

one. All brands when sheathed, passed "gallery test 1" with charges twice that of the respective unit with deflative charge. All brands passes "test 4," although only 5 of the sheathed brands were fired with charges of 3 pounds, exclusive of weight of sheath. Detonation rates were determined for some of the brands; the rate for sheathed cartridges averaged 200 meters per second lower than that for unsheathed cartridges.

#### Effect of Sheaths on Poisonous Gaseous Products from Permissible Explosives

Recent studies by the Explosives Division and earlier tests by both this division and testing stations abroad indicate that the ignition hazard of explosives fired in the presence of gassy atmospheres may be reduced by the addition of a suitable sheath. However, reduced ignition hazard does not necessarily mean that an explosive is safer, because poisonous gases are produced in the detonation of explosives and may present an important hazard if present in sufficient quantities.

The quantity of poisonous gases produced by permissible explosives shot in the Bichel gage based on 1.5 pounds of explosive determines the fume classification into which explosives are placed:<sup>42/</sup> Class A, not more than 53 liters; class B, more than 53 but less than 106 liters; and class C, more than 106 but less than 158 liters. An explosive is not permissible if more than 158 liters of poisonous gases are produced from 1.5 pounds of explosive or if more than 5 liters of oxides of nitrogen are produced from 1.5 pounds of explosive when sheathed. Since the oxygen balance of the explosive, the nature of the material in contact with the explosive, and other factors are known to affect the gaseous products from explosives, it was of interest to determine how gaseous products are affected by sheaths composed of flame-extinctive materials and sometimes containing carbonaceous combustible material in addition to the sheath wrapper. Two types of apparatus were employed in the determination of the gaseous products: In the Bichel gage, gases are produced by detonation at low loading densities, without stemming; the Crawshaw-Jones (C-J) apparatus permits tamping and use of stemming, affording a higher degree of confinement. Fifteen permissible explosives, 6 of which were in two sizes of cartridges, and 8 different sheaths were tested in continuation of the previous study of the effects of sheaths on the gaseous products from explosives. Three of these explosives were of the gelatin type, and 2 were low-density explosives. The rates of detonation ranged from 1,800 to 4,800 meters per second. No. 6 mercury fulminate-potassium chlorate electric detonators with 4-foot leg wires insulated with cotton impregnated with an asphaltic material and paraffin were used in tests in the Crawshaw-Jones apparatus; in Bichel-gage tests the insulation was removed from the leg wires. The oxygen balance of the complete detonator was -8.6 grams and -2.8 grams with the cotton insulation removed. Oxygen requirements, as well as the nitrogen and carbon contents of the detonator, were included in the material balances. Toxic carbon monoxide and even more toxic oxides of nitrogen are normal products of the decomposition of explosives and are of primary importance. Figures 10 and 11 show the effects of sheaths on the production of these gases. An indication of possible performance properties and extent of decomposition of the sheath, the total gaseous products are important. Figure 12 indicates the effects of sheaths on total gaseous products. In the Bichel gage,

<sup>42/</sup> See footnote 41.

sheaths increased the amount of carbon monoxide when the oxygen available was greater than 80 to 85 percent of the oxygen required for complete combustion. With less oxygen, the sheaths may decrease the quantity of carbon monoxide. Weight ratio of sheath to explosive was important and influenced the production of carbon monoxide. The use of a sheath increased the volume of oxides of nitrogen, but the amounts involved were negligible in Bichel-gage tests, except for low-density explosives which may produce large quantities of this toxic gas when the weight ratio of sheath to explosive is large. This phenomenon also may occur with other explosives, if the weight ratio of sheath is large enough. Total gaseous products were usually increased by the addition of a sheath in the C-J tests but may be decreased in the Bichel-gage tests for oxygen conditions less than 80 to 85 percent of theoretical requirements. Tests in the C-J apparatus were made under three conditions: (1) Cartridges of unsheathed explosive tamped in the borehole and stemmed ("density-of-1"); (2) cartridges of unsheathed explosive laid single-file in the borehole and stemmed; and (3) sheathed cartridges laid single-file in the borehole and stemmed. The results indicate that shots loaded at density-of-1 always produced less carbon monoxide than either air-spaced or sheathed shots. Air-spaced shots produced less carbon monoxide than sheathed shots when the available oxygen exceeded 80 percent of the theoretical requirements for complete combustion. In general, air-spaced shots produced the least amount and a negligible quantity of oxides of nitrogen. Shots loaded at density-of-1 generally produced the largest quantity, and sheathed shots produced intermediate amounts of oxides of nitrogen. When the explosive is nearly balanced or has a positive oxygen balance, large amounts of oxides of nitrogen may be produced from sheathed shots or those loaded at unit density, and significant quantities may be produced from air-spaced shots. The results indicated that sheathed explosives introduce no important hazards in the production of carbon monoxide but may cause undesirable conditions by the increased production of oxides of nitrogen under adverse conditions.

#### Sensitivity of Explosives to Initiation by Electrostatic Discharges

Of all hazards associated with explosives, those generally ascribed to static electricity are probably least understood. In 1942 the Explosives Division started an investigation for the Safety and Security Division of Army Ordinance to evaluate certain static electrical hazards associated with the manufacture, storage, and use of explosives. Later, other service and industrial organizations requested the Bureau of Mines to obtain information on static electrical hazards associated with particular problems in the handling of explosives or potentially explosive materials. In connection with these investigations considerable data on static spark sensitivities of explosives have been accumulated. For security reasons, much of this information is restricted at present.

Only a brief summary of the general trends observed from test data that are unrestricted can be presented here. The energy for ignition varies with voltage and overvoltage, but the trend of variation was not the same for all explosives. Large particles ignited less readily than smaller particles, although for some explosives under confinement this effect was not appreciable. Except for primary explosives, the degree of confinement usually had a marked

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effect on ease of ignition and completeness of propagation of the ignition. The ignitions of secondary high explosives unconfined were apparently explosions of fine dust dispersed in the air by the spark, whereas under confinement these explosives detonated. The ignition energies for unconfined samples of finely ground secondary high explosives were invariably less than for the same types of samples under confinement. Metal powders were more sensitive when tested unconfined. Black powder was much more sensitive when tested under confinement. Moist black powder (up to 7 percent moisture) was more sensitive than dry when tested under confinement.

It was of interest to know the electrostatic charge energy that might be built up on the human body. The capacity of the human body depends on many factors, such as body structure and the proximity of other conductors or insulators. If there is contact between the body and some other object of high capacity the over-all capacity will be considerably larger. Some measurements were made of the capacity of several individuals in a building with a grounded-steel framework. When the individual was insulated from the floor by either rubber-soled shoes or a 3/4-inch plate of glass, values of capacity ranging from 0.0001 to 0.0004 microfarad could be obtained. The value of 0.0004 was obtained with the individual leaning over a steel girder while wearing a leather jacket. Some tests also were made in a reinforced-concrete bombproof. Values of 0.00028 to 0.00032 microfarad were consistently obtained when the individual leaned against a wall. For two individuals holding hands the capacity was approximately the sum of their separate capacities. If 0.0003 microfarad is considered a reasonable value of capacity under not too extreme conditions, then an individual charged to 10,000 volts would have a charge energy of  $5 \times 0.0003 \times 10^{-7} \times (10,000)^2 = 0.015$  joule. On the basis of present information, it is believed that precautions should be taken to prevent the accumulation of electrostatic charges on individuals around operations involving the handling of explosives that may ignite with electrostatic energies of 0.015 joule or less. It must be emphasized that ungrounded pieces of equipment, wiring, or structures may acquire much larger energies than 0.015 joule and that precautions should always be taken to prevent accumulation of charges on such items around all operations involving explosives.

#### Effect of Humidity on Sensitivity and Dispersion of Black Powder

Results of studies of the effect of humidity on the sensitivity and dispersion of black powder were published.<sup>43</sup> This report covers the study of four properties of black powder that might be affected by moisture: (1) Ignition by flame or hot spark; (2) ignition by heat; (3) ignition by friction; (4) ignition by impact. In addition, the effect of moisture on the dispersibility of black-powder dust was studied to obtain information on its possible influence in the decrease or increase in the incidence of ignition. Humidification of black powder, unless raised to a moisture content where the powder disintegrated, increased the hazard from ignition by flame or hot particles. Fine-grained powders were more readily ignited by flame or hot particles than were coarse-grained powders. When black powder was heated to some

Moore, R. H., and Huff, W. J., Studies of the Effect of Humidity on the Sensitivity and Dispersion of Black Powder: Rept. of Investigations 9782, 1944, 18 pp.

temperature below its ignition point, an exothermic self-accelerated reaction occurred which ultimately resulted in ignition unless means of removing the generated heat were provided. Depending on outside conditions, this reaction may become important at temperatures near the melting point of sulfur. Small samples and rapid heating did not give satisfactory ignition temperatures by the test method used. Frictional-impact and pressure-friction tests indicated that black powder is relatively insensitive to friction, at least at ordinary temperatures. Impact tests showed that, under moderate confinement, black powder is moderately sensitive to impact. Two percent or more of moisture decreased the sensitivity to impact. Humidification of black powder effectively lowered the dispersibility, except where the deposit had been disturbed or mechanically agitated before being subjected to a blast. Aside from the electrical effects involved, the importance in minimizing accidental ignition of black powder is probably related to decreased sensitivity of moist black powder to impact. Black powder should be kept cool; temperatures should not approach 100° C.

#### Miniature-Cartridge Test for Detonators

A new test, called the "miniature-cartridge test," was developed for evaluating the relative initiating efficiency or strength of detonators.<sup>44/</sup> The test is based on the fundamental and generally accepted concept that the ability of a detonator to initiate an insensitive explosive is the best measure of its initiating efficiency. Various mixtures of TNT and iron oxide of known physical and chemical properties were selected to represent a wide range of insensitive explosives. The experimental technique combined the known advantages of the sand test and the TNT-iron oxide insensitive-powder test. A 5-gram charge of a homogeneous TNT-iron oxide mixture was packed to a constant density ( $0.94 \pm 0.02$ ) in a paper cartridge, 0.5 inch I.D. and 2.75 inches long, and a detonator was inserted to such a depth as to produce maximum initiation. The extent of detonation of the desensitized TNT was measured by firing the miniature cartridge and its detonator in the center of 1,000 grams of rescreened, standard Ottawa sand contained in a steel bomb of 3-inch I.D. and determining the amount of sand crushed. The crushed sand, which passed through a U. S. Standard No. 30 sieve after a prescribed manner of screening, was then weighed to the nearest 0.1 gram and represented the sand pulverized by the TNT-iron oxide and the detonator. From this weight was subtracted the "detonator blank" obtained under similar technique, except that 5 grams of pure iron oxide was substituted for the TNT-iron oxide mixture. The value of sand crushed, thus derived, represented the initiating efficiency of the detonator. Various factors affecting the test were carefully studied. Among the more important findings resulting from investigations with this test were: (1) A priming charge of 80:20 mixture of lead azide and lead stypnate was found to be more efficient than any other priming charge tested; (2) the initiating efficiency of a detonator was improved by substitution of

<sup>44/</sup> Grant, R. L., and Tiffany, J. E., Detonators: Initiating Efficiency by the Miniature-Cartridge Test: Bureau of Mines Tech. Paper 677, 1945, 34 pp.; Determining the Initiating Efficiency of Detonators. The Miniature-Cartridge Test: Ind. Eng. Chem., Anal. Ed., vol. 17, 1945, pp. 13-19.

tetryl, PETN, and hexogen, in the order named, for an 80:20 mixture of mercury fulminate-potassium chlorate; and (3) the test is applicable to both commercial and military detonators and is believed to provide a more accurate quantitative measurement of the initiating characteristics of detonators than any other previously used test. A brief review of other detonator tests for determining the relative initiating efficiency of detonators was given.

#### Determination of Explosibility of Potassium Perchlorate and of Mixtures Containing Potassium Perchlorate

In recent years potassium perchlorate has come into extensive use as an oxidizing agent in combustible mixtures. This use was accentuated by the war because of the increased demand for pyrotechnics and the increased use of blasting devices in mining. Certain perchlorate mixtures are used in blasting devices to supply the heat necessary to gasify an inert confined liquid, which, on changing state and increasing in volume, builds up enough pressure within a shell to rupture a strong disk and perform the work ordinarily done by an explosive in the mine. Although these mixtures function to supply heat, they contain all the essentials of explosives, namely, an oxidizing agent with combustibles, which on interaction are capable of releasing a large quantity of heat and gases. Fire hazards associated with the transportation, storage, and use of mixtures containing oxidizing materials and combustibles are generally recognized, but the possible explosion hazard associated with some of the "deflagrating" mixtures is often overlooked. It has been generally assumed by manufacturers that the heater mixtures would merely burn and could not be made to detonate under the most severe conditions. This assumption was based on the fact that they merely burn slowly in the open when ignited by a squib and cannot be detonated in the open, even by a No. 8 detonator.

Potassium perchlorate is a powerful oxidizing agent frequently used as an ingredient of explosive compositions. Under the influence of heat it undergoes decomposition, releasing its oxygen and leaving potassium chloride as a residue. Because it may thus decompose in the absence of a reducing agent, the Bureau of Mines is frequently asked about its explosibility *per se* and has made a number of tests to obtain this information. Because the data are not complete for all of the work, only general conclusions indicated by test results on three samples will be given. Table 6 shows the composition of the samples tested.

TABLE 6. - Composition of samples

Sample No.	H <sub>2</sub> O, percent	KClO <sub>4</sub> , percent	KClO <sub>3</sub> , percent	KCl, percent	Charcoal, percent	Oil, percent	Oxygen-percent of requirement for complete combustion
1229	0.6	85.2	0.6	0.6	12.3	0.7	111
1332	.3	83.3	3.1	.2	12.6	.5	111
1339	.4	86.5	(KCl + KClO <sub>3</sub> = .1)		12.4	.6	112



Standard sample M-7229 failed to pass the fiber-shoe pendulum-friction test, showing a hazardous friction sensitivity. The sample was not sensitive enough to fail the pressure-friction test. Samples M-7332 and M-7339, containing more and less chlorate, respectively, than sample M-7229 passed the fiber-shoe pendulum-friction test. The results are not conclusive because foreign matter was observed in sample M-7229 and the samples were not dried before testing. Sample M-7229 was insensitive to static spark, both unconfined and confined; unconfined samples were not affected by small amounts of chlorates. Sample M-7229 and others containing up to 3 percent chlorate had high ignition temperatures, 325° to 387° C.; there was no obvious effect due to the presence of chlorate. The three samples showed the same sensitivity in the brass-cup impact test; with the 5-kg. weight, the lower limit was 20 cm. and the upper limit 50 cm. - sensitivity comparable to that of tetryl. Above 300° C., the lower limit for M-7229 did not change from that at room temperature in the brass-cup impact test; the upper limit, however, was lower at the higher temperature. Large-scale impact tests showed that preignited samples were extremely sensitive to impact. Unignited samples required a fall of 8.0 feet for a 45-pound weight to affect initiation; preignited samples with the same weight gave a detonation with a fall of only 5 inches. When confinement was heavy enough sample M-7229 detonated, the rate of detonation being about 2,050 meters per second. Chlorate appreciably increased the detonation rate when only 3 percent was present. From combined experimental methods a value of pressure between 23,200 and 26,950 p.s.i. for sample M-7229 was determined to be the pressure at which change from deflagration to burning bordering on detonation or actual detonation occurred. Comparisons were made with a chlorate mixture which was deemed hazardous because an explosion had occurred during its manufacture. The chlorate mixture showed greater sensitivity to impact and heat and a higher detonation rate; the spark sensitivity of this mixture showed no hazard. The mixture, contrary to the action of all others, exploded on testing with the steel shoe; however, it passed the fiber-shoe tests. This sample has not been analyzed, and friction sensitivity was determined on samples that were not dried.

The standard mixture M-7229, on the basis of tests made to date, is only extraordinarily hazardous where friction may be encountered or where the possibility of a blow on the burning mixture exists. Tests on ignition temperature and static spark sensitivity show no great hazard. The brasscup impact tests indicate that the mixture has an impact sensitivity comparable to tetryl and greater than TNT. Contrary to the beliefs of some, the mixture will detonate if the confinement is heavy enough. The detonation rate is considerably lower than that of military high explosives. Potassium perchlorate per se at elevated temperatures could not be brought to explosion by direct mild impact and did not explode at ordinary and elevated temperatures when subjected to high velocity impact and detonation while confined. Explosion of potassium perchlorate mixed with underoxidized products of explosion from neighboring explosives such as tetryl may readily occur. Potassium perchlorate did not explode by heat shock, although decomposition under such conditions appeared rapid enough to produce pressure higher than atmospheric around the decomposing mass.

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Surface Storage of Explosives

Satisfactory storage facilities have not generally been provided for explosives at the operations where used.<sup>45/</sup> This condition was emphasized by inspections of explosive magazines by Bureau engineers in administration of the Federal Explosives Act and revealed the inadequacy of the magazines as well as hazards caused by improper storage. Remodeling of old magazines or construction of new ones is needed to afford suitable protection against fire, deterioration, and detonation of explosives. The fundamental features of suitable magazines are shown by sketches and drawings, and recommended types of constructions are listed. Safe procedures in operating explosive magazines are given.

Disposal of Deteriorated Explosives

The problem of destroying explosives that have become unfit for use or are unsuited to any need at their location is occasionally presented to Bureau representatives. Authoritative information indicates that most explosives, except detonators, are best destroyed by burning.<sup>46/</sup> Methods of handling and burning various types of explosives and alternative methods of disposal and precautions to be taken are described.

Ignition Temperatures of Isobutane-Air Mixtures

Ignition temperatures of mixtures of isobutane in air were determined by the "static" method in a 131-cc. quartz bulb. Seven mixtures of known percentages of isobutane ranging from 2.18 to 10.55 percent by volume in air were tested. The minimum ignition temperature was found to be 464° C. for a mixture containing 9.68 percent of isobutane and 90.32 percent by air.

Prevention of Benzene-Air Explosions by Addition of Inert Gases

Earlier studies by the Bureau of Mines have developed procedures whereby the explosibility of many complex gaseous mixtures may be calculated in a rather simple manner without the necessity of performing laborious laboratory experiments. These studies have been of great benefit to the mining and other industries in eliminating, or at least mitigating, the explosion hazards of various combustible gases. The extensive use of complex gaseous mixtures containing various percentages of benzene vapor in the solvent industry and in the manufacture of high explosives emphasized the need of data on the limits of inflammability of benzene-air mixtures alone and on such mixtures to which various volumes of inert gases had been added, both in the lower- and upper-limit ranges. A report giving essential data required for the calculation of complex combustible gaseous mixtures containing varying percentages of benzene was issued.<sup>47/</sup> Graphs and tables were prepared from experimental data which

<sup>45/</sup> Harrington, D., and Warncke, R. G., Surface Storage of Explosives: Bureau of Mines Inf. Circ. 7307, 1945, 16 pp.

<sup>46/</sup> Leitch, R. D., and Moyer, P. R., Destruction of Damaged, Deteriorated, or Unwanted Commercial Explosives: Bureau of Mines Inf. Circ. 7335, 1945, 6 pp.

<sup>47/</sup> Jones, G., W., Prevention of Benzene-Air Explosions by Addition of Nitrogen and Carbon Dioxide: Bureau of Mines Rept. of Investigations 3787, 1944, 20 pp.

show the inflammable areas of all possible mixtures of benzene vapor, air, and added nitrogen and of benzene vapor, air, and added carbon dioxide. By means of these graphs and tables, the limits of inflammability of complex gaseous mixtures containing benzene may be calculated, and the percentages of oxygen in the mixtures that must not be exceeded to prevent the mixtures from becoming inflammable may be determined. The limits of inflammability of benzene in air were determined to be 1.40 percent by volume of benzene vapor for the lower and 7.10 percent for the upper limit of inflammability. Results obtained on benzene-air-nitrogen mixtures covering their entire range of inflammability showed that at least 21.2 volumes of nitrogen must be added for each volume of benzene vapor to make all mixtures with air noninflammable. Similar tests with benzene-air-carbon dioxide mixtures showed that the extinctive effect of carbon dioxide was greater than that of nitrogen; only 12.9 volumes of carbon dioxide per volume of benzene vapor were required to render all mixtures noninflammable. The ratio between the volumes of carbon dioxide and nitrogen, 12.9:21.2, equals 0.61. This value is close to the average ratio of 0.57 experimentally found necessary to render 1 volume of benzene, of 11 other hydrocarbons, or of carbon monoxide noninflammable under all conditions of dilution with air. The reason for this close relationship appears to be the relative heat capacity of nitrogen and carbon dioxide. If it is assumed that the flame-propagating temperature for the 13 different combustible gases tested was 1,400° C., the mean molar heat capacity between laboratory temperature and 1,400° C. is, by calculation, 7.46 for nitrogen and 11.85 for carbon dioxide. If the extinctive effect of the added inert gas is due entirely to its heat-absorbing capacity, the relative efficiency of two inert gases for extinguishing flames should be proportioned to their heat capacities or inversely proportional to their volumes required to extinguish 1 volume of the different combustible hydrocarbons. This ratio of heat capacity of nitrogen to that of carbon dioxide is  $7.46:11.85 = 0.63$ , whereas the ratio by volume of carbon dioxide to nitrogen required to extinguish 1 volume of benzene vapor is 0.61. These values agree well with the average value of 0.57 found for benzene vapor, 11 other hydrocarbons, and carbon monoxide. Therefore, if the volume of nitrogen or of carbon dioxide required to extinguish the flame of a given combustible gaseous mixture is known, the volume of the other inert gas needed may be calculated with fair accuracy by using this average ratio. The use of inert gases to dilute explosive atmospheres and thereby dilute the air or oxygen concentration to the point where the mixtures become noninflammable has found many applications in recent years. Data of the type just described have proved of great benefit to industry. By applying this information, combustible mixtures containing benzene can be removed safely from containers and equipment or the mixtures may be introduced into such vessels originally containing air without creating inflammable atmospheres, if the proper volumes of inert gases - nitrogen or carbon dioxide, or a mixture of the two - are present in the proper concentration.

#### Acetylene-Generator Explosions

Information on the ignition temperatures of acetylene and of acetylene-air mixtures has been of particular interest in recent years due to a number of explosions that have occurred in 500-pound, double-rated, medium-pressure acetylene generators. The range of pressures in these generators may vary

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from below atmospheric to 15 pounds gage. Air may find its way into the generators during abnormal operation or may remain in the carbide hopper of the generator following the purging and charging operations. A study was made to determine the effects of pressure on the ignition temperature of pure acetylene and of acetylene containing varying amounts of air.<sup>48</sup> A special "hot-spot" ignition-temperature apparatus was developed to reduce the violence of the explosions by keeping most of the test mixtures at room temperature and using a heated quartz-ignition tube of 17 mm. or less I.D. At atmospheric pressure acetylene showed an ignition temperature of 635° C.; at 15 pounds per square inch above atmospheric the ignition temperature was reduced to 540° C. Addition of up to 10 percent of air to acetylene decreased the ignition temperature of acetylene only to a small extent; however, the pressure of 15 percent or more of air reduced the ignition temperature by 200° C. or more below that of pure acetylene at any given pressure. Acetylene containing 15 percent of air showed an ignition temperature (320° to 340° C.), only slightly higher than mixtures containing up to 75 percent of air (305° to 315° C.).

#### PREPARATION OF COAL

##### Recovery of Waste Coal

In normal prewar mining practices developed during pioneer days in the United States when its coal reserves were considered to be inexhaustible, it was common procedure to discard varying proportions of unmarketable coal, to leave parts of the coal bed unmined, and to pick out and throw away slightly off-grade coal during preparation. A tentative survey showed that such wastes exist in virtually every mining field of the country and are the results of many factors, such as the mine location, differences in natural conditions of the coal beds, and local mining practices. In the aggregate, these losses of off-grade coals amount to a large yearly tonnage, which, it is believed, can be largely recovered as usable fuel by the application of modern coal-preparation methods. A careful series of preparation tests of such material, now wasted on the surface at the rate of 2,500 tons a day by one group of mines near Pittsburgh, Pa., showed that this could be profitably treated to recover about 20 to 30 percent of the raw material as good steam coal of 9 to 11 percent ash content and 13,560 B.t.u. per pound heating value. Projected studies of this kind, in other fields, offer great possibilities for economy in use of fuel reserves in the postwar period. Furthermore, such investigations, extended to cover the industry as a whole, will uncover opportunities for new and attractive local industries connected with the recovery and utilization of this material.

##### Preparation of Special Low-Ash Coal

In connection with the Synthetic Liquid Fuels Program, in which very low ash coal is needed, an extensive project was initiated to examine available

Jones, G. W., and Kennedy, R. E., Effect of Pressure on the Ignition Temperature of Acetylene and Acetylene-Air Mixtures: Bureau of Mines Rept. of Investigations 3809, 1945, 6 pp.