DEPARTMENT OF THE INTERIOR
BUREAU OF MINES
JOSEPH A. HOLMES, DIRECTOR

SAMPLING COAL DELIVERIES
AND TYPES OF GOVERNMENT SPECIFICATIONS
FOR THE PURCHASE OF COAL

BY

GEORGE S. POPE

WASHINGTON
GOVERNMENT PRINTING OFFICE
1913
CONTENTS.

Introduction ................................................................................................................. 5
Theory of sampling ......................................................................................................... 7
The method of sampling as a part of coal specifications ............................................. 7
Practical considerations ................................................................................................. 8
  Moisture ....................................................................................................................... 8
  Ash and heating value ............................................................................................... 12
  Volatile matter ........................................................................................................... 12
  Sulphur and clinker ................................................................................................. 13
Need of experience and caution in sampling ............................................................. 14
Directions for sampling ............................................................................................... 15
  Size of the gross sample ......................................................................................... 15
  When to collect samples ....................................................................................... 22
  Collection of gross samples .................................................................................. 22
    Wagonload deliveries ......................................................................................... 23
    Carload deliveries ............................................................................................... 24
  Cargo shipments ........................................................................................................ 25
  Sample receptacle ..................................................................................................... 28
  Collection of special moisture samples ................................................................. 29
  Preparation of the gross sample ........................................................................... 30
  Sampling buckets ...................................................................................................... 37
  The mixing and reducing machine ......................................................................... 37
Collection of samples in the District of Columbia ....................................................... 38
  The crushing room .................................................................................................. 38
A simple crushing and sampling installation ............................................................... 41
Sealing and mailing ....................................................................................................... 43
Reporting analyses ...................................................................................................... 46
Coal specifications and proposals ............................................................................... 47
  Specifications and proposals for bituminous and anthracite pea and buckwheat No. 1 coal for steam-power plants ............................................................. 52
  Specifications and proposals for anthracite furnace (broken), egg, stove, and chestnut coal ................................................................................................................. 64
Publications on fuel technology .................................................................................. 67

ILLUSTRATIONS.

PLATE I. A. Crushed gross sample in conical pile; B. Crushed gross sample remixed in long pile; C. Reduced sample quartered ......................... 34
       II. A. Sampling bucket; B. Mixing and reducing machine ..................... 38
       III. Machinery for mixing and reducing gross samples ....................... 40
       IV. Sealing and labeling sample can ...................................................... 44

FIGURE 1. Curves showing how the heating-value determination becomes more representative with increase in size of gross sample .................. 17
  2. Curves showing how the ash determination becomes more representative with increase in size of gross sample ........................................ 18
  3. Design of a simple coal-sampling plant ......................................................... 42
SAMPLING COAL DELIVERIES, AND TYPES OF GOVERNMENT SPECIFICATIONS FOR THE PURCHASE OF COAL.

By George S. Pope.

INTRODUCTION.

The purchase of coal by the Government under specifications depending on the heating value of the coal, its content of ash and of moisture, and other considerations, rather than upon the reputation or trade name of the coal, was based on the fuel investigations begun by the Technologic Branch of the United States Geological Survey in 1904. The plan was first adopted by the Treasury Department in 1906. Since then the plan, variously modified in form but the same in principle, has been gradually adopted by other departments until at present of the coal used by the Government, the total value of which approximates $8,000,000 annually, more than half is purchased under specifications. The Government publications dealing with the adoption by the Government of the specification plan, the number of contracts awarded on that basis, and the quality of the coal delivered under such contracts in the several fiscal years covered by the reports are given in publications* listed at the end of this bulletin.

* Under the authority of acts of Congress making appropriations for analyzing and testing fuels belonging to or for the use of the United States Government, a laboratory is maintained at the headquarters of the Bureau of Mines, Washington, D. C., where samples representing deliveries of coal purchased under specifications for Government use are analyzed and tested.

At this laboratory more than 1,200 samples have been analyzed and tested in one month. With the complete equipment and the efficient force employed, the analytical work has been so perfected that the analyses and heating-value tests of the samples received are as accurate as may be reasonably expected in laboratory work of this nature.

One of the serious drawbacks to the general adoption of the specification method for the purchase of coal is the difficulty of obtaining at reasonable cost samples of coal that can be considered fairly representative of the commercial product delivered in wagons, railroad

* See Bulletins 11 and 41, Bureau of Mines.
cars, or ships. Therefore the method of taking and preparing samples for shipment to the laboratory has been given fully as much care as the making of the analyses and tests, and a general plan of collecting samples fairly representative of the delivered coal has been evolved through various modifications and improvements based on experience and increased knowledge of the physical and chemical characteristics of the various coals that are purchased by the Government. The method that is in general use by the Government is described in the following pages.

In connection with studies of the coal deposits of the country, of the best methods of preventing waste in mining, and of increasing efficiency in the utilization of coal belonging to or for the use of the Government, geologists and engineers of the United States Geological Survey and of the Bureau of Mines have visited more than 1,700 coal mines scattered through all of the coal-producing States and Territories. From each mine from 2 to 8 or more samples were taken, the number depending upon the size of the mine and its output. The analyses and descriptions of the samples collected up to July 1, 1910, are published in a Bureau of Mines bulletin, entitled "Analyses of Coals in the United States," which is now in course of publication.

A study of the analyses of these samples and of the samples taken from cars shipped from a number of the same mines shows that the mine samples are as a rule of higher grade than the average commercial shipments, particularly with respect to containing a lower percentage of ash and having a correspondingly higher heating value. This difference is due to the fact that the Government inspector, proceeding on the basis of what can be done by a good miner, usually removes more of the partings of bone, slate, and other extraneous matter from his mine samples than the average miner does in ordinary practice, the aim of the miner being to get the maximum number of tons past the tipple inspection, as his earnings are based on his output. The average miner, therefore, does not always take as much care as he might in rejecting the impurities. The difference may be caused, too, by the presence of pieces of the mine roof and floor. The Government inspector can readily exclude these from the mine sample, but they often get into the commercial coal as a result of the character of the roof and floor and of the mining methods employed. The efficiency of the tipple inspection and the means employed in rejecting impurities when the coal is loaded into the railroad car are also factors that often largely account for the difference between mine and commercial samples. Most of the samples collected from the mines by the Government inspectors show a higher moisture content than commercial samples, because of the generally moist atmosphere of the mine and the precaution taken to prevent loss of moisture in the collection, preparation, and analysis of mine samples.
When properly taken, the mine samples are of great value, as they indicate the general character of the coal and the uniformity of the coal bed and enable one to determine its probable value for any designated purpose, providing due consideration is given to the character of the partings, the roof, and the floor, and to the possibility of pieces from these being loaded with the commercial output.

The collection of mine samples by the Bureau of Mines and the Geological Survey is done in a systematic manner, according to a prearranged plan, and the same procedure is always followed where circumstances permit. A special outfit for use in collecting mine samples has been developed. The method followed and a description with illustrations of the outfit are published in Bureau of Mines Technical Paper 1, entitled "The Sampling of Coal in the Mine."

**THEORY OF SAMPLING.**

To determine with utmost accuracy the ash content and heating value of a quantity of delivered coal would require the burning of the entire quantity, and special apparatus arranged to measure the total heat liberated, or would require crushing the whole quantity, and reducing it by an elaborate scheme of successive crushings, mixings, and fractional selections to portions weighing approximately 1 gram, the minute quantity which the chemist requires for each determination. Either of these procedures is obviously impracticable if the coal is to be used for the production of heat and power.

The method actually employed is to select portions from all parts of a consignment or delivery of coal and to systematically reduce the gross sample, obtained by mixing these portions, to quantities that the chemist requires for making ash determinations or that can be burned conveniently in the calorimeter, an apparatus for determining the heating value. The gross sample should be so large that the chance admixture of pieces of slate, bone coal, pyrite, or other impurities in an otherwise representative sample will affect but slightly the final results. Increasing the size of the gross sample tends toward accuracy, but the possible increase is limited by the cost of collection and reduction. In reducing the gross sample by successive crushings and halvings or fractional selections, the object is to procure a small laboratory sample that, upon analysis, will give approximately the same results as the gross sample itself, or, in fact, the entire quantity of coal from which the gross sample was obtained.

**THE METHOD OF SAMPLING AS A PART OF COAL SPECIFICATIONS.**

Recognizing the importance of the method of sampling as being a definite commercial procedure and of having the method clearly set forth in the specifications to become a part of the contract, and recognizing also the desirability of insuring uniformity and similarity
in the specifications used by the different branches of the Federal service for the purchase of coal, representatives of the executive departments and independent establishments of the Government held a conference under the auspices of the Bureau of Mines in February, 1912, for the purpose of discussing these and other features of the specifications. At this conference committees were appointed to prepare specifications in accordance with the views of the members.

As these specifications state the method of sampling in more detail than previous Government specifications, the specifications which were generally used by the Government for the purchase of coal for the fiscal year 1912–13, with such modifications as have later appeared desirable, are given on pages 52–66, with the view of presenting here-with a specification which will very probably be typical of the general specifications which will be used for the fiscal year 1913–14. It was recognized at the conference that in general specifications, such as were recommended, certain requirements had to be of wide application, as the specifications cover such a wide variety of conditions, not only as to character and quality of coal but as to type of furnace equipment, size of deliveries, methods of delivering, etc.

PRACTICAL CONSIDERATIONS.

MOISTURE.

The specifications which were used for the purchase of coal on the heat-unit basis prior to the fiscal year 1912–13 were on the B. t. u. (British thermal unit) "as received" basis; that is, payment for delivered coal was directly affected by the moisture content of the sample received by the laboratory. This method was based on the assumption that the moisture in the samples collected at the time of weighing and delivery could be preserved with slight loss during the storing and subsequent working down of the gross sample to a quantity convenient for transmittal to the laboratory and in its later treatment in the laboratory. From experiments that have been made and from a large mass of data, it is known that the moisture content of coal does not remain constant, and that the moisture content reported by the laboratory may be as much as 5 to 10 per cent lower than that actually contained in excessively wet or high-moisture coal at the time of weighing.

In one investigation, 254 gross samples were reduced, at the delivery point, to samples weighing approximately 5 pounds each and then the 5-pound samples were divided into two equal parts ("duplicates"), which were placed in mailing cans and sent to the Bureau of Mines for analysis. The moisture contents of the "duplicates" were presumably identical, but analysis showed that the average difference of the moisture contents of the 254 pairs of "duplicates" was 0.256
per cent and the maximum difference was 3.6 per cent. These figures indicate the moisture differences that may exist even after the gross sample has been reduced to approximately 5 pounds, but they do not show the moisture lost, by the gross sample while in storage and while being reduced to 5 pounds. As stated above, the total loss of moisture may be as much as 5 to 10 per cent in high-moisture or excessively wet coals.

As a sample loses moisture, its B. t. u. "as received" value correspondingly rises, with the result that the price for delivered coal determined on the "as received" value is, with rare exceptions, higher than that warranted by the quality of the coal at the time of weighing. As a general statement, payment based on the "as received" B. t. u. value will be higher than warranted, unless the sampling and laboratory work can be carried on under conditions that minimize moisture loss, as under freezing temperatures.

Recognizing the uncertainty involved in taking the moisture determination in the laboratory as representative of the moisture content of the delivered coal and the consequent possibility of payment of a higher price than is warranted, the Bureau of Mines recommended to the executive departments and independent establishments of the Federal service that the heating value in the coal specifications for the fiscal year 1912-13 be on the "dry coal" basis.

In preparing these specifications the fact was recognized that the amount of moisture contained in coal produced from day to day from the same mine, or group of mines working the same bed, is largely accidental, and is a matter over which the buyer and seller have only slight control. However, in order to place a negative value on high-moisture coals and to protect the Government against the delivery of coals containing excessive amounts of moisture, the specifications require the bidders to specify the maximum moisture content in coal offered. This value becomes the standard of the contract.

If coal of uniform B. t. u. "dry coal" value is delivered on a contract, the contractor receives the advantage on any delivery in which the moisture content approaches the maximum specified, because he is paid for the weight of water contained in the coal in excess of a normal amount, whereas if the coal is very dry, containing less than the normal amount of moisture, the purchaser receives the advantage.

For example, coal is delivered under a contract in which the standards are 14,300 B. t. u. per pound, "dry coal," and a maximum moisture content of 3.5 per cent. The heating value of a ton (2,240 pounds) of "dry coal" would be 32,032,000 B. t. u. Assume that the average moisture content of deliveries for a year is 2.5 per cent,
then for every 2,240 pounds of "dry coal" having a heating value of 32,032,000 B. t. u., the purchaser is required to pay for 56 pounds of water at the same rate per ton as for "dry coal," but as this percentage of moisture in average deliveries is inherent in a constituent of the coal, it is considered as part and parcel of the coal by both the purchaser and the seller. If the coal delivered contains 3.5 per cent moisture, to procure 32,032,000 B. t. u., "dry coal," the purchaser has to pay 1 per cent more for coal because of the excess water above the normal amount, whereas if the coal contains 1.5 per cent moisture, the purchaser pays 1 per cent less for water. As the variations in moisture content, 1.5 or 3.5 per cent, are largely accidental, the season of the year being partly responsible for them, it is equitable that the purchaser and seller should share the uncertainty. The purchaser justly has a right, however, to demand that the seller shall guarantee a maximum moisture content, as a means of enabling the purchaser to compare one coal with another, as a guarantee that the seller will observe precautions against delivering coal that is unduly wet, and as a basis for adjusting the price of exceptionally wet coal.

The United States Weather Bureau in its annual reports gives the total precipitations per month and the maximum in 24 hours for different sections of the United States. At Washington, D. C., the greatest rainfall for any one month during the year ended December 31, 1910, was 5.89 inches, and the maximum for 24 consecutive hours was 3.67 inches.

As an example of the effect of a heavy rain on a car of coal in transit, a precipitation of 3 inches of water on a loaded 50-ton car, area of top about 360 square feet, would increase the weight of the coal 5.01 per cent, provided none of the water drained out or evaporated. It is obvious that if this coal is weighed and delivered immediately, special samples for moisture determinations should be collected and prepared at once and sent to the laboratory, as a basis for equitable adjustment of payment on account of the excessive amount of water in the coal. As the weight of the coal was increased by the excess water, there should be a corresponding decrease in the price to be paid.

If a railroad car or wagon so rained on should not be unloaded immediately after weighing and special moisture samples should not be properly collected, prepared, and sent hermetically sealed to the laboratory, it is obvious that the purchaser would pay a higher price than warranted, especially if the car or wagon stood for some time before sampling and some of the water drained out. Further, if the coal was not immediately unloaded and sampled or if the car continued in transit after weighing, then the coal at the top would soon dry; and in either case the effect of the 3-inch rainfall,
as indicated by the analysis, might be only a fractional percentage of the moisture contained in the coal at the time of weighing.

The determination of the moisture of coal delivered from stock piles is often of great importance, for the proportion of moisture contained in the small sizes, which are most abundant near the center of a stock pile and which absorb the rains, and melting snows in districts of heavy snows, may be from 10 to 15 per cent higher than when stocked. It is apparent, therefore, that special moisture sample determinations are necessary for equitable adjustment of payment on account of excessive moisture in coal which is stocked in piles exposed to the weather.

The specifications provide for the collection of "special moisture samples" if, in the opinion of the Government officials sampling it, the delivery contains moisture in excess of that guaranteed by the contractor. The "special moisture samples" are prepared in a manner to minimize moisture losses and may be taken and prepared independently of the gross samples collected for the determinations of heating value (B. t. u.), ash, and other specified data. If the analysis of the special sample shows a moisture content in excess of the contractor's guaranty, a proportionate deduction is made from the price to be paid for the coal.

"Special moisture samples" representing coal as delivered should be preserved in such a way as to minimize moisture loss, because if the moisture content of the sample, as shown by analysis, is less than the actual moisture content of the coal at the time it is weighed, either because of the sample being nonrepresentative or because of subsequent moisture loss during the storage or the preparation of the sample, the price to be paid for the coal delivered is correspondingly increased and an injustice is done the purchaser. It is equally important to protect the sample during collection or storage from being wet by rain, snow, or water from any other source in order to insure the sample representing the delivered coal. Evidently, therefore, particular attention should be given to procuring for the laboratory a sample containing the same percentage of moisture as the delivered coal.

To minimize moisture loss, the sample must be placed in a tight container and stored in a cool place before it is reduced. Moreover the sample should be reduced and transmitted to the laboratory as soon as practicable. It is well to remember that a sample taken from coal that has been exposed to a relatively high temperature, as coal from a boiler or furnace room, or from adjacent bins, has lost moisture and does not represent the coal as delivered. For the same reason samples should not be stored in the boiler room.

If the contractor does not guarantee a moisture content lower than can be actually maintained on an average, the collection of "special
moisture samples" and the making of price corrections on account of excessive moisture will seldom be necessary. Thus, the placing of heating value (B. t. u.) on the "dry coal" basis, with a maximum moisture content, eliminates frequent corrections of price on account of uncertain moisture variations.

ASH AND HEATING VALUE.

The heating value of coal from the same mine or from a group of mines operating the same bed of uniform character is directly influenced by the percentage of ash. By ash is meant earthy matter and impurities that do not burn. As the proportion of ash inherent (sometimes termed "intrinsic ash") in the coal substance as a rule does not vary widely in coal from the same bed, the heating value is largely determined by the amount and character of the free (sometimes termed "extraneous") impurities, and hence the manner in which coal is cleaned and prepared at the mine may greatly affect the heating value of commercial shipments. In collecting samples, therefore, it is of utmost importance that the samples should contain within reasonable limits the same proportion of impurities as the delivered coal from which they were taken.

Since the specifications provide for adjustment of price according to the ash content or the heating value, or both, it is evident that samples taken from delivered coal should show, by analysis, practically the same ash content and heating value as the delivered coal. In other words, the sample should contain the same proportion of slate, bony coal, pyrite and other impurities as the quantity delivered, in order that the price adjustment based on the analyses may be fair to both purchaser and seller. Obviously, it is important to guard against any accidental admixture of sand, cement, clinkers, or other foreign matter, while the sample is in storage or while it is being prepared for transmittal.

In this connection, attention is called to the fact that the gross sample should contain the same proportion of lump and fine coal as the delivery, for it has been determined that fine or slack coal may have an ash content, or a heating value, different from lump coal from the same shipment.

VOLATILE MATTER.

The volatile matter\(^a\) of coal, as shown in analyses, generally contains some inert noncombustible matter, the proportion of which may range from 1 to 15 per cent. The character of the volatile matter in any given coal and the temperatures at which it is given off bear directly on the design and operation of furnaces for burning the coal efficiently and without smoke. The proportion of combus-

---

tible and noncombustible constituents in the volatile matter and the character of the combustible constituents, differ in different coals, and, therefore, the heating value of a coal can not be determined from a proximate analysis. Moreover, different coals with the same proportion of volatile matter may not behave alike in the furnace. In order to determine the comparative value of two coals for the same purpose, it is important to know both their chemical composition and their heating value. Hence the specifications recommended by the Bureau of Mines provide that before final awards of contracts, practical service tests may be made to determine the relative suitability of the coals offered.

In the specifications the contractor is required, in addition to giving the name and the location of the mine or mines producing the coal and the name of the coal bed worked, to specify the volatile matter content and other proximate analysis determinations of the coal he proposes to furnish. The content he specifies becomes the standard of his contract, and delivery of coal with a different percentage of volatile matter, indicating the substitution of a coal other than that offered, may result in the coal being rejected and the Government purchasing coal in the open market (the contractor being charged with the difference, if any, in cost) or in the contract being canceled.

The Government does not consider any scheme of applying penalties on account of variations in volatile matter equitable, because the character of the volatile matter and its heating value are not necessarily indicated by the volatile matter determination, and because this determination is made by an empirical method whereby duplicate determinations on the same sample may differ as much as 2 per cent in different laboratories, or, in fact, in the same laboratory. Accordingly, no corrections in price are made for variations in volatile matter.

The bureau has received copies of commercial and municipal specifications drawn up apparently without regard to these facts. One specification, for instance, provides for a correction of 2 per cent in price for each 1 per cent of volatile matter in excess of the standard guaranteed. On a coal sold at $3 per ton, a deduction of 12 cents per ton for an apparent excess of 2 per cent in volatile matter might be made, when, in fact, the actual volatile matter of the coal was not above the standard. Specifications of this nature furnish legitimate grounds for opposition from coal companies and do much to discredit the specification method for the purchase of coal.

**SULPHUR AND CLinker.**

Sulphur is commonly present in combination with iron or other elements. For a long time it was thought that the sulphur formed clinker,
but recent investigations point to the fact that sulphur is not the only cause of clinking; in fact, there may be no difficulty from clinker in burning coal containing as much as 5 per cent or more sulphur. The relative proportions of iron, sulphur, lime, alumina, silica, etc., in the ash affect its fusibility, whereas the method of firing and the rate of combustion are important factors in the formation of clinkers. The exact relation of clinking to the constituents of the ash is not known so well that one can definitely predict from an analysis of the ash whether a coal will or will not clinker. At many power plants the fireman slices the fire too often and works the ash up from the grates into the hot coal bed, where it melts and fuses into heavy dense masses of clinker. At high rates of combustion the ash in a given coal may clinker (though at lower rates it does not), because of the ash being raised to the fusing temperature. The fact that the percentage of sulphur does not necessarily indicate the behavior of the coal in the furnace is recognized in the specifications recommended by the Bureau of Mines. The contractors, however, are required to specify the sulphur content so that standards for the coals to be delivered may be established.

Many commercial and municipal specifications exact penalties for a slight increase in the sulphur content, although coal of high sulphur content may clinker less and its heating value may be higher. One specification received by the Bureau of Mines exacts a deduction of 5 per cent in price for each 1 per cent of sulphur in excess of the standard. In the case of a coal supplied at $3 a ton, the presence of 1 per cent of sulphur in excess of the standard, as indicated by analysis, would often result in an unwarranted deduction of 15 cents a ton. Under such a contract, the variations which it is recognized exist in sampling and analysis may cause a contractor unjustly to suffer a heavy deduction.

Both the sulphur and the volatile-matter content should be used to classify coals and to identify the coal guaranteed. Variations indicating the substitution of an unsatisfactory coal should be considered cause for rejection of the coal or for cancellation of the contract.

NEED OF EXPERIENCE AND CAUTION IN SAMPLING.

Persons without experience generally select a sample better than the average run of the coal delivered. Occasionally, a lump unusually free from layers of slate and impurities, and representing the best coal in the lot rather than the average, is selected. After being broken it is shipped to the laboratory in a cloth sack, so that it loses moisture during transit. The analysis of such a sample necessarily indicates a value higher than that of the coal delivered. As a quantity of coal
may vary greatly in composition, containing not only what may be termed coal proper with certain more or less constant impurities, but also slate, pyrite, and bony coal, a lump may be anything from almost pure coal to material without fuel value. Hence the analysis and test of a single lump may indicate a composition greatly different from that of the coal at hand. It is well to remember that, since the larger lumps of coal roll down and collect near the bottom of a pile or load, a sample taken entirely from near the floor does not always fairly represent the whole.

In spite of every precaution taken to prevent loss of moisture during the collection, preparation, and analysis of samples it is certain that loss of moisture may occur; also there may be too little or too much slate, bony coal, or other foreign matter collected in what is otherwise a truly representative gross sample, so that the determination of the heating value or ash content does not strictly agree with the actual value of these factors in the coal delivered. However, an experienced collector, by using good judgment and following the general directions given for collecting and preparing samples, can obtain samples so fairly representative that the results of the analyses are reasonably accurate. The suggestions that follow are presented for the guidance of those who wish to send representative samples to a laboratory for analysis and heating-value tests.

**DIRECTIONS FOR SAMPLING.**

**SIZE OF THE GROSS SAMPLE.**

The number of pounds to be taken as a gross sample to represent a given lot of coal varies with the character and condition of the coal, and not the amount of coal to be sampled. The character and proportion of the bony coal, slate, etc., and the size of the particles of both coal and impurities are the governing factors. It is therefore evident that sampling should not be left to an inexperienced person, but should be done by one who is thoroughly familiar with the significance of these factors and has some knowledge of the coal to be sampled.

There is greater probability of taking too little than of taking too much coal for a gross sample. It is generally true that the larger the gross sample the less is the chance of its being nonrepresentative. Large samples must be taken in sampling coals that carry a varying proportion of large pieces of slate, bony coal, or pyrite, for it is evident that including or excluding large pieces of the impurities must affect the analysis of a small sample considerably; hence, the analysis may not indicate the quality of the coal sampled and, consequently, may be worthless for determining the price to be paid for
the coal. If the free impurities are small particles and are well distributed throughout the coal, representative samples may be obtained easily. As stated by Bailey: a

The larger the size of the pieces of impurities the larger should be the original sample to prevent excessive error, and the same is true with respect to the quantity of impurities.

The Bureau of Mines has carried on experiments and tests to determine the quantity of coal necessary in gross samples to make them fairly representative of the coal sampled. The table following shows the results of one series of tests and brings out very clearly the necessity of gross samples larger than those generally collected.

Increase in accuracy of B. t. u. determination with increase of gross sample.

<table>
<thead>
<tr>
<th>Weight of sample (pounds)</th>
<th>B. t. u. &quot;dry coal&quot; differences.</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th>Number of B. t. u. determinations involved in arriving at the average difference.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>a</td>
<td>b</td>
<td>c</td>
<td>d</td>
<td>e</td>
<td>f</td>
<td>g</td>
<td>h</td>
<td>i</td>
<td>j</td>
</tr>
<tr>
<td>100,...........</td>
<td>158</td>
<td>301</td>
<td>38</td>
<td>190</td>
<td>620</td>
<td>10</td>
<td>325</td>
<td>40</td>
<td>365</td>
<td>459</td>
</tr>
<tr>
<td>200,...........</td>
<td>132</td>
<td>173</td>
<td>40</td>
<td>125</td>
<td>625</td>
<td>130</td>
<td>220</td>
<td>65</td>
<td>285</td>
<td>305</td>
</tr>
<tr>
<td>300,...........</td>
<td>120</td>
<td>39</td>
<td>18</td>
<td>177</td>
<td>410</td>
<td>17</td>
<td>92</td>
<td>43</td>
<td>135</td>
<td>179</td>
</tr>
<tr>
<td>400,...........</td>
<td>86</td>
<td>65</td>
<td>55</td>
<td>140</td>
<td>283</td>
<td>62</td>
<td>89</td>
<td>45</td>
<td>194</td>
<td>151</td>
</tr>
<tr>
<td>500,...........</td>
<td>0</td>
<td>67</td>
<td>51</td>
<td>156</td>
<td>244</td>
<td>16</td>
<td>41</td>
<td>20</td>
<td>61</td>
<td>67</td>
</tr>
<tr>
<td>600,...........</td>
<td>61</td>
<td>97</td>
<td>86</td>
<td>208</td>
<td>539</td>
<td>62</td>
<td>12</td>
<td>22</td>
<td>34</td>
<td>36</td>
</tr>
<tr>
<td>700,...........</td>
<td>54</td>
<td>67</td>
<td>55</td>
<td>133</td>
<td>88</td>
<td>56</td>
<td>2</td>
<td>12</td>
<td>10</td>
<td>13</td>
</tr>
<tr>
<td>800,...........</td>
<td>35</td>
<td>52</td>
<td>67</td>
<td>102</td>
<td>107</td>
<td>49</td>
<td>27</td>
<td>9</td>
<td>36</td>
<td>27</td>
</tr>
<tr>
<td>900,...........</td>
<td>17</td>
<td>28</td>
<td>59</td>
<td>85</td>
<td>124</td>
<td>69</td>
<td>2</td>
<td>23</td>
<td>25</td>
<td>11</td>
</tr>
<tr>
<td>1,000,...........</td>
<td>30</td>
<td>19</td>
<td>34</td>
<td>49</td>
<td>94</td>
<td>59</td>
<td>8</td>
<td>35</td>
<td>27</td>
<td>11</td>
</tr>
<tr>
<td>1,100,...........</td>
<td>42</td>
<td>26</td>
<td>26</td>
<td>34</td>
<td>51</td>
<td>64</td>
<td>1</td>
<td>29</td>
<td>28</td>
<td>16</td>
</tr>
<tr>
<td>1,200,...........</td>
<td>18</td>
<td>8</td>
<td>15</td>
<td>70</td>
<td>53</td>
<td>21</td>
<td>30</td>
<td>61</td>
<td>26</td>
<td>32</td>
</tr>
<tr>
<td>1,300,...........</td>
<td>7</td>
<td>5</td>
<td>22</td>
<td>55</td>
<td>45</td>
<td>41</td>
<td>15</td>
<td>56</td>
<td>2</td>
<td>25</td>
</tr>
<tr>
<td>1,400,..................</td>
<td>18</td>
<td>8</td>
<td>15</td>
<td>70</td>
<td>53</td>
<td>21</td>
<td>30</td>
<td>61</td>
<td>26</td>
<td>32</td>
</tr>
<tr>
<td>1,600,..................</td>
<td>38</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The table shows the differences obtained by two different collectors on samples weighing 100 pounds, 200 pounds, 300 pounds, etc. On test (a) the collectors first took 100-pound samples which showed a difference of 158 B. t. u. in heating value. Each man then collected 100 pounds more. The heating values of the first and second 100-pound samples were averaged for each collector and the difference between the average results of the two collectors for two 100-pound samples was 132 B. t. u. Each man then collected 100 pounds more of coal. The averages of the two collectors for the three 100-pound samples differed by 120 B. t. u. In like manner the difference in heating value for each successive 100 pounds of coal was determined. Ten (a to j) similar tests were made. For the cargo, test (a), each collector took thirteen 100-pound samples of coal, or 1,300 pounds, to represent the cargo, and the average of the 13 B. t. u. determina-

---

tions for the 13 samples of one collector differed by only 7 B. t. u. from the average of the 13 B. t. u. determinations of the other collector.

The average differences are of especial significance as showing the effect of the size of the sample as a factor in obtaining a heating value which truly represents the coal sampled, because the variations that are recognized to exist in the reduction of gross samples and in the analytical work were minimized by averaging; for example, in determining the average difference of 37 B. t. u. for the 1,000-pound sample, 100 heating-value determinations were averaged for each collector, 200 such determinations being involved in obtaining the

![Graph showing heating value vs. weight of sample](image)

**Figure 1.**—Curves showing how the heating-value determination becomes more representative with increase in size of gross sample.

difference of 37, and this difference of 37 B. t. u. may be considered as representing the actual difference in the heating values per pound of the two 1,000-pound gross samples.

The results given in the table have been plotted in figure 1, the heating-value differences being used as ordinates and the weights of the samples as abscissas. The differences in ash, "dry coal," of the samples are also plotted (fig. 2), the average differences in the percentages being used as ordinates and the weights of the samples in pounds as abscissas.

The curves show very strikingly the effect that the size of the gross sample has in insuring representative results. As the size of the sample is decreased the differences between separate samplings become
greater and greater—extending the curves toward the left will show that with very small samples the difference may become equivalent to the difference between pure coal and "slate." On the other hand, the curves show that as the weight of the sample is increased the differences of ash and heating value rapidly decrease until a point is reached where the accuracy obtained by taking larger samples would not ordinarily be warranted, because of the expense which would be involved in making special provisions for handling the very large samples.

The large differences with the small samples show very forcibly the necessity for collecting large gross samples to insure the results of analyses and heating value tests being reliable for determining the price to be paid for delivered coal and for preventing injustice to either seller or buyer. The collectors each endeavored to collect 100 pounds of coal representative of the quantity sampled, but with samples weighing only 100 pounds a maximum difference of 620 B. t. u., "dry coal," resulted. This difference was not due so much to any difference in the actual heating value of the coal substance as to a collector unintentionally and by chance including or excluding pieces of slate, bony coal, pyrite, and other impurities in taking his sample. Obviously payment based on either one of two samples differing 620 B. t. u. in heating value would probably have worked to the disadvantage of either the seller or the buyer.

One should remember that the differences given in the table for the samples as they grow larger decrease, not only because of the fact that the samples gradually approach each other in homogeneity, but because the variations in analytical work and in the reduction of the samples are diminished as the number of determinations used in
obtaining the averages increases. The maximum difference of 620 B. t. u. for the 100-pound samples is the difference between two single determinations, each of which includes the variations due to laboratory work and the reduction of the samples. In this case, if the samples had again been reduced and analyzed, variations due to laboratory work and sampling might have given a difference greater or less than 620 B. t. u. The maximum difference of 94 B. t. u. for the 1,000-pound sample is the difference between the average of 10 heating-value determinations for one collector and the average of 10 determinations for the other collector. The laboratory and sampling variations in this case are, it is seen, averaged or divided, and it is obvious that the effect of these variations is greatly less in this case than in that of the two single determinations which differed by 620 B. t. u.

As has been stated and as is indicated by the curves, the differences in ash and heating value rapidly decrease as the size of gross sample is increased until a point is reached where the accuracy obtainable by taking larger gross samples is affected but slightly. The table below shows the results of a series of four tests in which each collector took samples of 2,500 to 4,450 pounds to represent cargoes of approximately 5,500 tons each:

The effect of size of gross sample on heating-value determination.

<table>
<thead>
<tr>
<th>Test</th>
<th>Weight of gross sample (Pounds)</th>
<th>Number of samples</th>
<th>B. t. u., &quot;dry coal.&quot;</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Regular.</td>
<td>Experimental.</td>
</tr>
<tr>
<td>A</td>
<td>2,500</td>
<td>14,656</td>
<td>14,652</td>
</tr>
<tr>
<td>B</td>
<td>4,450</td>
<td>14,722</td>
<td>14,743</td>
</tr>
<tr>
<td>C</td>
<td>5,920</td>
<td>14,892</td>
<td>14,899</td>
</tr>
<tr>
<td>D</td>
<td>3,640</td>
<td>14,876</td>
<td>14,887</td>
</tr>
</tbody>
</table>

One object of these tests was to establish the fact that beyond certain limits accuracy is little affected by larger gross samples, and on comparing the differences in this table with the differences in the table on page 16 it is seen that this fact is borne out.

In this table the weight of the gross sample, in test A, for instance, is the quantity of coal which each collector took to represent the cargo. Each collector’s gross sample was reduced to five successive quantities—that is, in test A, after the collector had accumulated 500 pounds, he prepared it for transmittal to the laboratory. After each of his 500-pound samples had been reduced to approximately 6 pounds, it was halved by the use of a riffle and the halves placed
in separate mailing cans. One of these halves, termed the "duplicates," is ordinarily retained and held as a reserve, while the "original" is mailed. In this investigation, however, the "duplicates" were mailed as well, and the "originals" and "duplicates" were both analyzed. Then in test A the average of the analyses of the five "original" samples was 14,656 and of the five "duplicates" 14,652, the average of the "originals" and "duplicates" being 14,654. The samples collected by one collector are termed the "regular" samples, while the samples collected by the other collector are termed the "experimental."

In tests A, B, and C the collectors sampled the same cars, portions of coal being taken from every second car of coal discharged into the ship. In test D one collector took portions from the first, third, fifth, etc., cars, while the other collected portions from the second, fourth, sixth, etc., cars, so that their combined gross samples of 7,280 pounds was made up of coal from every car loaded. As the collectors sampled entirely different cars in test D, the fact that the difference between the heating values of their samples is slightly greater than on the other tests is not surprising, and shows by comparison with tests A, B, and C that the method of sampling every second car gives results which can be taken as representing an entire cargo.

The differences obtained between the "originals" and "duplicates" vary from 1 B. t. u., for the "experimental" samples of test B, to 35 for the "experimental" samples of test D, which shows that there is an element of chance which sample is forwarded and termed the "original." In the routine reporting on cargoes only one set of samples is analyzed to represent a cargo; thus in test D it may be considered that the value which might have been reported on the cargo would have been either 14,876, 14,887, 14,805, or 14,840, depending on which set of samples had by chance been forwarded for routine analysis and report—that is, a difference of 82 B. t. u. in the reports may have resulted. Differences due to such causes, as well as to others, must be recognized in interpreting a coal analysis and in drawing up specifications that provide for adjustment in price according to the determinations reported by the laboratory. These determinations reported are given a liberal construction in the specifications prepared by the Government (see pp. 52–66).

The tests were made with Pocahontas and New River coals. These coals are relatively free from the "extraneous" impurities, and are comparatively easy to sample. Greater differences are to be expected with coal of firmer physical structure containing a considerable proportion of impurities in large pieces or large lumps of coal with strata of bone, slate, pyrite, or sulphur balls or lenses.
Hence larger gross samples should be collected from such a coal to insure the results of analyses and tests being fairly representative of the coal delivered.

Because small samples may, and quite generally do, indicate a value for the coal sampled that differs from the actual value, the specifications that are recommended by the Bureau of Mines provide for the collection of a gross sample weighing not less than approximately 1,000 pounds. If the coal to be sampled contains an unusual amount of impurities, and if the pieces of such impurities are very large, it may be necessary to collect larger gross samples, of even 1,500 pounds or more.

Whether a delivery consists of 1 ton or 100 tons, the need of the gross sample weighing 1,000 pounds or more is the same. One such sample carefully taken and reduced to a quantity convenient for transmittal to the laboratory can well represent a delivery of several hundred or a thousand tons of coal.

For convenience, however, and to avoid long storage of the samples, the Bureau of Mines considers it advisable that one sample of 1,000 pounds or more should be collected each week in the case of Government contracts calling for more or less regular deliveries each week. If, however, the quantity delivered during a week is relatively small, then the sample may represent the coal delivered during a longer period. To facilitate accounting, many branches of the Government service order contractors to deliver certain quantities, usually 100 to 500 tons. In such cases the samples are collected to represent the order without special regard to the period covered, and one or more gross samples of 1,000 pounds or more each is collected, as may be most practical and expedient in view of the facilities for sampling and the other considerations involved.

In sampling cargo deliveries of 5,000 and more tons, the Bureau of Mines collects from 4,000 to 5,000 pounds of coal as a gross sample. In order that the preparation of the samples may proceed while the cargo is being loaded, after approximately 500 pounds has been collected it is reduced down to a quantity convenient for mailing to the laboratory, and each succeeding 500 pounds is likewise reduced. This procedure makes unnecessary the accumulation of a quantity of coal that can not be systematically and conveniently handled in the short time and the small space usually available. Two or more of the samples are combined and reduced to one in the laboratory, and four or five analyses are usually made for a cargo, and a report on the cargo is obtained by averaging the analyses. The samples may, however, be mixed in the laboratory and only one analysis made to represent the cargo. Though the experiments which have been made indicate that a sample of approximately 1,000 pounds will give results fairly representative of the cargo, the objection to
the 1,000-pound sample is that it is too small to allow of the frequent collection of shovelfuls or portions of any quantity throughout the loading of the cargo. As it generally happens that coal from a number of mines is loaded into the same cargo, it is desirable to collect a considerable quantity of coal, so that each mine may be well represented in the gross sample. It is obvious that the more frequently the portions are collected and the greater the quantity sampled the less the probability that the sample will be nonrepresentative; accordingly, the bureau considers that in sampling 5,000-ton cargoes safety lies rather in the larger gross sample.

WHEN TO COLLECT SAMPLES.

The best opportunities for procuring representative samples are afforded while the coal is being unloaded from railroad cars, ships, and barges, or while it is being dumped from wagons. Once the coal is stored in piles or bins, or loaded on vessels, the procuring of representative samples is practically impossible unless the whole quantity of coal is immediately handled again and the conditions for sampling become favorable. Samples collected from the coal exposed in piles, bins, barges, or ships can be considered representative only under the condition that the mass of coal is homogeneous throughout. Such a condition is highly improbable and uncertain, and the analysis of samples collected from the surface may give results that are very unreliable as indicating the nature of the entire quantity, and that may be worthless as a basis for determining an equitable price to be paid for the coal.

COLLECTION OF GROSS SAMPLES.

When coal is being unloaded from wagons, railroad cars, ships, or barges, a shovel or a specially designed tool may be used for taking portions or increments of 10 to 30 pounds to make up the gross sample of coal. As the size of the increments should be governed by the size and weight of the largest pieces of coal and impurities, increments of more than 30 pounds may be required for coals containing large pieces of coal and impurities.

If one chute or conveyer is used for delivering a considerable quantity of coal to or from wagons, cars, or ships, it may prove expeditious and economical to devise a mechanical means for collecting portions from fractional parts of the discharged coal, or continuously deflecting a portion of the coal as it falls down the chute, or diverting from the conveyer definite portions of coal, and thus mechanically and automatically collecting the gross sample.

The mechanical collection of samples is preferred to shovel sampling, as it eliminates the personal equation. As the mechanical
sampler does not discriminate for or against taking more or less "slate" or other impurities, so a person should collect samples with a shovel in the main without regard to impurities, because the amount of the impurities included in a sample must largely be left to chance, since it is impossible to rate correctly the proportion of the impurities concealed in the coal, however competent the sampler may be. A mechanical sampler should preferably take the whole of the stream of coal flowing down the chute a part of the time rather than a part of the stream all the time, because the sizes and character of the pieces of coal and impurities are not apt to be evenly distributed across the stream. Excellent opportunity is afforded for procuring representative samples if the entire consignment of coal is crushed immediately after it is weighed and delivered, for then the samples can be collected from the crushed coal. If the coal is conveyed from the crusher by a conveyer, means can be devised for mechanically and automatically diverting from the conveyor definite portions of coal to make up the gross sample.

The portions should be regularly and systematically collected, so that the entire quantity sampled will be represented proportionately in the gross sample. The interval at which the portions are collected should be regulated so that the gross sample collected will weigh not less than approximately 1,000 pounds. If the coal contains an unusual proportion of impurities, such as slate, bony coal, and pyrite, and if the pieces of such impurities are very large, it will be necessary to collect gross samples of even 1,500 pounds, or more, but for slack coal and for small sizes of anthracite, if the impurities are not in abnormal proportion or in pieces larger than about three-quarters of an inch, and if the impurities are evenly distributed throughout the coal, a gross sample of approximately 600 pounds may prove sufficient. The gross sample should contain the same proportion of lump coal, fine coal, and impurities as the coal delivered. As the portions are collected they should be deposited in a receptacle having a tight-fitting lid provided with a lock.

WAGONLOAD DELIVERIES.

A gross sample taken by hand from coal delivered by wagon at a Government building should consist of shovelfuls of coal taken from every first, second, or third wagonload as it is being discharged, the number of shovelfuls taken and the loads sampled being dependent on the number of loads which the gross sample is to represent. If the coal is discharged immediately into a crusher, it is preferable to collect shovelfuls of the crushed coal.

If it is desired to sample coal delivered in small lots by wagons to a large number of buildings from one source of supply where the coal
is all weighed, and if the collection of samples at each building will involve considerable expense, samples may be conveniently collected at minimum expense at the source of supply when the coal is loaded into the wagons. In such case the samples are collected without regard to delivery points, the object being to sample the coal loaded into the wagons. At the end of the month or upon the completion of an order the corrected price per ton, if there be any corrections on account of coal varying from the standards guaranteed by the contractor, applies to each individual delivery point. Shovelfuls of coal should be taken from each wagonsload, or every second or third, etc., wagonsload, the number of shovelfuls taken and the number of wagonsloads sampled being dependent upon the number of loads which the gross sample is to represent.

It is important to obtain representative portions of coal from every part of the delivery, so that the sample will show the quality of the delivery or order as a whole. The gross sample should contain about the same proportion of lump coal, fine coal, and foreign matter as the coal delivered.

**CARLOAD DELIVERIES.**

Samples taken from railroad cars should not be limited to a few shovelfuls of coal procured from the top of a car, for the size of the coal and the proportion of foreign matter may vary from the top to the bottom of the car. The only way to obtain a representative sample is to take a number of shovelfuls or portions of coal from different points in a car, from top to bottom and from end to end, while the coal is being unloaded.

When sampling coal delivered from open cars and unloaded by hand shovelfuls should be taken at regular intervals as the coal is unloaded into wagons or bins.

When coal is being sampled from dump cars, ladlefuls (see p. 25) or shovelfuls should be taken from the stream of coal being discharged to the bins or ship. If the discharged coal is immediately crushed the gross sample should preferably be collected after the coal leaves the crusher.

If a number of carloads are delivered on an order or during a short period the preparation of a gross sample of 1,000 pounds or more for each car would involve considerable time, labor, and expense at the delivery point, as well as in the laboratory; in fact, a gross sample for each car would not be required, for if a gross sample is carefully taken and prepared it can well represent a number of cars. If a gross sample is collected to represent two or more cars representative portions of the coal should be taken in equal quantities from each car.

The method followed by the Bureau of Mines in sampling coal discharged from railroad cars directly into ships is given under "Cargo shipments."
CARGO SHIPMENTS.

In sampling cargoes, as in sampling carloads, portions of coal should be taken in equal quantities and at frequent and regular intervals so as to represent proportionate parts of the consignment as a whole, either while the coal is being loaded or unloaded. There is no assurance that a sample or a series of samples taken from the top of the cargo represents the cargo as a whole; in fact, it is very doubtful if such samples are ever representative. If the vessel is being loaded directly from the railroad car portions of coal should be taken from as many cars as practicable; for cargoes of 4,000 tons and more loading in 12 to 36 hours it may be impossible to collect portions from every railroad car dumped, unless a number of sample collectors are employed or the sample is collected automatically by a mechanical device, because of the rapidity with which the cars may pass over the pier. In this event portions should be taken from every second car if practicable and these portions mixed to form gross samples.

The Bureau of Mines has charge of the sampling of cargo shipments of coal to the Isthmus of Panama, account of the Panama Railroad Co. The coal is loaded at present from piers on Hampton Roads, Norfolk, and Newport News, Va., directly from railroad cars into ships carrying from 4,000 to 6,500 tons of coal. The method followed is to collect portions of coal from every second railroad car dumped, from 60 to 70 pounds being taken from each car sampled. From 4,000 to 5,000 pounds are usually collected as gross samples to represent a cargo (see p. 21 under "Size of the gross sample"). The gross samples are reduced in successive stages, rather than accumulated and later reduced to quantities convenient for transmittal to the laboratory.

The portions making up the gross samples are taken from the coal as it is discharged from the bottom-dump cars by the use of a shovel or a specially constructed ladle. The ladle has a handle about 5 feet long and a bowl 1 foot in diameter at the top, 9 inches at the bottom, with depth of 9½ inches, and holds from 25 to 30 pounds of coal. To collect samples with the ladle, it is rested on the rails of the track or on the chains that support the gates of the car. Two ladlefuls are usually taken from a car, one from one side and the other from the other side at the opposite end, thereby obtaining portions from different parts of the car. Care is observed to not collect portions of the first or last coal spilling from the car, for the moisture content or proportions of foreign matter in such coal may render the sample unrepresentative. If circumstances permit, the ladle is shifted and filled from different sections of the stream of falling coal. It sometimes happens that the coal is discharged very rapidly, in which case the collector must be alert to collect portions at the most desirable
periods and must take care that the coal does not wrench the ladle out of his hands or jerk him down and do him bodily injury.

The method of sampling cargo shipments has been established as the result of numerous experiments, and it is considered that the analytical reports obtained are representative within limits reasonably to be expected for work of this nature. In the table below are given the results obtained by two men (in two cases, three) separately and independently collecting samples to represent the same cargo. Under test A, three men collected separately and independently 13 100-pound samples each, and the average of the analyses of the 13 samples of the man regularly delegated on the work is indicated as the “Regular” result, while the results of the other two are designated “Experimental.” The first differences under column headed “Difference” are between the “Regular” and first “Experimental,” and the second differences are between the “Regular” and second “Experimental,” while the third differences are between the two “Experimentals” (for all practical purposes of comparison, one of the “Experimentals” being considered as “Regular” in obtaining the third differences).

The samples were collected with shovel or ladle, as indicated by S or L, one object of the tests being to determine relative values of the two tools for use in collecting samples—a study of the table shows that as far as results are concerned, it is immaterial which is used.

All the samples of certain sets were analyzed in the Bureau of Mines laboratory at Pittsburgh, Pa., the others being analyzed in its Washington laboratory. The samples analyzed in Pittsburgh are indicated by P, those in Washington by W. A study of the results shows that for practical purposes, it is immaterial in which laboratory the determinations were made, especially with respect to the ash content and the heating value. The laboratories differ somewhat, however, in the moisture determinations, this being due to the fact that when the experiments were conducted, the Washington laboratory did not follow the “air-drying” method used at Pittsburgh for determining moisture. The methods are diagrammatically shown on pages 40 and 41. The results show, as expected, that the “air-drying” method gives a slightly higher moisture content.

In tests A to F, inclusive, each man sampled every third car, collecting about 35 pounds to the car, three such portions, or 100 pounds, representing every 9 cars loaded into the ship. The men sampled the same cars, except those indicated by asterisks; in which cases the “Experimental” samples were collected from cars not sampled by the other man or men.

In tests G, H, I, and J, the men collected approximately 70 pounds from every second car, 8 such portions being mixed, giving from 500
to 550 pounds to represent 16 cars loaded into the ship for tests G and H, whereas 4 such portions were mixed for tests I and J.

For practical purposes, the table shows that it is immaterial whether the shovel or ladle is used; whether samples are analyzed in Washington or Pittsburgh laboratories; that the larger gross samples do not give closer agreement than the smaller ones; and that portions of coal collected from every second or third car give results which fairly represent a cargo.

*Check cargo sampling.*

<table>
<thead>
<tr>
<th>Test</th>
<th>Number of samples</th>
<th>Weight of gross samples</th>
<th>Regular.</th>
<th>Experimental.</th>
<th>Difference.</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>1,300</td>
<td>(W) (S) 2.52</td>
<td>4.61</td>
<td>15,017</td>
<td>4.53</td>
</tr>
<tr>
<td>B</td>
<td>1,300</td>
<td>(W) (L) 1.85</td>
<td>6.92</td>
<td>14,710</td>
<td>6.76</td>
</tr>
<tr>
<td>C</td>
<td>1,300</td>
<td>(W) (L) 2.71</td>
<td>7.06</td>
<td>14,664</td>
<td>6.64</td>
</tr>
<tr>
<td>D</td>
<td>1,100</td>
<td>(W) (L) 3.09</td>
<td>4.85</td>
<td>14,992</td>
<td>4.59</td>
</tr>
<tr>
<td>E</td>
<td>1,300</td>
<td>(W) (L) 3.09</td>
<td>6.43</td>
<td>14,742</td>
<td>6.98</td>
</tr>
<tr>
<td>F</td>
<td>1,500</td>
<td>(W) (L) 2.68</td>
<td>6.63</td>
<td>14,700</td>
<td>6.57</td>
</tr>
<tr>
<td>G</td>
<td>2,500</td>
<td>(W) (L) 1.72</td>
<td>6.70</td>
<td>14,654</td>
<td>6.96</td>
</tr>
<tr>
<td>H</td>
<td>4,450</td>
<td>(W) (L) 2.28</td>
<td>6.57</td>
<td>14,733</td>
<td>6.34</td>
</tr>
<tr>
<td>I</td>
<td>3,920</td>
<td>(W) (S) 2.64</td>
<td>5.70</td>
<td>14,806</td>
<td>5.42</td>
</tr>
<tr>
<td>J</td>
<td>3,640</td>
<td>(W) (S) 3.49</td>
<td>5.15</td>
<td>14,882</td>
<td>5.53</td>
</tr>
</tbody>
</table>

Average difference: .27 .24 29

The bureau is making a study of the conditions on the piers, with a view of devising means whereby the samples can be automatically and mechanically collected, prepared, and reduced to quantities convenient for transmittal to the laboratory. At one of the three railroad terminals loading at Hampton Roads, Va., the bureau has installed a crusher for crushing the gross samples to ¼-inch mesh and finer, and parting devices for reducing the samples in quantity. It is proposed to install crushers and equipment at the other two points.

Because of the suddenness with which the coal may break through and drop out of the railroad car after the gates are open and because of the momentum of the rapidly falling coal, it may be impossible to collect a satisfactory sample by attempting to catch coal in a shovel or ladle. In such event, it may be necessary to collect shovelfuls of
the coal that has overflowed on the pier. If beams 10 to 12 inches wide span the pockets immediately underneath the car, a fairly satisfactory sample can often be collected in shovelfuls from the coal lodging on the beams.

Though the collector may use the shovel or ladle to the best of his ability, these tools may collect portions of coal that do not contain lump coal in the same proportion that exists in the car. Especially may this occur if the coal contains a large proportion of lumps of considerable size. In that event, the collector should collect portions of lumps from time to time and add them to the sample. Necessarily the collector must be relied upon to collect a sample under these conditions that will fairly represent the proportions of lump and slack coal contained in the coal sampled and it follows that the collector must have experience in sampling and be able to judge the coal and the sample.

In sampling large quantities of coal in a short period the collector frequently works under disadvantages and has not the opportunity to select more leisurely and methodically portions of coal to make up a gross sample, as he can in sampling wagonload deliveries or in single carloads or barges unloaded by shovel, clam shells, or grab buckets, and this fact should be considered in comparing the results of sampling cargo with wagon or railroad-car deliveries.

In collecting samples from coal as it is unloaded from a ship, the same general instructions apply; the cargo being systematically sampled during the entire period of unloading, so that samples will be collected which represent the quantity as a whole. If unloaded by grab buckets or into barrows, shovelfuls should be collected at regular intervals from the buckets or barrows. If the coal is crushed immediately after it is unloaded, it is preferable to collect samples from the crushed coal.

**SAMPLE RECEPCTACLE.**

As the wagons or railroad cars may arrive irregularly and the coal be intermittently unloaded, a metal receptacle or wooden box of a size to hold a gross sample of at least 1,000 pounds, with a tight-fitting lid, which can be locked, is required for holding the portions of coal taken from each wagon or car until the gross sample is completed. In sampling cargo deliveries, buckets holding 60 to 70 pounds may prove more satisfactory to use for receiving the portions making up a gross sample, as the samples are usually worked down as the loading progresses and the buckets are convenient for carrying the coal to the space available for preparing the gross samples. If the gross samples are stored, a box should be provided or else a sufficient number of buckets with tight-fitting lids and locks should be available.
The buckets, boxes, or receptacles should be inspected each time before using and thoroughly cleaned to remove the coal dust remaining from previous samples and any foreign matter that may by chance be in them.

COLLECTION OF SPECIAL MOISTURE SAMPLES.

During the collection of gross samples and their reduction to quantities that are convenient for transmittal to the laboratory and that correctly represent the ash, sulphur, and heating value of the coal sampled, it is ordinarily impossible to retain in the sample all the moisture that was in the delivered coal. Obviously, if it is desired to determine the amount of moisture in delivered coal, special moisture samples are usually necessary. Owing to the fact that a sample unavoidably loses moisture during every stage of handling and preparation, the special moisture samples must be, in a sense, grab samples and must be collected, prepared, and placed in a sealed container with as little delay as possible.

If a gross sample is collected during a period of a few hours or a very few days and the sample is collected and stored under conditions so as to preserve its moisture content, a special moisture sample may be collected from the gross sample after it has been rapidly crushed, so that it will all pass through a 1-inch screen (the fineness to which the gross sample is reduced by the first crushing, see table on p. 33). It should be collected in a place comparatively cool and protected from rain, snow, wind, and the sun's rays. A small scoop may be used for collecting the sample. The scoop should have a capacity to hold about one pound of coal—a scoop with bottom about 2½ inches wide and 8½ inches long and vertical sides about 2 inches high is about the right size. As the crushed coal is shoveled into a conical pile (p. 34), scoopfuls should be regularly and systematically collected so that approximately one scoopful will be collected to every two shovelfuls (about 30 pounds) deposited on the cone, thereby collecting a special moisture sample weighing from 30 to 50 pounds. As the scoopfuls are collected they should be placed in a receptacle which can be tightly closed. After the gross sample has been formed into a conical pile (p. 34) and the special moisture sample weighing 30 to 50 pounds has been accumulated, the special moisture sample should be immediately and rapidly crushed so that no pieces of coal or impurities are larger than one-half inch; and it should be rapidly coned, flattened, and quartered, and a mailing can (p. 43) filled by taking portions from each quarter by use of the scoop (each portion only partly filling the scoop). The mailing can should be properly sealed at once (p. 43) and forwarded to the laboratory.

If the gross sample in the above case is crushed mechanically and reduced to the quantity desired for transmittal to the laboratory by
use of sampling machines in such a manner and in machines so
designed that moisture losses are minimized, then the collection of a
special moisture sample may prove unnecessary, as the moisture
determination made on the regular sample will represent, within
reasonable limits, the moisture content in the coal delivered.

If a gross sample is collected during a period of several days, and if
it is manifest that the sample will lose moisture during its storage
and preparation, the special moisture sample should be accumulated
by placing in a receptacle small portions of the freshly taken incre-
ments making up the gross sample. Under these conditions it is
desirable that a receptacle which can be hermetically sealed and has
a capacity of about 70 pounds be provided in which to preserve the
portions making up the special moisture sample as they are taken
each day. After the gross sample is accumulated a quantity con-
venient for transmittal to the laboratory should be selected from the
special moisture sample (in accordance with the method given above)
and forwarded in the mailing can, properly sealed for special moisture
determination.

If two or more railroad cars are to be represented by one gross
sample, and if the cars contain different amounts of moisture seem-
ingly in excess of the maximum moisture content guaranteed, mois-
ture samples should be taken separately from each car. If a single
gross sample is to represent several days' delivery, and if because of
heavy intermittent rains there is a considerable difference in moisture
content between each day's delivery, and each contains moisture in
excess of the maximum content guaranteed, then a special moisture
sample should be taken representing each day's delivery. Payment
for the entire quantity on account of ash and B. t. u., "dry coal," is
determined from the analysis of the gross sample, but corrections on
account of excessive moisture should apply to the particular car or
cars, or day's delivery. The purchaser would be at a disadvantage
on account of heavy rain if corrections for moisture did not apply to
each day's delivery or fraction of the delivery, because if the special
moisture samples were mixed, and one special moisture determina-
tion only made, the effect of the heavy rains would largely be averaged
out in the mixture, and, in addition, in storing, mixing, and reducing
the samples more or less moisture would be lost.

PREPARATION OF THE GROSS SAMPLE.

Though a gross sample may be collected ever so carefully and may
represent the coal sampled, unless it is prepared in accordance with
well recognized principles, the results of analysis and test may be worth-
less for determining equitable settlement for the coal.

The portions taken in making up the gross sample should be imme-
diately placed in a box or a receptacle having a tight-fitting cover
and lock for storage until it is reduced to a quantity convenient for transmitting to the laboratory. Each receptacle should be securely locked and the key held by a responsible employee.

If it is desired to determine the moisture content of a gross sample that has been collected in a comparatively short time under precautions to minimize moisture loss, the sample should be placed in a comparatively cool place and the crushing, mixing, and reduction for shipment to the laboratory should be done as rapidly as possible; this is imperative if the analysis of the sample is to represent the approximate condition of the coal with respect to its moisture content at the time it was weighed. Obviously, a sample on which a moisture determination is desired should be protected from rain and snow and strong air currents or winds and the sun’s rays during its storage and preparation.

The proper preparation of a gross sample for shipment to the laboratory involves three operations: (1) Crushing, (2) mixing, and (3) reduction in quantity. The operations proceed in stages until the final sample is obtained.

The crushing may be done by a mechanical crusher or by hand with an iron tamping bar or sledge on a smooth, clean, sheet-iron plate, of suitable dimensions, or on a solid floor—in the absence of a sheet-iron plate or smooth tight floor, the crushing may be done on a heavy canvas—to prevent the accidental admixture of any foreign matter. The mixing and reduction may be done by hand with a shovel, or, mechanically, by means of riffles or sampling machines.

It is obvious that if the gross sample is reduced in quantity without crushing, as the sample becomes smaller, the effect of the selection or rejection of one or more of the large pieces of slate, or other impurities, in the portion of the sample retained multiplies rapidly. To illustrate: A sample of 1,000 pounds contains a piece of slate weighing 1 pound, which is one-tenth per cent of the weight of the gross sample. If the sample is halved in quantity without crushing, the half of the sample retained for further reduction will contain two-tenths per cent ash more or less than the rejected half, according to whether the piece of slate went into the retained half or into the rejected half. In halving the 500-pound sample, the 1-pound piece of slate would have an effect of four-tenths per cent on the ash content of either the retained or rejected half. If, in continuing the reduction of the sample by halving each time, the 1-pound piece of slate by chance should fall into the retained half on each successive halving, it would have an effect of 12.8 per cent on a 71\(\frac{1}{8}\)-pound sample—that is, in halving the 15\(\frac{3}{4}\)-pound sample, the 1-pound piece of slate would cause the ash content of one-half of the sample to be 12.8 per cent higher than the other; in other words, if the average ash of the coal is 10 per cent, one of the 71\(\frac{1}{8}\)-pound samples would show an ash content of 22.8 per cent.
This fundamental principle that the weight of the largest piece of impurities should be relatively very small in ratio to the weight of the sample at each halving, is recognized in the instructions for sampling issued by the Bureau of Mines which specify that the sample should be successively crushed, mixed, and reduced.

In the sampling of ores, it is recognized that the particles of ore must be crushed to varying degrees of fineness in order to obtain results within an allowable limit of error, and to accomplish this, elaborate and costly plants are constructed and maintained. Brunton states that experiments and calculations and a general consideration of the subject indicate that the size to which ore must be crushed for sampling, in order to come within an allowable limit of error, will depend upon:

1. The weight or bulk which the sample is to have. Evidently the smaller the sample the finer the material must be crushed.

2. The relative proportion between the value of the richest mineral and the average value of the ore. If the average grade of the ore is high, in comparison with the grade of the richest mineral, a particle of richest mineral of a given size and value will have less percentage effect on the sample than the same particle would have on the same amount of lower-grade ore; therefore, other conditions being the same, with high-grade ores we may crush more coarsely than with low-grade ones, and still keep within the same percentage of error; while if the richest mineral is of comparatively high grade, a particle of it, of given size, will have a greater effect on the sample than if it is of low grade, and this will necessitate finer crushing.

3. The specific gravity of the richest mineral. The higher the specific gravity of the richest mineral the greater the value contained in a particle of given size and grade, and hence the greater the influence of such particle on the sample; from which follows the necessity of keeping down the size of the largest particles by finer crushing than is required when the richest mineral is of lower specific gravity.

4. The number of particles of richest mineral which are likely to be in excess or deficit in the sample is evidently an important factor; a liability to a large number necessitating especially fine crushing. But such liability can result only from imperfect mixing, and for material mixed with average thoroughness this number must be small.

And in conclusion, this paper further states that:

The results of the investigations recorded in this paper show how absolutely necessary it is that ore samples should be recrushed after each successive “cutting-down,” so that as the sample diminishes in weight, there may be a nearly constant ratio between the weight of the sample and that of the largest particle of ore contained therein.

In applying these principles to coal, slate and other impurities are to be considered as taking the place of the “richest mineral,” but as coal is a low-priced commodity, the cost of collecting and preparing samples must necessarily be correspondingly small, making the installation and operation of elaborate sampling plants prohibitive.

Though the fineness to which the Bureau of Mines specifies that samples be crushed may not be strictly in accordance with the

---

fineness that would be necessary for theoretically accurate reduction of the samples, and since, in fact, a coal of a definite physical character and composition would require special treatment, the fineness specified in the table below, it is believed, will give results that are fairly representative.

When prepared by hand, the pieces of coal and impurities should be crushed to the following approximate sizes before each reduction:

<table>
<thead>
<tr>
<th>Weight of sample to be divided.</th>
<th>Size to which coal and impurities should be broken before each division.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1,000 pounds or more...</td>
<td>Inch.</td>
</tr>
<tr>
<td>500 pounds</td>
<td>1</td>
</tr>
<tr>
<td>250 pounds</td>
<td>2</td>
</tr>
<tr>
<td>125 pounds</td>
<td>3</td>
</tr>
<tr>
<td>60 pounds</td>
<td>4</td>
</tr>
</tbody>
</table>

*Weights of samples and corresponding sizes required.*

*Diagram showing the treatment of a 1000-pound sample.*

1,000-pound gross sample, crush to 1-inch mesh; mix by coning and long-pile method; halve by alternate shovel method.

<table>
<thead>
<tr>
<th>Rejected portions.</th>
<th>500 pounds</th>
<th>250 pounds</th>
<th>125 pounds</th>
<th>62 1/4 pounds</th>
<th>31 1/4 pounds</th>
<th>15 5/8 pounds</th>
<th>7 1/4 pounds</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>500 pounds, crush to 1/2-inch mesh; mix by coning and long-pile method; halve by alternate shovel method.</td>
<td>250 pounds, crush to 1/4-inch mesh; mix by coning and long-pile method; halve by alternate shovel method.</td>
<td>125 pounds, crush to 3/8-inch mesh; mix by rolling on blanket; halve by quartering method.</td>
<td>62 1/4 pounds, crush to 1/8-inch mesh; mix and halve by riffles (or sampling machines) or by blanket and quartering method.</td>
<td>31 1/4 pounds; mix and halve by riffles (or sampling machines) or by blanket and quartering method.</td>
<td>15 5/8 pounds; mix and halve by riffles (or sampling machines) or by blanket and quartering method.</td>
<td>7 1/4 pounds; mix and halve by riffles (or sampling machines) or by blanket and quartering method.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>31/2 pounds.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Fill 3-pound can and mail to laboratory.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

31/2 pounds.

Fill 3-pound can for reserve sample.

77550°—13—3
Care should be exercised to crush finely pieces of foreign matter before each reduction so that the crushed impurities can be distributed through the sample, and when crushing to keep pieces of slate and other impurities from flying out of the sample. In crushing the coal on wood, brick, cement, or floors of such materials splinters or small fragments may be broken from the floor and be mixed with the sample. Such floors, if used, should be thoroughly clean and free from cracks. If a sheet-iron plate is used, it should be free from rust.

After each crushing the sample should be thoroughly mixed before reduction in quantity. The method which gives generally satisfactory results is as follows:

The crushed coal is formed into a conical pile by depositing each shovelful of coal on top of the preceding one (Pl. I, A). (Pl. I, A, shows approximately 1,100 pounds of coal crushed to 1-inch mesh and finer, properly coned.) As the shovelfuls are deposited the fine material forms the apex of the cone, while the coarse particles roll down toward the base. By walking around the cone and systematically depositing shovelfuls on the apex of the cone from every side, care being taken to maintain the original form, the sampler will properly distribute the fine and coarse coal. A new, long, pile is then formed by taking a shovelful at a time (as the sampler fills the shovel he should walk around the cone, thus systematically removing the coal from the base of the cone) and spreading it out in a straight line or ribbon the width of the shovel; the length is 8 to 10 feet for a shovel holding about 15 pounds. Each new shovelful is spread over the top of the preceding one, beginning at opposite ends, and so on until all the coal has been formed into one long pile. (Pl. I, B, shows the coal of the cone formed into a long pile.) The sample is then halved in quantity by shoveling the long pile to one side, alternate shovelfuls being discarded while the retained shovelfuls are formed into a new cone. In shoveling the coal from the long pile the sampler takes the shovelfuls of coal systematically around the pile, advancing around at each shovelful a distance about equal to the width of the shovel, thereby preserving the symmetry in the form of the pile. If the pile should be reduced by shoveling all of the coal from either end, and if the alternate shovelfuls discarded contained coal mainly from the sides of the pile, the rejected half of the sample would contain a preponderance of coarse coal, while the retained half would contain relatively too much fine coal. This is because the coarse coal rolls down the sides of a pile or cone while the fine coal builds up, so that the relative proportions of coarse and fine coal in outer and inner portions of the pile are quite different. The alternate shovelfuls of coal which are retained are formed into a new cone.
A. CRUSHED GROSS SAMPLE IN CONICAL PILE.

B. CRUSHED GROSS SAMPLE REMIXED IN LONG PILE.

C. REDUCED SAMPLE QUARTERED.
In coning, care should be observed to deposit each shovelful so that the center of the cone as started will not be drawn to one side, for in quartering a cone the center of which has been drawn, two opposite quarters will contain an excess ratio of fine material, while the other two quarters will contain a deficiency. This will be apparent when it is considered that when a cone is formed, the fines build up the apex while the coarse particles roll down the sides. In ore sampling this may be of especial importance, since the fines are generally the richest ore, and as a result the metallic content of the final sample will be more or less than the average of the original pile, depending upon which two quarters are retained. D. W. Brunton, in a paper entitled “Modern Practice of Ore-Sampling,” shows by illustrations and an example the effect of “drawing the center.” He takes as an example the reduction of a 2,000-pound lot of ore to 62½ pounds (requiring quartering five times), and supposing that at each stage the sample taken represented 98 per cent of the actual value of the cone, he shows that the final sample would only give 90.3 per cent of the true value of the cone.

The above “coning,” “long pile,” and “alternate shovel” method of mixing and reducing the sample is followed until the sample is reduced to from 125 to 250 pounds. Samples smaller than 125 to 250 pounds are mixed on a canvas about 6 by 8 feet in dimension by raising first one end of the canvas and then the other, thereby rolling the sample back and forth. After being thoroughly mixed in this manner, the sample is formed into a conical pile by gathering the four corners of the blankets. The cone is then flattened, its apex being pressed down with the shovel or a board, so that each quarter contains the material originally in it. The flattened mass which should be of uniform thickness and diameter is then marked off into quarters with a board held edgewise, or a piece of sheet iron, along two lines that intersect at right angles directly under the apex of the original cone. The diagonally opposite quarters are shoveled away and discarded, and the spaces which they occupied brushed clean (Pl. I, C, shows the four quarters and the intersecting lines; quarters 1 and 3 will be rejected). The coal remaining is successively mixed, coned, and quartered on the canvas until two opposite quarters are equal to or somewhat less than the quantity (approximately 3 pounds) required to fill the sample can for shipment to the laboratory. If after two opposite quarters are placed in the sampling can, it is found that the can is not compactly filled, the other two quarters should be mixed, coned, flattened, and quartered, and the remaining space in the can then filled by taking equal segments from opposite quarters, using the sampling scoop (p. 29). The two rejected quarters are not thrown into the discard, but are placed in a sampling
can, hermetically sealed and held in reserve at the delivery point until report of analysis of the regular sample is received and settlement made for the coal.

The operations and methods followed in preparing and reducing the gross sample to a quantity convenient for transmittal to the laboratory are diagrammatically shown on page 33. The treatment of the 3-pound sample when it is received by the Bureau of Mines is diagrammatically shown on pages 40 and 41.

Accuracy in reducing the gross samples requires that the coal be crushed as directed, thoroughly and systematically mixed, formed in piles, and accurately divided, either by the alternate-shovel method or by quartering, so that the rejected portions and the retained portions will be uniform in character and weight. Thorough cleanliness must be maintained during the entire operation.

The method of coning and quartering coal and the principles which must be recognized are in essential features as given by Richards for reducing ore samples.

Whenever the different increments of samples are collected throughout some considerable period of time, each increment may be crushed as soon as taken, and the pieces of coal and impurities may be broken sufficiently small to permit of two or more reductions of the accumulated samples before further crushing is necessary.

If deliveries extend over a considerable period, what would otherwise be a gross sample may be worked down, as it accumulates, in successive stages to quantities of a size suitable for transmittal to the laboratory, and the samples representing the several equal parts may be analyzed and the several analyses averaged, or they may later be mixed (at the delivery point or in the laboratory and reduced to one sample) and one analysis made.

If the contract amounts to a considerable quantity, necessitating several samples in relatively short periods, the installation of a crusher has been found in some cases expedient and economical for reducing the gross samples to one-quarter-inch mesh, or finer, and in such case, instead of the mixing and reducing being done by hand, the reducing buckets or mixing and reducing machine shown in Plate II are used. Even though the contracts are relatively small and the samples are crushed by hand, the use of the reducing bucket or machine is recommended. These devices are generally used after the gross sample has been mixed and has been reduced by the "alternate-shovel" or quartering method to about 60 pounds.

After the gross sample has been reduced to about 200 pounds, a shovel takes too large a proportion of the coal, making further reduction by alternate shovelfuls unreliable. The blanket and quartering methods are introduced after the sample has been reduced by

---

alternate shovels to 125 to 250 pounds, as the capacity of the ordinary shovel is out of proportion to the size of the sample. It may prove desirable in sampling coals containing considerable quantities of free impurities of uneven size to use small shovels of 10 pounds and less capacity in reducing the gross sample by alternate shovels, for as the size of the shovel is diminished the number of fractional parts into which the sample is divided is increased. As the sample becomes smaller, greater precision in quartering is required, and, consequently, refinements in the manner of mixing and reducing should be introduced. The use of buckets or the machine makes thorough mixing possible and the riffles insure accurate division.

A mechanical crusher and mechanical means for preparing the samples for transmittal to the laboratory may be installed and the collection and preparation of the sample can then be made a continuous and purely mechanical process. When mechanical crushers are used the samples should be inspected before or while being fed to the crusher to make certain that the sample does not by chance contain a piece of iron, such as a tie spike, accidentally loaded with the coal in the mine and undetected in collecting the sample, or some other highly abrasive substance, otherwise the abrasion of the iron may introduce errors which would alter appreciably the final results.

**Sampling buckets.**

When the sampling buckets are used, two similar ones are required. About half of the top of each bucket is covered with a riffle. The coal is placed in one of the buckets, and the projections \( aa' \) (Pl. II, A) of the stiffening rod of this bucket are placed in the notches \( bb' \) of the second bucket. When the coal is poured from the first bucket it flows to the riffle of the second bucket and every alternate section cut out by the riffle is discarded and the other sections are caught in the second bucket, thus halving the sample. The sample is poured from one bucket to the other until it is reduced to about 3 pounds, but the discarded 3-pound half is placed in a can and held as the reserve sample.

**The mixing and reducing machine.**

If more thorough mixing than can be done with the buckets is desired, the mixing and reducing machine is used. Plate II, B, shows the apron of the cylinder of this machine open for receiving a sample. After the sample is poured in, the apron's position is shifted, \( a \) being moved to \( a' \). The cylinder is then closed and revolved counterclockwise. The closed sides of the riffles plow through and thoroughly mix the coal, and no coal can be discharged through the riffle while the cylinder is revolved in this direction if the level of the coal
is below the axis of the cylinder. After the sample has been mixed, the cylinder is rotated one turn clockwise; the coal in the cylinder is then cut by the planes of the riffle and half of it is discharged into the receiving tray. The coal remaining is again mixed by revolving the cylinder counterclockwise. By alternately changing the direction of rotation, the coal is alternately mixed and halved until about 6 pounds remain in the cylinder. The tray is then emptied of the discarded coal and the 6-pound sample mixed and halved, and the 3-pound sample caught in the tray is put in a can and becomes the official sample, while the 3-pound sample remaining in the cylinder is put in a can and held as the reserve sample. The interior of the machine is easy of access and should be brushed clean after each sample.

Generally speaking, the use of mechanical means for sampling coal and preparing samples gives more reliable and satisfactory results than hand labor, as the personal equation is partly eliminated.

**COLLECTION OF SAMPLES IN THE DISTRICT OF COLUMBIA.**

Gross samples are collected from deliveries under Government contracts in the District of Columbia in accordance with the method given in the specifications and as set forth in this paper. Instead of the gross sample being reduced to 3 pounds, as is necessary in the case of deliveries elsewhere, the sample after it is reduced to 125 to 250 pounds, is placed in galvanized-iron buckets, each large enough to hold about 70 pounds of coal and having a close-fitting lid that can be locked. The locked buckets of coal are immediately delivered to the crushing room in the Bureau of Mines building, where the preparation of the sample for the laboratory is continued.

**THE CRUSHING ROOM.**

For preparing the samples collected in Washington, after they have been reduced at the delivery point to 125 to 250 pounds, specially designed machinery is installed in the crushing room of the Bureau of Mines plant. The samples are put through a motor-driven hammer crusher which crushes the coal to pass a one-quarter inch mesh.

Plate III is a view of the coal-crushing machinery through which the samples are passed. The crusher (not shown in the plate, being hidden by the extensions of the platform) rests on metal framework, its base being nearly on a level with the platform, which is 14 feet 4 inches from the floor of the crushing room. The buckets of coal are raised to the platform by means of a hydraulic elevator (not shown in the view). The samples are fed from the buckets to the crusher through the hopper.

After the entire sample has been crushed and caught in the bin or pocket (a, Pl. III) immediately below the crusher, it is passed into
A. SAMPLING BUCKET.

B. MIXING AND REDUCING MACHINE.
the revolving cylinder or mixer (b, Pl. III). This cylinder can be locked in position, with the discharge opening of the pocket registering with the opening in the mixer. When the sample is discharged from the pocket, the openings of the pocket and the cylinder are closed by suitable gates. By releasing the locking device and throwing in a clutch the cylinder is caused to revolve. The crusher and pocket are then free to receive another sample.

After the sample is thoroughly mixed, the mixer is stopped, its opening registered with the opening of the chute directly below the mixer, and the mixer locked in this position. The gate of the cylinder is then opened, and the coal is discharged into the separating chute (c, Pl. III).

Immediately below the opening at the top of the separating chute the coal passes over a riffle, which consists of a series of vertical parallel planes, equally spaced and so constructed that the coal when being passed over them is cut into sections. Every alternate section is deflected to the discharge, the other sections pass through and are retained. One-half of the coal is thus deflected into a receiving bin and eliminated from the sample. The other half falls vertically through the chute to a second riffle, where it is again halved, one half being carried to a second receiving bin, and the other half passing down to a third riffle. There are in all four riffles in the chute, and the quantity finally received in the receptacle directly below the chute is one-sixteenth of the quantity of the original sample that was received into the chute. By means of doors in the chute each riffle can be inspected and cleaned.

Four of the five bins for receiving discharged coal from the separating chute can be seen in Plate III (1, 2, 3, and 5). Four of these bins receive discarded coal, the largest bin receiving the discarded half from the first riffle, the next largest the discarded half from the second riffle, and so on, the final sample being received in the fifth bin (Pl. III, 5) directly below the chute.

Except for the platform, the crusher mechanism is constructed wholly of metal. The bins, chute, and other parts through which the coal is passed are made as dust proof as possible, iron cement being used to close leaks. However, more or less free dust arises from the crusher. This dust is carried away by means of a ventilating system. An exhaust fan driven by a direct-connected motor is located in the penthouse on the roof of the building. Galvanized-iron ducts lead from the fan to the laboratory, crushing room, and sampling room. In the crushing and sampling rooms, running off from the main ventilating duct (d, Pl. III), are branches connecting with each bin, some with hoods being placed over dust-producing machines. On each one of these branch ducts, as well as on the main
ventilating pipe, dampers are placed, by which the draft is regulated. The system works very satisfactorily and keeps the crushing and sampling rooms free from dust.

If the quantity of coal finally delivered from the chute is larger than is desired, it is further reduced by using two sampling buckets (Pl. II, A) or the reducing machine (Pl. II, B). The mixing machine is more generally used, because the machine mixes the coal more thoroughly than the buckets and prevents the sample from being exposed to the air.

All samples are reduced to a quantity that will nearly fill a 3-pound galvanized can. The samples are then in the same stage of preparation as those received from points outside of Washington, and like them are further prepared in the sampling room. The methods of preparation are diagrammatically shown below:

*Diagrams showing treatment of the 3-pound sample in the laboratory.*

**METHOD A.**

3-pound sample crushed by roll crusher to 20-mesh.

<table>
<thead>
<tr>
<th>3 pounds, less 3 ounces.</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 ounces immediately placed in rubber-stoppered bottle for total moisture determination only.</td>
</tr>
<tr>
<td>Successively passed through riffles and reduced to not more than 3 ounces. Rejected coal returned to the can and held as reserve.</td>
</tr>
<tr>
<td>3 ounces.</td>
</tr>
</tbody>
</table>

3 ounces ground by planetary-disk crusher to 60 mesh and placed in a rubber-stoppered bottle. (This is the laboratory sample proper.)

<table>
<thead>
<tr>
<th>1 gram (about 1 ounce).</th>
<th>1 gram.</th>
<th>1 gram.</th>
<th>1 gram.</th>
</tr>
</thead>
<tbody>
<tr>
<td>For moisture in laboratory sample.</td>
<td>For volatile-matter determination.</td>
<td>Sulphur determination by Eschka method.</td>
<td>For heating-value determination in a bomb calorimeter.</td>
</tr>
</tbody>
</table>

Ash in this 1-gram sample determined after the moisture is determined.

Sulphur is determined on the washings and residue from the calorimeter after combustion.

*The method of preparation of the samples in the sampling room, with a description of the laboratory methods and equipment, is given on p. 74 to 91, Bureau of Mines Bulletin 41.*
3-pound sample dried in air-drying oven for "total moisture" determination.

Crushed by rolls to 20 mesh.

Reduced in quantity by riffles to 8 ounces. Rejected coal returned to the can and held as reserve.

8-ounce sample pulverized to 60 mesh in Abbe ball mill.

8-ounce sample reduced in quantity by riffles to 3 ounces, placed in a rubber-stoppered bottle and becomes the laboratory sample proper. Rejected coal returned to the can and held as reserve.

3-ounce laboratory sample treated the same as the 3-ounce sample under method A.

Both methods of procedure given above are followed in the Bureau of Mines laboratory in Washington, D. C., wherein the samples representing Government coal deliveries are analyzed and tested—method B being followed for most anthracite samples and for any samples of high-moisture or wet coals, as by this method a more representative moisture value can be obtained than by method A, for in method A high-moisture or wet coals unavoidably lose more or less moisture in the crushing of the 3-pound sample. Method B, somewhat modified, is followed on all samples in the Bureau of Mines laboratory in Pittsburgh, Pa., which is maintained for analyzing and testing samples necessary for the conducting of certain fuel, mining, and metallurgical investigations which the bureau is making.

A SIMPLE CRUSHING AND SAMPLING INSTALLATION.

The Bureau of Mines receives requests from different branches of the Federal Service for suggestions as to the type and design of installations for crushing and reducing coal samples. Figure 3 shows the suggested design for a simple coal-sampling plant for the United States penitentiaries at Atlanta, Ga., and Leavenworth, Kans. The several parts of the hopper and riffle were so developed on separate blue prints that they are readily understood and can be made without difficulty by a tinner.

---

The gross sample is accumulated in buckets, each holding approximately 70 pounds of coal, and the filled buckets are stored on the platform. Each bucket of coal making up the gross sample is successively passed through the motor-driven crusher which reduces the coal to \( \frac{1}{4} \)-inch mesh and finer (practically all of the coal will pass through \( \frac{1}{4} \)-inch mesh), and the coal is halved by a riffle, one-half being deflected to a bin for discarded coal and the other half into a bucket. As the buckets are emptied into the crusher, they are available for catching the retained half from the riffle. Buckets containing the one-half of the gross sample are easily swung to the platform and the sample again halved in quantity by dumping the coal through the trapdoor (shown in fig. 3) and repassing it over the riffles. Elevating the sample to the platform and halving the sample are repeated
until the sample is reduced to the quantity convenient for transmittal to the laboratory.

Only the relation of one bin wall to the riffle is shown in the drawing; the shape of the bin can be varied to suit the arrangements in the building. If the building in which the installation is housed is so situated that a chute for the discarded coal can lead directly into a wagon body, car, or the boiler room, the disposal of this coal will be simplified.

For the inspection of the riffle and the removal of matter clogging the riffle a small door is provided in the main hopper. After each crushing the hopper and riffle should be brushed clean.

This particular form of equipment is developed with a view to simplicity and cheapness. By placing a series of riffles one below the other, the sample can be reduced to one-quarter, one-eighth, one-sixteenth, etc., of its original quantity, depending upon the number of riffles installed. As more riffles are added, the cost is increased and the platform must be raised, requiring other means than hand labor for elevating the parts of the samples. The Bureau of Mines is experimenting with other devices and types with a view to increasing the efficiency of the installation so that it will accurately select fractional parts of the gross sample with a minimum of handling and at a relatively low cost.

SEALING AND MAILING.

The final 3-pound sample is immediately placed in the galvanized-iron can furnished by the Bureau of Mines and sealed air-tight. The coal should be firmly packed in the can, so as to occupy as much of the space as possible, since in this way the air is more nearly excluded. This packing is best accomplished by having the coal finely crushed in the manner described in the preceding pages and by shaking or jarring the can repeatedly and vigorously while filling it.

The can is 11 inches in length and 3½ inches in diameter (inside dimensions), with a screw cap 2 inches in diameter. Its edges are crimped and carefully soldered so as to make it air-tight and strong. The screw cap has a gasket or washer of rubber or other flexible material to exclude the air. As a further protection and to insure tightness the cap when in place and screwed down is wrapped carefully with several layers of adhesive tape, the first layer of which completely covers the joint between the lower edge of the cap and the neck of the can. In Plate IV, a shows the first layer of the tape being forced down with thumb and forefinger; b the can properly sealed, and c the can ready for mailing. It is not advisable to use solder, paraffin, or sealing wax of any kind, because some of the material may be mixed with the coal, either when it is applied or when the cap is removed. Before being filled each can should be carefully inspected as to tightness and freedom from rust.

After the can is properly sealed data concerning the sample are properly recorded on a blank form furnished by the Bureau of
Mines and the form is placed (not pasted) around the can, an addressed franked wrapper (c, Pl. IV), is put over it and the can is mailed. The wrapper has a gummed end, but to insure its sticking and keeping the form from being lost a rubber band is put on or a string is tightly tied around the can, as shown in the illustration.

The blank form is in two sections—an original and a duplicate. The original form accompanies the sample, furnishes the bureau complete information as to the sample, and becomes the bureau’s permanent record. The duplicate is used as a file copy for the office submitting the sample.

Special attention should be given to filling out the form and promptly forwarding the sample. Failure to fill out the form properly or to place it around the can may cause indefinite delay in making the analysis of a sample and in reporting the results.

A letter should be written informing the bureau that a sample or samples (giving can numbers) have been forwarded. As the tonnage on many orders or deliveries during a month may be considerable, and as samples may be submitted from time to time, unless the bureau is informed it has no knowledge whether all samples have been received to represent the tonnage, nor has it any intimation as to which is the first or last sample, although this information is necessary to insure prompt reports. To furnish the necessary information, it should be stated in the letter, as follows:

This is the first and only sample which will be submitted on order No. ——, or of the deliveries during the month of ——.

Or,

This sample is the —— (give number) one submitted on order No. ——, or of the deliveries during the month of ——, and other samples on this order or month’s delivery will be submitted.

Or,

This is the last sample on order No. ——, or of the deliveries during the month of ——, and is to be considered with samples submitted in cans numbered ——.

If a sample is submitted representing coal from a mine or from a source other than that specified in the contract, the letter transmitting the sample should so state, in order that the records of the Bureau of Mines will be complete.

A copy of the front and reverse sides of the two sections comprising the form mentioned above are herewith given.

*Forms for reporting samples.*

[Original, front.]

**DEPARTMENT OF THE INTERIOR.**

**BUREAU OF MINES.**

Information to accompany each sample of coal submitted for analysis.

Coal delivered to

(If ship or barge, state where loaded.)

Number of can

Number of sample

Name of contractor
SAMPLING COAL DELIVERIES.

Coal, kind and size ..................................................
Number of tons or pounds delivered represented by this sample ...............................
Dates of delivery ................................................................
Number of contract ................. Number of order ..................
Date of mailing sample ........ Date received .......................
For the bureau's information in reporting on an order or month's delivery, state
whether this sample is the first, last, or only sample, or whether it is to be con-
sidered with other samples on this order or month's delivery .........................

Original.  
Signed.................................................................

[Signed, back.]

SUGGESTIONS AS TO FILLING AND SEALING CANS.

The coal sample should be firmly packed in the can, so as to occupy as much of
the space as possible, since in this way the air is more nearly excluded. To insure
the tightness of the can, the cap when in place and screwed down should be wrapped
carefully with several layers of adhesive tape, the first layer of which should com-
pletely cover the joint between the lower edge of the cap and the neck of the can.
It is not advisable to use solder, paraffin, or sealing wax of any kind, because some of
the material may be mixed with the coal either when the material is applied or when
the cap is removed. Before being filled each can should be carefully inspected as
to tightness and freedom from rust. The Bureau of Mines will furnish a month's
supply of cans, addressed postal-frank mailing wrappers, and this form; if additional
supplies are needed they can be obtained from the bureau monthly on request.

[For instructions as to use of this form, see instructions on back of attached (duplicate) section.]

[Duplicate, front.]

DEPARTMENT OF THE INTERIOR.

BUREAU OF MINES.

Coal delivered to .................................................. (If ship or barge, state where loaded.)
Number of can ................................................. Number of sample.
Name of contractor ..........................................
Coal, kind and size ..............................................
Number of tons or pounds delivered represented by this sample ..............
Dates of delivery ...................................................
Number of contract .......................... Number of order ..........
Date of mailing sample .................. Date received ...............
For the bureau's information in reporting on an order or month's delivery, state
whether this sample is the first, last, or only sample, or whether it is to be con-
sidered with other samples on this order or month's delivery .....................

Duplicate.  
Signed.................................................................

[Duplicate, back.]

INSTRUCTIONS AS TO THE USE OF THIS FORM.

Fill out this form for each sample of coal forwarded to the Bureau of Mines; the
office filling out the form is to retain the duplicate copy. The original must be placed
around the can (but not pasted to the can—it may be held in place by a rubber band),
under the addressed postal-frank wrapper, in such a manner that the sample and the
information regarding it can not be separated in mailing. When the sample reaches
the Bureau of Mines the franked wrapper is torn off and complete information relative
to the sample is found on the card. This form must be properly filled out and forwarded in order to expedite testing and reporting. A letter should be written informing the Bureau that sample or samples (giving can numbers) have been forwarded. The receipt of the sample will be immediately acknowledged.

[For suggestions as to filling and sealing cans, see back of attached (original) section.]

**REPORTING ANALYSES**

The analyses and tests of samples are reported by the laboratory to the fuel-inspection section, where the record of the samples is kept. The laboratory receives the samples with an identification number only, which is given the sample by the fuel-inspection section when the sample is received from the mail, and the laboratory reports the analysis and test by number only. If a report is to be based on the analyses of two or more samples, the analyses are averaged, each analysis being given a weight according to the proportion of the total tonnage which it represented. The results are then reported in triplicate on the following letter form to the branch of the service submitting the sample or samples, which in turn furnishes the contractor one of the copies:

*Form for reporting analysis.*

Serial No. .......

DEPARTMENT OF THE INTERIOR.

BUREAU OF MINES.

*Washington, D. C., ............

Sir: In reference to the .............. tons of ..............
coal delivered on your contract No. ...................... and your order
No. ...................... to the ......................

........................................, 191 , by ......................

The analysis of the samples of coal received by the Bureau of Mines was as follows:

<table>
<thead>
<tr>
<th></th>
<th>As received.</th>
<th>Dry coal.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moisture</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Volatile matter</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fixed carbon</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ash</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sulphur</td>
<td></td>
<td></td>
</tr>
<tr>
<td>British thermal units</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

This information is for the use of the Government and the dealer or operator furnishing the coal. It is confidential until it is published by the United States Government.

Remarks:

Certified: ........................................

*Engineer in charge
Fuel Inspection.*

Respectfully,

*Assistant to the Director.*
COAL SPECIFICATIONS AND PROPOSALS.

There are given in the following pages coal specifications and proposals typical of those in use by the Government for the purchase of coal under specifications based on the heating value, the content of ash and of moisture, and other considerations.

Two classifications of the coal purchased are made, and specifications accordingly prepared, namely, (a) coals for steam power plants, which include bituminous (semibituminous, subbituminous, lignite) and the small sizes of anthracite (pea and buckwheat No. 1), and (b) the large sizes of anthracite (broken, egg, chestnut, and stove), which are used in small house-heating furnaces and stoves for heating and domestic purposes. The specifications for steam power plants can be readily modified to provide for the purchase of smaller sizes (see table, p. 51) of anthracite—that is, coal which will pass through a mesh one-fourth inch square. If it is desired to purchase any particular coal, a specification can readily be prepared from the two types of specifications herein presented.

The purpose of the specifications is to clearly set forth the character and quality of coal desired, to obtain bids which fully specify the coal offered, the values offered in the case of bituminous coal by the successful bidder becoming a part of the contract, to furnish means whereby the Government may be assured of receiving the coal contracted for, providing for a definite procedure for determining equitable settlement for coals differing in character and quality, and to include concise statements of the necessary legal phases, etc., all with the view that the specifications and proposal signed by the successful bidder may become a contract which will work to the advantage and justice of both the Government and the contractor.

Attention is especially directed to instructions for sampling given in the specifications and which become a part of the contract. Prior to the fiscal year 1912-13 the method of sampling was given scant mention, leaving one of the most important features determining the successful and satisfactory application of the specification method of the purchase of coal almost wholly in the hands of the purchaser, the seller having little or no means whereby he could exercise a control of the manner and method of collecting and preparing samples that should represent the coal furnished. It is as essential that an established and an agreed-upon method of sampling be followed, as it is that the sample be analyzed by a reputable laboratory; in fact, the sampling is of first consequence, for if a sample is haphazardly taken and carelessly reduced to a quantity convenient for transmittal to the laboratory, and hence is nonrepresentative, it is usually impossible or impracticable to get another sample; whereas if the analysis and test of a representative sample are in error, the remaining part of the sample can be analyzed and tested, and by another
laboratory if desired. Unwarranted corrections in price and resulting injustice and hardship to the buyer or seller may easily and unintentionally occur through lack of perception of the relative importance of sampling and the observance of proper methods of collecting and preparing samples. By clearly setting forth the method of sampling as a part of the contract, the seller or the buyer has something tangible on which to base legitimate complaints if samples are not properly collected and prepared. Such is the purpose of putting in the Government specifications the method of sampling in some detail.

As the specifications given herein are so general, applying generally to all coals purchased by the Government under every condition of delivery, it is impossible to state therein specific directions for sampling, but for any particular conditions of delivery more definite directions can be prepared and proper consideration for the character of the coal given. By observance, however, of the general directions for sampling, which are given in the specifications that follow, samples that are fairly representative of the coal sampled can be obtained without difficulty.

Though a contract may be let under the specification basis, the sampling of small orders of, say, 25 tons or less, may be discretionary with the Government, a provision to this effect appearing in the contract. If samples are not taken the bid price per ton is paid, unless coal is delivered which gives unsatisfactory results because of excessive clinkering, excessive ash, or any other cause which would make it subject to rejection, in which case the procedure under section 48, "Unsatisfactory fuel," of the bituminous specifications would be followed. This discretionary right of sampling small orders was included in the specifications prepared in the office of the chief of the Quartermaster Corps for the purchase of coal for the Army stations in the United States for the fiscal year 1912-13. This provision made it unnecessary to sample deliveries under one large general contract of from a half to a few tons delivered to small launches or boats, or the different quarters where facilities for sampling or storing accumulated samples were not at hand. It is obvious that the expense of collecting and preparing a sample to represent such small tonnages, together with the cost of analysis, would make the unit cost per ton ordinarily prohibitive and disadvantageous.

Under "Price and Payment" for bituminous coal, page 60, 2 per cent variation from the guaranteed standard of British thermal units (B. t. u.) is allowed before price corrections. On 14,000 B. t. u., "dry coal," this means that there is no price correction for delivered coal of an apparent heating value as reported by the laboratory between 13,720 and 14,280. This is allowed to provide (a) for the reasonable variations that, it is recognized, may be obtained with the
same 3-pound sample in two different determinations in the same laboratory, (b) for variations that result in preparing and reducing the gross sample to a quantity convenient for transmittal to the laboratory, (c) for variations due to the collection of gross samples as representing the coal sampled, and (d) for allowing the contractor latitude in the preparation of the coal, since it is recognized that the quality of his coal expressed in terms of ash and B. t. u. can not be controlled within strictly narrow limits.

In interpreting a heating value determination, then, the value reported by the laboratory must be considered as the apparent value of the coal sampled, as the actual value of the coal may have been more or less than the apparent value because of the variations above cited. If the reported value differs by more than 2 per cent from the guaranteed standard, the result is considered as evidence that coal of a quality other than that contracted for was delivered and the price is corrected accordingly. If a number of gross samples are taken to represent a total quantity of coal delivered, and a report is obtained by averaging the several analyses and tests, the apparent value reported by the laboratory may be within 1 per cent or less of the actual value of the entire quantity, but in specifications as general as those herein given a 2 per cent variation from the standard is considered more equitable and will eliminate frequent and unwarranted price corrections, especially if payment for a delivery or order is based on a single determination. In the sampling of cargo shipments to the Isthmus of Panama (p. 25), the reported results between two separate and independent series of samples representing the same cargo agree on an average within less than 50 B. t. u. The samples are collected by experienced collectors and prepared very systematically, and the reported results for a cargo are determined by averaging a number of analyses. With such sampling the variations above enumerated are largely averaged and eliminated, and the variation that may be allowed before price corrections may, under such conditions, be reduced to 1 per cent or even less.

It is not the intent of the specifications continually to make corrections in price for slight variations of the actual heating value from the guaranteed standard, and it is desired to eliminate corrections which are unwarranted because of the difference between the reported apparent heating value and the actual heating value, the first purpose of the specifications being to insure the Government is receiving coal similar within reasonable limits to the standard of the contract.

The bituminous specifications require the bidder to specify the quality of coal offered in terms of moisture, "as received," ash, sulphur, volatile matter, and B. t. u., "dry coal," these values becoming the standards of the contract to determine rejectable coal and the price to be paid for delivered coal. Bidders have in some cases
specified a higher B. t. u. value and a lower ash content than the quality of the coal warranted, upon the theory that the high B. t. u. and low ash values would give them an advantage in the comparison of bids. The bid price may be correspondingly higher, the bidder presumably expecting a deduction to be made and to receive a price on his delivered coal lower than the bid price. The apparent price may be, therefore, higher than the actual price received, and use may be made of the apparent price for advertising purposes. Bidders are cautioned against offering higher standards than can be maintained on an average, for to do so may result in the bid being rejected (see sec. 8, p. 53, of the specifications) or may result in excessive penalties, the purchase of the coal in the open market, the difference in cost of coal so purchased being charged against the contractor, or may result in the cancellation of the contract (see sec. 48, p. 59).

By reference to the specifications for anthracite, broken, egg, stove, and chestnut sizes, it will be noted that bidders are not required to specify the quality of the coal in terms of ash, B. t. u., moisture, sulphur, and volatile matter, and that regular and systematic sampling of all deliveries is not required to determine the price to be paid for each and every delivery. The specifications provide, however, for the sampling of coal that proves unsatisfactory because of excessive ash or clinkering and for price corrections if the ash as shown by analysis is in excess of a permitted variation from the standard for the particular size of coal, these standards being determined from hundreds of ash determinations made during a period of six years. B. t. u. standards are not used, as it has been determined that the heating value for the different sizes is, in the main, a function of the ash content, varying inversely and in proportion with the ash; that is to say, if the ash content is increased, for example, 1 per cent, the heating value is decreased 1 per cent.

Because of economic considerations and the physical character of anthracite, the specifications used for bituminous coal requiring sampling are not adapted for the purchase of the large sizes of anthracite. Most of the Government contracts for these sizes are for relatively small yearly tonnages with deliveries of \( \frac{1}{2} \) ton to 50 tons, but seldom more to a building. To collect regularly samples from such small deliveries would make the unit cost per ton of sampling prohibitive, the cost being generally greater than any probable saving. To obtain samples that would fairly represent the quality of these coals would require collecting samples of 1,000 to 1,500 pounds, or more, and to obtain a final sample for analysis that would represent the gross sample within reasonable limits would require crushing and recrushing the gross sample, thereby perhaps destroying the value of the gross sample for use in a house-heating furnace or stove, and largely wasting it, unless a Government steam-power plant were
available in which it could be advantageously burned. The total or partial loss in value of 1,000 or 1,500 pounds of coal at $5 to $10 per ton from a small delivery is manifestly a matter deserving consideration. Owing to the hardness and brittleness of anthracite, the crushing of a gross sample by hand is difficult and tedious and requires hours of labor; in fact, a mechanical means of crushing is almost absolutely necessary, but the cost of the necessary equipment would prove prohibitive in the case of small contracts.

Because of the above facts, as well as the manner in which anthracite is prepared at the colliery and the small area of the Pennsylvania anthracite fields, and because of other considerations, the Government does not consider the application of the specifications which are adapted for bituminous coal generally suitable for the purchase of the large sizes of anthracite. The specifications that are used provide for the acceptance and use of coal and payment at contract price so long as no difficulty is experienced, and the collection of samples is necessary only as set forth in the specifications.

Anthracite is graded into sizes before shipment, and each grade commands a certain price. The size of the openings in screens and the types of screens used in preparing the sizes may vary slightly; however, the following table indicates the commercial sizes of anthracite:

Sizes of anthracite

[Prepared with screens of square mesh.]

<table>
<thead>
<tr>
<th>Sizes</th>
<th>Through meshes having a diameter of</th>
<th>Over meshes having a diameter of</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Inches</td>
<td>Inches</td>
</tr>
<tr>
<td>Broken (furnace)</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>Egg</td>
<td>2½</td>
<td>2</td>
</tr>
<tr>
<td>Stove</td>
<td>1½</td>
<td>1</td>
</tr>
<tr>
<td>Chestnut</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Pea</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Buckwheat No. 1</td>
<td>¾</td>
<td>½</td>
</tr>
<tr>
<td>Buckwheat No. 2</td>
<td>1½</td>
<td>1</td>
</tr>
<tr>
<td>Buckwheat No. 3</td>
<td>¾</td>
<td>½</td>
</tr>
</tbody>
</table>
SPECIFICATIONS AND PROPOSALS FOR BITUMINOUS AND ANTHRACITE PEA AND BUCKWHEAT NO. 1a COAL FOR STEAM POWER PLANTS.

I. PROPOSALS.

1. Sealed proposals, in duplicate, to furnish the quantities of coal specified in the schedule herewith, required for the use of (the name of department, bureau, or institution) for the fiscal year ending June 30, 19.., will be received until 2 o'clock p. m., 19.., at the office of ........................................, and then opened.

2. Each bidder shall have the right to be present either in person or by attorney when the bids are opened.

II. ADDRESS OF PROPOSALS.

3. Proposals, in duplicate, must be forwarded to ................................................................., postage prepaid. Addressed envelope for mailing is included herewith.

III. PROPOSALS—GUARANTY.

4. Proposals must be made in duplicate on the form furnished by ................................................................., and must be signed by the individual, partnership, or corporation making the same; when made by a partnership, the name of each partner must be signed. If made by a corporation, proposals must be signed by the officer thereof authorized to bind it by contract and be accompanied by a copy, under seal, of his authority to sign.

5. The proposals must be accompanied by cash or by a certified check drawn payable to the order of the Secretary of the ................................................................., in an amount equal to 2 per cent of the estimated cost of the items for which bids are submitted, the minimum amount in any case to be $10. This requirement is solely to guarantee, if an award is made on the proposal, that within 10 days after notice is given that an award has been made, the bidder will enter into a contract in accordance with the terms of the proposal and execute a bond for the faithful performance thereof, with good and sufficient sureties as hereinafter required. In the event of the failure of the bidder to enter into contract or execute bond, the cash or check guaranty will be forfeited.

IV. CONTRACTOR'S BOND.

6. Each contractor shall be required to give a bond, with two or more individual sureties or one corporate surety duly qualified under the act of Congress approved August 13, 1894, in which they shall

* If smaller sizes of anthracite are required, the specifications can readily be modified to include them.
covenant and agree that, in case the said contractor shall fail to do or perform any or all of the covenants, stipulations, and agreements of said contract on the part of the said contractor to be performed as therein set forth, the said contractor and his sureties shall forfeit and pay to the United States of America any and all damages sustained by the United States by reason of any failure of the contractor fully and faithfully to keep and perform the terms and conditions of his contract to be recovered in an action at law in the name of the United States in any proper court of competent jurisdiction. Such sureties (except corporate sureties) shall justify their responsibility by affidavit showing that they severally own and possess property of the clear value in the aggregate of double the amount of the above-mentioned forfeiture over and above all debts and liabilities and all property by law exempt from execution; the affidavit shall be sworn to before a judge or a clerk of a court of record or a United States attorney, who must certify of his own personal knowledge that the sureties are sufficient to pay the full penalty of the bond.

7. If the estimated amount involved in the contract does not exceed the sum of $200, then the bond may be waived with the consent of the department involved.

May be waived.

V. RESERVATIONS.

8. The right will be reserved by the Secretary of ............ to reject any and all bids, to waive technical defects, and to accept any part of any bid and reject the other part, if, in his judgment, the interests of the Government shall so require; also the right to annul any contract, if, in his opinion, there shall be a failure at any time to perform faithfully any of its stipulations, or in case of a willful attempt to impose upon the Government coal inferior to that required by the contract; and any action taken in pursuance of this latter stipulation shall not affect or impair any right or claim of the United States to damages for the breach of any of the covenants of the contract by the contractor. Bidders are cautioned against guaranteeing higher standards of quality than can be maintained in delivered coal (this applies more especially to bituminous coal), as the Government reserves the right to reject any and all bids if the analyses and test results which the Government may have on record indicate that higher standards have been offered than can probably be maintained.

Rejection and annulment.

9. The estimated quantity of coal to be purchased will be based upon the previous annual consumption, but the right will be reserved to order a greater or less quantity, subject to the actual requirements of the service.

Estimated quantity.

10. The right will be reserved by the Government to purchase, for the purpose of making boiler tests, other coal than that herein contracted for, provided the amount so purchased does not exceed five per cent (5 per cent) of the coal used at the plant during the period covered by this agreement.

Tests.

11. If it should appear to the best interests of the Government to do so, the right is reserved to award the contract for supplying coal at a price higher than that named in a lower bid or in lower bids, on the basis of the quality of the coal offered.

Lowest bids may not be considered.

12. If the bidder to whom the award is made should fail to enter into a contract as herein provided, then the award may be annulled and the Failure to contract.
contract let to the next most desirable bidder without further advertise-
ment, and such bidder shall be required to fulfill every stipulation
expressed herein, as if he were the original party to whom the contract
was awarded.

13. No contract can be lawfully transferred or assigned.

14. No proposal will be considered from any person, firm, or corpora-
tion in default of the performance of any contract or agreement made
with the United States, or conclusively shown to have failed to perform
satisfactorily such contract or agreement.

VI. DESCRIPTION OF COALS DESIRED.

(A) BITUMINOUS.

15. Bids are desired on coal as specified below:

The coal must be a good steam
\[
\begin{array}{c}
\text{coking} \\
\text{noncoking} \\
\text{run-of-mine} \\
\text{slack} \\
\text{lump (give size)}
\end{array}
\]

bituminous coal, free from bone, slate, dirt, and excessive dust, and
adapted for successful use in the particular furnace equipment.

16. Bituminous coal that shows on analysis a quality lower than that
indicated below will not be considered:

- Moisture in “delivered coal” ................. ... per cent.
- Ash in “dry coal” ...................................... per cent.
- Volatile matter in “dry coal” ...................... per cent.
- Sulphur (separately determined) in “dry coal” .... per cent.
- British thermal units in “dry coal” below ...........

17. Bidders are required to specify the coal offered in terms of
moisture, “as received”; ash, volatile matter, sulphur, and British
thermal units, “dry coal”; which values become the standards for
the coal of the successful bidder. In addition, the bidders are required
to give the name and location of the mine producing the coal, the
name or other designation of the coal bed, name of operator of mine,
and the trade name of the coal. This information to be furnished in
spaces provided under section 57 (A).

(B) ANTHRACITE PEA AND BUCKWHEAT NO. 1.

18. The coal must be best quality Pennsylvania white-ash anthracite.

19. It must be well screened, practically free from dirt, must not
contain undue percentages of moisture, slate, or bone, and must equal
in quality and preparation the best white-ash anthracite coal produced.
The coal must not contain more than the following percentages of ash
on the “dry-coal” basis:

<table>
<thead>
<tr>
<th>Size of coal</th>
<th>Ash, “dry coal”</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pea...........</td>
<td>16 per cent.</td>
</tr>
<tr>
<td>Buckwheat No. 1</td>
<td>18 per cent.</td>
</tr>
</tbody>
</table>

20. The bidder will be required to specify the coal field, district, and
colliery producing the coal, the name and address of the operator, and
the railroad upon which the colliery is located. This information to
be given in spaces provided under section 57 (B).

\[a\] The percentages and the heating value to be filled in by the office inviting bids.
VII. AWARD.

(A) BITUMINOUS.

21. Bids will be considered on each item separately; and in determining the award of the contract consideration will be given to the quality of the coal (expressed in terms of ash in "dry coal," of moisture in coal "as received," and of British thermal units in "dry coal") offered by the respective bidders, to the operating results obtained with the coals on previous Government contracts, as well as to the price per ton.

22. In order to compare bids as to the quality of the coal offered, all proposals will be adjusted to a common basis. The method used will be to merge all four variables—ash, moisture, calorific value, and price bid per ton—into one figure, the cost of 1,000,000 British thermal units, so that one bid may readily be compared with another. The procedure under this method will be as follows:

(a) All bids will be adjusted to the same ash percentage by selecting as the standard the proposal that offers coal containing the highest percentage of ash. Each 1 per cent of ash content below that of this standard will be assumed to have a positive value of 2 cents per ton, and the price will be accordingly decreased 2 cents, the amount of premium that is allowed under the contract for 1 per cent less ash than the standard established in the contract. Fractions of a per cent will be given proportional values. The adjusted bids will be figured to the nearest tenth of a cent.

(b) To reduce bids to a common basis with respect to the moisture in the coal offered, the price quoted, adjusted in accordance with the above, will be divided by the difference between 100 per cent and the per cent of moisture guaranteed in the proposal. The adjusted bids will be figured to the nearest tenth of a cent.

(c) On the basis of the adjusted price, allowance will then be made for the varying heat values by computing the cost of 1,000,000 British thermal units for each coal offered. This determination will be made by multiplying the adjusted price per ton by 1,000,000 and dividing the result by the product of 2,240, multiplied by the number of British thermal units guaranteed.

23. If from practical service experience or by test any of the coals have in the past proved unsuited for the furnace and boiler equipment, or have failed to meet the requirements of the city smoke ordinances, the bids thereon may be eliminated from further consideration, regardless of their calculated costs per million B. t. u. The selection of the lowest bid of the remaining bids on the basis of the cost per million B. t. u. will be considered as a tentative award only, the Government reserving the right to have practical service test or tests made under the direction of the Bureau of Mines, the results to determine the final award of contract. The interested bidder or his authorized representatives may be present at such test.

(B) ANTHRACITE PEA, AND BUCKWHEAT NO. 1.

24. Bids will be considered on each item separately; and in determining the award of the contract, consideration will be given to the operating results obtained with similar coals on previous Government contracts offered by the respective bidders, as well as to the price per ton.
25. Before making final award of contract, practical service tests, under the direction of the Bureau of Mines, will be made of selected coals to determine the suitability and adaptability of the coals for the particular furnace and boiler equipment concerned. The interested bidders or their authorized representatives may be present at such tests. Samples will be collected from the coals tested, and complete analyses and calorimetric determinations will be made, as well as determinations of the fusing temperature of the coal ash.

26. The results of the service test of the coal that proves a satisfactory fuel and the results of the analyses and tests of the samples of that coal will become a part of the contract establishing the standard of the coal offered by the bidder to whom the final award is made. The results become the basis for determining rejectable coal during the life of the contract.

VIII. DELIVERY.

27. The coal shall be delivered in such quantities at such times as the Government may direct.

28. All the available storage capacity of the Government coal bunkers will be placed at the disposal of the contractor to facilitate delivery of coal under favorable conditions. When an order is issued for coal, the contractor upon commencing a delivery on that order shall continue the delivery with such rapidity as not to waste unduly the services of the Government inspector. Information is furnished in the schedule herewith in relation to the several places, etc., for the delivery of coal, but the bidder is invited to visit those places and inspect the conditions for his own information.

29. After verbal or written notice has been given to deliver coal under this contract, a second notice may be served in writing upon the contractor to make delivery of the coal so ordered within 24 hours after receipt of said second notice. Should the contractor, for any reason, fail to comply with the second request, the Government will be at liberty to buy coal in the open market and for coal so purchased to charge against the contractor and his sureties any excess in price over the contract price.

30. The contractor will be allowed to deliver coal during the usual hours of teaming, that is, between 8 a. m. and 5 p. m.

31. The coal will be weighed by representatives of the Government without expense to the contractor.

IX. SAMPLING.

32. As payment for bituminous coal is based upon the quality of coal delivered as shown by analyses of representative samples, it is imperative that samples representing every order of coal be taken and that the proper officials of the Government buildings see that such samples are obtained. The Bureau of Mines will have general direction of sampling, giving instructions in the methods of obtaining representative samples, and lending all practicable assistance.

33. If desired by the coal contractor, permission will be given to him or his representative to be present and witness the collection and preparation of the samples to be forwarded to the Government laboratories.

34. The coal will be sampled at the time it is being loaded or unloaded from railroad cars, ships, barges, or wagons, or when discharged
from contractors' supply bins, except as provided for in section 27 of the specifications for anthracite broken, egg, stove, and chestnut.

35. When the coal is being unloaded, a shovel or specially designed tool will be used for taking portions or increments of 10 to 30 pounds of coal. For slack or small sizes of anthracite increments as small as 5 to 10 pounds may be taken. The size of the increments depends on the size and weight of the largest pieces of coal and impurities.

36. The increments will be regularly and systematically collected, so that the entire delivery will be represented proportionately in the gross sample. The frequency of collecting the increments should be regulated so that a gross sample of not less than 1,000 pounds will be collected. If the coal contains an unusual amount of impurities, such as slate, and if the pieces of such impurities are very large, it will be necessary to collect gross samples of even 1,500 pounds or more. For slack coal and for small sizes of anthracite, if the impurities do not exist in abnormal quantities or in pieces larger than three-quarters of an inch, a gross sample of approximately 600 pounds may prove sufficient. The gross sample should contain the same proportion of lump coal, fine coal, and impurities as is contained in the coal delivered. As the increments are collected, they will be deposited in a receptacle having a tight-fitting lid and provided with a lock.

37. After the gross sample is collected, it will be systematically crushed, mixed, and reduced in quantity to convenient size for transmission to the laboratory. The crushing will be done by a mechanical crusher or by hand with an iron tamping bar on a smooth and solid floor. In the absence of a smooth, tight floor, the crushing may be done on a heavy canvas, to prevent the accidental admixture of any foreign matter. The mixing and reduction will be done by hand with a shovel, or mechanically by means of riffles or sampling machines.

38. When prepared by hand, the pieces of coal and impurities will be crushed to the approximate size indicated in the table below before each reduction:

<table>
<thead>
<tr>
<th>Weight of sample to be divided</th>
<th>Size to which coal and impurities should be broken before each division</th>
</tr>
</thead>
<tbody>
<tr>
<td>1,000 pounds or more</td>
<td>1 inch.</td>
</tr>
<tr>
<td>500 pounds</td>
<td>½ inch.</td>
</tr>
<tr>
<td>250 pounds</td>
<td>¼ inch.</td>
</tr>
<tr>
<td>125 pounds</td>
<td>⅛ inch.</td>
</tr>
<tr>
<td>60 pounds</td>
<td>⅛ inch.</td>
</tr>
</tbody>
</table>

The 60-pound sample will then be reduced by quartering, or by the use of riffles or sampling machines, to the desired quantity for transmission to the laboratory.

39. After each crushing, the sample will be thoroughly mixed before reduction in quantity, the procedure being as follows:

The crushed coal will be shoveled into a conical pile. A new long pile will then be formed by taking a shovelful at a time and spreading it out in a straight line (8 to 10 feet long for a shovel holding 15 pounds). Each new shovelful will be spread over the top of the preceding one,
beginning at opposite ends, and so on, until all the coal has been formed into one long pile. By walking around the long pile and systematically taking shovelfuls, and shoveling the coal to one side, alternate shovelfuls being discarded, the sample will be halved in quantity.

40. The above "long-pile" and "alternate-shovel" method of mixing and reducing the sample will be followed with samples of 125 to 250 pounds or more. Samples smaller will be mixed on a canvas about 8 feet square by raising first one end of the canvas and then the other, thereby rolling the sample back and forth. After thoroughly mixing in this manner, the sample will be formed in a conical pile and reduced in quantity by quartering.

41. Whenever the different increments of samples are collected throughout some considerable period of time, each increment may be crushed as soon as taken and the pieces of coal and impurities broken sufficiently small to permit two or three reductions of the total accumulated sample before further crushing is necessary.

42. In the reduction of the gross sample to the sample for transmittal to the laboratory the gross sample will unavoidably lose moisture. To determine the moisture content in the coal delivered, a separate special moisture sample must be taken. This will be accumulated by placing in a hermetically sealed receptacle small parts of the freshly taken increments of the gross sample.

43. The collection of special moisture samples shall be discretionary with the Government. Special moisture samples will be taken if in the opinion of the Government inspector the coal contains moisture in excess of the amount guaranteed by the contractor. The special moisture samples will be taken so as to represent the coal with respect to the moisture contained at time of weighing.

44. If deliveries extend over any considerable period, what would otherwise be a gross sample may be worked down in successive stages to samples of a size suitable for transmittal to the laboratory, and the samples representing the several equal parts of a delivery may be analyzed and the several analyses averaged, or the several samples may later be mixed (at the delivery point or in the laboratory and reduced to one sample) and one analysis made.

**X. ANALYSIS.**

45. Immediately on receipt of a sample in the laboratory it will be analyzed and tested by the Government in accordance with the method recommended by the American Chemical Society, and by the use of a bomb calorimeter.

**XI. CAUSES FOR REJECTION.**

(A) BITUMINOUS.

46. All coal delivered during a fiscal year is expected to be of the same character as that specified by the contractor. It should, therefore, be supplied as nearly as possible from the same mine or group of mines.

47. It is important that the standards furnished with bids shall not establish a higher value than can be actually maintained under the terms of the contract. In this connection it should be recognized that the small "mine samples" usually indicate a coal of higher economic value than that actually delivered in carload lots, because of the care taken to separate extraneous matter from the coal in the "mine samples." It is evident, therefore, that it will be to the best
interests of the contractor to furnish a correct description with average values of the coal offered, as a failure to maintain the standard he establishes will result in deductions from the contract price, and may cause a cancellation of the contract, whereas deliveries of coal of higher grade than quoted will be paid for at an increased price per ton.

48. Coal containing percentages of volatile matter or sulphur higher than the limits indicated under "Description of Coals Desired," or having a moisture content in excess of that guaranteed, or containing percentages of ash greater than indicated in the column "Maximum limits for ash" in the table in the section entitled "Price and Payment," or failing to give satisfactory results because of excessive clinkering or a prohibitive amount of smoke, or proving for any other cause to be an undesirable fuel, will be subject to rejection, and the Government will have the right to cause the contractor to remove such coal at no cost to the Government. Such event may result in the Government purchasing in the open market, or through competitive bidding, such quantity of coal to supply the deficiency caused by such failure, or annulling the contract by giving notice in writing to that effect to the contractor, and the Government, in its discretion, purchasing such coal in the open market or by contract upon competitive proposals; the contractor to remain liable for all damages sustained by the United States on account of such failure, including the difference, if any, between the cost of purchasing and delivering said coal and the price at which the contractor agreed to furnish it. The contract price must be understood to be the corrected price per ton based upon analysis, as hereinafter described under the section entitled "Price and Payment." If it shall be impracticable to cause the contractor to remove coal subject to rejection, the Government may use such rejectable coal, deducting penalties as determined under the section entitled "Price and Payment," and may in addition, as circumstances warrant in the opinion of the Government, deduct a further penalty of twenty-five (25) percent of the amount of the bill, based on the tonnage of the coal under question and at the contract price per ton.

(b) ANTHRACITE PEA AND BUCKWHEAT NO. 1.

49. It is understood that the coal delivered during the year will be of the same character as that supplied for the service test made to determine the final award of the contract. It is important, therefore, that the quality and character of the coal furnished for service tests shall not establish a standard higher than can be maintained, for a failure to maintain the standard may cause the Government to purchase coal in the open market, and charge against the contractor being made for the excess in cost over the bid price; or the contract may be cancelled.

50. If during the life of the contract, coal is delivered that gives unsatisfactory service results as compared with the results obtained on the coal tested to determine the final award of the contract, or if the analysis and tests on a "dry-coal" basis of a sample taken from coal used during any consecutive twenty-four (24) hours show an ash content of 5 per cent more or a yield of British thermal units of 5 per cent less, than was shown by the sample taken to determine the final award of the contract, or should any of the other results of analysis or test indicate coal of inferior quality or of different character than that designated in the contract, then the lot of coal from which the coal fired for twenty-four (24) hours was obtained will be subject to rejection, and the Government will have the right to cause the contractor to remove at no cost to the Government the remaining coal of the delivery. Such
event may result in the Government purchasing in the open market, or through competitive bidding, such quantity of coal to supply the deficiency caused by such failure, or annulling the contract by giving notice in writing to that effect to the contractor, and the Government, in its discretion, purchasing such coal in the open market or by contract upon competitive proposals; the contractor to remain liable for all damages sustained by the United States on account of such failure, including the difference, if any, between the cost of purchasing and delivering said coal and the price at which the contractor agreed to furnish it. If it shall be impracticable to cause the contractor to remove coal subject to rejection, the Government may use such rejectable coal, and may deduct a penalty of 25 per cent of the amount of the bill based on the tonnage of the delivery under question and at the contract price per ton, if in the opinion of the Government the circumstances warrant the deduction.

51. Coal containing an undue percentage of fine coal, bone, slate, dirt, or moisture will not be accepted by the Government inspector.

**XII. PRICE AND PAYMENT.**

**(A) BITUMINOUS COAL.**

52. Payment will be made promptly upon receipt of a report from the Bureau of Mines on the quality of the coal under consideration. The Bureau of Mines will furnish such report in not more than fifteen (15) days after the receipt of the sample or samples.

53. Payment for coal specified in the proposal will be made upon the basis of the price therein named, corrected as follows for variations in heating value, ash, and moisture from the standards specified in the contract (see section 48 for an additional deduction on coal subject to rejection):

(a) Considering the coal on a "dry-coal" basis, no corrections in price will be made for variations of 2 per cent or less in the number of British thermal units from the guaranteed standard. When the variation in heat units exceeds 2 per cent of the guaranteed standard, the correction in price will be a proportional one and will be determined by the following formula:

\[
\text{B. t. u. delivered coal ("dry-coal" basis)} \times \frac{\text{bid price}}{\text{B. t. u. ("dry-coal" basis) specified in contract}}
\]

For example, if coal delivered on a contract guaranteeing 14,000 British thermal units on a "dry-coal" basis at a bid price of $3 per ton shows by calorific test results varying between 13,720 and 14,280 British thermal units, there will be no price correction. If, however, the delivered coal shows by calorific test 14,300 British thermal units on a "dry-coal" basis for example, the price for this variation from the contract guarantee is, by substitution in the formula:

\[
\frac{14,300 \times 3}{14,000} = 3.064
\]

The correction will be figured to the nearest tenth of a cent.

(b) For all coal that by analysis contains less ash on a "dry-coal" basis than the percentage specified herein, a premium of 2 cents per ton for each whole per cent less will be paid. An increase in the ash content of 2 per cent above the standard established by the contractor will be tolerated without exacting a penalty. When such excess is greater than 2 per cent, deductions will be made in accordance with the following table:
<table>
<thead>
<tr>
<th>Ash as established in proposal</th>
<th>No deduction for limits below—</th>
<th>Cents per ton to be deducted.</th>
<th>Maximum limits for ash, a</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Per cent.</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>4</td>
<td>6, inclusive</td>
<td>6.01–7.00</td>
<td>7.01–8.00</td>
</tr>
<tr>
<td>5</td>
<td>7, inclusive</td>
<td>7.01–8.00</td>
<td>8.01–9.00</td>
</tr>
<tr>
<td>6</td>
<td>8, inclusive</td>
<td>8.01–9.00</td>
<td>9.01–10.00</td>
</tr>
<tr>
<td>7</td>
<td>9, inclusive</td>
<td>9.01–10.00</td>
<td>10.01–11.00</td>
</tr>
<tr>
<td>8</td>
<td>10, inclusive</td>
<td>10.01–11.00</td>
<td>11.01–12.00</td>
</tr>
<tr>
<td>9</td>
<td>11, inclusive</td>
<td>11.01–12.00</td>
<td>12.01–13.00</td>
</tr>
<tr>
<td>10</td>
<td>12, inclusive</td>
<td>12.01–13.00</td>
<td>13.01–14.00</td>
</tr>
<tr>
<td>11</td>
<td>13, inclusive</td>
<td>13.01–14.00</td>
<td>14.01–15.00</td>
</tr>
<tr>
<td>12</td>
<td>14, inclusive</td>
<td>14.01–15.00</td>
<td>15.01–16.00</td>
</tr>
<tr>
<td>13</td>
<td>15, inclusive</td>
<td>15.01–16.00</td>
<td>16.01–17.00</td>
</tr>
<tr>
<td>14</td>
<td>16, inclusive</td>
<td>16.01–17.00</td>
<td>17.01–18.00</td>
</tr>
</tbody>
</table>

* These limits are used in determining rejectable coal, see section 48, marginal heading "Unsatisfactory fuel."
As an example of the method of determining the deduction in cents per ton for coal containing ash exceeding the standard by more than 2 per cent, suppose coal delivered on a contract guaranteeing 10 per cent ash on the "dry coal" basis shows by analysis between 14.01 and 15 per cent (both inclusive), or, for instance, 14.55 per cent, the deduction according to the table is 7 cents per ton (reading to the right on line beginning with 10 per cent on the extreme left, which in this case is the standard, to the column containing "14.01-15," the deduction at the top of this column is seen to be 7 cents).

Note.—If the ash standard is an uneven percentage, the table will be revised in order to determine deductions on account of excessive ash. For example, if the ash standard is 6.53 per cent, each percentage value beginning with 6 in the left-hand column and all figures in the line reading to the right of 6 will be increased by 0.53. There would be no deduction then in price for ash in delivered coal up to and including 8.53 per cent, while for coal having an ash content, for instance, between 11.54 and 12.53 per cent the deduction would be 12 cents per ton.

(c) The price will be further corrected for moisture content in excess of the amount guaranteed by the contractor, the deduction being determined by multiplying the price bid by the percentage of moisture in excess of the amount guaranteed. The correction will be figured to the nearest tenth of a cent. For example, if coal delivered on a contract guaranteeing 3 per cent moisture with bid price of $3.50 per ton shows by analysis 4.65 per cent moisture, the bid price is multiplied by 1.65 (the excess moisture), which gives 5.8 cents ($0.058) as the deduction per ton.

\[3.50 \times (4.65 - 3.00) = 1.65 \text{ per cent} = 5.775 \text{ cents.}\]

(B) ANTHRACITE PEA AND BUCKWHEAT NO. 1.

Prompt payment.

54. Payment, which will be promptly made upon completion of an order, will be based upon the contract price, provided the coal is not subject to rejection (see section entitled "Causes for rejection").

XIII. INFORMATION TO BE SUPPLIED.

55. Estimated quantity of coal required, —— tons (2,000 or 2,240 pounds).
56. (The point of delivery, method of delivery, capacity and facilities for storage, etc., are here furnished.)
57. The bidder must insert in the blank spaces below the information called for on the coal he proposes to furnish, without which information the proposal will be informal:

(A) BITUMINOUS.a

(a) Commercial name of the coal ........................................
(b) Name of the mine or mines ...........................................
(c) Location of the mine or mines (town, county, State) ............
(d) Railroad on which mine is located ..................................

---
a Bidders are cautioned against specifying higher standards than can be maintained, for to do so may result in the bid being rejected (sec. 8), or may result in rejection of delivered coal or cancellation of the contract and the Government purchasing coal in the open market and charging against the contractor the difference in cost (see secs. 47 and 48).
(e) Name or other designation of the coal bed or beds ........................................

(f) Name of operator of mine or mines .................................................................

(g) British thermal units per pound of "dry coal" ..............................................

(h) Percentage of ash in "dry coal" .................................................................

(i) Percentage of sulphur in "dry coal" ............................................................

(j) Percentage of volatile matter in "dry coal" ..................................................

(k) Moisture in coal "as received" .......................................................................

(l) Additional description of coal as deemed of importance by the bidder .............

(m) Price per ton of ...... pounds (this price is understood to be the bid price per ton, see section 53 for method of determining price for delivered coal) .................................................................

(B) ANTHRACITE, PEA, AND BUCKWHEAT NO. 1.

(a) Coal field ........................................................................................................

(b) District ...........................................................................................................

(c) Colliery and location .......................................................................................

(d) Name and address of operator ......................................................................

(e) Railroad upon which colliery is located ....................................................

(f) Name or other designation of the coal bed or beds ....................................

(g) Additional description of coal as deemed of importance by the bidder ..

(h) Price per ton of ...... pounds:

   Pea ...........................................................................................................

   Buckwheat No. 1 ..............................................................................

The Secretary of the Department:

The undersigned hereby propose .... to furnish and deliver to .....

the coal as above specified, and at the price stated above, subject to all the conditions of the specifications and proposal, for the fiscal year commencing on the 1st of July, .......

and ending on the 30th of June, .......

The undersigned have read the specifications and proposal and agree... to comply therewith in every particular.

Signature of each member of the firm and firm name. If a corporation, its name, and signature of the officer authorized to sign for the corporation, together with a copy, under seal of his authority to sign; also, the name of the State in which incorporated.

Doing business under the firm name of ..........................................................

Place of business, .........................................................................................

Note.—Owing to the difficulty in deciphering signatures, a typewritten copy of same should be attached.
SPECIFICATIONS AND PROPOSALS FOR ANTHRACITE FURNACE (BROKEN), EGG, STOVE, AND CHESTNUT COAL.

I. PROPOSALS.
1. (Same as section 1, page 52.)
2. (Same as section 2, page 52.)

II. ADDRESS OF PROPOSALS.
3. (Same as section 3, page 52.)

III. PROPOSALS—GUARANTY.
Signature.
Cash or certified check.
4. (Same as section 4, page 52.)
5. (Same as section 5, page 52.)

IV. CONTRACTOR’S BOND.
Sureties.
May be waived.
6. (Same as section 6, page 52.)
7. (Same as section 7, page 53.)

V. RESERVATIONS.
Rejection and annulment.
Estimated quantity.
Lowest bids may not be considered.
Failure to contract.
Contracts non-transferable.
Default.
8. (Same as section 8, page 53.)
9. (Same as section 9, page 53.)
10. (Same as section 11, page 53.)
11. (Same as section 12, page 53.)
12. (Same as section 13, page 54.)
13. (Same as section 14, page 54.)

VI. DESCRIPTION OF COAL DESIRED.
14. The coal must be the best quality Pennsylvania white-ash anthracite.
15. It must be well screened, practically free from dirt, must not contain undue percentages of moisture, slate, or bone, and must equal in quality and preparation the best white-ash anthracite produced. The coal must not contain more than the following percentages of ash on the “dry-coal” basis:

<table>
<thead>
<tr>
<th>Size of coal</th>
<th>Ash in “dry coal”</th>
</tr>
</thead>
<tbody>
<tr>
<td>Furnace</td>
<td>10 per cent.</td>
</tr>
<tr>
<td>Egg</td>
<td>11 per cent.</td>
</tr>
<tr>
<td>Stove</td>
<td>12 per cent.</td>
</tr>
<tr>
<td>Chestnut</td>
<td>14 per cent.</td>
</tr>
</tbody>
</table>

Information to be supplied by bidder.
16. (Same as section 20, page 54.)

VII. AWARD.
17. Bids will be considered on each item separately, and in determining the award of the contract consideration will be given to the
results obtained with coals furnished on previous Government contracts by the respective bidders, as well as to the price per ton specified. 18. If it should appear to the best interests of the Government to do so, the right will be reserved to award the contract for supplying coal at a price higher than that named in a lower bid or in lower bids.

VIII. DELIVERY.

19. (Same as section 27, page 56).
20. (Same as section 28, page 56).
21. (Same as section 29, page 56).
22. (Same as section 30, page 56).
23. (Same as section 31, page 56).

IX. SAMPLING.

24. Samples which may be taken (see section 27) will be collected in accordance with the methods and principles which are a part of the specifications generally used by the Government for the purchase of coal under specifications and as set forth in U. S. Bureau of Mines Bulletin 83.

X. ANALYSIS.

25. Samples will be analyzed and tested by the Government in accordance with the method recommended by the American Chemical Society.

XI. CAUSES FOR REJECTION.

26. If the percentage of bone, dirt, slate, or smaller sizes in a given coal exceeds the percentage required by the best preparation, or if the given coal fails to give satisfactory results because of excessive clinkering, or excessive ash-pit refuse, it will be subject to rejection, and the Government will have the right to cause the contractor to remove such coal at no cost to the Government. The Government may then purchase coal in the open market and make charge against the contractor for the excess in cost of coal so purchased. The Government inspector will not accept coal if in his opinion it is rejectable, or if it contains an undue percentage of moisture, and he will have the right to refuse to accept coal from a source other than that specified by the bidder under section 32, unless the contractor may have received permission from the Government to substitute said coal.

27. If it is impracticable for the Government to cause the contractor to remove coal that produces excessive ash-pit refuse, samples may be taken during the consumption of such coal, and if on analysis the ash content on the "dry-coal" basis is equal to or greater than the following percentages for the respective sizes of coal, ten (10) per cent of the bid price of the coal delivered and unused at the time of sampling will be deducted:

<table>
<thead>
<tr>
<th>Size of coal</th>
<th>Ash in &quot;dry coal,&quot; per cent.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Furnace</td>
<td>14</td>
</tr>
<tr>
<td>Egg</td>
<td>15</td>
</tr>
<tr>
<td>Stove</td>
<td>16</td>
</tr>
<tr>
<td>Chestnut</td>
<td>18</td>
</tr>
</tbody>
</table>

28. The delivery of unsatisfactory fuel may result in the Government purchasing in the open market, or through competitive bidding, open-market purchases.
such quantity of coal to supply the deficiency caused by such failure, or annulling the contract by giving notice in writing to that effect to the contractor, and the Government, in its discretion, purchasing such coal in the open market or by contract upon competitive proposals; the contractor to remain liable for all damages sustained by the United States on account of such failure, including the difference, if any, between the cost of purchasing and delivering said coal and the price at which the contractor agreed to furnish it.

XII. PRICE AND PAYMENT.

29. Payment will be promptly made on completion of an order and will be based on the contract price, provided the coal is a satisfactory fuel. If the coal is unsatisfactory (see sections 26 and 27), and it is impracticable for the Government to cause the contractor to remove such coal, payment will be promptly made on ninety (90) per cent of the total amount of the bill, based on the contract price and the tonnage of the order, the ten (10) per cent being withheld to cover the deduction provided for under section 27, "Ash deductions."

XIII. INFORMATION TO BE SUPPLIED.

30. (Same as section 55, page 62.)
31. (Same as section 56, page 62.)
32. The bidder must insert in the blank spaces the information called for on the coal he proposes to furnish, without which information the proposal will be informal:

(a) Coal field.
(b) District.
(c) Colliery and location.
(d) Name and address of operator.
(e) Railroad upon which colliery is located.
(f) Name or other designation of the coal bed or beds.
(g) Price per ton of ...... pounds:
   Furnace
   Egg
   Stove
   Chestnut

The Secretary of the Department:

The undersigned hereby propose to furnish and deliver to ...... the coal as above specified and at the price stated above, subject to all the conditions of the specifications and proposal, for the fiscal year commencing on the 1st of July, ......, and ending on the 30th of June, ......

The undersigned have read the specifications and proposal and agree to comply therewith in every particular.

Signature of each member of the firm and firm name. If a corporation, its name and signature of the officer authorized to sign for the corporation, together with a copy, under seal, of his authority to sign; also the name of the State in which incorporated.

Doing business under the firm name of ......
Place of business ......

NOTE.—Owing to the difficulty in deciphering signatures, a typewritten copy of same should be attached.
PUBLICATIONS ON FUEL TECHNOLOGY.

The following Bureau of Mines publications may be obtained free by applying to the Director, Bureau of Mines, Washington, D. C.:

**BULLETIN 1.** The volatile matter of coal, by H. C. Porter and F. K. Ovitz. 1910. 56 pp., 1 pl., 9 figs.

**BULLETIN 2.** North Dakota lignite as a fuel for power-plant boilers, by D. T. Randall and Henry Kreisinger. 1910. 42 pp., 1 pl., 7 figs.

**BULLETIN 3.** The coke industry of the United States as related to the foundry, by Richard Moldenke. 1910. 32 pp.

**BULLETIN 4.** Features of producer-gas power-plant development in Europe, by R. H. Fernald. 1910. 27 pp., 4 pls., 7 figs.


**BULLETIN 6.** Coals available for the manufacture of illuminating gas, by A. H. White and Perry Barker, compiled and revised by H. M. Wilson. 1911. 77 pp., 4 pls., 12 figs.

**BULLETIN 7.** Essential factors in the formation of producer gas, by J. K. Clement, L. H. Adams, and C. N. Haskins. 1911. 58 pp., 1 pl., 16 figs.

**BULLETIN 8.** The flow of heat through furnace walls, by W. T. Ray and Henry Kreisinger. 1911. 32 pp., 19 figs.

**BULLETIN 9.** Apparatus and methods for the sampling and analysis of furnace gases, by J. C. W. Frazer and E. J. Hoffman. 1911. 22 pp., 6 figs.


**BULLETIN 11.** Briquetting tests of lignite at Pittsburgh, Pa., 1908-9; with a chapter on sulphite-pitch binder, by C. L. Wright. 1911. 64 pp., 11 pls., 4 figs.

**BULLETIN 12.** The uses of peat for fuel and other purposes, by C. A. Davis. 1911. 214 pp., 1 pl., 1 fig.

**BULLETIN 13.** The transmission of heat into steam boilers, by Henry Kreisinger and W. T. Ray. 1912. 180 pp., 78 figs.

**BULLETIN 14.** Physical and chemical properties of the petroleum of the San Joaquin Valley, Cal., by I. C. Allen and W. A. Jacobs, with a chapter on anaylses of natural gas from the southern California oil fields, by G. A. Burrell. 1911. 60 pp., 2 pls., 10 figs.


**BULLETIN 16.** Steam testing of coals and related investigations, September 1, 1904, to December 31, 1906, by L. P. Breckenridge, Henry Kreisinger, and W. T. Ray. 1912. 380 pp., 2 pls., 94 figs.


BULLETIN 41. Government coal purchases under specifications, with analyses for the fiscal year 1909–10, by G. S. Pope, with a chapter on the fuel-inspection laboratory of the Bureau of Mines, by J. D. Davis. 1912. 97 pp., 3 pls.

BULLETIN 43. Comparative fuel values of gasoline and denatured alcohol in internal combustion engines, by R. M. Strong and Lauseon Stone. 1912. 243 pp., 3 pls., 32 figs.


TECHNICAL PAPER 1. The sampling of coal in the mine, by J. A. Holmes, 1911. 18 pp., 1 fig.

TECHNICAL PAPER 2. The escape of gas from coal, by H. C. Porter and F. K. Ovitz. 1911. 14 pp., 1 fig.


TECHNICAL PAPER 5. The constituents of coal soluble in phenol, by J. C. W. Frazer and E. J. Hoffman. 1912. 20 pp., 1 pl.

TECHNICAL PAPER 8. Methods of analyzing coal and coke, by F. M. Stanton and A. C. Fieldner. 1912. 21 pp., 5 figs.


TECHNICAL PAPER 20. The slagging type of gas producer, with a brief report of preliminary tests, by C. D. Smith. 1912. 14 pp., 1 pl.


TECHNICAL PAPER 26. Methods of determining the sulphur content of fuels, especially petroleum products, by I. C. Allen and I. W. Robertson. 1912. 13 pp., 1 fig.