# Determination of Carbon and Sulfur in Metal-Bearing Ores and Related Materials

*LECO Corporation; Saint Joseph, Michigan USA*


## Instrument: CS844

### *Introduction*

Determining the amount of carbon and sulfur present in metal-bearing ores is a necessary step in the metal recovery process. This information is used by mine operations to control metallurgical process kinetics and to support environmental monitoring of the process waste. This technique leverages the fact that most metal-bearing ores are a mixture of various sulfide and carbonate minerals with known stoichiometry. The majority of the work is done via acid/base accounting, where the amounts of total carbon and sulfur are compared against the amounts of sulfur after pyrolysis and carbon after acid digestion. When mining for copper, these calculations provide estimates of the net calcium carbonate content of the ore and the acid generation potential of the leach residues, waste rock, and tailings. When mining gold, these calculations are used to determine the amount of organic carbon, which is known to decrease the gold recovery process efficiency. The CS844 provides the perfect blend of rapid combustion, wide analytical range, and high precision necessary to quickly and accurately support mine operations.

### *Sample Preparation*

Samples should be uniform powder; preferably passing through a 100 mesh (150 micron) sieve. Results are typically reported on a dry basis. Samples are normally dried at 105°C for 1 hour; alternately, moisture can be determined on a separate portion of the sample and results corrected to a dry basis. Some Reference Materials require drying; see the Certificate of Analysis for drying instructions if applicable.

### *Method Reference*

ASTM E1915

### *Accessories*

528-018 or 528-018HP Ceramic Crucibles*; LECOCEL (763-266 or 763-263) or LECOCEL II (501-008) or LECOCEL II HP (502-173) accelerator, and Iron Chip accelerator (501-077 or 502-231)

**For best precision, ceramic crucibles should be baked in a muffle or tube furnace (LECO TF10) at 1250°C for a minimum of 15 minutes, or at 1000°C for 40 minutes. The crucibles are removed from the furnace, allowed to cool for 1 to 2 minutes, and transferred to a desiccator for storage. If the crucibles are not used within four hours, they should be re-baked. After preheating, handle crucibles with clean tongs only; do not use fingers.*

### *Calibration*

NIST Reference Materials and/or LECO 502-318, 502-319, 502-320, 502-372 Ore Calibration Materials.

### *Method Parameters*

*General Parameters*

| | |
|---|---|
| Purge Time: | 10 sec. |
| Delay Time: | 20 sec. |
| Sample Cool Time: | 0 sec. |
| Furnace Mode: | Constant |
| Furnace Power: | 100% |

| *Element Parameters* | *Carbon* | *Sulfur* |
|---|---|---|
| Integration Delay: | 0 sec. | 0 sec. |
| Starting Baseline: | 2 sec. | 2 sec. |
| Use Comparator: | No | No |
| Integration Time: | 55 s | 55 s |
| Use Endline: | Yes | Yes |
| Ending Baseline: | 2 s | 2 s |
| Range Select: | Auto | Auto |
| Range Lower Limit: | 800 | 800 |
| Range Upper Limit: | 950 | 950 |

### *Procedure*

1. Prepare instrument for operation as outlined in the operator's instruction manual.
2. Determine the instrument Blank.
   a. Login a minimum of 3 Blank reps.
   b. Add 1 (773-579) scoop (~1.2 g) of LECOCEL, LECOCEL II or LECOCEL II HP accelerator to the crucible.
   c. Add 1 (773-579) scoop (~0.8 g) of Iron Chip accelerator to the crucible.
   d. Place the crucible on the furnace pedestal (or appropriate autoloader position if applicable), and initiate analysis.
   e. Repeat steps 2b through 2d a minimum of three times.
   f. Set the Blank according to the procedure set forth in the operator's instruction manual.
3. Instrument calibration/drift correction.
   a. Login a minimum of 3 Standard reps for each calibration/drift reference material to be used for calibration/drift.
   b. Weigh ~0.2 to 0.25 g of a calibration/drift reference material into the preheated crucible and enter the mass and reference material identification into the standard login.
   c. Add 1 (773-579) scoop (~1.2 g) of LECOCEL, LECOCEL II, or LECOCEL II HP accelerator on top of the reference material.
   d. Add 1 (773-579) scoop (~0.8 g) of Iron Chip accelerator on top of the reference material.
   e. Place the crucible on the furnace pedestal (or appropriate autoloader position if applicable), and initiate analysis.
   f. Repeat steps 3b through 3e a minimum of three times for each calibration/drift standard intended for calibration/drift.
   g. Calibrate/drift correct by following the procedure outlined in the operator's instruction manual.

Inorganic Application Note

Delivering the Right Results

4. Sample Analysis
   a. Login a Sample with the desired number of reps.
   b. Weigh ~0.2 to 0.25 g of sample into the preheated crucible and enter the mass and sample identification into the sample login.
   c. Add 1 (773-579) scoop (~1.2 g) of LECOCEL, LECOCEL II, or LECOCEL II HP accelerator on top of the sample.
   d. Add 1 (773-579) scoop (~0.8 g) of Iron Chip accelerator on top of the sample.
   e. Place the crucible on the furnace pedestal (or appropriate autoloader position if applicable), and initiate analysis.
   f. Repeat steps 4a through 4e as necessary.

## *Typical Results*

| *Description* | *Mass (g)* | *% Carbon* | *% Sulfur* |
|---|---|---|---|
| NIST SRM 886 | 0.2486 | 5.75 | 1.480 |
| (5.7)% Carbon | 0.2491 | 5.78 | 1.484 |
| 1.47% Sulfur | 0.2503 | 5.75 | 1.496 |
| Gold Ore | 0.2480 | 5.74 | 1.493 |
| | 0.2497 | 5.74 | 1.491 |
| | ***X=*** | ***5.75*** | ***1.489*** |
| | ***s=*** | ***0.02*** | ***0.007*** |

| *Description* | *Mass (g)* | *% Carbon* | *% Sulfur* |
|---|---|---|---|
| LECO 502-320 | 0.2510 | 2.63 | 2.42 |
| 2.63% Carbon | 0.2499 | 2.63 | 2.41 |
| 2.44% Sulfur | 0.2508 | 2.63 | 2.43 |
| Ore Tailings | 0.2502 | 2.64 | 2.43 |
| | 0.2476 | 2.64 | 2.41 |
| | ***X=*** | ***2.63*** | ***2.42*** |
| | ***s=*** | ***0.004*** | ***0.01*** |

| | | | |
|---|---|---|---|
| LECO 502-318 | 0.2487 | 0.16 | 0.52 |
| 0.17% Carbon | 0.2493 | 0.16 | 0.53 |
| 0.54% Sulfur | 0.2494 | 0.15 | 0.53 |
| Ore Tailings | 0.2483 | 0.15 | 0.54 |
| | 0.2508 | 0.16 | 0.52 |
| | ***X=*** | ***0.16*** | ***0.53*** |
| | ***s=*** | ***0.001*** | ***0.007*** |

| | | | |
|---|---|---|---|
| LECO 502-491 | 0.2005 | 11.46 | 11.06 |
| 11.44% Carbon | 0.1992 | 11.49 | 11.12 |
| 11.16% Sulfur | 0.2022 | 11.51 | 11.14 |
| Ore Tailings | 0.2009 | 11.51 | 11.12 |
| | 0.2024 | 11.54 | 11.11 |
| | ***X=*** | ***11.50*** | ***11.11*** |
| | ***s=*** | ***0.03*** | ***0.03*** |

*Low Carbon and Sulfur detectors calibrated using single standard Linear Force through Origin Calibration.*
*High Carbon and Sulfur detectors calibrated using multi-point standard Linear Full Regression Calibration.*

**LECO Corporation** | 3000 Lakeview Avenue | St. Joseph, MI 49085 | 800-292-6141 | Phone: 269-985-5496
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