator Bulb (Figure 27). Bulb should remain firm. If Bulb collapses, check Bulb and Hose to Connector Tip for cracks or other source of leakage. Replace defective parts. If there are no apparent leaks in the Sampling Assembly, replace Inlet Check Valve. **Small hole end of Inlet Check Valve fits in Hose and large hole end fits in the Aspirator Bulb (Figure 26).**

Now seal end of metal Sampling Tube with finger, and collapse Aspirator Bulb. (Figure 28). If the Bulb returns to original shape in less than 15 seconds, inspect Hose, Filter, Saturator Tube and Metal Sampling Tube for leaks. If none are found, replace the Outlet Check Valve. **Small hole end of Outlet Check Valve fits in Aspirator Bulb and large hole end fits in the Hose (Figure 26).**

Discard Filter Packing when it becomes dirty or clogged. Push old packing out of, and new packing into, Filter Saturator Tube with a pencil or small rod (See Section 6.9).

6.8 Storing FYRITE and Refill Fluid

When FYRITE is not used over periods between tests, store it and its Sampling Assembly in a cool, dry place. Prolonged storage, for example, at high temperatures reached in an automobile trunk over the Summer is not recommended. When stored unused over the Summer, it is good practice to drain old fluid and replace with fresh charge (fluid) when needed in the Fall.

FYRITE Refill Fluid should also be stored in a cool, dry location in the carton provided. A recommended practice is to accumulate stock only sufficient for one year requirement and to use oldest stock first. Fluid can be tested for performance according to Section 6.2.

Use only Bacharach CO₂ or O₂ Fluid Refills for the range FYRITE selected. The Kits below contain three Refill Bottles each.

7% CO ₂ range	Refill Kit 10-5100
20% and 60% CO ₂ range	Refill Kit 10-5057
7% O ₂ range	Refill Kit 10-5103
21% and 60% O ₂ range.....	Refill Kit 10-5060

6.9 Replacing Saturator Filter Packing Part #11-0121 (Refer to Figs 29 thru 32)

Remove the filter tube nipple and bushing (See Figure 29) from each end of the tube. Use a pencil or similar object to remove packing when it becomes dirty or clogged.

Wrap replacement packing around the hand (See Figure 30). If testing unsaturated gases (most non-combustion applications), saturate packing in water as shown in Figure 3, and squeeze out excess moisture.

Insert saturated packing using a pencil or small rod into filter tube (See Figure 32); then reassemble nipple and bushing.

7.0 ILLUSTRATED PARTS LIST FYRITE CO₂/O₂ (Refer to Figure 33 FYRITE Parts Breakout)

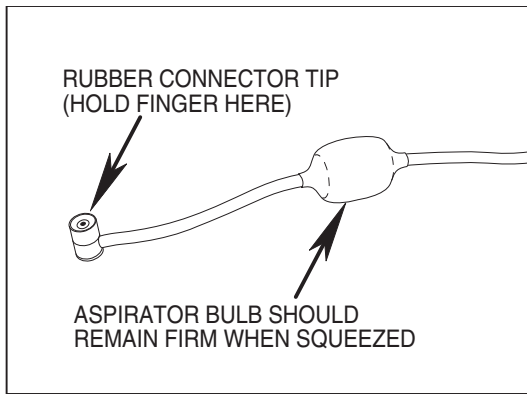


Figure 27. Testing Sampling Assembly (outlet side) for leaks.

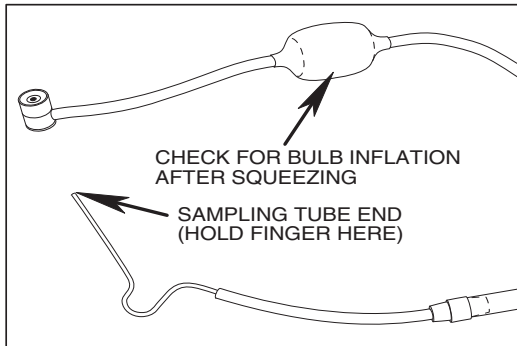


Figure 28. Testing Sampling Assembly (inlet side) for leaks.

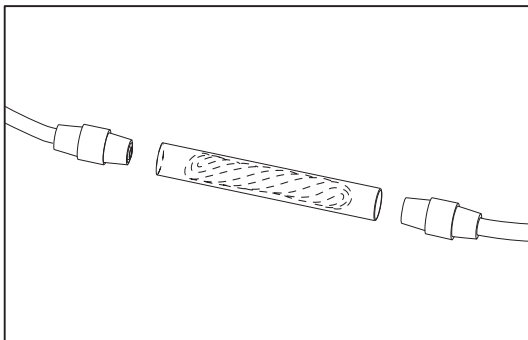


Figure 29. Removing End Plugs from Saturator Filter Tube.

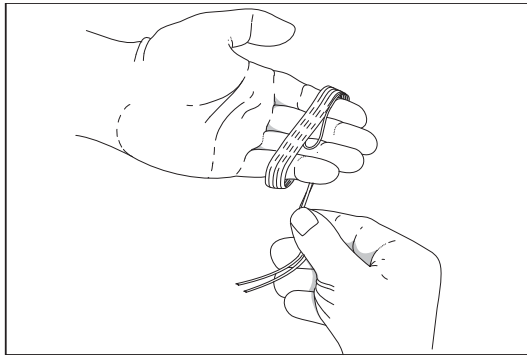


Figure 30. Wrapping Replacement Filter Material.

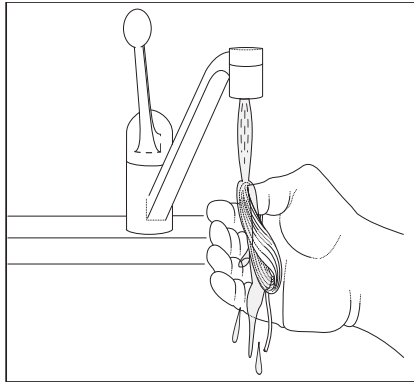


Figure 31. Wet Filter Material then squeeze out excess water.

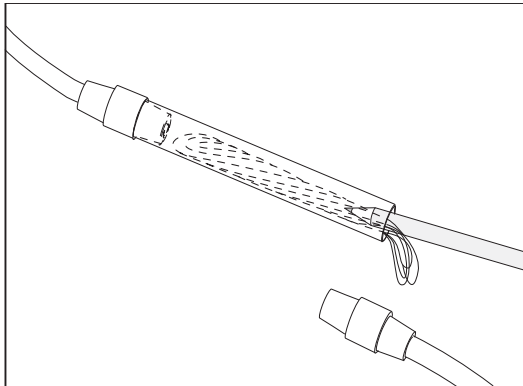


Figure 32. Installing wetted Filter Material into Saturator Tube.

Part #	Description	Qty-Rq'd
11-0102	Bezel	4
11-0188	Oval Head Screw	8
11-0110	Bezel Screw	4
11-0109	Top Cap Ring Gasket (Optional, Part of 11-0136)	1
11-0105	Scale Screw	1
02-3690	Scale Screw Nut	1
11-0021	Diaphragm	1
11-0126	Bottom Cap	1
11-0132	Top Cap	1
11-0019	Valve Plunger	1
11-0026	Valve Plunger Spring	1
11-0020	Valve Plunger Gasket	1
11-0136	Top Cap Ring with Gasket	1
11-0143	Top Gasket (7%, 20% & 21% Models only)	1
11-0140	FYRITE Body (All Models except 7.0% CO ₂ / O ₂)	1
11-0154	FYRITE Body (7% Models only)	1
11-0062	Filler 60% FYRITE (Adapter Plug)	1
05-5134	Bezel Gasket "O" Ring	2
05-5169	O-Ring Filler (Outer 60%)	1
05-5155	O-Ring Filler (Inner 60%)	1
11-0144	CO ₂ Scale 20%	1
11-0145	O ₂ Scale 21%	1
11-0147	CO ₂ Scale 60%	1
11-0150	O ₂ Scale 60%	1
11-0155	CO ₂ Scale 7%	1
11-0157	O ₂ Scale 7%	1
10-5057	Carton of FYRITE CO ₂ Fluid (3 Bottles) 20/60% range Models	1
10-5060	Carton of FYRITE O ₂ Fluid (3 Bottles) 21/60% range Models	1
10-5100	Carton of FYRITE CO ₂ Fluid (3 Bottles) 7% range Models	1
10-5103	Carton of FYRITE O ₂ Fluid (3 Bottles) 7% range Models	1

7.1 FYRITE ILLUSTRATED PARTS

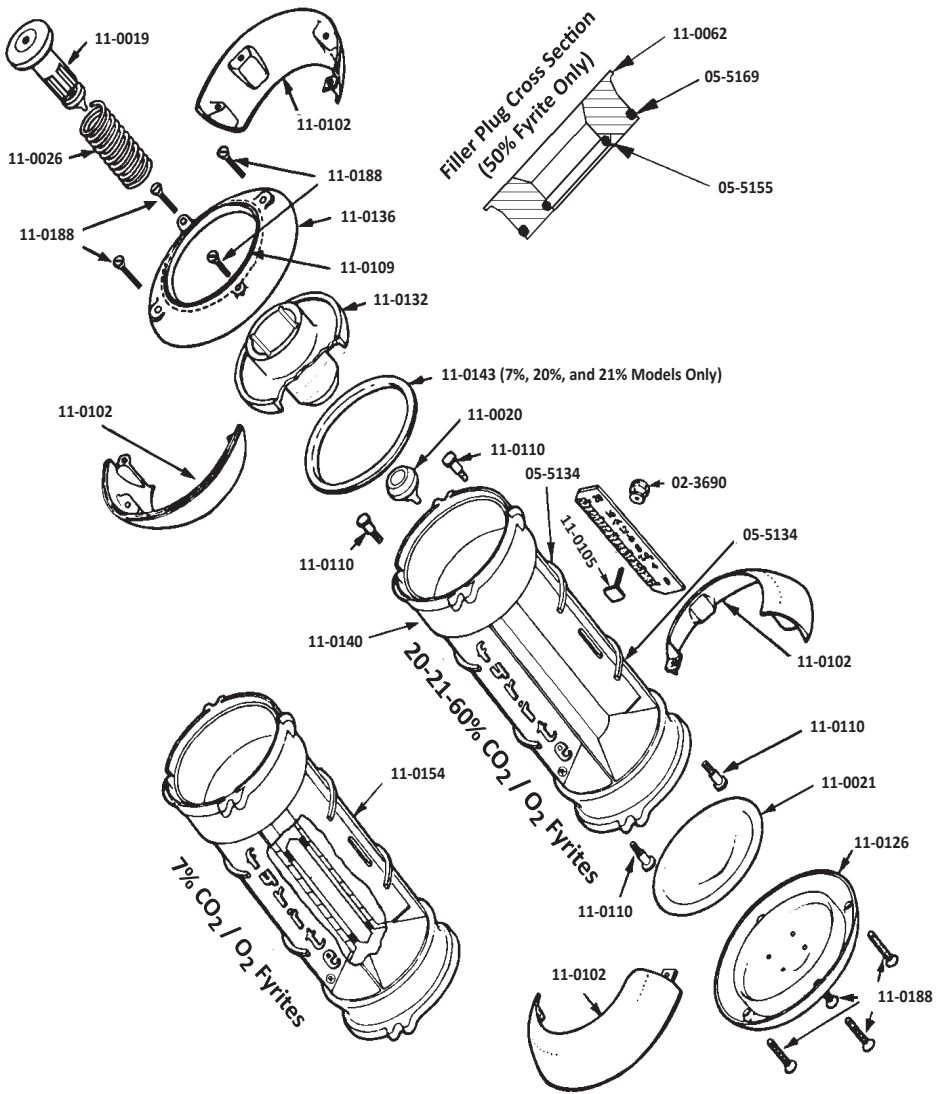


Figure 33. FYRITE parts breakout.

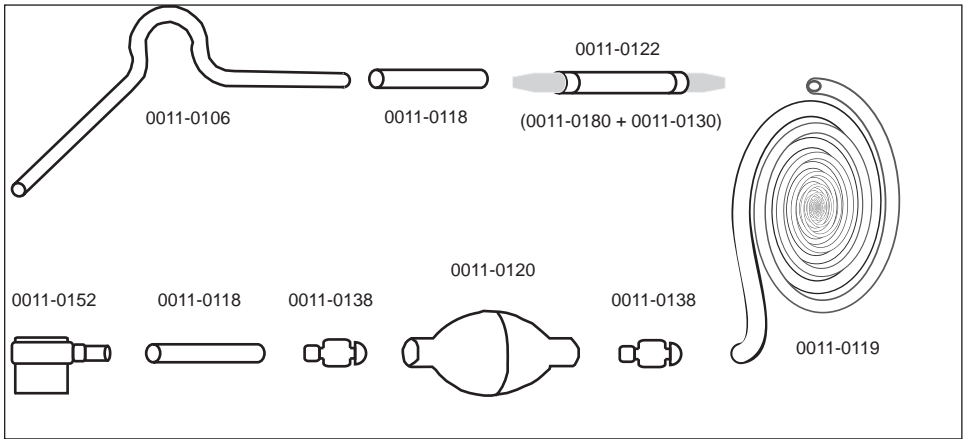
7.2 PARTS LIST FOR FYRITE SAMPLING ASSEMBLIES

STANDARD SAMPLING ASSEMBLY

Part No. 11-7029

Gases saturated with water vapor (combustion products).

Dry gases when filter material is wetted.



Current Part #	Former List #	Description	# Req'd
11-0152	10-0019	Connector Tip with Tube	1
11-0156	10-0029	Rubber Tubing, 10' Length	1
11-0118	10-0020	Rubber Tubing, 6" Length	2
11-0165	10-0030	Filter Tube, Aluminum	1
19-5004	19-9004	Gas Collecting Bladder with Orifice	1
11-0120	10-0022	Aspirator Bulb	1
11-0138	10-0023	Inlet/Outlet Valve (Red)	2
11-0119	10-0024	Rubber Tubing, 3' length	1
11-0180	10-0025	Filter Nipple with Bushing	2
11-0130	10-0026	Filter Tube, Plastic	1
11-0106	10-0027	Sampling Tube	1
11-0161	10-0040	Condenser Coil	1
11-0179	10-0042	Rubber Tubing, 15' length	1
11-0121	10-0033	Envelope of Filtering Material (10 per pack)	
11-0181	10-0032	Filter Saturator (Aluminum) Assembly Comprising 11-0180, 11-0122, and 11-0165	

Notes

Notes

Notes

Bacharach, Inc.

621 Hunt Valley Circle, New Kensington, PA 15068

Phone: 724-334-5000 • Fax: 724-334-5001 • Toll Free: 800-736-4666

Web: www.mybacharach.com • E-mail: help@mybacharach.com

