The Netherlands State Mines or loess process grew out of the difficulties experienced in obtaining such special materials as barite and magnetite. The scraper-discharge type of separator common to all the European heavy-medium processes is modified in The Netherlands process to shallow depth, with the top and bottom scraper lines close enough together to furnish mechanical agitation affecting virtually the entire content of the vessel. By this means rather unstable media of varying size consist are kept in suspension, and there is no place for large accumulation of middle products. Virtually all the material is drawn at once into one or the other of the two scraper lines. In practice, the gravity of separation is adjusted so that all the doubtful material goes with the refuse and subsequently is recovered in a separate middlings rewash operation.

Perhaps the most important fact about these processes for us is that a number of plants in successful operation in Europe and Great Britain demonstrate the feasibility of using semistable suspensions.

Additional information on coal-preparation practice in Germany and The Netherlands is given in a report previously published.[38]

Coal Preparation in Western Germany

A survey was made of coal-preparation practices in western Germany to discover any technological or organizational developments that might be of value to the American coal industry; to discover any special devices or techniques that may have been developed to prepare special grades of fuel to meet emergency war needs; and to ascertain the grades of coal and the methods of their preparation for use in the synthetic liquid-fuels industry.

The coal-preparation industry in Germany is organized very much as in America, in that the erection of new plants and extensive alterations are generally handled on contract by specialized equipment manufacturers who also control very largely the exploitation of new technological developments.

In the comparison of contemporary German and American coal-preparation practices there is (1) the greater predominance of conventional jig washers in the German field (although the Baum jig is also the most popular washer in America); (2) presizing of coal before jigging, as compared to almost universal practice of jigging unsized coal in America; (3) treatment of fine coal on jigs in Germany, contrasted to use of tables, launders, and classifiers in America; (4) extensive use of froth flotation in Germany; (5) widespread use of the Chance sand-flotation process in America, with no direct counterpart in Germany, although there is a more definite trend in that country to the use of substantially stable suspensions; and (6) loading of the product through bins in Germany, compared with the practice of direct continuous loading of prepared grades from preparation units to transport facilities in American practice.

38/ Yancey, H. F., and Fraser, Thomas, Coal Preparation in Germany and The Netherlands: Am. Inst. Min. and Met. Eng., Tech. Pub. 2112, 1946, 14 pp.

Although Germany was the greatest coal producer in continental Europe before the war, 95 percent of its energy requirements being supplied by solid fuels, it lacked liquid fuels, as well as other materials. One essential material, derived from crude oil, which was virtually unobtainable, was petroleum coke for making electrodes for aluminum reduction and other metallurgical operations. This lack of an adequate source of pure carbon made necessary the development of methods of obtaining it from coal. Three methods resulted and are as follows: (1) Solution of coal in organic solvents and removal of inorganic impurities by filtration; (2) a two-stage cleaning process, comprising of a heavy-medium separation in a suspension of magnetite, followed by grinding of the clean coal and its recleaning by froth flotation; and (3) a combination of cleaning by froth flotation and digestion of the product in a hot, dilute mixture of hydrochloric and hydrofluoric acids to give a final product containing only 0.5 percent ash, which was then coked in standard byproduct ovens.

The three commercial plants incorporating these means of ultra-cleaning were all heavily bombed during the war and were not in operating condition at the time of the survey. However, such data as could be obtained regarding the technological functioning and performance of these plants are published in some detail.39/

Drying Lignite

Experimentation on steam drying of lignite in the 25-ton-a-day pilot plant at Grand Forks, N. Dak., was continued. After several hundred tons of lignite and subbituminous coal were dried, it was proved that the dried fuel was susceptible to spontaneous combustion and that it was dangerous to ship the product in railroad cars without further treatment. Consequently, a study was made of some of the factors effecting the spontaneous heating of dried lignite. Two experimental bins were constructed, one of which simulated a railroad car. This was an open-bottom steel bin 5 feet square and 3 feet high. The bottom was not welded, and on one side a 2-inch opening extended the entire width, allowing air to enter as it does in a gondola railroad car. Ten thermocouples were installed in this bin, 5 on a plane 1 foot above the bottom and 5 on a plane 2 feet above the bottom, and were connected to a recording pyrometer. The other bin was the same size, but the sides and bottom were welded gastight, and thermocouples were placed 1 and 2 feet from the bottom. Natural lignite, dried with 400-pound-pressure steam, was then fed to the bins at various temperatures, and the tendency of the coal to ignite spontaneously was observed. Tables 8 and 9 summarize the results of these tests.

39/ Fraser, Thomas, and Driessen, M. G., Coal-Preparation Practice in Western Germany: Bureau of Mines Inf. Circ. 7389, 1946, 70 pp.

TABLE 8. - Spontaneous combustion of steam-dried lignite in an open-bottom bin1/

Test No.	Condition	Temperature, °F. (Average of 10 thermocouples)2/ Time, hours: 0	10	20	30	40	50	60	70	80	90	100	Maximum final temperature, °F.	Minimum final temperature, °F.
3	Cooled for 18 hours3/	39	43	48	53	59	65	70	75	73	72	4/70	77	46
4	Partly cooled5/	61	91	118	126	126	121	7/111	109	104	100	4/96	99	59
5	Loaded from chute6/	105	135	155	145	140	250	7/365					575	140
6	do.6/	101	130	125	100	90	95	105	165	7/250			600	75
7	Filled manually8/	105	160	150	135	125	115	105	100	95	90	4/85	75	65
8	Filled and packed manually9/ .	97	165	190	180	185	200	7/295					560	245
9	Oil treatment filled manually10/	120	175	165	160	165	7/200						535	90
10	Mixed oil treatment filled manually11/	108	165	150	140	135	130	125	120	115	115	4/110	125	60
11	do.11/	105	180	160	155	150	165	210	7/300				645	105

1/ Steel bin 5 x 5 x 3 ft. not welded at bottom. One side of bottom provided with 2-inch opening extending full length of bin, simulating railroad car.
2/ 5 thermocouples on plane 1 foot from bottom, and 5 thermocouples on plane 2 feet from bottom.
3/ Spread on floor, 6 inches deep, cooled 18 hours and shoveled into bin.
4/ Did not ignite.
5/ Each batch spread on the floor, 6 inches deep; after the 7th batch all coal was shoveled into the bin.
6/ Each batch run directly into bin and leveled.
7/ Discontinued; ignited.
8/ Each batch was run on floor and immediately shoveled into bin. Prevents continuous segregation.
9/ Each batch was run on floor and immediately shoveled into bin and manually tamped.
10/ Each batch was run on floor, sprayed with 11 lb. No. 2 fuel oil, and immediately shoveled into bin.
11/ Each batch was run on floor, sprayed with 11 lb. mixed oil (50 percent No. 2 fuel oil and 50 percent lignite-tar oil), and immediately shoveled into bin.

TABLE 9. - Spontaneous combustion of steam-dried lignite in a closed-bottom bin 1/

Test No.	Condition	Temperature, °F. (lower center, 1 ft. from bottom) Time, hours 0	20	40	60	80	Final	Temperature, °F. (upper center, 2 ft. from bottom) Time, hours 0	20	40	60	80	Final
4	Partly cooled 2/	50	72	106	128	3/126	98	50	81	128	155	3/150	113
6	Loaded from chute 4/	70	90	185	5/220		220	70	105	195	5/220		220
7	Filled manually 6/	95	135	150	5/140		125	95	150	190	5/205		220
8	Filled and packed manually 7/	110	140	200	5/205		405	110	140	200	5/400		540
9	Mixed-oil treatment 8/	105	110	195	5/185		385	105	130	195	5/240		585
10	do. 8/	105	110	195	5/180		185	105	145	200	5/250		495

1/ Steel bin 5 x 5 x 3 ft. open at top and welded on all seams.
2/ Each batch spread on floor 6 inches deep; after the 7th batch all coal was shoveled into the bin.
3/ Did not ignite.
4/ Each batch run directly into bin and leveled.
5/ Discontinued; ignited.
6/ Each batch run on floor and immediately shoveled into bin. Prevents continuous segregation.
7/ Each batch run on floor and immediately shoveled into bin and manually tamped.
8/ Same as test 7; in addition, each ton treated with 11 lb. mixed oil (50 percent No. 2 fuel oil and 50 percent lignite tar oil).

In all of the tests with the open-bottom bin in which the coal finally ignited, the maximum temperature increased rapidly during an initial period of from 5 to 15 hours, usually to the range of 185° to 200° F., then decreased or remained approximately constant for an additional 25 to 35 hours, after which it rose rapidly to above 500° F. All of the 10 thermocouples followed this general pattern. In the tests in which dried coal did not ignite, the temperature of all thermocouples rose rapidly for the first 5 to 8 hours, then decreased very gradually.

In all of the tests with the closed-bottom bin, the temperatures increased more or less uniformally for the first 30 to 40 hours to the range of 180° to 200° F., then they leveled off for a brief period or rose rapidly to ignition and burning temperatures. In all cases, the burning started in the upper section of the bin.

Further work remains to be done; however, it is indicated that adequate initial cooling of the steam-dried lignite will prevent spontaneous ignition.

STORAGE OF COAL

In 4 years of operation, during which 30,000 tons of slack coal were utilized, it was demonstrated that storage in large open pits is feasible, with a loss of heating value as low as 1.5 percent in 1 year.[40]

As given in the above publication, the following general points should be considered:

1. The walls of the storage pit should be tight, preferably made of concrete, or excavated in dense earth or clay.

2. It is important to avoid segregation of sizes in the coal as it is being unloaded or placed in the pit. The accumulation of zones of fine and coarse coal provides air entry courses which will supply oxygen to the interior of the stored coal. The entire mass of stored coal should be as homogeneous as possible.

3. In placing the coal in the pit, care should be taken to store it in shallow benches 2 to 3 feet in depth. Observations have shown the latter to be both practical and economical. Each bench should be leveled and compacted to as high a packing density as is practical. A bulk density of 56 pounds per cubic foot can be attained readily with slack coal.

4. It has been demonstrated that uniform compaction of the pit should be practiced, taking care of the marginal edges as well as the inner areas. Remnants of old coal remaining from the previous storage should be spread out in thin, uniform layers over the bottom of the pit before benches of new coal are placed in storage. Observations have revealed that snow, weeds, and other debris, which have accumulated on the bottom of the pit or on

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40/ Goodman, John B., Parry, V. F., and Landers, W. S., Storage of Subbituminous Slack Coal in Open Pits: Bureau of Mines Rept. of Investigations 3915, 1946, 37 pp.

benches of coal, should be removed before any new coal is placed, since they preclude dense packing and eventually become loosened void spaces which enable air to circulate.

5. The finished stored coal should be level in appearance and, if possible, flush with the top edge of the pit walls to avoid entrainment of wind currents. Valleys and peaks appearing on the surface of the storage pile should be leveled, because irregularities will catch wind currents and will induce air circulation to cause self-heating.

6. In a pit with tight side walls, air can enter only through the top surface. To impede movement of air into the coal mass, the surface should be compacted by rolling or scraping to break down the top few inches of slacked coal into fines.

UTILIZATION OF COAL FOR COMBUSTION

Fuel-Engineering Service

Fuel-engineering service to Government establishments in the inspection, selection, and use of fuel and fuel-burning equipment was continued. At the request of the Veterans Administration, total operating-cost comparisons were made when oil, gas, and coal are used, and the type of fuel-burning equipment was recommended for 38 new projects; the complete design of a new boiler plant at Fresno, Calif., was studied, and recommendations were made for improvement. At the request of the Federal Works Agency, a study was made of boiler plant changes for improving operation at the Lexington, Ky., Marine Hospital. At the request of the Federal Housing Agency, fundamental designs for two types of proposed standard boiler plants were planned and recommended. At the request of the Federal Public Housing Administration, recommendations were made on changes in operation and in boiler furnace and baffles at its Springfield, Ill., project, where external corrosion of boiler tubes was causing excessively high maintenance costs. At the request of the Public Buildings Administration, a study was made of revamping the Washington, D. C., Government fuel yard coal-storage system. Inspections were made of four Federal Housing projects in the vicinities of Philadelphia, Pa., and Newark, N. J. Recommendations were made on the control of corrosion difficulties and on the handling and burning of the fuel. Service on 65 special problems was given 24 different Government agencies. Although the war project, "The National Fuel Efficiency Program," was terminated at the close of the war, requests have been continually received for hundreds of copies of the literature and posters used during that program for improving fuel utilization. Consulting service as to the purchase of fuel appropriate for the equipment was given the Justice Department and the Office of Indian Affairs for all of their plants, and also for a number of plants of various other agencies. A representative of the Bureau of Mines served as chairman of the interdepartmental Federal Fuel Purchasing Committee created to establish Government policies on fuel purchases; he also served as chairman of the Technical Committee on Solid Fuels, created to prepare standard Federal specifications for solid fuels. Work with the American Society for Testing

Materials included the chairmanship of a section "Combustion of Coal and Coke," created to prepare a write-up covering the significance of tests of coal and coke in relation to combustion in different types of fuel-burning equipment.

Cooperative work with the Air Preheater Corp. on research on the prevention of deposits and corrosion of boiler air preheaters was continued. Laboratory tests are being run, and field-test and operating data from many installations throughout the United States are being accumulated. Different materials and changes of operation are being studied. Substantial progress is being made in improving operation and lowering maintenance cost.

Boiler Feed-Water Conditioning

Analyses and resulting recommendations were made on 9,129 samples of boiler water during the fiscal year, as follows: 6,388 from the War Department; 1,095 from the Veterans Administration; 476 from District of Columbia plants; 294 from the Post Office Department; 284 from the National Housing Agency; 260 from the Office of Indian Affairs; 184 from the Department of Justice; 55 from the Public Health Service; 29 from the Department of Agriculture; 27 from the Navy Department; 19 from the Department of Commerce; 9 from the Federal Works Agency; 6 from the Atomic Energy Commission; and 3 from the War Assets Administration. Special analyses and recommendations were made on 7 samples of several types of water for various agencies. Reports and recommendations covering 22 analyses of various scales, sludges, and deposits and 18 covering analyses of boiler compounds were made. An average annual saving of about $240.00 was effected by the use of standard chemicals instead of proprietary compounds at several National Housing Agency plants. Two hundred and seventy eight special Bureau of Mines field-water test kits, 9,000 bottles of chemical reagents, and 10,517 test-kit replacement items were distributed to various Government activities. Visits were made to 189 heating plants operated by a number of Federal agencies in the local area of the District of Columbia to advise on boiler-water treatment, give instructions in boiler-water testing, and inspect boilers for scale and sludge.

At the request of the National Advisory Committee for Aeronautics, a visit was made to Langley Field, Va., to give instructions on building chemical feeding equipment. As a result of the visit, a saving of $3,000 was effected in the cost of feeding equipment; in addition, silica jell used for protection of idle boilers was replaced by quicklime, a much cheaper material. At the request of the Navy Department, instructions on boiler-water conditioning were given to personnel at the U. S. Naval Torpedo Station in Alexandria, Va., and the U. S. Naval Torpedo Testing Range in Piney Point, Md. At the request of the District Government, instructions were given to District Government Headquarters' engineers on boiler-water testing and on boiler-water treatment and control. A report was made to the District Government of an acceptance test of a zeolite softener at Gallinger Hospital. Consulting service was given the Public Buildings Administration on control of corrosion in return lines; the Veterans Administration in preparing a manual on boiler-water treatment and on boiler-water testing; the Capitol Power Plant on boiler-tube failure; the Bureau of Yards and Docks, Navy Department, on writing a manual on boiler-water treatment; and the Second Army Headquarters on boiler-water treatment. At the request of the Federal Public Housing Authority, plans were completed for extending the boiler-water-conditioning service to Federal housing plants throughout the United States.

Instructions on Testing of Boiler Water

An instruction booklet[41] on testing for tannin by boiler-water color was revised and printed, with illustrations. A pH test for water from low-pressure boilers by the use of indicator paper was developed, and directions for the test were completed.[42] An instruction booklet[43] for testing boiler water for phosphate and causticity was rewritten and revised, with illustrations.

Innovations in Boiler-Water-Control Testing

A comparative study was made of the determination of total dissolved solids in boiler water by hydrometer, electrical conductivity, and evaporation to dryness. The electrical conductivity method was not found to be superior to the hydrometer in accuracy for routine samples coming from widely dispersed sources. The stability of the standard phosphate solution was tested and a procedure determined for increasing the stability in the type of bottle used. Comparison was made of changes in the silica content of boiler-water samples in rubber and glass bottles to determine methods of bottling boiler-water samples for determination of silica. Study was continued, throughout the year, of the determination of chloride in boiler waters containing tannin, using the Mohr titration, that is, titration with silver nitrate, using a chromate indicator. The presence of the tannin obscures the end point. Also, high concentrations of phosphate, which may be present in boiler-water samples, interfere with the accuracy of the test. A procedure is being worked out for removing the tannin by decolorizing carbon for this test and for making necessary adjustments to eliminate interference of phosphate. Work was published[44]

41/ Bureau of Mines, Boiler-Water Service Section, Instructions for Bureau of Mines Boiler Water Test Kit for Tannin by Boiler Water Color: Form BWS9.

42/ Bureau of Mines, Boiler-Water Service Section, Bureau of Mines pH Test for Boiler Water from Low Pressure Boilers by Use of Indicator Paper: Form BWS14.

43/ Bureau of Mines, Boiler-Water Service Section, Instructions for Bureau of Mines Boiler Water Test Kit for Phosphate and Causticity: Form BWS1.

44/ Goldman, L., and Love, R. N., Colorimetric Phosphate Tests for Boiler Waters Containing Tannin: Bureau of Mines Rept. of Investigations 3983, 1946, 11 pp.

Goldman, L., and Love, R. N., Colorimetric Phosphate Tests for Boiler Waters Containing Tannin: Power Plant Eng., vol. 50, No. 1, 1946, pp. 76-79.

Goldman, L., and Love, R. N., Testing Boiler Water: Heating and Ventilating, vol. 44, No. 1, January 1947, p. 110.

Goldman, L., and Love, R. N., Tests for Boiler Water Containing Tannin: Combustion, vol. 18, No. 7, January 1947, p. 44.

Goldman, L., and Love, R. N., Tests for Boiler Waters Containing Tannin: Chem. and Eng. News, vol. 25, No. 5, February 3, 1947, p. 325.

on the determination of phosphate in boiler water containing tannin. Three procedures were studied: (1) Coagulation of sludge by heating with potassium nitrate and use of color blanks to cancel out the color of the tannin; (2) bleaching of the tannin with potassium persulfate; and (3) removal of the tannin with decolorizing carbon, a new method developed in our laboratories. A gravimetric A.S.T.M. method was adapted for use as a reference method for the three colorimetric methods. It was shown that values obtained by any of the three colorimetric methods agree. This indicates that calcium phosphate sludge can be filtered out completely, even though tannin is present in the sample, as in the potassium nitrate coagulation method. The new method (3) was shown to be the most rapid and convenient of the methods studied.

Boiler-Water Research

Research was continued on the use of amines in boiler water, which volatilize with the steam and destroy the carbon dioxide acidity of the condensate formed. When such condensate is returned to the boiler as feed water, its amine content is again volatilized with the steam. Loss in wasted condensate in blow-down and at vents must be replaced periodically. A compounded dye was developed to add to a sample of condensate so that the boiler operator would know when the proper range of amine content was being carried. A method of calculation was devised so that a close approximation of the quantity of amine required for treatment could be determined when the percentage of make-up and blow-down was known for a given water. Such calculations furnish quantity and cost data from which it can be estimated whether or not the cost of amine treatment would be economical. A field study of chemical treatment[45] showed that three amines, cyclohexylamine, benzylamine, and morpholine, of widely different alkalinity and volatility prevented corrosion equally well when present in sufficient quantity to neutralize carbonic acid in the condensate. Cyclohexylamine is very volatile in boiling water and quite alkaline, benzylamine is moderately volatile and moderately alkaline, and morpholine least volatile and only mildly alkaline. High volatility tends to result in losses during deaeration; low volatility tends to result in losses in the blow-down. High alkalinity tends to prevent carbon dioxide removal, thereby increasing the percentage recirculation of this substance and its concentration in the system. The higher the concentration of amine required in the system, the greater the amine make-up required since, in general, losses are due principally to wasted condensate. At the particular plant tested, which was operated at a steam pressure of 65 pounds per square inch, cyclohexylamine was lost in appreciable quantity at the feed-water heater vent, as well as in the wasted condensate; blow-down losses were important only with morpholine; benzylamine averaged superior to the others in these respects, owing to its intermediate volatility. The morpholine content decreased during the distribution of the steam at low pressures (5 psi). With these data as background, suitable chemical treatment for preventing corrosion in condensate piping has been recommended for a large number of Government-operated heating plants.

[45] Berk, A. A., and Nigon, J., Amine Volatility and Alkalinity in Relation to Corrosion Control in Steam-Heating Systems: Bureau of Mines Tech. Paper; in press.