Garrett Gas Train

Instruction Manual

Manual No. 209962, Revision E

Instrument No. 209961

fann®
Fann Instrument Company

Garrett Gas Train Instruction Manual

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1 Introduction

During the drilling operation, several gases are present in the drilling fluid. Hydrogen sulfide (H_2S) and carbon dioxide (CO_2) are undesirable gases that can be detected and quantitatively measured using the Garrett Gas Train method.

Hydrogen sulfide gas is toxic and dangerous to human health. At 20 ppm hydrogen sulfide is a health hazard and can be fatal at higher concentrations. The results of a Garrett Gas Train analysis reveal whether or not sulfide concentration in the drilling fluid is increasing or that hydrogen sulfide gas could be released into the atmosphere.

Carbon dioxide (CO_2) in the drilling fluid can cause severe corrosion and damage to the drilling rig equipment. Knowing the concentration of carbonates in the drilling fluid makes it possible to calculate the treatment dosage necessary for corrosion control.

Fann's Garrett Gas Train kit contains the equipment and reagents for measuring the concentration of soluble sulfides and soluble carbonates in drilling fluids according to API Recommended Practice 13B-1 and 13B-2. This kit consists of the Garrett Gas Train apparatus, Dräger tubes, gas cartridges, reagents, and a pressure regulator.

1.1 Garrett Gas Train Method

The Garrett Gas Train has three chambers. Sample is added to the first chamber where it is mixed with acid. An inert carrier gas carries hydrogen sulfide or carbon dioxide that is released through the chambers. This gas stream passes through a Dräger Tube in the third chamber. The Dräger tube contains chemical reagent on solid material which reacts to the gas and changes color.

1.1.1 Hydrogen Sulfide Detection

A Dräger tube is the preferred H_2S detector for quantitative sulfide analysis. The Dräger tube responds to H_2S by progressively darkening along its length as the H_2S reacts with the reagent.

A hydrogen sulfide test paper disk can be used in the Garrett Gas Train for routine tests to detect H_2S, noted by discoloration of the hydrogen sulfide test paper. A Dräger tube should be used for quantitative analysis.

Total soluble sulfides include sulfide (S^{2-}) and bisulfide (HS^{-}) ions. Two types of Dräger tubes are used to adequately span the range of hydrogen sulfide concentration in drilling fluids. A low-range Dräger tube, H_2S 100/a, is white until H_2S turns it brownish-black. A high-range Dräger tube, H_2S 0.2%/A, is pale blue until H_2S turns it jet black. These color changes are characteristic of a reaction with H_2S.

The Dräger tube changes color along the length of the tube as the reaction occurs. The length of the darkened section depends not only on the concentration of sample gas, but also depends on the flow rate and time that sample flows through the tube. Tube factors that relate to the divisions on the tube are listed in Table 4-1and 6-1 for hydrogen sulfide concentration and carbonate concentration, respectively.

For water-based drilling fluids, the filtrate is tested for sulfides. For oil-based drilling fluids, the entire drilling fluid is analyzed for active sulfides. Active sulfides are typically the neutralization products of H_2S and lime plus any unreacted H_2S. A weak acid is added to the oil-based drilling fluid and H_2S gas from active sulfides (not inert sulfides) is released.

1.1.2 Carbon Dioxide Detection

The concentration of soluble carbonates in the water-based drilling fluid filtrate can be determined by Garrett Gas Train. Total soluble carbonates include carbon dioxide (CO_2), carbonate (CO_3^{2-}) and bicarbonate (HCO_3^{-}) ions.

Acid is added to the drilling fluid filtrate in the Garrett Gas Train, and carbonates are converted to CO_2, which is transported by an inert gas. The gas stream is collected in a one liter bag and drawn through a Dräger tube at a fixed flow rate. The Dräger tube responds to the CO_2 by progressively staining along its length, as the CO_2 reacts with a chemical that causes a crystal indicator to turn purple. The stain length is sensitive to the CO_2 amount, but it also responds to the CO_2 distribution, total volume, and gas flow rate.

1.2 Document Conventions

The following icons are used as necessary in this instruction manual.

NOTE. Notes emphasize additional information that may be useful to the reader.

CAUTION. Describes a situation or practice that requires operator awareness or action in order to avoid undesirable consequences.

MANDATORY ACTION. Gives directions that, if not observed, could result in loss of data or in damage to equipment.

WARNING! Describes an unsafe condition or practice that if not corrected, could result in personal injury or threat to health.

ELECTRICITY WARNING! Alerts the operator that there is risk of electric shock.

HOT SURFACE! Alerts the operator that there is a hot surface and that there is risk of getting burned if the surface is touched.

EXPLOSION RISK! Alerts the operator that there is risk of explosion.

2 Safety

Safe laboratory practices and procedures should be observed while operating and maintaining the Garrett Gas Train.

Safe operation of the Garrett Gas Train requires that the user be familiar with the proper operation and potential hazards associated with pressurized equipment.

While pressurizing the Garrett Gas Train cell, even at low pressure, the cell or associated pressurization equipment may leak and/or release sample gas or pressurizing gas which could cause serious injury.

Several precautions that should be observed are listed in this section.

- Usually carbon dioxide is the choice of pressurizing gas when testing sulfides.
- Nitrous oxide (N_2O) or nitrogen must be used for the carbonates analysis.

Carbon dioxide, nitrous oxide, and nitrogen are the gases used with the Garrett Gas Train. Never connect this instrument to any other gas.

- Nitrogen must be supplied from an approved nitrogen gas cylinder. Nitrogen cylinders must be secured and meet all safety standards. Refer to Table 9-1 (first four items) for the equipment required for nitrogen connection.
- Carbon dioxide and nitrous oxide are normally supplied in small cartridges, which contain about 900 psig (6206 kPa) pressure. They are primarily used for pressurization.

Keep the CO_2 cartridges away from direct sunlight or heat. These cartridges can explode if overheated.

- Maintain pressure regulators in good condition. Never use oil on pressure regulators.
- Leaking pressurization systems should be repaired or replaced.
- Gauges, fittings and hoses should be kept in good condition and leaks should be found and corrected. Refer to Section 8-2 Pressure Regulator Maintenance.
- Periodically test the safety relief valve attached to the regulator. Never plug or bypass this safety valve.
- When preparing to pressurize the Garrett Gas Train cell, always make sure the regulator is closed. (T-screw backed all the way out, counterclockwise.)
- Hydrogen sulfide (H_2S) smells like rotten eggs. Prolonged exposure to this gas will deaden sense of smell and the user will assume the danger is over. However, hydrogen sulfide concentrations may be present at dangerously high concentrations, with no perceivable odor.

When collecting H_2S samples for Garrett Gas Train, use extreme caution. Avoid breathing any hydrogen sulfide. Use an approved breathing mask or breathing air backpack.

3 Features and Specifications

The Garrett Gas Train kit contains the apparatus, laboratory supplies, and reagents to perform sulfide and carbonate analyses. The Garrett Gas Train apparatus meets API RP specification. See Table 3-1 Garrett Gas Train Specifications.

Tables 3-2, 3-3, and 3-4 list the required equipment for specific tests and drilling fluid samples. The equipment listed in Table 3-2 is also required for these tests.

Figure 3-1 Garrett Gas Train Kit

Table 3-1 Garrett Gas Train Specifications

Apparatus Material	Transparent acrylic; inert to acid, H_2S, and sulfides	
Chamber 1	Depth	3.54 in. (90 mm)
	Diameter	1.52 in. (39 mm)
Chambers 2 & 3	Depth	3.54 in. (90 mm)
	Diameter	1.18 in. (30 mm)
Passages Between Chambers	0.08 in. (2 mm)	
Dispersion Tube	Stem Length	7.1 in. (180 mm)
	Stem Diameter	0.315 in. (8.0 mm)
	Frit	Medium porosity
	Frit Diameter	1.18 in (30 mm)
Flowmeter	Floating Ball, Plastic Body, 0.06 to 0.5 LPM (60 to 500 cm^3 per minute) air	

Table 3-2 Required Equipment for All Tests

Item	Specifications	
Gas Train Apparatus	Refer to Table 3-1	
Pressure Regulator Assembly	Pressure Regulator	High pressure – Low flow, chrome plated
	Pressure Gauge	30 psig (207 kPa), dial 1.5 in. (38 mm), chrome plated
	Needle valve (bleed valve)	1/8 in. NPT, chrome plated
	Relief Valve	Adjustable, 5–25 psig (34.5–172.5 kPa)
	Pressure Source	CO_2 or NO_2 cartridges
Hypodermic Syringe	10.0 ml glass or plastic (inert to oil-based drilling fluids), Luer-Lok™	
Graduated Cylinder	25 ml TC, glass, 0.2 ml divisions, ± 0.2 ml	

Table 3-3 Required Equipment for Sulfides Test

Water-based Drilling Fluids	Oil-based Drilling Fluids
CO_2 Cartridges	CO_2 Cartridges
Sulfuric Acid, 5N ACS reagent grade	Citric Acid/IPA Demulsifier
Octanol Defoamer	Octanol Defoamer
Dräger Tube, Low Range: H_2S 100/a, 100 to 2000 mg/L	Dräger Tube, Low Range: H_2S 100/a, 100 to 2000 mg/L
Dräger Tube, High Range: H_2S 0.2%/a, 0.2% to 7.0%	Dräger Tube, High Range: H_2S 0.2%/a, 0.2% to 7.0%
Hypodermic Syringe	Hypodermic Syringe
Graduated Cylinder	Graduated Cylinder
H_2S Test Paper Disks[a]	Heated Magnetic Stirrer[b]

[a] Hydrogen sulfide test paper disks (P/N 210141) are optional and must be ordered separately.

[b] A magnetic stirrer (P/N 205996) is required, but not supplied in this kit. This item is available as a separate purchase.

Table 3-4 Required Equipment for Carbonate Test

Water-based Drilling Fluids
Dräger CO_2 Tube: CO_2 100/a (No. 8101811)
Dräger Alcotest® Test Gas Bag, 1 liter
Dräger Multigas Detector with hand-operated pump, Model 31
Stopcock, 2-way bore, 8 mm glass with PTFE plug
Sulfuric Acid, 5N reagent grade
Octanol Defoamer and dropper bottle
Nitrous Oxide Cartridges

A nitrogen gas cylinder with a low-pressure regulator can be used for both sulfides and carbonate tests. See Section 7 Nitrogen Pressurization for instructions on connecting to the Garrett Gas Train.

4 Sulfide Analysis of Water-Based Drilling Fluids

The Garrett Gas Train and required equipment for this analysis is shown in Figure 4-1. This section describes the setup and procedure using this kit.

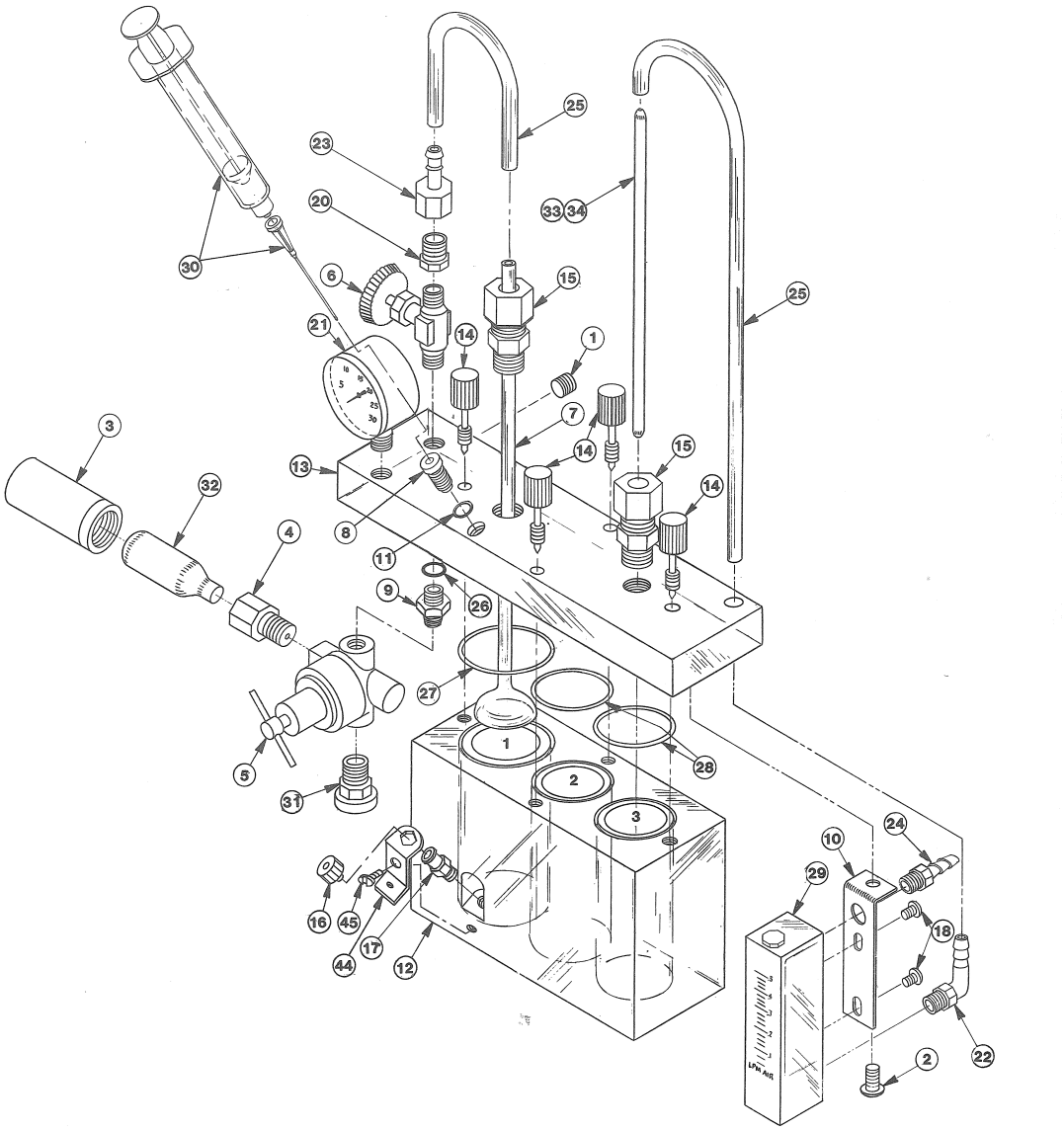

Figure 4-1 Garrett Gas Train Sulfide Analysis: Water-Based Drilling Fluids

4.1 Set Up

Refer to Figure 4-1.

If it is not known that CO_2 gas was used in the last test, the regulator, tubing, and dispersion tube should be purged with CO_2 gas for two minutes.

To run the sulfides test using a hydrogen sulfide test paper disk instead of the Dräger tube, fit the test disc under the O-ring of chamber 3 of the Garrett Gas Train. The hydrogen sulfide test paper will indicate the presence or absence of sulfides in the sample. If flowing CO_2 for fifteen minutes is applied, hydrogen sulfide test paper can provide an estimate of sulfides when compared to a Hach color chart. (The hydrogen sulfide test paper is not preferred for quantitative analysis.)

To run the sulfides test using a hydrogen sulfide test paper, install the 3-in. tube in place of the Dräger tube in chamber 3. Connect the tube to the flowmeter. Omit steps 6 and 7 in this Section 4.1 Set Up, and also omit steps 6 and 7 in Section 4.2 Sample Analysis.

1. Be sure the gas train is clean, dry, and on a level surface, with the top [13] removed.
2. Add 20 ml deionized water to chamber 1.
3. Add 5 drops octanol defoamer to chamber 1.
4. Assemble the top [13] onto the gas train body [12] using the four thumb screws [14]. Make sure the O-rings [27, 28] have properly sealed (flattened around O-ring circumference).
5. Place the dispersion tube [7] in chamber 1 to sit approximately 0.25 in (0.6 cm) above the bottom.

6. Select the proper Dräger tube for the expected concentration of sulfides. (Refer to Table 1 for sample volumes and Dräger tube ranges).

7. Apply Lubriseal® on both ends of Dräger tube. Break the tips on both ends by inserting them in the hole in bracket [44]. With the arrow on the Dräger tube pointed up, insert the tube [33 or 34] into the loosened connector [15] on top of chamber 3 until first line on scale is level with the top of the connector. Hand-tighten the tubing connector nut. Connect the Tygon® tube [25] from the flowmeter inlet fitting [22] to the Dräger tube.

8. Make sure the Luer-Lok™ cap [16] is secured on the sample inlet fitting [17].

9. Loosen (turn counterclockwise) the regulator T-screw [5] until it turns freely.

10. Install and puncture the CO_2 cartridge [32]. Or open the supply pressure, if using nitrogen.

11. Adjust the regulator to 5 psig (34 kPa) on the gauge [21].

Do NOT pressurize higher than 10 psig (69 kPa).

12. Adjust the needle valve [6] for 0.3 to 0.5 liters/minute on the flowmeter [29].

13. Flow CO_2 carrier gas for 15-seconds to purge air from the system. Check the system for leaks as described below.

4.1.1 Leak Test

1. Close the discharge at the top of the flowmeter [29] by fitting a piece of Tygon® tubing [25] over the barbed insert [24], and then plugging or pinching the tubing to seal it closed.

2. Verify approximately 5 psig pressure on gauge [21]. Back out the T-screw on the regulator [5] until it turns freely to shut off the carrier gas supply.

3. Allow the system to remain pressurized approximately 5 minutes and observe the gauge reading. If the pressure is less than 3 psig, use soap solution to find the leak.

4. If the system passes the pressure, remove the tubing plug and readjust the regulator to 5 psig.

5. Shut off the CO_2 carrier gas at the needle valve [6].

4.2 Sample Analysis

The estimated concentration of soluble sulfides will determine the volume of filtrate that will be required. Refer to Table 4-1.

During drilling fluid sampling, filtration, and analysis, avoid extensive exposure to air because sulfides are rapidly lost by air oxidation.

1. Using an API Low Pressure/Low Temperature Filter Press (P/N 207127), run a filtration test on the sample and collect a sufficient volume of solids-free filtrate for analysis. Refer to Table 4-1 for the required volume.

2. Using a 10 ml hypodermic syringe [30], inject the sample into chamber 1 through the injection port [8].

3. Using a clean syringe, slowly inject 10 ml sulfuric acid solution into chamber 1 through the injection port [8]. Gently shake the gas train to mix the acid and the sample.

Moisture in the gas train apparatus can cause the ball in the flowmeter to float erratically and may affect the accuracy of the Dräger tube reading.

4. Immediately restart the CO_2 carrier gas flow by turning the needle valve [6] to achieve a steady flow of 0.3 liters/minute for 4 minutes when using the hydrogen sulfide paper. One cartridge is sufficient for either size Dräger tube and should provide 15 to 20 minutes of charge at 0.3 liters/minute. With the hydrogen sulfide paper, three to four tests can be made with one cartridge, but the paper should not be used more than three or four times. For any quantitative test, the test must be run for 15 minutes.

5. Observe changes in appearance of the Dräger tube. Before the front starts to smear, note and record the maximum darkened length (in units marked on the tube). Although the front may attain a diffuse and feathery color, continue flowing gas for 15 minutes total. If sulfites are present in the sample, an orange color (caused by SO_2) may appear in the high-range tube ahead of the black front. When recording darkened length, the orange SO_2 region should be ignored.

6. When de-pressurizing, shut off the supply pressure by closing the two shut off valves [6] on the CO_2 manifold. If a nitrogen system is being used, close the cylinder valve. Bleed the system of pressure, and then loosen the regulator T-screw.

7. Calculate sulfides in the sample using this equation:

$$GGT\ Sulfides, mg/l = \frac{(Darkened\ Length)\ x\ (Tube\ Factor)}{(Sample\ Volume, ml)}$$

Table 4-1 Dräger Tube Sample Volumes and Tube Factors for H_2S Analysis

Sulfide Range mg/l	Sample Volume ml	Dräger Tube	Tube Factor
1.2 to 24	10.0	H_2S 100/a	0.12[a]
2.4 to 48	5.0		
4.8 to 96	2.5		
30 to 1050	10.0	H_2S 0.2% /a	1450[b]
60 to 2100	5.0		
120 to 4200	2.5		

[a] Tube Factor 0.12 applies to new style tubes, H_2S 100/a (Dräger Tube No. CH-291-01 or Fann Part No. 209967) with calibration marks from 100 to 2000. Older style tubes with 1 to 20 scale use a Tube Factor of 12.

[b] Tube Factor 1450 applies to new style tubes, H_2S 0.2%/a (Dräger Tube No. CH-281-01 or Fann Part No. 209967) with calibration marks 0.2 to 7.0.

5 Sulfides Analysis of Oil-Based Drilling Fluids

The Garrett Gas Train and required equipment for this analysis is shown in Figure 5-1. This section describes the setup and procedure using this kit.

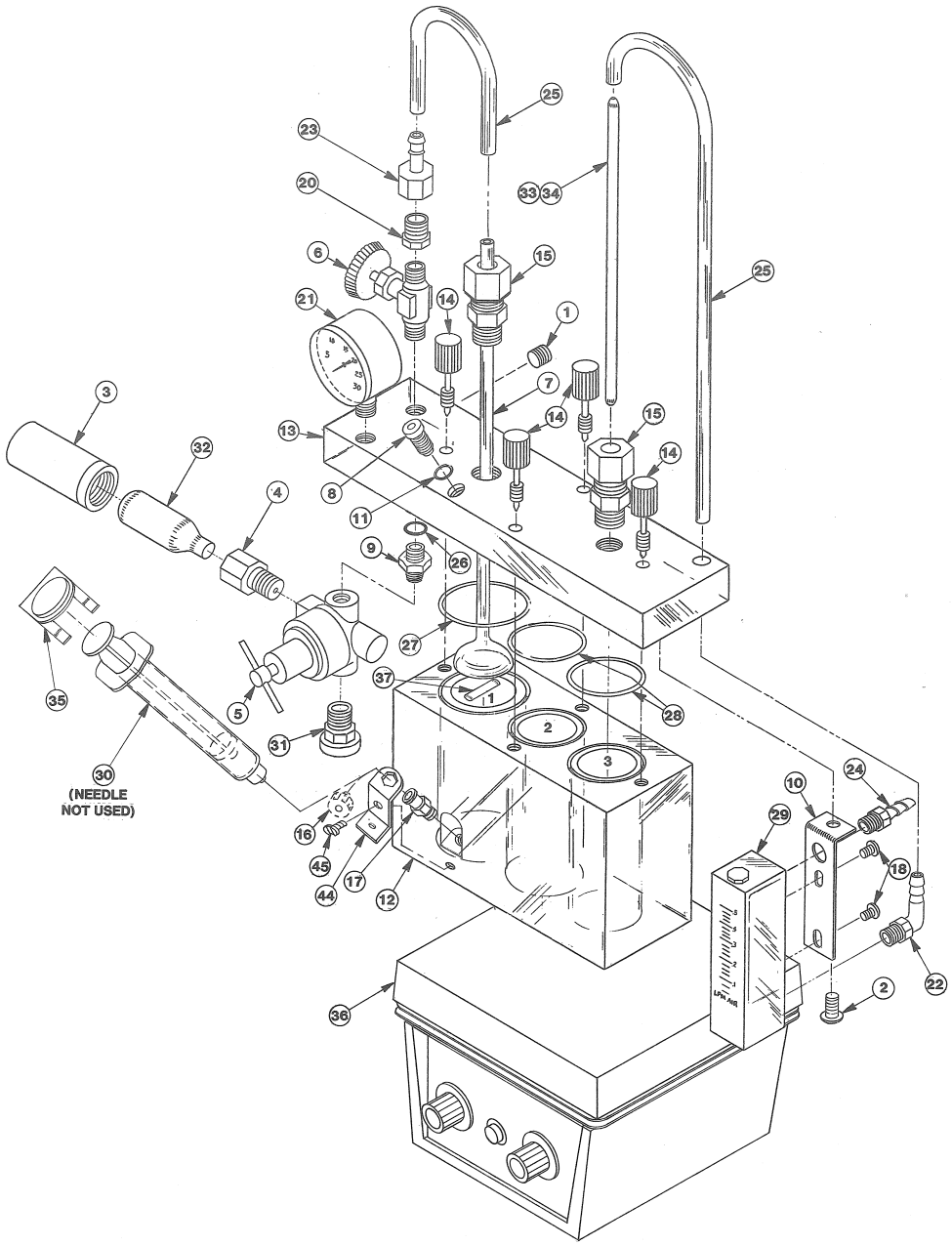

Figure 5-1 Garrett Gas Train Sulfides Analysis: Oil-Based Drilling Fluids

5.1 Set Up

If it is not known that CO_2 gas was used in the last test, the regulator, tubing, and dispersion tube should be purged with CO_2 gas for two minutes.

Refer to Figure 5-1.

1. Be sure the gas train is clean and dry, and the top [13] is removed. Set the body [12] of the Garrett Gas Train on the magnetic stirrer [36], positioning the center of chamber 1 over the center of the stirrer. Place the stirring bar [37] in chamber 1.

2. Add 20 ml of citric acid/demulsifier/isopropyl alcohol solution to chamber 1.

3. Add 10 drops of octanol defoamer to chamber 1.

4. Assemble the top [13] onto the gas train body [12] using the four thumb screws [14]. Make sure the O-rings [27, 28] have properly sealed (flattened around the O-ring the circumference).

5. Loosen and tighten the connector [15] to adjust the dispersion tube [7] in chamber 1 to sit slightly above the liquid level.

6. Select the proper Dräger tube [33 or 34] for the expected concentration of sulfides. Refer to Table 4-1.

7. Apply Lubriseal® onto both ends of the Dräger tube. Break the tips off both ends by inserting them in the hole in bracket [44]. With the arrow on the tube pointed up, insert it [33 or 34] into the loosened connector [15] on top of chamber 3 until first line on scale is level with the top of the connector. Hand-tighten the tubing connector nut. Connect the Tygon® tube [25] from the flowmeter inlet fitting [22] to top of Dräger tube.

8. Make sure the Luer-Lok™ cap [16] is secured on the sample inlet Luer-Lok™ fitting [17].

9. Back out the regulator T-screw [5] until it turns freely.

10. Install and puncture the CO_2 cartridge [32]. Or open the supply pressure, if using nitrogen.

11. Adjust the regulator to about 5 psig (35 kPa) on the gauge [21]. Then adjust needle valve [6] for a flow of 0.3 to 0.5 liters/minute on the flowmeter [29].

12. Keep the dispersion tube [7] frit above the liquid level in chamber 1. Flow CO_2 carrier gas for 15 seconds to purge air from the system and to check for leaks. Shut off the CO_2 carrier gas at the needle valve [6]. Refer to Section 4.1.1 for checking leaks.

5.2 Sample Analysis

The estimated concentration of soluble sulfides will determine the volume of oil-based drilling fluid that will be required. Refer to Table 4-1.

Care should be taken during sampling and analysis to avoid extensive exposure of sample to the air because sulfides are rapidly lost by air oxidation.

Refer to Figure 5-1.

1. Load a 10 ml syringe without needle [30] with a sample of the oil-based drilling fluid. The sample size is the value in Table 4-1 plus 0.1 ml of excess sample. This excess sample (0.1 ml) compensates for the hold-up volume inside the injection fitting.

2. Wipe the outside of the syringe to clean off any sample. Especially clean the area on the tip where the syringe will connect to the injection fitting.

3. Remove the cap [16] from the fitting [17] on the side of chamber 1.

4. Insert the loaded hypodermic syringe into the fitting and turn 1/4 to the right.

5. Turn on the magnetic stirrer [36]. Adjust its speed [37] until a vortex is formed. Then carefully lower the gas dispersion tube [7] into the liquid, just above the rotating stirring bar [37]. Be careful not to let the dispersion tube hit the stirring bar.

6. Very slowly inject the sample, and then lock the syringe closed with the syringe lock clip [35]. Increase the stirring speed to improve dispersion and to prevent the oil-based drilling fluid from sticking to the chamber walls. Continue stirring about one minute.

7. Restart the CO_2 carrier gas flow by turning the needle valve [6]. The flowrate should be about 0.3 liters/minute for 15 minutes. A second cartridge may be required for the full 15 minutes.

8. Observe changes in the appearance of the Dräger tube [33 or 34] which will begin at the inlet end (lower end). Note and record the maximum darkened length (in units marked on the tube) before the front starts to feather and smear. Although the front may attain a diffuse and feathery coloration, continue flowing for a total of 15 minutes. If sulfites are present in the sample, an orange color (caused by SO_2) may appear in the high-range tube ahead of the black front. When recording darkened length, the orange SO_2 region should be ignored.

9. Using the measured sample volume (not including the 0.1 ml hold up volume), the Dräger tube maximum darkened length, and Dräger Tube Factor (Table 4-1), calculate sulfides in the oil drilling fluid sample.

$$GGT\ Sulfides, mg/l = \frac{(Darkened\ Length)\ x\ (Tube\ Factor)}{(Sample\ Volume, ml)}$$

6 Carbonate Analysis

The Garrett Gas Train and required equipment for this analysis is shown in Figure 6-1. This section describes the setup and procedure using this kit.

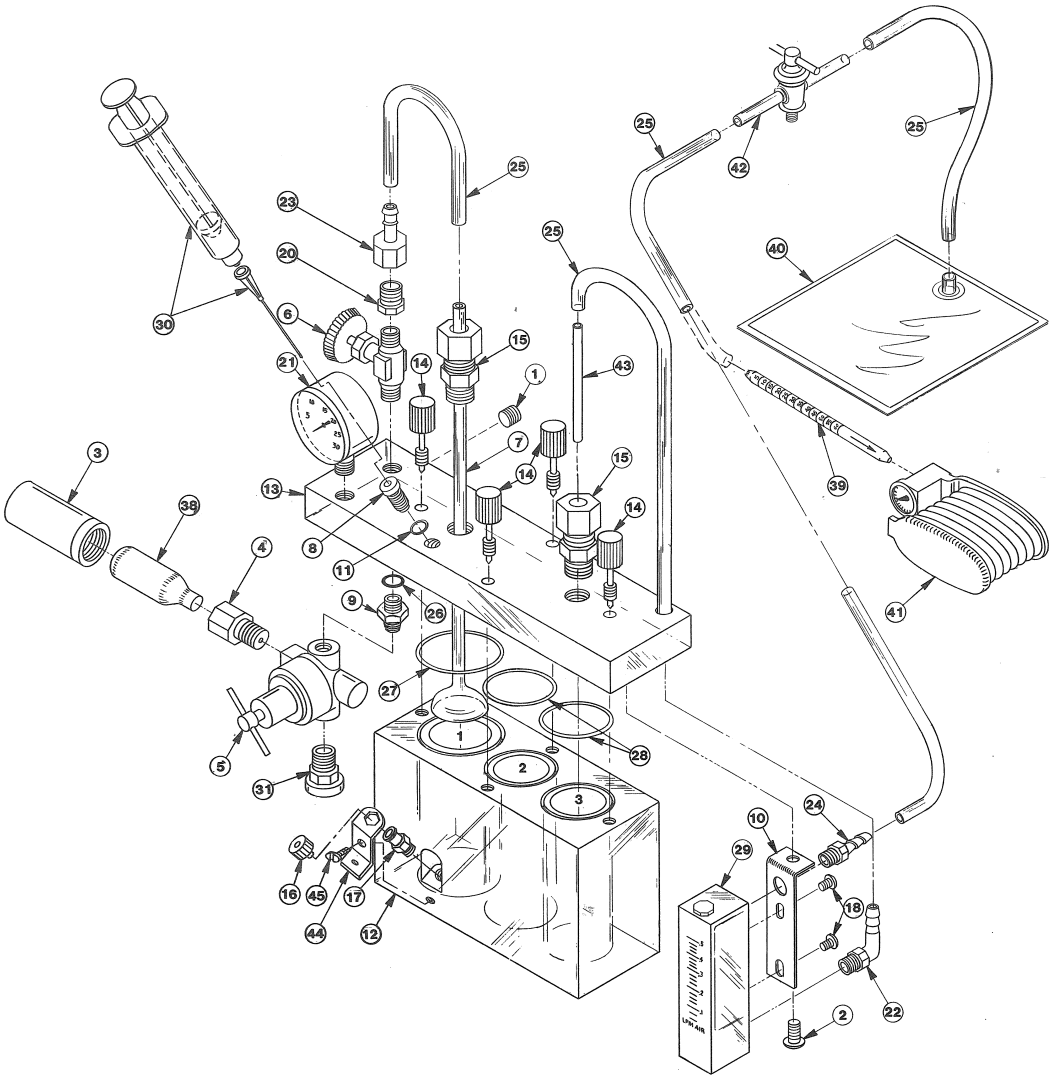

Figure 6-1 Garrett Gas Train Carbonates Analysis

6.1 Set Up

If it is not known that nitrous oxide gas was used in the last test, the regulator, tubing, and dispersion tube should be purged with nitrous oxide gas for two minutes.

See Figure 6-1.

1. Be sure the gas train is clean, dry, and on a level surface, with the top [13] removed.
2. Add 20 ml deionized water to chamber 1.
3. Add 5 drops of octanol defoamer to chamber 1.
4. Assemble the top [13] onto the gas train body [12] using the four thumb screws [14]. Make sure the O-rings [27 and 28] have properly sealed (flattened tops all around O- ring circumference).
5. Adjust the dispersion tube [7] in chamber 1 to approximately 0.5 cm above the bottom.
6. Apply Lubriseal® lubricant to the 5/16-in. x 3-in. plastic tube [43] and insert this tube into the tubing connector [15] on top of chamber 3. Hand-tighten the connector nut.
7. Make sure the Luer-Lok™ cap [16] is secured on the sample inlet Luer-Lok™ fitting [17].
8. With regulator T-screw [5] backed off, install and puncture an N_2O cartridge [38].
9. Adjust the regulator to about 5 psig (35 kPa) on gauge [21]. Then adjust the valve [6] for 0.3 to 0.5 liters/minute on flowmeter [29]. (For maintenance instructions for regulators, refer to Section 8 and Figure 8-1).
10. Flow N_2O for 10 seconds to purge air from the system. Check for leaks. Refer to Section 4.1.1 Leak Test. Shut off the N_2O carrier gas at the needle valve [6].

11. Connect the gas bag [40] and stopcock [42] to the hand pump [41] using tubing [25]. Start with the bag essentially empty. Fully depress and release the hand pump. When the bag is completely empty and free of leaks, the pump will remain depressed for several minutes. If leakage is detected, check the pump and all connections. To check the pump alone, insert a sealed Dräger tube [39] into the pump opening and depress bellows. It will remain depressed if the pump does not leak.

12. With the bag fully collapsed, close the stopcock and disconnect the pump. Install the flexible tubing [25] from the stopcock and bag onto the top barbed tubing connector of the flowmeter [24].

13. Using an API LPLT filter press and standard filtration procedure, collect a sufficient volume of solids-free filtrate for analysis.

6.2 Sample Analysis

1. Fill a 10 ml syringe [30] with solids-free sample and inject the required volume into chamber 1 through the top injection port [8]. Refer to Table 6-1 to determine the sample volume.

2. Fill another 10 ml syringe with sulfuric acid solution and slowly inject 10 ml into chamber 1 through the injection port [8]. Gently shake the gas train to mix the acid and sample.

3. Open the stopcock [42] on the gas bag [40]. Restart the gas flow at a steady flow of 0.1 liters per minute for 10 minutes. This will fill the gas bag with 1 liter of gas. After 10 minutes, shut off the gas flow by closing the valve [6] and the stopcock [42]. Immediately proceed to the next step.

4. Apply Lubriseal® to both ends of the Dräger tube. Break off the tips of the tube [39] by inserting the tips in the hole in the bracket [44]. Remove the tubing [25] from the flowmeter barbed tubing connector [24] and install it onto the upstream end of the Dräger tube. Observe that an arrow on the Dräger tube indicates gas flow direction. Attach the Dräger tube hand pump [41] to the downstream end of Dräger tube [39].

5. Open the stopcock [42] on the bag [40]. With steady hand pressure, fully depress hand pump [41]. Release the pump so that gas flows out of bag and through the Dräger tube. Operate the pump and count the strokes until the bag is empty.

Ten strokes should empty the bag. If it takes more than 10 strokes, there is a leak; test results will not be correct.

6. Calculate total soluble carbonates (CO_3 + HCO_3) in the filtrate sample, using this equation:

$$GGT\ Carbonates, mg/l = \frac{(Stain\ Length)\ x\ (2.5)}{(Sample\ Volume, ml)}$$

Table 6-1 DrägerTube Factors for Carbonate Analysis

Carbonate Range mg/l	Sample Volume ml	Dräger Tube	Tube Factor
25 to 750	10.0	CO_2 100/a	2.5[a]
50 to 1500	5.0		
100 to 3000	2.5		
250 to 7500	1.0		

[a]Tube Factor "2.5" applies to new style tubes, CO_2 100/a (Dräger Tube catalog no. 8101811 or Fann Part No. 209964) with 100 mg/l to 3000 mg/l scale.

7 Nitrogen Pressurization (Optional)

A nitrogen cylinder with a low pressure regulator can be used for sulfides and carbonates analysis by the Garrett Gas Train apparatus.

A nitrogen gas cylinder (P/N 208649), a low-pressure regulator (P/N 208652), adapter (P/N 208603), and 3-ft hose (P/N 207929) are available as separate purchase.

Follow these instructions to connect the low pressure regulator (P/N 208652) to the Garrett Gas Train:

1. Remove the pipe plug [1] shown in Figure 4-1, 5-1, and 6-1.
2. Replace the plug with an 1/4 x 1/8 NPT adapter.
3. Connect the regulator to a nitrogen cylinder.
4. Connect the 3-ft hose from the regulator to the adapter.

8 Troubleshooting and Maintenance

Troubleshooting and regular maintenance procedures are described in this section. If extensive maintenance or service is required, please contact Fann Instrument Company.

8.1 Garrett Gas Train Cleaning and Maintenance

Refer to Figure 4-1, 5-1, or 6-1 for Garrett Gas Train assemblies.

1. Adjust the pressure regulator [5] counterclockwise until the pressure on the diaphragm is released.
2. Remove the Dräger tube [33, 34 or 39] and the plastic tube [43] from connector [15].
3. Remove gas train top [13] by loosening the four thumb screws [14]. Then remove the dispersion tube [7].
4. Wash the chambers with a soft brush, using warm water and mild detergent.
5. Use a pipe cleaner to clean the passages between chambers.
6. Wash and rinse the dispersion tube, and then blow dry it with a dry gas.
7. Rinse the unit with deionized water and let it dry.
8. Inspect the O-rings for cuts, hardening, or flat spots. Make sure the O-ring grooves are clean.
9. Inspect the flowmeter [29] for contamination and/or sticking of the ball. The flowmeter may be dissembled from the gas train cover [13] by removing screw [2]. The plug in the top of the flowmeter can be removed to gain access to the ball and the tube bore.
10. Wash all graduated cylinders, syringes, and other laboratory containers with a soft brush, warm water, and mild detergent.
11. Wash and rinse the dispersion tube, and then blow dry it with a dry gas.

For maintenance of the pressure regulator [5] refer to Section 8.2.

8.2 Pressure Regulator Maintenance

Most regulator malfunctions are caused by leaking fittings or faulty pins and seats. Rarely does a diaphragm rupture.

Refer to Figure 8-1.

8.2.1 Checking for leaks

If regulator will not hold pressure, check the fittings connected to it.

- Apply pressure to the system and look for escaping gas in the form of bubbles. There are two ways to do this:
  - Apply soapy water to the fitting areas.
  - Carefully immerse the entire regulator, except the pressure gauge in a container of water.
- If leaks are apparent, disassemble and apply tape thread sealant to the threads.

Do NOT use oil-based thread sealant or oil on any regulator.

8.2.2 Replacing the seat and pin

If regulator connections do not leak, the seat and pin probably need replacement. Use the following procedure. Refer to items shown on Figure 8-1.

1. Using a wrench on the hex of the spring case, unscrew the spring case. All parts, including the diaphragm will remain in the spring case.
2. Remove the thrust plate.
3. Unscrew the retainer and remove the seat with the pin.
4. Inspect the regulator for dirt or drilling fluid in the regulator body. Clean the regulator body, if necessary. An outlet filter (P/N 208626) is available to prevent dirt or drilling fluid from entering the regulator body.
5. Replace the pin and seat.
6. Reassemble the regulator.

8.2.3 Checking the relief valve

Verify the relief valve will relieve at 12 psig to14 psig (88 kPa to 96 kPa).

Periodically test the safety relief valve, which points down and attaches to the regulator. Refer to item 31 of Figure 4-1, 5-1, and 6-2.

Never plug or bypass this safety valve.

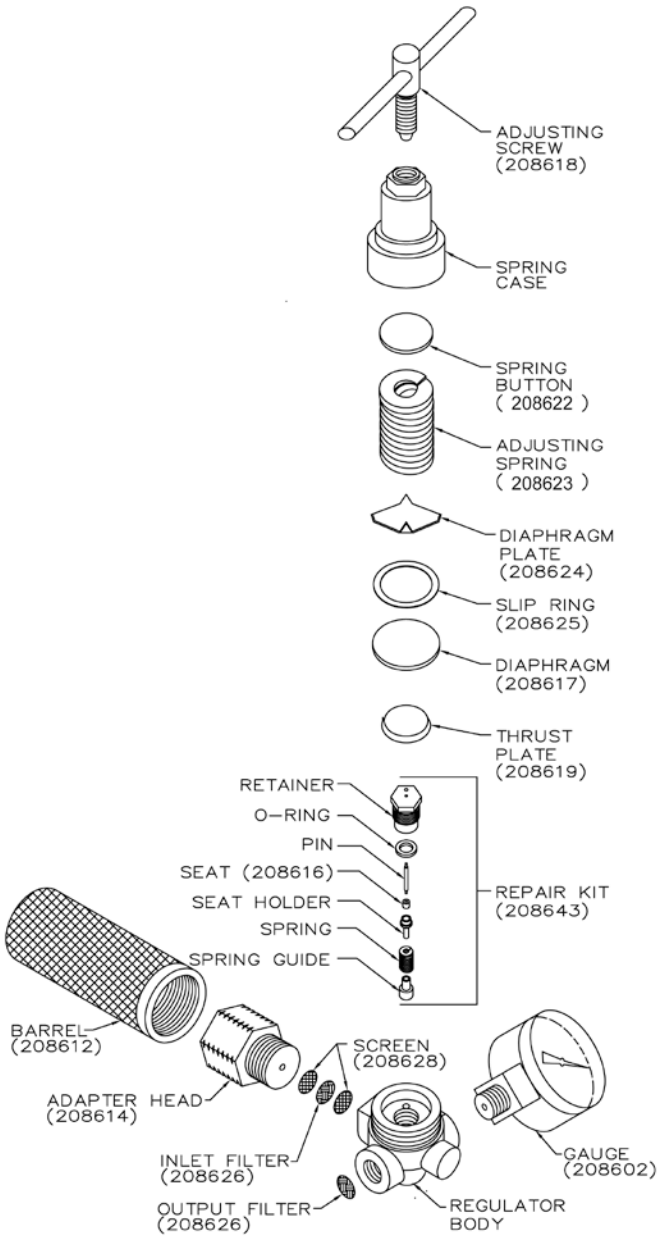

Figure 8-1 CO_2 Regulator Assembly, P/N 208615

9 Accessories

These items are not supplied with the Garrett Gas Train kit. They are available as separate purchases.

Table 9-1 Accessories

Part No.	Description
208603	ADAPTER, 1/4 X 1/8 NPT
210141	HYDROGEN SULFIDE PAPER DISK, 100/PACKAGE
207929	HOSE, 3FT
205996*	MAGNETIC STIRRER, HEATED, 115V, 60 HZ
208649	NITROGEN CYLINDER, SIZE D
208652	REGULATOR ASSEMBLY FOR NITROGEN CYLINDER
209875*	SULFURIC ACID, 5N, 16 OZ., POLYBOTTLE

* Required for test, but not supplied in standard kit.

10 Parts List

Item numbers in Tables 9-1, 9-2 and 9-3 refer to Figure 4-1, 5-1, and 6-1. Some items are not shown in those drawings and are marked as N/S.

Table 10-1 Garrett Gas Train Kit, P/N 209961, Rev H

Item No.	Part No.	Description
—	102047020	GARRETTT GAS TRAIN KIT WITHOUT CHEMICALS
32	208608	CO_2 CARTRIDGES, 10/BOX
38	208609	NITROUS OXIDE CARTRIDGES, 10/BOX
N/S	209818	OCTANOL DEFOAMER, 2 OZ.
N/S	209879	CITRIC ACID/IPA DEEMULSIFIER, 16 OZ.
N/S	205625	STOPCOCK LUBRICANT GREASE, 75 GM

Table 10-2 Garrett Gas Train Kit w/o Chemicals, P/N 102047020, Rev A

Item No.	Part No.	Quantity	Description
1	206776	1	PLUG, 1/8 PIPE
2	207851	1	SCREW, 1/4 - 20 X 1/2, FLOWMETER, MOUNT BRACKET
3	208612	1	CARTRIDGE ADAPTER BARREL
4	208614	1	CARTRIDGE ADAPTER HEAD
5	208615	1	PRESSURE REGULATOR
6	208759	1	REGULATING VALVE
N/S	209962	1	INSTRUCTION MANUAL
7	209965	1	DISPERSION TUBE (FRITTED DISK)
8	209966	1	INJECTION PORT
9	209970	1	ADAPTER, 3/8 - 24 X 1/8 NPT
10	209974	1	FLOWMETER BRACKET
11	209975	1	INJECTION GASKET (11 SPARE)
N/S	102106271	1	CARRYING CASE, PLASTIC
12	209984	1	GAS TRAIN BODY
13	209985	1	GAS TRAIN TOP
14	209963	4	THUMB SCREW 1/4-20
15	209981	2	CONNECTOR, DRÄGER TUBE & FRITTED DISK
16	209982	1	CAP, SAMPLE INLET LUER-LOK™ FITTING
17	209983	1	SAMPLE INLET LUER-LOK™ FITTING
18	203421	2	FLOWMETER MOUNTING SCREW, 10-32 X 1/4 RHMS
20	205588	1	REDUCING BUSHING, 1/4 MNPT X 1/8 FNPT
21	205606	1	PRESSURE GAUGE

Item No.	Part No.	Quantity	Description
22	205615	1	BARBED TUBING ELBOW CONNECTOR, 1/8 MNPT
23	205617	1	BARBED TUBING CONNECTOR, 1/4 FNPT
24	205618	1	BARBED TUBING CONNECTOR, 1/8 MNPT
25	205623	2	TUBING, TYGON®, 1/4 IN (6.3 MM) ID X 1/6 IN (1.6 MM) WALL
26	205651	1	O-RING (1 SPARE), 5/16 X 1/16, NITRILE
27	205666	2	O-RING (1 SPARE), 1-5/8 X 1/16 , NITRILE
28	205667	4	O-RING (2 SPARES), 1-5/16 X 1/16, NITRILE
29	205804	1	FLOWMETER
N/S	205868	1	25 ML GRADUATED CYLINDER
30	205898	4	10 ML PLASTIC SYRINGE W/22 GAUGE NEEDLE
31	205605	1	SAFETY VALVE
32	208608	1	CO_2 CARTRIDGES, 10/BOX)
33	209967	1	DRÄGER TUBES H_2S - LOW RANGE 100 TO 2000 MG/L, 10/ BOX
34	209969	1	DRÄGER TUBES H_2S - HIGH RANGE 0.2% TO 7.0%, 10 /BOX
35	209980	1	SYRINGE PLUNGER LOCK
37	206001	1	STIRRING ROD 1/4 IN (.63 CM) DIA X 1 IN (2.54 CM) LONG
38	208609	1	NITROUS OXIDE CARTRIDGES, 10/BOX
39	209964	1	DRÄGER TUBES, CO_2 ANALYSIS (SCALED IN MG/L)
40	209971	3	DRÄGER GAS BAG, 1 LITER (2 SPARES)
41	209972	1	DRÄGER HAND VACUUM PUMP
42	209973	1	STRAIGHT BORE STOPCOCK
43	209976	1	CONNECTOR TUBE, PLASTIC, 5/16 IN (8MM) DIAMETER X 3 IN (7.6 CM) LONG
44	209979	1	BRACKET, INLET PORT
45	207487	1	SCREW, 6-32 X 1/4 BHMS, INLET PORT BRACKET

Table 10-3 Required Parts (Not Included)

Item No.	Part No.	Quantity	Description
36	205996	1	MAGNETIC STIRRER, HEATED, 115V, 60 HZ
N/S	209875	1	SULFURIC ACID, 5N, 16 OZ., POLYBOTTLE

Table 10-4 Equipment Required for Water-Based Sample, H_2S Detection

Item No.	Part No.	Quantity	Description
32	208608	1	CO_2 CARTRIDGES, 10/BOX)
33	209967	1	DRÄGER TUBES H_2S - LOW RANGE 100 TO 2000 MG/L, 10/ BOX
34	209969	1	DRÄGER TUBES H_2S - HIGH RANGE 0.2% TO 7.0%, 10 /BOX

Table 10-5 Equipment Required for Oil-Based Sample, H_2S Detection

Item No.	Part No.	Quantity	Description
32	208608	1	CO_2 CARTRIDGES, 10/BOX)
N/S	209879	1	CITRIC ACID/IPA DEEMULSIFIER, 16 OZ.
33	209967	1	DRÄGER TUBES H_2S - LOW RANGE 100 TO 2000 MG/L, 10/ BOX
34	209969	1	DRÄGER TUBES H_2S - HIGH RANGE 0.2% TO 7.0%, 10 /BOX
35	209980	1	SYRINGE PLUNGER LOCK
36	205996*	1	MAGNETIC STIRRER, HEATED, 115V, 60 HZ
37	206001	1	STIRRING ROD 1/4 IN (.63 CM) DIA X 1 IN (2.54 CM) LONG

* Required for test, but not supplied in standard kit.

Table 10-6 Equipment Required for Water-Based Sample, CO_2 Detection

Item No.	Part No.	Quantity	Description
38	208609	1	NITROUS OXIDE CARTRIDGES, 10/BOX
39	209964	1	DRÄGER TUBES, CO_2 ANALYSIS (SCALED IN MG/L)
40	209971	3	DRÄGER GAS BAG, 1 LITER (2 SPARES)
41	209972	1	DRÄGER HAND VACUUM PUMP
42	209973	1	STRAIGHT BORE STOPCOCK
43	209976	1	CONNECTOR TUBE, PLASTIC, 5/16 IN (8MM) DIAMETER X 3 IN (7.6 CM) LONG

11 Warranty and Returns

11.1 Warranty

Fann Instrument Company warrants only title to the equipment, products and materials supplied and that the same are free from defects in workmanship and materials for one year from date of delivery. THERE ARE NO WARRANTIES, EXPRESS OR IMPLIED OF MERCHANTABILITY, FITNESS OR OTHERWISE BEYOND THOSE STATED IN THE IMMEDIATELY PRECEDING SENTENCE. Fann's sole liability and Customer's exclusive remedy in any cause of action (whether in contract, tort, breach of warranty or otherwise) arising out of the sale, lease or use of any equipment, products or materials is expressly limited to the replacement of such on their return to Fann or, at Fann's option, to the allowance to Customer of credit for the cost of such items. In no event shall Fann be liable for special, incidental, indirect, consequential or punitive damages. Notwithstanding any specification or description in its catalogs, literature or brochures of materials used in the manufacture of its products, Fann reserves the right to substitute other materials without notice. Fann does not warrant in any way equipment, products, and material not manufactured by Fann, and such will be sold only with the warranties, if any, that are given by the manufacturer thereof. Fann will only pass through to Customer the warranty granted to it by the manufacturer of such items.

11.2 Returns

For your protection, items being returned must be carefully packed to prevent damage in shipment and insured against possible damage or loss. Fann will not be responsible for damage resulting from careless or insufficient packing.

Before returning items for any reason, authorization must be obtained from Fann Instrument Company. When applying for authorization, please include information regarding the reason the items are to be returned.

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