



# USGS COAL DESORPTION EQUIPMENT AND A SPREADSHEET FOR ANALYSIS OF LOST AND TOTAL GAS FROM CANISTER DESORPTION MEASUREMENTS

by

Charles E. Barker <sup>1</sup>, Todd A. Dallegge<sup>2</sup> and Arthur C. Clark <sup>3</sup>

<sup>1</sup>U.S. Geological Survey, Denver, Colorado. [barker@usgs.gov](mailto:barker@usgs.gov)

<sup>2</sup> now with ConocoPhillips, Houston, Texas.

<sup>3</sup>U.S. Geological Survey, Denver, Colorado. [aclark@usgs.gov](mailto:aclark@usgs.gov)

This report is preliminary and has not been reviewed for conformity with the U. S. Geological Survey editorial standards or with the North American Stratigraphic Code. Any use of trade names is for descriptive purposes only and does not imply endorsements by the U.S. government.

Open-File Report 02-496

**U.S. DEPARTMENT OF THE INTERIOR  
U.S. GEOLOGICAL SURVEY**

## Abstract:

We have updated a simple polyvinyl chloride plastic canister design by adding internal headspace temperature measurement, and redesigned it so it is made with mostly off-the-shelf components for ease of construction. Using self-closing quick connects, this basic canister is mated to a zero-head manometer to make a simple coalbed methane desorption system that is easily transported in small aircraft to remote localities. This equipment is used to gather timed measurements of pressure, volume and temperature data that are corrected to standard pressure and temperature (STP) and graphically analyzed using an Excel® based spreadsheet. Used together these elements form an effective, practical canister desorption method.

## Introduction:

This paper presents a system for coal core and drill cuttings desorption that is simplified from existing custom made designs (McLennan et al., 1995; Mavor and Nelson, 1997). This system emphasizes simpler desorption canisters and manometers constructed with off-the-shelf materials and parts. This construction is used because our field areas are usually in remote, sparsely developed areas, our concept is to keep the method and equipment as simple yet light as practical and still have robust equipment that can stand up to unattended air or road transport to remote localities. Further, because the equipment is adapted from widely available, off the shelf equipment, it has proven possible to buy materials and construct canisters in rural locations. Our system, with 10 to 20 three-inch canisters to desorb and sample gases, can fit in three 20 to 40 gallon plastic household storage containers. At the well site, the storage containers also serve as tanks for the constant temperature baths.

## Construction of Basic Desorption Equipment:

### Canisters

The canister body is made from polyvinyl chloride (PVC) plastic pipe and fittings that are all commercially available schedule 40 grade materials (Appendix 1). The canister body diameter is determined by two factors, the core diameter, and the need to fit the core piece length and diameter as closely as possible to minimize headspace. For core diameters in the 2 to 2.75 inch range, we use 3 inch internal diameter schedule 40 PVC pipe. For cores in the 3 to 3.75 in range, we use 4 inch internal diameter schedule 40 PVC pipe. We cut this material in a 14 inch length (Figure 1) for a 12 inch core piece. The extra two inches are to allow one inch for pressure plug insertion and one inch for the inefficient packing of inadvertently broken core pieces. We find that the 14 inch length and 3- and 4 inch pipe diameters cover the common range of coal core pieces available to us. While intermediate PVC pipe diameters may fit core diameters more closely, the pipe fittings for these sizes can be harder to find and even less commonly found in rural field areas. Other sizes are possible based on a scaled version of our design, but we have found that the three and four inch pipe diameters fit most of the common core sizes used on exploration wells.

Core pieces of less than 12 inch length and cuttings sample volumes too small to completely fill a canister can be accommodated with a minimum of headspace by using in-pipe, rather than end of pipe, pressure plugs. The in-pipe plug is simply slid up the

canister body and the hexagon nut tightened using a socket wrench, socket extension and T-handle to reduce the headspace to near the base of the sample. However, we have only found in-pipe plugs for 4 inch internal diameter pipe. Alternately, canisters of various lengths can be made ahead of time or, using a saw, the canister can be cut to length to fit the core pieces. We have also used non-reactive materials, such as marbles, to fill the headspace. A note of caution—we have heard of a case where copper coated BB shot was used to fill the headspace. Subsequently, the shot reacted in the canister and produced far more gas than adjacent samples.

**Construction.** The canister body is cut using a 12 inch chop saw fitted with a fine (50) tooth blade for smooth cuts. The 12 inch blade is used because it can cut completely across a schedule 40 PVC pipe up to 4.5 inch outside diameter. The PVC cap is drilled and tapped with a ¼ inch NPT pipe thread as shown in Figure 1. We use a drill press to keep the tap aligned perpendicular to the cap top. After tapping, the cap is glued on to the cut pipe using the standard PVC cementing procedure consisting of a three step process. Both surfaces to be joined are sequentially swabbed with cleaner, primer and then cement. For aesthetic reasons, we use a clear primer rather than the purple-dyed version. For a better appearance, we also use cleaner to remove dirt as well as the ink marks applied during pipe manufacture. After cleaning and priming a two-inch section at one end of the pipe, the cement is applied liberally to the same pipe portion. The cleaned and primed cap is immediately fitted to the wet cement portion of the pipe, set on a surface with the cap down. A several pound weight is then placed on the open end of the pipe to keep the pipe in place as the cement dries overnight.

After the cement cures, a self-closing quick connect and thermocouple well are threaded into the tapped holes in the cap using Teflon® tape as a sealant on the thread surfaces. Using a felt tip pen, the canister, an appropriate plug and a base, if used, are all assign the same sequence number, so the unit can be kept together after it is weighed. We mark the empty weight directly on the canister with a felt tip pen so this weight is permanently recorded.

### **Manometer.**

Because our spreadsheet is designed to work with desorbed gas volume data collected at ambient temperature and atmospheric pressure, a manometer that makes zero-head measurements is required. A zero head measurement is facilitated using either a sliding reservoir tank, a hand held reservoir, or a hand-held sliding graduated cylinder (Diamond and Levine, 1981; Close and Erwin, 1989; Ryan and Dawson, 1993 McLennon et al., 1995; Diamond and Schatzel, 1998). Our manometer design is based on a design used by River Gas Corporation (Jeffrey Levine, Geologist, Dallas, TX, 2000, written comm.). In this design, zero head measurements are made by manually lifting the measuring graduated cylinder until the water levels in the reservoir and in the measuring graduated cylinder are equal in height and therefore, at zero head (Appendix 1). In our experience, this is the quickest method yet devised for measuring gas volumes at the ambient atmospheric pressure.

### **P-V-T-t instrumentation**

Assessing gas content by the U.S. Bureau of Mines method requires that Pressure (P) volume (V), temperature (T) and time (t) measurements be made rapidly while minimizing the chance for errors. The equipment we use to make these rapid measurements is listed in Appendix 1 (slide 10). The chance for errors is high because the U.S. Bureau of Mines lost gas correction uses measurements made about every 10

to 20 minutes for about the first four hours. At every timed measurement point, the P-T-V-t data must be measured for each canister. This leads to a measurement rate on a 10 foot thick coal core of (10 canisters x 3 to 6 per hour x 4 measurements) of 120 to 240 per hour-- or 480 to 960 measurements over the lost gas period. Such a measurement rate makes errors quite easy for well-site personnel who often work 12 hour or longer shifts during drilling operations. Thus, we recommend a procedure with the lowest measurement cycle time and the simplest measurement methods. Of course, automated readings input directly to the spreadsheet from the measurement devices would reduce error but require more equipment and interconnection that are at odds with our simple and mobile concept and, therefore, are not utilized here.

Temperature. Use very small diameter, grounded sheath thermocouples for the fastest equilibration time in the canister thermocouple well. We use the hand held Cole-Palmer dual thermometer so that we can monitor two temperature probes at once. Note that a water-filled canister has essentially zero head space and headspace temperature measurement is not needed because, in this case, the headspace correction is zero.

Pressure. We now use high-quality electronic barometers that have a calibration traceable to the U.S. National Institute of Standards and Technology (NIST), because we have found that less-expensive electronic barometers (like those used by amateur meteorologists) have a problem with calibration drifts with time and(or) they cannot easily handle elevation change. Although a mercury barometer is more precise and accurate, we don't think its practical to fly or drive one into remote sites. However, we do use mercury barometers as a laboratory standard to periodically check the calibration of our digital barometers.

Time. We use one timepiece for all measurements or at least synchronize all time pieces to rig time as kept in the mud loggers trailer. We use a 24 hour clock, rather than am or pm designation, to minimize errors.

## **Discussion:**

### **Time zero and lost gas correction**

Lost gas is the unmeasured volume of gas that is desorbed from a coal sample from the time it is cut by the drill bit to the time the coal is sealed within the desorption canister. Lost gas is directly controlled by coal diffusivity, pressure gradients in the borehole, and the length of time required to retrieve a sample. Sample temperature as discussed below is an indirect control. Lost gas is estimated by measuring the apparent rate of gas desorption from the sample sealed in the canister. This desorption rate is used to extrapolate back to time zero – the time of the onset of sample desorption during retrieval. Thus, knowing time zero accurately is crucial to determine the volume of lost gas.

Our experiments at several wells indicate a close correspondence between the mud temperature and the coal sample temperature. For drill cuttings, heat transfer is promoted between the large volume of turbulently flowing drilling mud and the relatively small volume of finely divided drill cuttings entrained in the mud. In this environment, cooling is thought to quickly occur and therefore the cuttings rapidly stabilize at the mud temperature as the cuttings travel up the well bore. Similarly, during coring the core is bathed in flowing drill mud, typically on the order of tens of minutes to hours, before retrieval occurs. Our measurements at the well head indicate that core barrels as they

rise out of the drilling mud after coring are at mud temperature as is the core itself immediately after extraction from the barrel. Thus, the drilling mud temperature is the relevant temperature of desorption for an accurate lost gas measurement in either coring or cuttings based desorption.

Given that mud temperature is typically less than formation temperature, then it can be inferred that most core and cutting samples are retrieved with the coal is undersaturated with respect to gas storage capacity. In general, lower sample temperature reached in the mud stream acts to increase the gas storage capacity of a coal. Thus, a saturated coal at virgin formation temperature would, generally, be undersaturated as it is being retrieved in the drilling mud stream.

Most lost gas correction methods calculate lost gas time from a time zero fixed when the borehole hydrostatic pressure due to column of drilling mud becomes less than the formation pressure. However, this estimate of time zero is only true if the coal is saturated at the sample temperature in the borehole. In any case, saturated or unsaturated, desorption will not start until the pressure is less than the critical desorption point (CDP) for that coal. For the purpose of time zero calculation, the critical desorption point is defined by the intercept of the isotherm (measured at the mud temperature) with the line representing the estimated total gas content for that sample. However, because the isotherm and CDP can only be determined after desorption is complete, time zero cannot be accurately determined at the well head. Once the CDP is known then simple calculations using mud weight converted to pressure versus depth together with the measured rate of sample retrieval up the borehole indicate the time during the sample recovery at which borehole pressure is less than the CDP and hence the time of onset of desorption (time zero) during the lost gas period can be calculated.

### **Desorption water tank temperature**

As argued above, lost gas estimates should be run at the mud temperature because this is the temperature at which the gas is actually lost during the desorption experiment. Thus, the bath temperature should be set at the mud temperature for the lost gas period that lasts about 4 hours after the canister is placed in the water bath.

This method has the advantage in that drilling mud temperature is readily measurable at the shale shaker at the time of coring or cuttings capture. This method eliminates dependency on the often dodgy reconstruction of the equilibrium reservoir temperature from BHT or mean annual surface temperature and geothermal gradient from remote wells in the basin or regional data. Direct measurement of mud temperature is an attractive way of setting experimental conditions in real time at the drill site.

### **PVC versus aluminum canisters**

PVC canisters have the advantage of being made of non-corroding, lightweight, non-reactive plastic that is widely available even in remote locations and can be fabricated on-site, i.e., cut to length to minimize headspace. However, care should be taken to make up the canister ahead of time so the solvents used in construction have evaporated to reduce or eliminate interference with measurements of gas composition (wetness).

Aluminum canisters are robust but relatively heavy. The canisters are not easily fabricated in the field and most designs require welding. A significant advantage of aluminum is its high heat conduction leading to faster temperature equilibration in the water tank. A major disadvantage is that aluminum is reactive metal, easily corroded especially by the low pH water associated with coal. The low pH water may react and produce hydrogen gas and alter gas composition and isotopic results.

### **Water versus Helium for filling Canister headspace**

Water. A major advantage of using water to fill the headspace is that it keeps sample moist and may purge non-absorbed air in the headspace that may react with the sample. Maintaining moisture is important because inherent moisture in coals is difficult, and may be impossible, to replace. The main objection to water-filled headspace is that water is the most common biological growth media in the world as well as the most common near-earth-surface chemical reaction media. So while water promotes reactions, carefully filling the headspace with water can essentially fill all of the empty headspace with liquid and displace any gas, including oxygen, that is thought to be capable of rapidly altering coal, especially low rank coal. However, when the coal is cut it is bathed in aerated drilling mud and the extracted core is handled in air before sealing in the canister. So, no conventional coring method will completely preserve the core from air contact. Further, water is an oxide in itself and may be capable of supplying oxygen species to the core. Also, hydrogen exchange may occur between coal and water and affect isotopic analyses of the desorbed gas. Chemical reactions between an aluminum canister and the coal may be enhanced by the presence of water as a solvent and (or) possible galvanic action that a conductive fluid like water makes possible. Some workers suggest that the water pressure of 0.43 to 0.86 psi due to hydraulic head from top to bottom of a typical one to two foot long canister may inhibit desorption – especially when internal canister gas pressure approaches atmospheric pressure near the end of desorption.

Another problem is that because desorbed gas slowly dissolves into the water when the canister is closed and exsolves when it is open, the manometer response can be very sluggish. Consequently, the endpoint of each volume measurement on a water filled canister is a subjective judgment by the geologist. Also, keeping the headspace completely filled proves difficult in practice because the desorbed gas dissolves in the water and when the canister valve is opened to the manometer, the exsolution of gas bubbles can cause the water to move up into the manometer tubing and be lost. So, as volume measurements proceed, zero headspace evolves to a small headspace. Most workers assume that the small headspace that evolves is negligible. Lastly, adding water to fill the headspace may make it necessary to correct the desorbed gas volumes for a continuing contribution of water vapor to the desorbed gas stream (Ryan and Dawson, 1993).

In any case, if water-filled headspace is used, we preheat the distilled water that will fill the canister headspace to the reservoir temperature. This is done by simply placing the jugs of water in the heated tanks well ahead of use.

Helium. A common alternative to water fill is using helium to purge the headspace of air. This method also has disadvantages. First of all, compressed helium tanks are heavy and, by law in the USA, cannot be transported on passenger planes as baggage. Second, relative to distilled water or boiled sterilized local water, helium can be difficult and, likely impossible, to find in remote areas. Third, helium purging also occurs after the canister is mostly filled with coal and sealed. Consequently, because only low pressure helium can be used with safety in plastic-plugged PVC canisters, getting a vigorous flow of gas into and out of the canister through the normal single valve port is mechanically difficult. Purging seems especially ineffective in canisters filled with relatively fine drill cuttings that are tightly packed into a canister. The effectiveness of a helium purge is seemingly increased by repeating the helium fill-and-release procedure several times, but this also extends the lost gas time by about a minute. Lastly, coal samples in helium-filled canisters will dry out as volume measurements proceed and water from the core continues to evaporate into the headspace gas. Some workers infer that drying out of the coal can markedly alter desorption results--especially in low-rank coals. However, this inference is made on canisters that were filled with air rather than helium. It is unknown whether drying out in a helium atmosphere alters desorption results. As in water filled canisters, the partial pressure of water vapor in the desorbed gas stream may be significant and require a correction to the desorbed gas content. A correction for helium produced in the gas stream may also be required if the headspace volume is too large.

We assert that the main advantage of helium purge is that it reduces the possibility of chemical reactions and microbial metabolism compared to a water-filled canister. Another advantage of helium filled canisters is that they are relatively light, and much easier to transport than water-filled canisters.

In any case, if using inert gas to purge the headspace, do not use argon as this interferes with gas composition analysis by chromatography because argon elutes out with any nitrogen naturally present in the desorbed gas.

### **Canister sample density**

It is possible to easily calculate the apparent sample density, once the headspace volume in the canister is measured. The formula is: mass of coal/volume of coal = ((Can + coal mass) - can mass) / (empty canister volume - headspace). Most workers fill the headspace with water and measure the mass of the water added. In this case, the headspace volume is assumed equal to the weight of the water added to the canister converted to volume by assuming that 1gram of water = 1 cc of headspace volume. Adding water is only needed if the headspace helium purge method described above is used. To calculate density using the water filled headspace method requires, in addition to the normal canister and canister+coal mass measurements, the measurement of the mass of water added at the time the headspace is filled at the well site.

For example:

Measured by water addition: can headspace = 1948 g

Total can volume = Empty canister filled with water – canister weight = 2762 g

Therefore, within this canister, coal volume is equal to (2762g – 1948g) x (1cc/g) = 814cc

Can + coal mass = 2122 g

Can mass = 1028 g  
coal mass = 2122g – 1028g = 1094g  
Coal density = 1094g /814 cc = 1.34 g/cc

Note that this is a relatively clean coal. A low-ash bituminous coal has a density of about 1.25 g/cc. Density data are important for resource assessment because plots of density versus total gas volume can be used in conjunction with a density log to estimate the gas content of undesorbed coals and carbonaceous coal in the same borehole.

## References

- Close, J.L. and Erwin, T.M., 1989, Significance and determination of gas content data as related to coalbed methane reservoir evaluation and production implications: Proceedings of the 1989 Coalbed Methane Symposium, The University of Alabama, Tuscaloosa, April 17-20, 1989. p. 37-55.
- Ryan, B.D. and Dawson, F.M., 1993, Coalbed methane canister desorption techniques; in Geological fieldwork 1993, B.C. Ministry of Energy, Mines and Petroleum Resources, Paper 1994-1, pages 245-256.
- Diamond, W.P. and Levine, J.R., 1981, Direct method determinations of the gas content of coals, procedures and results: U.S. Bureau of Mines Report of Investigations 8515, 36 p.
- Mavor, M. and Nelson, C.R., 1997, Coalbed reservoir gas-in-place analysis: Gas Research Institute Report no. GRI-97/0263, 134 p.
- McLennan, J.D., Schafer, P.S. and Pratt, T.J., 1995, A Guide to Determining Coalbed Gas Content: Gas Research Institute Report GRI-94/0396. 181p.

## Review Papers

- Diamond, W.P., and S.J. Schatzel, 1998, Measuring the gas content of coal: a review, in R.M. Flores, ed., Coalbed methane: from coal-mine outbursts to a gas resource: International Journal of Coal Geology, v. 35, p. 311-331.
- Ryan, B.D. and Dawson, F.M., 1993, Coalbed methane canister desorption techniques; in Geological fieldwork 1993, B.C. Ministry of Energy, Mines and Petroleum Resources, Paper 1994-1, pages 245-256.

Note: The appendices listed below refer to linked files. To access these files, click on the link.

**Appendix 1 [Canister and manometer illustrated details of construction and use \(Link\)](#)**

**Appendix 2 [Spreadsheet instructions \(Link\)](#)**

**Appendix 3. Forms for desorption**

- a. [Pre-drilling Desorption Information Checklist \(Link\)](#)
- b. [Form for collecting timed P-V-T from cuttings samples for input into the spreadsheet \(Appendix 4, link\)](#)
- c. [Form for collecting timed P-V-T from core samples for input into the spreadsheet \(Appendix 4, link\)](#)

**Appendix 4. [Excel Spreadsheet for the analysis of canister desorption data \(Link\)](#)**

# Pre-Drilling Desorption Information Check List

I. Well Name: Operator \_\_\_\_\_ Lease \_\_\_\_\_

A. Location \_\_\_\_\_ ° \_\_\_\_\_ Latitude \_\_\_\_\_ ° \_\_\_\_\_ Longitude

B. Elevation: Ground: \_\_\_\_\_ Kelly Bushing \_\_\_\_\_

B. State \_\_\_\_\_ County \_\_\_\_\_ Country \_\_\_\_\_

C. API no. \_\_\_\_\_ Well permit no. \_\_\_\_\_

D. Township: \_\_\_\_\_ Range: \_\_\_\_\_ Section \_\_\_\_\_ ¼ section: \_\_\_\_\_ Baseline \_\_\_\_\_

E. USGS Quadrangle: USGS Geologic Map:

F. Rig road conditions: \_\_\_\_\_ 4x 4: required \_\_\_ suggested \_\_\_ not needed \_\_\_

G. Directions to site from well known point:

## II. Geology

A. Net coal thickness expected in well: \_\_\_\_\_ ft. / Canister spacing \_\_\_\_\_ ft. = \_\_\_\_\_ # cans needed

B. Number of 2-4 ft thick coals: \_\_\_\_\_ ≥ 5ft coals \_\_\_\_\_ For drill cuttings ≈ # cans needed

C. Core points: 1) \_\_\_\_\_ ft 2) \_\_\_\_\_ ft 3) \_\_\_\_\_ ft. 4) \_\_\_\_\_ ft.

D. Core diameter: \_\_\_\_\_ (should be about ¼ to ½ inch less than canister I.D.)

E. For Cuttings: Bit type: \_\_\_\_\_ Vertical or Directional Drilling? \_\_\_\_\_  
( avoid PDC bits because they can grind the cuttings too fine for adequate gas retention).

F. \_\_\_ Caliper; \_\_\_ Gamma; \_\_\_ Neutron density/ porosity logs available from nearby well ?  
(some method to determine depth to coal, net coal, and any local markers)

The nearby well name:

G. BHT, DST (better) or other equilibrium coalbed temperature data available?

If so, the measured equilibrium coalbed temperature: 1) \_\_\_\_\_ °F at \_\_\_\_\_ ft.  
2) \_\_\_\_\_ ° at \_\_\_\_\_ ft. 3) \_\_\_\_\_ ° at \_\_\_\_\_ ft. 4) \_\_\_\_\_ ° at \_\_\_\_\_ ft.

If not, 1) mean annual surface temp. \_\_\_\_\_ °F 2) local geothermal gradient \_\_\_\_\_ °F/100 ft.

## Pre-Drilling Desorption Information Check List (Continued)

### III. Well Site Information:

A. 12 or 24 hour drilling: \_\_\_\_\_ Spud date: \_\_\_\_\_ Estimated days to first coal \_\_\_\_\_

1) Daily high \_\_\_\_\_ ° and low \_\_\_\_\_ ° temp (tank insulation or cooling needed?, etc.)

B. Mud loggers on site? Y or N their names: \_\_\_\_\_

Company: \_\_\_\_\_ Phone at rig : \_\_\_\_\_

If not, Geologist on rig: Y or N If not, is there a mud stream gas detector on rig? Y or N

C. Well Site Geologist: \_\_\_\_\_ Rig Phone: \_\_\_\_\_

D. Company man: \_\_\_\_\_ Rig Phone: \_\_\_\_\_

E. Tool Pusher: \_\_\_\_\_ Phone \_\_\_\_\_ Rig phone : \_\_\_\_\_

B. Cuttings: 1) Stairs or other quick access to shale shaker? (required)

2) a cuttings catcher platform just below the shaker outlet or something to hang a bucket from or somehow place a bucket to catch cuttings

2) Lights at shale shaker (required for night drilling)

3) Water at shale shaker. (required)

C. Space to park USGS Trailer (if used) \_\_\_\_\_ or interior space at rig to put equipment? \_\_\_\_\_

D. Lodging at well site for us: Y or N Food for us at well site: Y or N Showers: Y or N

E. 110 v \_\_ or 220 v \_\_ rig power ? Power stable? Y or N Bring trailer generator? Y or N

F. How close to power source can we get? \_\_\_\_\_ ft . ≈ number of feet of power cable needed.

### IV. Local supplies:

A. Welding supply for He: \_\_\_\_\_ Town: \_\_\_\_\_ Phone: \_\_\_\_\_

B. Hardware store: \_\_\_\_\_ Town: \_\_\_\_\_ Phone: \_\_\_\_\_

D. Local Motel: \_\_\_\_\_ Town: \_\_\_\_\_ Phone: \_\_\_\_\_

F. Local Restaurants: Y or N suggestions: \_\_\_\_\_

G. Best Airport to fly to: \_\_\_\_\_ Town: \_\_\_\_\_ Airlines: \_\_\_\_\_

### V. Shipping address for well site:

### VI. Notes:

Company: \_\_\_\_\_ Well name \_\_\_\_\_ CUTTINGS CAN# \_\_\_\_\_

Location: \_\_\_\_\_ Can Sample interval \_\_\_\_\_

API: \_\_\_\_\_ Mud logger Co and logger names \_\_\_\_\_

CRITICAL DATA: Drilling break depth : \_\_\_\_\_ Drilled Sample Depth \_\_\_\_\_ TVD: \_\_\_\_\_

Time: drilling break \_\_\_\_\_ Time: lag time (min.) \_\_\_\_\_ est. Time: Coal drilled: \_\_\_\_\_

Time canister closed : \_\_\_\_\_ Date: \_\_\_\_\_ Pressure estimator: Mud wt: \_\_\_\_\_ ppg

Reading	Date (mm/dd/yy)	Reading Time (24 Hr clock)	Ambient Temp. (oF)	Barometric Pressure (in. Hg)	$\Delta V$ (cc)	Canister Temp. (oF)	Bath Temp. (oF)	Fix a reading	(Note for fix a reading: use these annotations: $T_a$ = ambient; $T_i$ = internal; $T_b$ = bath; $\Delta V$ = volume; $P$ = pressure; time = t)
0					0.0				< take 0.0 readings as can is closed
1									<b>CRITICAL MASS DATA:</b>
2									1. Can + Coal Mass:
3									2. Empty Can mass:
4									3. (1-2) = raw coal mass:
5									4. -(proxH2O+ash) mass:
6									5. = D.A.F. coal mass:
7									
8									<b>Calc. <math>T_b</math>:</b> do early so bath can heat up
9									$T_b = (dT/dZ \times (\text{sample depth}/100) ) + T_s$
0									$T_s = T_{\text{surface}} = dT/dZ =$
1									$T_b = \text{est. Formation } T =$
2									OR: measure mud temperature
3									out of well=
4									
5									<b>Headspace:</b> (taken after desorption)
6									1. measure Coal+ H <sub>2</sub> O fill + can mass
7									2. Coal+ can mass:
8									3. Subtract 2 from 1 = net H <sub>2</sub> O
9									4. Using 1g H <sub>2</sub> O = 1cc, net water mass
0									= Headspace = cc
1									
2									<b>Empty Can. Vol.</b>
3									(if density needed for Mavor method)
4									Empty coal, clean, weigh empty
5									Fill with H <sub>2</sub> O, reweigh
6									Using 1g H <sub>2</sub> O = 1cc, net water mass =
7									Can. Vol = cc
8									<b>Sample Density</b>
9									Density: raw coal mass / (empty can V - headspace V)
0									Density = g/cc

Describe core in canister:

Formation name:

Company: \_\_\_\_\_ Well name \_\_\_\_\_ CORE CAN# \_\_\_\_\_  
 Location: \_\_\_\_\_ Can Sample interval \_\_\_\_\_  
 API: \_\_\_\_\_ Mud logger Co and logger names \_\_\_\_\_

**CRITICAL TIME DATA:** Pressure estimator: Mud wt: \_\_\_\_\_ ppg  
 Time: core off bottom \_\_\_\_\_ Time: Core at surface: \_\_\_\_\_ Time canister closed: \_\_\_\_\_

Reading	Date (mm/dd/yy)	Reading Time (24 Hr clock)	Ambient Temp. (oF)	Pressure (in. Hg)	$\Delta V$ (cc)	Internal Can T oF)	Bath Temp. (oF)	Fix a reading	(Note for fix a reading: use these annotations: T <sub>a</sub> = ambient; T <sub>i</sub> = internal; T <sub>b</sub> = bath; $\Delta V$ = volume; P = pressure; time = t)
0					0.0			< take 0.0	readings as can is closed
1									<b>CRITICAL MASS DATA:</b>
2									1. Can + Coal Mass:
3									2. Empty Can mass:
4									3. (1-2) = raw coal mass:
5									4. -(proxH2O+ash) mass:
6									5. = D.A.F. coal mass:
7									
8									Calc. T <sub>b</sub> : do early so bath can heat up
9									dT/dZ = _____ x sample depth/100
0									Add T <sub>surface</sub> of:
1									Total = Formation T=
2									OR: measure mud temperature
3									out of well=
4									
5									<b>Headspace:</b> (taken after desorption)
6									1. measure Coal+ H <sub>2</sub> O fill + can mass
7									2. Coal+ can mass:
8									3. Subtract 2 from 1 = net H <sub>2</sub> O
9									4. Using 1g H <sub>2</sub> O = 1cc, net water mass
0									= Headspace Vol. = _____ cc
1									
2									<b>Empty Can. Vol.</b>
3									(if density needed for Mavor method)
4									Empty coal, clean, weigh empty
5									Fill with H <sub>2</sub> O, reweigh
6									Using 1g H <sub>2</sub> O = 1cc, net water mass =
7									Can. Vol = _____ cc
8									<b>Sample Density</b>
9									Density: raw coal mass / (empty can V - headspace V)
0									Density = _____ g/cc

Describe core in canister: \_\_\_\_\_ Formation name: \_\_\_\_\_