The WELDING ENCYCLOPEDIA

THIRTEENTH EDITION

The WELDING ENCYCLOPEDIA

☆

Thirteenth Edition

1951

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THE WELDING ENCYCLOPEDIA

Completely Revised and Re-edited by

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Editor, The Welding Engineer and
The Welding Encyclopedia

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Preface to Thirteenth Edition

Many changes have taken place in the use of welding and its allied processes since the advent of the first edition of *The Welding Encyclopedia* over thirty years ago. As progress has been made in welding it has been recorded in the various editions of *The Welding Encyclopedia* until now the 13th edition has come into print.

The Welding Encyclopedia has been completely revised to provide an up-to-the-minute reference book for the rapidly changing world of welding. Arranged as a dictionary, the subjects are easily located alphabetically. To assure complete coverage of a subject, the index has been greatly enlarged to provide an adequate cross reference.

As in the past, *The Welding Encyclopedia* is in five parts; an encyclopedia of welding; an appendix of tables and charts; a dictionary of trade names; a buyers' manual and an index. Each section has been enlarged with much new and original material being presented for the first time. Over 100 pages of subject matter which has become obsolete over the years has been removed and replaced by new material to expand the book by 24 pages over the previous edition.

In revising *The Welding Encyclopedia*, the editor has endeavored to take into account the changing trend in the knowledge desired in the welding field. In considering these factors information regarding metallurgy and the various welding processes has been greatly enlarged as has been the discussion dealing with various welding applications.

Many of the alterations and additions are those which have been suggested by criticisms and inquiries for information from students, weldors, supervisors and engineers. The reader may therefore expect to find quickly almost anything he desires to know about the most universally used process of all the metals industry—welding.

The Editor wishes to express his thanks and sincere appreciation for the efforts, comments and suggestions contributed by many individuals to the production of this valuable book.

T. B. JEFFERSON.

Chicago, Ill., October 15, 1951

Preface to First Edition

THE experience of and the information collected by the Editors of *The Welding Engineer* made this work possible. It is also true that the splendid spirit of helpfulness exhibited by *The Welding Engineer's* little army of readers is responsible for much of the information contained in THE WELDING ENCYCLOPEDIA, and to these loyal friends, we make grateful acknowledgment. It is unfortunate that the information in question is distributed in such a manner that credit cannot be given in each specific case.

To some good friends we must acknowledge valuable assistance given us in the preparation of specific information; among them we find the names of M. Keith Dunham, E. H. Smith, David Ahldin, R. E. Bruckner, Robert E. Kinkead, A. M. Candy, F. J. Maurer, Stuart Plumley, Ben K. Smith, C. L. Bastian, W. H. Bailey, W. R. Hurlbut, L. I. Grinnell and C. J. Nyquist. To the Chicago and Pittsburgh Sections of the American Welding Society we are also indebted for interesting and instructive information by S. W. Miller, D. F. Miner and T. D. Sedwick.

It is the hope of the Editors that the welding industry will find in THE WELDING ENCYCLOPEDIA a useful text book. The reader is reminded of the fact, however, that the compilation of a work of this character is no light undertaking and criticisms and suggestions will always be welcomed.

L. B. MACKENZIE.

Chicago, January 27, 1921.

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The Welding Encyclopedia

—A—

A_1, A_2, A_3, A_4
See IRON-CARBON DIAGRAM.

AAC or AC
Abbr. U.S. Army Air Corps.

AAF
Abbr. Army Air Force.

AAR
Abbr. Association of American Railroads.

ABS
Abbr. American Bureau of Shipping.

AFA
Abbr. American Foundrymen's Association.

AGA
Abbr. American Gas Association.

AIEE
Abbr. American Institute of Electrical Engineers.

AISC
Abbr. American Institute of Steel Construction.

AISE
Abbr. Association of Iron and Steel Engineers.

AISI
Abbr. American Iron and Steel Institute.

AN
Abbr. for joint activities of the Army and Navy.

API
Abbr. American Petroleum Institute.

ASA
Abbr. American Standards Association.

ASCE
Abbr. American Society of Civil Engineers.

ASHVE
Abbr. American Society of Heating and Ventilating Engineers.

ASM
Abbr. American Society for Metals.

ASME
Abbr. American Society of Mechanical Engineers.

ASTE
Abbr. American Society of Tool Engineers.

ASTM
Abbr. American Society for Testing Materials.

AWS
Abbr. American Welding Society.

AWWA
Abbr. American Water Works Association.

Abrasion
A grinding action caused by abrasive solids sliding, rolling and rubbing against a surface resulting in wear.

Abrasive
See GRINDING MATERIALS.

Abrasive Belt
A cloth or paper belt coated with abrasives. The abrasive coating material may be sand or any hardness of abrasive up to carborundum dust depending upon the type of grinding for which the belt is to be used.

Abrasive Belt Grinders
A grinder which uses an abrasive belt instead of a wheel for the removal of surplus material. See SWING GRINDER.

Abnormal Grain Growth
Abnormal grain growth is a condition which results under certain critical conditions of strain and annealing temperatures. These conditions vary with different alloys but the amount of strain is usually quite low, sometimes in the order of 2% of the tensile strength.
In the case of annealing, abnormal grain growth is likely to occur when there is a strain gradient in the piece of metal. Consequently, it is quite important that the proper annealing stages be determined during such processes as deep drawing or spinning.

Absorptiometer
An instrument for the measurement of the absorption of gases by liquids.

Absorption-Bands
Dark bands in a spectrum, due to the selective absorption of the light. The absorbing media are generally solids or liquids through which the light of the spectrum has been transmitted.

Abstergent
A substance used in cleansing; a detergent; as soap is an abstergent.

A_C
See IRON-CARBON DIAGRAM.

A-C
Abbr. Alternating Current.

A-C Arc Welding
See ARC WELDING EQUIPMENT.

Acagine
A mixture of bleaching powder with lead chromate and sometimes barium sulfate. In the early days of welding this mixture was used as a purifier of acetylene.

Acetic Acid
A compound, CH_3COOH, which in the pure state is a colorless, pungent, biting liquid congealing in cool weather, and hence called glacial acetic acid.

Acetin
Any of three liquid esters formed when glycerin and acetic acid are heated together, and known respectively as monacetin, $C_3H_5(OH)_2C_2H_3O_2$, diacetin, $C_3H_5(OH)(C_2H_3O_2)_2$, and triacetin, $C_3H_5(C_2H_3O_2)_3$. The last is said to occur in small quantities in certain fats.

Acetone (CH_3-CO-CH_3)
An inflammable liquid of distinctive or ethereal odor and a biting taste. As a solvent agent for acetylene gas it has an absorptive capacity of 24 to 25 volumes acetylene per volume of liquid per atmosphere or about 420 volumes of acetylene

at 250 psi pressure. It boils at 133 F. One pint of acetone weighs approximately one pound. Acetone is used as the solvent liquid in acetylene cylinders.

See ACETYLENE CYLINDERS.

Acetylene

Acetylene gas, a hydro-carbon gas (C_2H_2), was discovered by Edmund Davy in 1836 but it was not until 1862 when Woehler announced the discovery that acetylene gas could be produced from calcium carbide that the gas really became known. This announcement was of little value though since commercial production of calcium carbide was impossible. It was not until 1892 that Thomas L. Willson of Spray, N. C., in an attempt to make metallic calcium discovered a means of producing calcium carbide and acetylene gas was becom- commercially practical. By 1895 Willson had established facilities to produce calcium carbide and acetylene gas was becoming recognized as a valuable illuminant.

Since then acetylene has become the most important of all gaseous hydro-carbons used in the gas welding industry. The process of welding as we know it today can be said to have been born with the introduction of the commercial production of calcium carbide in 1895. With the inventions of practical methods for the manufacture of oxygen, the development and application of high temperature torches became very rapid. This progress is still continuing, and acetylene is still the leader of all the combustible gases used in the gas welding industry.

Acetylene can be produced by the direct combination of carbon and hydrogen, as well as by various other methods. The only method that has proved to have any practical value is to allow water to re-act upon calcium carbide CaC_2, a chemical compound produced by fusing together lime and coke in an electric furnace. The reaction between water and carbide is instantaneous, and as a result, the carbon in the carbide combines with the hydrogen in the water, forming acetylene, while the calcium combines with the oxygen and water, forming slaked lime, or calcium hydrate.

Generation

The calcium carbide and water are brought in contact with each other in generators, either by allowing water to come in contact with an excess of carbide, or, by dropping carbide in an excess of water. The latter, "carbide-to-water" process, has proven itself best suited for the production of large quantities of acetylene, such as used in the welding trade, and practically all generators on the market today for welding purposes are constructed in accordance with this principle. Several devices have been perfected to make the generators automatic, so as to produce acetylene at the same rate as it is consumed at the torch, and stop all generation when the torch is not in use.

Another classification of the generator constructions is based on the pressure carried in the generators when the gas is produced. In the low pressure type a pressure of approximately a 16 in. water column is maintained, whereas in the pressure type, a maximum pressure of fifteen pounds per square inch is maintained. A still higher pressure can, of course, be produced in the generators, but for reasons that will be explained later, all such attempts should be abandoned, and too intense a warning cannot be given possible "inventors" to keep away from any attempts to construct such dangerous machines. The low pressure and the pressure generators have no separate fields to cover in the welding trade. Under some conditions the low pressure generator is preferable, under other conditions the pressure type. Each problem has to be studied individually, and the type of generator decided upon from the local conditions. In large plants, where the acetylene is later compressed into cylinders, the low pressure type has proven the best, whereas, in plants from which the gas is piped through long pipelines to numerous welding stations, the pressure type has proven to possess several advantages, although even in such cases the low pressure generator can be used to advantage, if combined with a compression unit, arranged to deliver the acetylene to the pipeline at a pressure not exceeding fifteen psi.

Before leaving this brief description of acetylene generators, it might be allowable to express one additional warning. The process for production of acetylene from calcium carbide is very simple, but before trying to simplify existing constructions or attempting any radical departure from the conventional designs be sure to study carefully the nature of carbide, acetylene, and the various constructive designs and materials, otherwise serious accidents are sure to be invited that might result in loss of life and property. If in doubt, confer with THE WELDING ENGINEER, or some other authority on the subject.

Chemical Characteristics

The chemical structure of acetylene is given in the formula C_2H_2 and shows that two atoms of carbon (atomic weight 12) are combined with two atoms of hydrogen (atomic weight 1.008) or, in other words, acetylene consists of 92.3% carbon and 7.7% hydrogen. The nearest gaseous hydrocarbon is ethylene C_2H_4, which therefore, consists of 85% carbon and 15% hydrogen. Acetylene, consequently, is, of all gaseous hydrocarbons, the one that contains the highest percentage of carbon. Add to this that acetylene is the only one of the unsaturated hydro-carbons that possesses endothermic properties (viz: absorbs heat during its production, and liberates heat when it is decomposed) and it is easy to realize the reason for the intense heat that is produced in the oxy-acetylene flame (6300 F), which cannot be approached by any other gas known, and is only exceeded by the heat evolved in the electric arc.

The specific gravity of acetylene as compared with air is .9056, from which figure can be calculated the weight of acetylene per cubic foot. For all practical purposes this figure has been accepted to be 69 pounds per thousand cu. ft. of pure, dry acetylene at 60 F., which figure expressed differently shows that one pound by weight of acetylene equals 14.5 cu. ft. Under normal temperature and pressure acetylene is without color, and with a sweet, not unpleasant odor and taste. If not purified it has a pungent, nauseating odor that is very easily recognized and detected, even if strongly diluted with air. Under atmospheric pressure the boiling point of acetylene has been established to be —121 F. The critical temperature is 98.7 F., and its critical pressure 61.6 atmospheres (905 psi.).

Critical Mixtures

Under low pressure and at normal temperature acetylene is a perfectly stable compound; a spark introduced into an acetylene volume under such conditions will not spread any appreciable distance, and its effect confined to the immediate space around the spark. It must be borne in mind, however, that acetylene, like any other combustible gas, becomes explosive if mixed with certain proportions of air, and a spark introduced into such a mixture will instantaneously spread through the whole volume. The range of explosive proportions that is generally attributed to acetylene is from 3% acetylene and 97% of air, to 82%

of acetylene and 18% of air. Other authors give the figures 3.35% and 52.30% as lower and upper limits of explosibility. In either case, it proves that the utmost care must be taken to exclude all air from generators and pipelines, and that all constructions must be based on this important requisite.

If generated under a pressure exceeding 25 psi., or compressed to such a pressure, the acetylene acquires explosive properties that must cause the operator to be on constant guard. If a spark or a sudden shock is introduced into such an accumulation of acetylene under pressure, the dissociation of the gas will travel through the whole gas-quantity. No air is needed to produce such an explosion, as the gas itself is decomposed into its original elements, carbon and hydrogen.

For this reason all generators should be constructed for an absolute maximum generating pressure of 15 psi., so as to eliminate any possibility of dangerous pressure in same. The National Board of Fire Underwriters have specified the above mentioned maximum pressure on all acetylene generators upon the urgent appeal of all acetylene men, that have the welfare of the industry at heart.

Before going into the description of compressed acetylene it might be well to mention here the impurities that are inherent to the commercial grade of calcium carbide, and the methods now used to eliminate same from the acetylene, and, consequently also from the weld.

Impurities

The principal impurities that are inherent to the commercial grade of calcium carbide, and which will contaminate the acetylene produced from same are lime dust, sulphur and phosphorous combinations, and ammonia. All these impurities are detrimental to a successful operation of the welding torch and to a good weld and should be eliminated from the acetylene, as should also the water vapor that follows the gas from the generator. The lime dust is produced in the generation, and is easily eliminated by the introduction of proper screens of hairfelt or the like. The ammonia can be taken out by leading the acetylene through a water seal, where the ammonia is dissolved and held in the water, while the gas passes on through the pipeline. The most efficient method of eliminating the sulphur and phosphor combinations from the acetylene is to force the gas through a finely divided substance holding some chemical reagent that will form nongaseous compounds with sulphur and phosphorus combinations. Various reagents have been perfected for this purpose, the most important ones being Acagine, Heratol, Frankolin, and Catalysol. Each one of them is today used with exceedingly good results, and the acetylene can easily be purified to within a very small fraction of 1%. A test can readily be made to determine the relative purity of the acetylene, by moistening a small piece of litmus paper or white blotting paper with a 5% solution of silver nitrate, and holding this paper in the flow of the gas. Raw gas will immediately produce a dark brown or even black spot on the paper, whereas pure gas will leave the paper perfectly white, even if the moistened paper is held in the gas stream for one minute. The moisture in the gas can be eliminated by passing the acetylene through boxes containing either quick lime or chloride of calcium. Both of these materials have a great affinity for water vapor, and the slightest traces of water can thus be eliminated.

Compressibility

Acetylene, like any other gas, can be compressed, and, if kept sufficiently cool it can even be liquefied, to a colorless, odorless liquid. At an extremely low temperature it has been possible to produce acetylene in solid form.

There is, however, one feature in connection with the compression and liquefaction of acetylene that is of the utmost importance to bear in mind when attempting such work. Acetylene, when compressed, becomes very unstable, and will, under the slightest provocation, completely dissociate into its chemical components, carbon and hydrogen, with an accompanying remarkable increase in temperature and pressure. This property of the acetylene can in part be explained by the chemical structure of the acetylene molecule and in part also by the endothermic nature acquired by the acetylene in its formation.

Limitations

In the early development of the acetylene industry very little was known about the chemical and physical properties of the acetylene and the gas was compressed into empty cylinders, with little or no precautions taken. This so compressed and even liquefied acetylene was placed on the market, and in spite of some sporadic accidents and explosions, this trade was carried on for a few years. The continued accidents with this gas, however, caused some governments to restrict its use, and finally all civilized countries prohibited the use of liquid acetylene. Compressed free acetylene was still allowed to be used, and it is only in recent years that a universal ruling prohibiting the use of this commodity has been accepted and enforced.

Storage Problems

Acetylene had, however, proved itself so superior to other gases that the problem of storing same in an absolutely safe manner was thoroughly investigated. Two French scientists, Claude and Hess, in their research work, established the fact that acetylene would completely dissociate or explode if compressed to a pressure of approximately 25 psi. or more. They furthermore proved that if acetylene under a pressure of more than 25 psi. was exploded in tubes of very small diameter, the walls of the tube absorbed the generated heat so quickly that explosion became confined to the particular spot where the explosion originated.

Basing their work on these facts, Claude and Hess constructed a container with the interior sub-divided into very minute cells, and experiments with containers filled with such porous mass proved that acetylene under pressure could with safety be stored in same. Further experiments have proved that an efficient porous mass can be produced with as high porosity as 80% without jeopardizing the necessary strength of same.

Simultaneously with these experiments Claude and Hess approached this problem of safely storing acetylene under pressure from a different viewpoint.

It is an established fact that all gases can be absorbed to a greater or lesser degree in various liquids, as, for instance, carbonic acid gas in water. Acetylene follows this law of nature, and, in investigating this property of acetylene, Claude and Hess found that the liquid acetone (dimethylketone) was able to absorb great quantities of acetylene. They found that at normal pressure and temperature one volume of acetone will absorb twenty-five volumes of acetylene. It was also established that this absorbing power increases in a proportionate rate with the pressure applied, so that for each atmospheric pressure applied, an additional twenty-five volumes of acetylene will be absorbed, and subsequently released when the pressure is reduced.

Another important feature of this acetone-acetylene solution proved to be that the exothermic properties of the acetone counteracts the endothermic properties of the acetylene, and, consequently, the acetone-acetylene solution is to a certain extent immune from a complete dissociation in case an ignition or explosion is introduced into same.

Safe Storage

In absorbing acetylene acetone increases in volume, in a proportionate rate to the volume of acetylene absorbed. In an equal manner the acetone decreases in volume when the acetylene is discharged. Consequently, it is seen that in a container holding acetone for absorbing or dissolving acetylene it is necessary to allow for this increase in the volume of acetone. This necessarily means that when the gas is being discharged from such a container a certain space is created, which contains free acetylene under pressure. Therefore, acetone alone in a container does not suffice for safe storage of acetylene under pressure. By combining the two ideas of a porous mass in a cylinder, and introducing acetone in this mass, Claude and Hess finally solved the problem of storing acetylene under pressure with absolute safety.[1]

After this solution of the problem had been accomplished there remained a certain amount of research work to be done in producing the correct commercial application of same. This work has been going on the last twenty years, and continuous progress has been made until today absolutely reliable constructions of acetylene cylinders have been obtained.

The combination of compression and absorption utilized in an acetylene cylinder for the storage of the acetylene makes it very difficult not to say impossible, to measure the available gas-quantity by a simple pressure gauge reading as can be done when dealing with other gases transported and sold under pressure. For this reason another method has been introduced to determine the gas-quantity in an acetylene cylinder at any time, regardless of pressure. The method thus employed simply consists in weighing the cylinder before and after its use, and computing the acetylene consumed from the known weight per cubic foot of acetylene. For work where absolute accuracy is a necessary requisite a correction should be made for temperature, but for all practical applications the above method has proven to be satisfactory.

When the gas is discharged from an acetylene cylinder a certain proportion of the acetone is taken out with the gas in the form of acetone vapor. The more rapidly a cylinder is discharged, the greater is the percentage of acetone vapor in the acetylene. Experience and numerous experiments have proved, however, that if the flow of gas from a cylinder is kept within certain limits, the acetone percentage is so small as to be negligible. The maximum gas flow from an acetylene cylinder should not exceed one-seventh of the cylinder's capacity per hour, or, in other words, an acetylene cylinder should not be discharged in less than seven hours actual working time. If the work should require a greater gas-consumption than the above figure it is recommended that two or more cylinders be connected in series to one master regulating valve, all cylinders being turned on together.[2]

All acetylene generator installations should be made in full accordance with the rules and regulations adopted by the National Board of Fire Underwriters, and the instructions issued by this board as well as by the responsible generator manufacturer should be adhered to strictly. See ACETYLENE GENERATOR.

Several sizes of acetylene cylinders exist in the market today, the smallest having a gas capacity of 10 cubic feet of acetylene, the largest ones a capacity of over 2,000 cu. ft. For the welding trade cylinders ranging in capacity from 100 cu. ft. to 300 cu. ft. have proved to be the most practical, as being easily transportable at the same time as holding enough gas for the average welding job. The maximum permitted charging pressure on all acetylene cylinders has been set to 250 psi. at 70 F. See ACETYLENE CYLINDERS.

The acetylene cylinders used in interstate traffic must comply with shipping container specification No. 8, now in force, issued by the Interstate Commerce Commission. Regulations for shipments of these cylinders have also been issued by this commission, and the enforcement of these specifications and regulations has been given the Bureau of Explosives, 30 Vesey Street, New York City.

For chemical and physical properties of acetylene, see GASES.

Acetylene Cutting

See FLAME CUTTING and CUTTING UNDERWATER.

Acetylene Cylinders

Acetylene cylinders are constructed in an entirely different manner from those which contain other gas, because of the differing characteristics of acetylene gas. These differences are discussed under CYLINDERS. If acetylene were compressed to a pressure of 250 to 300 psi into an ordinary empty cylinder, it might explode before it had reached a pressure in excess of 25 or 30 psi. This, of course, would depend somewhat on temperature and other conditions, but free acetylene, under a pressure in excess of 15 psi is not safe. Therefore, acetylene cylinders are constructed in a manner to prevent dissociation or breaking up, of the acetylene into its constituents, which is caused by pressure, thus making them safe.

Cylinder Has Porous Filler

This is accomplished by filling the acetylene cylinder completely full of a packing made of mixtures of asbestos, Balsa wood, charcoal, infusorial earth, cement, etc. When asbestos alone is used it is ordinarily compressed into disks and forced into the cylinders, after which the ends are brazed securely in position, Fig. 1. Another type forces a mixture of infusorial earth and Balsa wood under pressure into the cylinder before the bottom is welded into position, Fig. 2. Still another type uses a seamless drawn cylinder with a bottle shaped neck. Through this neck a mixture of asbestos, charcoal, infusorial earth, cement, and water is forced into the cylinder until it is completely full. These cylinders are baked in an oven for a considerable period of time until the water is entirely dried out, Fig. 3.

Acetylene Is Dissolved in Acetone

In all types of construction the object is to provide a porous filler which will completely fill the space within the cylinder, but divide it up into minute cells. Air is exhausted from these cells, and the cylinder is partly filled with acetone, which is a liquid hydro-carbon belonging to the alcohol family. Acetone will dissolve 25 times its own volume of acetylene for each atmosphere (14.7 psi) of pressure applied. The free acetylene which enters the cylinder is therefore dissolved in the acetone and split up in the cellular interior of the cylinder into small globules. This construction produces a cylinder which is absolutely safe, and may be shipped upon the railroads of

[1]*See "Acetone."*
[2]*See "Manifold."*

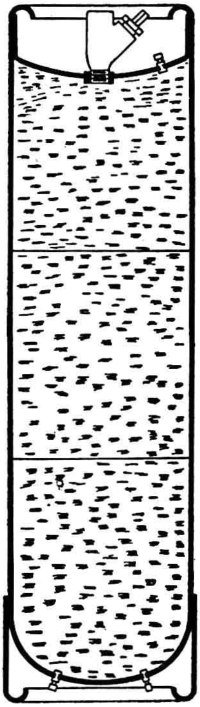

Fig. 1. Sectional view of a type of acetylene cylinder where the filler is made of pressed cylindrical disks of asbestos. The cylinder is a deep drawn vessel with an open end at the top. The disks are compressed to exactly fit the space, forced into place, and the head at the top of the cylinder pressed into position. It is then brazed and the top edge of the cylinder is rolled over as indicated. A base of a cylindrical piece of steel is rolled at the lower edge and shrunk upon the bottom of the cylinder. Note the fuse plugs at the bottom and the top of the cylinder. As the valve is in the recessed top of the cylinder, it is protected from injury, and no cap is necessary.

the country under the rules of the Interstate Commerce Commission. See ACETONE.

Cylinders Have Fuse Plugs

Acetylene cylinders are equipped with fuse plugs. These are small steel machine bolts, screwed through the steel shell of the cylinder, having holes which are filled with an alloy having a low melting point. Usually this metal will melt at a temperature of about 250 F., and if melted, will release the gas through these holes. There are two such fuse plugs in the top of certain types of cylinders, and three in the bottom. In other types of cylinders, the number of plugs and their location varies. The object of the fuse plugs is to release the gas in the event the cylinder is surrounded by fire in a burning building. With the release of the gas the fire is of course increased in violence, but the hazard caused by excessive pressure is eliminated.

From the weldor's point of view it is essential to remember that these plugs lie in the top of the cylinder. Many weldors do not know what they are, and in some instances inadvertently point the torch flame at the cylinder. It only takes a moment of such heat too close to the cylinder to melt the fuse plugs with a resultant escape of gas, which is hazardous.

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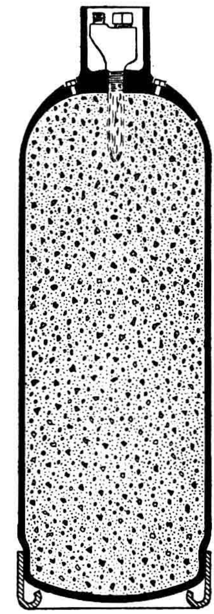

Fig. 2. (Left) This type of acetylene cylinder is made with a heavy neck at the top welded to the shell. The bottom is also pressed into position, and welded, and the base ring is shrunk onto the shell. The filling material is quite different, consisting of a layer of long fibre asbestos at the top of the cylinder, fine asbestos at the bottom of the cylinder, and the intermediate space filled with a mixture of Balsa wood and infusorial earth, which is essentially silica. This produces a very porous filler. The valve at the top of the cylinder is protected by a cap as indicated. Fuse plugs are placed at the bottom and top of the cylinder. All fuse plugs in acetylene cylinders are bolts having holes drilled through them which are filled with a low fusing point metal. In the event of fire adjacent the cylinder, heat of approximately 250 degrees will cause the fusable metal to melt and release the gas.

Fig. 3. (Right) This sketch shows a third type of cylinder which is a seamless drawn vessel formed and swaged until there is but one opening at the top where the valve screws into position. Through this opening the filler is forced while in a plastic condition, and the moisture is eliminated by baking the cylinder in an oven for a considerable period of time. The filler consists of a mixture of charcoal, infusorial earth, finely shredded asbestos, and Portland cement. During filling, the cylinder is jolted with a jolting mechanism to completely fill the interior with the mixture. The opening immediatey under the valve is a hole drilled in the filler and subsequently packed with asbe tos to permit the acetylene free access to the valve opening.

Cylinders Should Stand Upright

In welding out of doors, it is sometimes the custom of weldors to lay acetylene cylinders flat on the ground and attach the regulator to them in this position. When the cylinder lies flat in this manner it is much easier to withdraw acetone from it, which passing into the hose and torch burns with the flame at the tip. The withdrawal of acetone in this manner is expensive, injures the weld, and should be avoided. When the cylinder is returned to

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water. See ACETYLENE G f acetylene cylinders

Acetylene Generators mpression and ab-

In the United States common practice has established a design of acetylene generator which discharges the carbide from a hopper located in the upper part of the machine down into the tank containing the water. These are known as carbide to water type machines, and are universally used. There is another type of generator using carbide, molded into cakes, but the type of generator, common in Europe, where the water drops into the carbide, is almost wholly unknown in the United States except in the case of miner's lamps. This latter type is commonly referred to as the water to carbide type. Acetylene generators are constructed in accordance with many different details of design, and the feeding mechanism varies with different manufacturers, some manufacturers making several types of feeding mechanisms.

Revolving Feed Plates

One type of feeding mechanism is a weight-driven motor connected by a shaft to a revolving feeding disk directly underneath the hopper, which, when it slowly revolves, discharges the carbide into the water. The motor is controlled by a diaphragm operated by the pressure which develops within the machine. When the motor stops, caused by increased pressure, the feeding stops and the generation of acetylene. As the pressure is lowered by the delivery of acetylene through the pipe line to the torch, the motor is released and more carbide is fed into the water. This action is automatic and is dependent entirely upon the consumption of acetylene at the torch. Another type of machine controls the action of the motor by the movement up and down of a gasometer into which the acetylene is fed from the generator. Another type is operated by spring-propelled motors and still another type by a large rubber diaphragm located at the top of the hopper and moving a vertical sliding shaft up to close the opening and down to open it. As the pressure increases, this mechanism is raised, thus closing the valve. As acetylene is consumed the diaphragm lowers and open the feed outlet. The diaphragm is counterbalanced with an adjustable spring. There are many other types of generators, many of them automatic, and operating upon the general principles heretofore mentioned.

Two General Classes of Generators

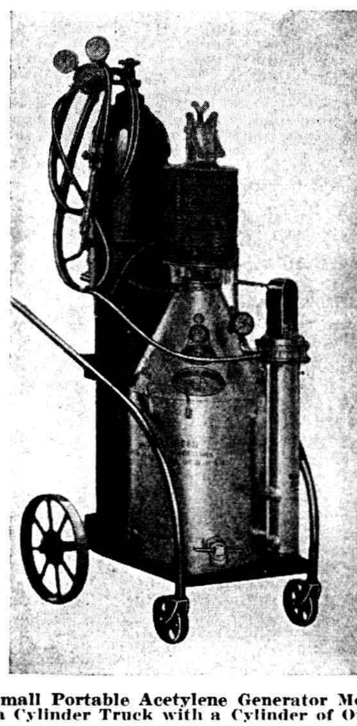
Generators are divided into two general classes, one of these being known as low pressure generators, and the other as medium pressure generators. A low pressure generator produces acetylene under a pressure of less than 1 psi and in the medium pressure generator at pressures varying from about 5 to 12 psi. The production of acetylene at more than 15 psi pressure is prohibited by the Underwriters' Laboratory.

Portable Generators

Portable acetylene generators in small sizes which can be carried by hand, and in larger sizes mounted on trucks and wheeled from place to place are in extensive use both in manufacturing plants and the smaller shops.

These generators operate generally in the same manner as the stationary machines, but the carbide feeding mechanism differs principally in a closure located between the carbide hopper and the water tank below. These devices vary in detail, but are the same in principle. By the movement of a lever or similar hand control the devices are closed when the generator is moved. This prevents discharge of carbide into the water, or splashing of the water up into the carbide hopper during movement of the generator from place to place.

There are portable generators of the pressure type operating at pressures from 5 or 6 psi up to 10 or 12 psi, and there are low pressure generators operating at less than 1 psi. Many of the latter type use a compressed cake of carbide.



A Small Portable Acetylene Generator Mounted on a Cylinder Truck with a Cylinder of Oxygen.

Some of these portable generators are equipped with glass hoppers to enable the operator to see how much carbide is in the hopper at any time.

The smaller pressure machines are in many cases operated by a diaphragm at the top of the hopper which actuates a rod constituting the feed mechanism. This type of generator uses finely pulverized carbide. The larger machines use this type of feeding mechanism and many other types.

Most of these machines comply with the rules of the Underwriters' Laboratories, Inc., Chicago, in so far as their construction and performance are concerned and should be used in accordance with the regulations of the National Board of Fire Underwriters (see also GAS SYSTEMS, RULES FOR OPERATION OF).

Insurance Regulations

The Underwriters' Laboratories are an organization maintained by the Insurance Companies of the United States acting jointly, for the inspection and testing of all types of equipment which may be involved as a fire or accident hazard. When such equipment is passed or permitted by the Laboratories, it must accord with certain definite standards of design and manufacture required by them for equipment of this type. As welding and cutting equipment including acetylene generators come under the head of such apparatus, the Underwriters' Laboratories have established a definite set of rules governing both design and construction, and these will be found under GAS SYSTEMS, RULES FOR OPERATION OF. There are two sets of rules pertaining to acetylene generators, one of these applying to the design of the machine, and its general construction. The other applies to the method of installing it in the factory or building where it is to be used, and the manner in which the acetylene pipe lines are erected throughout the factory. There is one other insurance authority publishing rules for acetylene generators, and this is the Associated Factory Mutual Fire Insurance Companies, Boston, Mass. These rules will also be found in the section entitled GAS SYSTEMS, RULES FOR OPERATION OF.

Gallon per Pound per Hour

One of the principal requirements in connection with the design of acetylene generators is that there must be within the generator one gallon of water for each pound of carbide contained within the carbide hopper. On this basis a fifty pound machine would contain fifty pounds of carbide and fifty gallons of water, a hundred pound machine, one hundred pounds of carbide, and one hundred gallons of water, etc. Another principal regulation is that the machine shall not be discharged of its full volume of acetylene, when operating at capacity, during any period of less than 5 hours. In other words, an acetylene generator must not discharge acetylene at a rate faster than one cubic foot, per pound of carbide, per hour. This rule is based on the assumption that one pound of carbide will produce five cubic feet of acetylene, and is so arranged that charging of the machine, when working at a maximum capacity, will take place in the morning, before welding is started, and at noon while the welding department is shut down for the lunch hour. It is true that there are some generators having a double, or greater, rating which are permitted to operate faster than this speed, but these are machines which through additional water capacity or otherwise, have demonstrated that they will not overheat excessively at the faster rate of generation.

Much Heat Is Produced

In order to fully understand these requirements, it is necessary to know that a good deal of heat is given off during the decomposition of carbide in water, to produce acetylene. One pound of carbide will increase the temperature of one gallon of water about 90 F during generation. The amount of water, and the rate of feeding carbide into it, is therefore restricted so that the temperature of the generating chamber will not become too hot during the period of operation.

Larger Generators Require Separate Houses

In the larger acetylene generator installations the machines are usually placed in a separate house and taken care of by a man employed especially for that purpose. There may be in the house only a hundred pound generator, or there may be twelve 300 pound machines, or perhaps a five hundred pound duplex machine, containing a total charge of a thousand pounds of carbide in two hoppers. The size of the machine and the number is dependent upon the requirements of acetylene in the plant.

Delivered in Pipe Lines

The acetylene is piped in suitable pipe lines to various points about the plant where it is required. Often an oxygen pipe line parallels the acetylene line, obtaining its oxygen from a number of oxygen cylinders located in a separate room near to or a part of the acetylene generator house, but not in the same room. These cylinders are manifolded together with an oxygen manifold equipped with regulators discharging into the pipe line. As a rule these large installations are made under the supervision of an experienced engineer furnished by the company manufacturing the equipment, and in such instances, are erected to comply with the requirements of the Underwriters' Laboratories, or the Factory Mutual. See GAS SYSTEMS PIPELINES AND MANIFOLD.

Generators Safe When Properly Handled

In small installations, portable acetylene generators may be used, but it should be remembered that such generators should not be operated in confined areas where the discharge of acetylene into the room for any reason might cause an explosive mixture of the gas with the air.

Acetylene generators are perfectly safe equipment when properly used, and the requirements for the handling of such equipment are thoroughly understood. Inexperienced men, or men lacking knowledge of such machines should, however, consult with the manufacturers, and obtain from them charts and directions for their operation, before attempting to put them in use.

Generator Houses

Acetylene generator houses are usually constructed either as a lean-to attachment to some other building, or as separate structures. It is important that they be constructed in accordance with the requirements of the insurance authorities, and general safety principles. If houses are of lean-to construction, there must be no opening from the generator house into the building, and the doors and windows must be constructed in the outside walls. A separate house is always preferable, and this should be of fire-proof construction. It is customary to build such houses, in manufacturing plants, of fire-proof materials such as brick or tile; a steel frame, with corrugated iron over the outside, and insulated board on the inside, corrugated roof, etc. It is good practice to make the roof light, so that should an explosion occur, within the house, it would be released upward. The floor should be of concrete, and the generators should stand upon a slightly raised platform, with corrugations in it to ventilate and drain beneath the generators. It is usual to have a trough molded in the concrete floor directly beneath the sludge outlets of the generators, leading to the sludge pits outside.

House Divided into Three Rooms

A common construction divides the generator house into three rooms, separated by brick partitions. In one of these the generators are located; in the middle room carbide is stored, and in the third room the oxygen cylinders and manifold are located. Often the oxygen manifold room and the carbide storage room are located at platform level. That is the level of a boxcar as it would stand on a railroad siding, alongside of the loading and unloading platform. With this construction, oxygen cylinders and carbide drums can be rolled directly out of cars onto the platform, and thence into their respective rooms without lifting.

Floor of Generator Room Below Grade

The floor of the generator room on the other hand, is sunk a foot or two below the general grade, so that a platform built five or six feet above the floor level will be on the same grade as the loading platform, and carbide storage room floor. This level would be about at the top of the generators, and enables the rolling of a drum of carbide from the carbide storage room onto the platform. where it may be dumped into the carbide hopper at the top of the generator without undue lifting. This is a very convenient design of gas house, and there are many of them in railroad shops and large manufacturing plants throughout the country.

Sludge Pits

The disposal of sludge from a series of large generators becomes a matter of much importance. If the sludge is run directly in the sewer, it will plug it up in a short time, and cause much trouble. It is, therefore, common practice to construct two or three sludge pits, made of concrete, outside of the generator house.

These pits have cast iron stand pipes about four inches in diameter which are threaded to elbows at the bottom of the pit, and lead to the sewer. The sludge pits are well ventilated at the top, and may be surrounded by a rail fence, or covered with a grating. Under no circumstances should they be covered tight. The stand pipes are adjustable, as to height, with a chain. The elbow at the base turns on the thread, and the outlet stand pipe may be raised or lowered to any level desired. When a generator is being discharged, the stand pipe is pulled up to its highest position, almost vertical. The sludge flows through an open trough from the sludge outlet of the generator into the sludge pit. It consists of slaked lime and water, and is a thick, milky white substance.

Sludge Allowed to Settle in Pit

It is allowed to settle in this pit until the water is clear, and all lime has precipitated to the bottom of the pit. The water is then drained off into the sewer, by lowering the stand pipe, until all clear water has been drained away. If it should be necessary to discharge a second generator while the first pit is settling, it is discharged into a second pit by the adjustment of sludge gates in the troughs in the floor of the house. Under no circumstances should the generators be directly connected by piping to the sludge pits. If this is done, the operator could not notice a slightly leaking sludge outlet valve, and the water might be drained away from the generator without his knowledge, creating a hazardous condition.

Ventilation Important

From time to time the sludge in the pits is shoveled out, and sold either for use as fertilizer, or for the making of mortar and plaster. Generator houses should be kept free and clean of all rubbish, and the floor should be washed down with a hose after each charging of the machines. Proper ventilation is absolutely important, and this should be secured through vents in the roof, so that acetylene, which is lighter than air, will rise and be unable to collect under any part of the structure. Ventilation is probably the most important factor in the safety of such installations. All electric wiring should be in conduit, and gastight globes should be installed instead of the ordinary electric light. All switches should be placed upon the outside of the building.

Under no circumstances should a carbide sludge pit be put beneath the house, or built in any other manner so that after-generation of the sludge could enter the building. There is always a certain amount of after-generation of acetylene which might produce just enough gas to cause an explosion. Sludge pits should also be located where sparks from a locomotive cannot cause ignition of the gas.

Acetylene Welding

See OXY-ACETYLENE WELDING.

Acid Brittleness

The brittleness induced in steel, especially wire or sheet, when pickled in dilute acid for the purpose of removing scale. This brittleness is commonly attributed to the absorption of hydrogen.

Acid Steel

See STEEL, ACID.

Actual Throat

See THROAT OF A FILLET WELD and WELDING TERMS.

Adapter

A device for connecting a regulator to a tank which has a valve threaded differently from the inlet connection of the regulator.

A device provided with a socket at one end in which a carbon or graphite electrode can be secured, and at the other end a wire shaped terminal which can be inserted in a metallic electrode holder so it can be used for low current graphite electrode welding or cutting.

Added Metal

A term sometimes used to describe the metal added to the base metal during welding. It is used when discussing arc, gas or thermit welding.

Adding Material

An early day term applied to the rod used in welding when the metals to be joined exceeded a certain thickness. This term was equally applicable to welding rods, electrodes and welding wire.

Adhesion

A condition in a weld resulting from imperfect fusion of the edges to be joined. This condition is sometimes caused by melting down the top of the V on to metal not yet melted and it is also caused by the presence of oxide in the welded seam. Adhesion is caused by the adding of molten metal on to metal already solidified, or to the lack of fluidity in the molten bath constituting the weld with the result that fusion is not attained. See FUSION and PENETRATION.