Sulphide Corporation Limited
COCKLE CREEK WORKS

1926

Description of Plants and Processes
E. ENGLAND

SULPHIDE CORPORATION LIMITED

Head Office:
Finsbury House, Blomfield Street
LONDON, E.C.

Managing Agents in Australia:
Messrs. Gibbs, Bright & Co.
34 Queen Street
MELBOURNE

INDUSTRIES:

Seaton Carew, Durham, Eng.—
Zinc Works and Acid Plants

Broken Hill, N.S.W.—
Central Mine

Cockle Creek, N.S.W.—
Cement, Acid, and Fertilizer Plants

Attunga, N.S.W.—
Limestone Quarries
Entrance to Works, showing Residences and General Office.
INTRODUCTORY.

THE Sulphide Corporation’s Works, at Cockle Creek, were established in 1896, for the treatment of zinc ores by the Electrolytic process, and later developed into a large lead smelting plant for the treatment of gold, silver and lead ores.

The main source of ore supplies was the Corporation’s own mine at Broken Hill, but in addition very large tonnages were purchased from all parts of Australia and New Zealand.

Previous to 1917, all bullion was exported to Europe for treatment, but in that year an up-to-date silver-lead refinery was installed and continued in operation until 1922.

From a metallurgical point of view, the results obtained from the lead smelting and refinery plants compared very favourably with any similar plants throughout the world.

After the war there was a great falling off in purchased ore supplies, and for that reason, in 1922, the Corporation decided to close down the smelting and refinery plants at Cockle Creek, and arrangements were made for the Central Mine output to be treated at Port Pirie.

Up to the present the smelting and refinery plants have been left intact in readiness for the resumption of operations should the need arise.

In connection with the smelting operations, a Mond Gas Plant was installed for the supply of gas to the roasting plant, and for the heating of the boilers; and from this such by-products as sulphate of ammonia and tar were recovered. On the cessation of smelting it was found economical to also close down the Mond Gas Plant.

The following figures for one year will give some idea of the extent of operations:—

<table>
<thead>
<tr>
<th>Product</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ore treated produced</td>
<td>2,750,783 ozs. Silver.</td>
</tr>
<tr>
<td></td>
<td>34,083 tons Lead.</td>
</tr>
<tr>
<td></td>
<td>36,758 ozs. Gold.</td>
</tr>
<tr>
<td>Superphosphate</td>
<td>30,000 tons</td>
</tr>
<tr>
<td>Sulphuric Acid</td>
<td>21,750 tons</td>
</tr>
<tr>
<td>Sulphate of Ammonia</td>
<td>800 tons</td>
</tr>
</tbody>
</table>

In 1913 plants were installed for the manufacture of sulphuric acid and fertilizers, and while this industry was started as a means of disposing of the by-products, it has developed into a very important part of the Corporation’s business.

Large tonnages of Superphosphate and other high grade fertilizers are produced, and are in great demand in the farming districts.

There is also a big demand for sulphuric acid, and large tonnages of this material are produced and railed to outside consumers.

A small plant was recently installed for the manufacture of hydrochloric acid, and this material is now being produced and sold to neighbouring industries.

During the regime of smelting, pyritic ores were roasted in Herreshoff furnaces for the recovery of gas for acid making; and on the closing down of smelting a new source of sulphur supplies had to be found. For a time the Works depended solely on brimstone, imported from America and elsewhere, but later on an arrangement was entered into with the Electrolytic Zinc Co. of Australasia, and a battery of furnaces was installed at Cockle Creek for the roasting of that Company’s concentrates. By this means the Corporation has an assured supply of Australian sulphur and is independent of the imported article; which is very important from a national point of view.
Superphosphate Plant

Workshops and Power Station.

Smelters and Acid Plants.

Cement Plant.

General View of the Cockle Creek Works.
General Office and Chemical Laboratory.
Canteen, Change House, and Ambulance Room.
The Corporation has a very complete generating station on the Works, from which electrical current is distributed for the driving motors on various parts of the plant. In addition, a large block of power is obtained from the Railway Commissioners' power house, at Zara Street, Newcastle. The current is brought out from Newcastle at 33,000 volts and transformed down to 415 volts, and this is used for supplying the cement plant.

The installation of a modern Portland Cement Plant at Cockle Creek marks the latest of the Corporation's activities. After careful consideration of the methods of manufacture now practised, the Corporation decided to adopt what is known as the "wet" process.

A large plant, replete with all modern appliances, was installed by Edgar Allen & Co., of Sheffield, England, at an expenditure of nearly a quarter of a million pounds, and in 1925 a start was made with the manufacture of Portland Cement by this wet, slurry process.

The present plant comprises one unit, with a capacity of 30,000 tons per annum. The plant, however, has been designed for three units, and already a start has been made with the erection of the second unit. This is practically a duplicate of the first unit, but further modernised by the introduction of a new Atomiser system for feeding slurry to the kiln. It is expected that this second unit will be completed by the end of 1926.

The limestone (which is the principal raw material) comes from the Corporation's extensive quarries at Attunga, and is of exceptional purity. The clay and shale are drawn from the Corporation's land at Cockle Creek, and the necessary coal is within easy reach of the Works.

As Cockle Creek the men are catered for as regards food by an up-to-date canteen on the Works. This is controlled by the men themselves, and meals are supplied at cost. There are also up-to-date change houses, with hot and cold showers, and an ambulance room.

At the present time the men engaged at Cockle Creek and Attunga total 500; besides which a large number of men are employed indirectly in other avenues, such as loading and unloading of zinc concentrates, phosphate rock, sulphur, and cement at wharves; and in the supply of stores, coal, etc.

**BLENDE ROASTING PLANT.**

Broken Hill concentrates represent a valuable source of sulphur for the vitriol maker, and to this end a battery of six furnaces has been installed at Cockle Creek.

The furnaces are of the Electrolytic Zinc Barrier Roasting type, of a design that originated in Belgium, but which has been considerably modified by the metallurgists of Australia. Each furnace consists of six hearths and a cover arch. Alternate hearths revolve, and rabbling is effected by teeth set in sockets forming part of the hearth above.

The zinc concentrates (the moisture content of which is about 3 per cent.) are fed by a screw on to the top hearth and worked down through the furnace, and finally discharged into a conveyor for disposal on the calcines stock pile. No outside fuel is used, but the ore once started can be kept burning by a careful regulation of the draught, which is supplied by steel fans.

The furnace gases, carrying about 5.5 per cent. SO₂, are delivered to the chamber plants through steel or cast iron flues.
Furnaces for roasting Zinc Concentrates for the recovery of gas for Sulphuric Acid.
SULPHURIC ACID.

CHAMBER PROCESS.

There are three chamber sets, the essential details of which are given below.

No. 1 PLANT.—This consists of five chambers (the first two of which are in parallel) and five towers for nitre supply and recovery. The total capacity is 180,000 cubic feet. The chambers are low in comparison with the other sets, being only 20ft. in height. The curtains are of 7lb. lead and the saucers of 8lb. lead. Situated between the glover tower and the leading chambers is the fan, built of regulus metal. Salt water is used in the acid coolers, and the acid for the gay lussac towers has to be as cool as possible. Pumping for the circulatory system is by Kestner pulsometer. A brick brimstone burner is available for use when required.

No. 2 PLANT.—Four chambers constitute this set, the first two being in parallel. These chambers are all 30ft. high, and the total capacity is 184,000 cubic feet. Two glover towers supply the necessary nitre and two gay lussac towers effect the subsequent recovery of nitre. In addition there are two inter-chamber towers. A brick brimstone burner is available for use when required.

No. 3 PLANT.—This set comprises four chambers, all in series, with two nitrating towers and three gay lussac towers. Chambers 1 and 4 are 35ft. high, Nos. 2 and 3 are 30ft. high. The plant has a total capacity of 176,000 cubic feet.

The reactions that take place in a chamber set are briefly as follows:—

The incoming SO₂ in its passage through the nitrating or glover towers is mixed with oxide of nitrogen N₂O₃, and this acts as a carrier of oxygen to the SO₃, and by contact with atomised water or steam, sulphuric acid is produced, and the oxide of nitrogen is liberated to do further work. The gay lussac towers, situated as they are, at the extreme end of the plant, recover the oxide of nitrogen from the spent furnace gases, and the nitrous vitriol from these towers is de-nitrated in the glover tower.

For concentration purposes, two sets of lead pans, coal fired, are installed and are capable of raising 68 per cent. acid up to 75 per cent., a grade required by some industries.

A vitreosil cascade is also used. This will concentrate acid up to 95 per cent. H₂SO₄, but at present is used for the production of 75 per cent., as any of the higher strengths are conveniently made from 98 per cent. acid from the contact plant.

CONTACT PROCESS.

The great advantage of this process is the purity and strength of the acid produced; the most serious impurity being iron. The high strength of the acid makes it particularly suitable and economical for transport by rail or sea.

The process may be divided into four stages:—

1. Burning the brimstone.
2. Cleaning and washing the gas.
3. Converting or oxidising the SO₂ to SO₃.
4. Absorption of the SO₃.

The burning is done in a brick burner having three hearths, the lowest being just below ground level and measuring 15ft. x 4ft. The brimstone is fed by a screw into this bottom hearth; cold air is admitted and the resultant temperature is high enough to produce considerable sublimed sulphur. This, however, is overcome by the admission of more air to the second hearth, where complete combustion takes place. A 7.5 per cent. SO₂ gas tenor is maintained
Three Chamber Acid Plants and Contact Acid Plant, with Hydrochloric Acid Plant and Contact Acid Storage in the foreground.
as closely as possible. The third hearth has 15 pre-heaters or heat exchanger pipes built into it, and here the heat of combustion of the sulphur is used to raise the purified gas to the required temperature for conversion. The gas leaves the burner at about 250 degrees C and enters the cooling and cleaning system. A tower and lead pipe grill (over both of which a flow of water is maintained) keeps the temperature down to about 40 degrees C, and the gas then passes through two coke filters in parallel. These filters catch the dust and sublimed sulphur, and condense a certain amount of moisture. The next stage is a wash with 60 per cent. and 77 per cent. Sulphuric acid. This is done in two small towers. A layer of acid of the required strength is maintained upon a punched lead screen, and the gas passes upward through the screen; and in this way an intimate association between gas and acid is obtained. This wash dries the gas, and also absorbs small quantities of chlorine. The final purification of the gas is made by two asbestos filters in series. Each filter consists of four trays of carded asbestos, each tray having a depth of 4in. of filtering material. All moisture, dust, sublimed sulphur, etc., is completely removed here, and a pure, dry gas goes to the blower and convertor. The blower is of the Connersville type, with a capacity of 500 cubic feet per minute. This forces the gas down through the convertor. The convertor consists of six trays of platinised magnesium sulphate; the total platinum in the convertor being in the vicinity of 100 ozs. The purified $SO_2$ gas has to be of a temperature of 300 to 380 degrees C before entering the convertor. The catalyst gets to work right away, as is shown by a rise of 80 degrees to 100 degrees in temperature after passing through the first section. From there on a gradual cooling takes place, the gas finally leaving at about 360 degrees. The $SO_2$ is air cooled on its way to the absorber, and the latter is reached with the gas at a temperature of about 110 degrees C.

The absorber is a cast iron tower packed from top to bottom with quartz, 8in. pieces at the bottom and 2in. at the top. A cast iron pump raises 98 per cent. acid to a distributor on the top of the tower, and in the descent of this acid the $SO_3$ is absorbed and the acid reaches the bottom surcharged with $SO_3$. On its way to the coolers a quantity of weak sulphuric acid (used only as a convenient carrier of water) is added to maintain the circulatory system at the correct strength of 98 per cent. The surplus acid not required for the circulatory system is run into a steel tank, from which it is pumped to where required. The acid scrubbers are replenished as required, by the addition of 98 per cent. acid. A small mixing system is provided for the weak acid required for the acid circulatory system. Alternatively, chamber acid can be used for this purpose provided it is reasonably clean and pure.

The present contact plant has a capacity of 35 to 40 tons per week, and this is now being extended by the addition of a second unit. This unit is an exact duplicate of the first, and will be ready to go into commission very shortly.

**HYDROCHLORIC ACID.**

This plant is a small unit with a capacity of two tons per day. Two stills are provided, followed by four cooling bottles and 15 cellarius tourrills, with a tower at the extreme end. The water flows counter current to the gas. Thirty per cent. acid is produced and this is stored in bitumenised wooden vats, and dispatched to consumers in crated jars and carboys. Each still takes a 10-cwt. charge of salt and the necessary acid for production of the acid sulphate of soda. If the acid be reduced below this point, the tendency is for the spent charge to solidify, and it then has to be dug out, whereas normally it is a thick liquid. Roughly two tons of 30 per cent. acid are produced for each ton of salt decomposed. At present no use is made of the bisulphate cake.
Loading Superphosphate, No. 2 Shed.
Loading Superphosphate from Storage Shed.
Bagging Superphosphate.
SUPERPHOSPHATE.

The basis of the process is the conversion of the insoluble phosphoric acid contents of phosphate rock into a soluble form, so that it is easily disseminated through the soil and thereby made readily available to plant life.

The raw phosphate rock contains phosphoric acid as tribasic phosphate of lime, insoluble in water, and consequently not assimilable by plants. Therefore, it is necessary to convert this insoluble phosphoric acid into the "water soluble" or "citrate soluble" form, in which it is available for plant food. This is done by treating the raw phosphate rock with sulphuric acid, which converts two parts of the lime into gypsum, leaving one part of the lime combined with all the phosphoric acid as the monobasic or water-soluble phosphate of lime. This product is known as "Superphosphate"—the prefix "Super" denoting that the ratio of phosphoric acid to lime is in excess of the normal tribasic phosphate.

The phosphate rock is imported from Ocean and Nauru Islands, in the Pacific Ocean. These deposits contain high percentages of phosphoric acid, ranging from 82 per cent. to 87 per cent. tribasic phosphate of lime.

Cargoes of phosphate rock are unloaded into trucks on the Corporation's wharf, at Newcastle, and thence despatched by rail to the Works at Cockle Creek. These trucks are discharged into large storage bins with a capacity of 1,000 tons.

The first step in manufacture is the crushing of the rock. Two systems of sizing are in use, namely, tapping screens and air separation. The desired fineness is a dust that will go through a 50 mesh screen.

The fine rock dust is weighed in an automatic scale and then mixed with 68 per cent. sulphuric acid, which is pumped from the acid plants to the mixing floor. After thorough but rapid mixing, the material is dropped into a den from the mixer. When the den is full and the mixture set, the front and bottom doors are removed, and the superphosphate is cut out by a rotary excavator. The moist, hot superphosphate is transported by conveyor belt to the storage sheds, there to compete the ripening and drying process. There are two large storage sheds with a combined storage capacity of 35,000 tons. One of these is 400ft. by 119 ft., and the other 400ft. by 126ft.

It is in these storage sheds that the final chemical reactions take place, and from these the fully-matured superphosphate is bagged ready for market. At the approach of the wheat sowing season the ripened pile of superphosphate is broken up and screened in bagging mills, of which there are three in each shed. At this stage is added any filler necessary, two grades of superphosphate being despatched, viz., 22 per cent. and 18 per cent. \( P_2O_5 \). From the bagging mills the superphosphate is loaded for transport into Government trucks placed alongside the platforms attached to each shed.

In addition to the more popular superphosphate, mixed manures are manufactured containing varying proportions of superphosphate, potash, ammonia sulphate, soda nitrate, and blood and bone. These mixtures are used mainly by the men engaged in intensive farming.

General View of Works, erection nearing completion.
CEMENT.

Briefly, Portland Cement is a chemical mixture of limestone and clay, and at Cockle Creek the method of manufacture is that known as the "wet" process. This process allows for greater refinement in the preparation of raw materials, as compared with the dry process: the raw materials can be ground much finer, and the mixing done more thoroughly. Also, the burning can be carried out to greater intensity, and the chemical composition becomes more complete. By this method a very high grade cement is obtained.

At the entrance to the cement plant is situated the clay wash mill. The clay and shale are carried to this mill from the bins by belt and steel band conveyors, the shale first passing through crushing rolls. Water is added in the mill. The wash mill is a tank, octagonal in shape, constructed of brick and concrete, with an inner wall of steel gratings. Harrows suspended from radial arms thoroughly churn up the clay and water, and the fine clay slurry is forced through the gratings. It then flows to a three-throw pump, which discharges the material into two steel silos at the back of the raw mill, where it is stored until required.

After the wash mill are the raw and finishing mills, slurry pumps, four slurry silos and air compressors. The clay slurry flows by gravitation to a special rotary feeder, thence to the feed end of the raw mill, where it meets the limestone coming from a steel hopper over a rotary feed table. Both materials, with water added, enter the mill together.

The raw mill is a 32ft. 6in. x 6ft. three-chambered combination mill, driven by a 350 h.p. synchronous motor. This mill reduces the limestone from 24in. mesh to a residue of about 12 per cent. on a 180 mesh sieve. For further refining the slurry is then pumped by one of the three pumps into a tube mill driven by a 200 h.p. motor. From this mill the slurry is discharged into four concrete silos (each 40ft. high x 18ft. dia.) in which the final adjustments of material are made. To ensure efficient mixing the slurry in the silos is constantly agitated by means of compressed air. When required the slurry is pumped to the feed box at the rotary kiln.

The limestone from the concrete track hopper is automatically fed by a finger feeder into a large jaw crusher (42in. x 30in.) capable of handling 100 tons per hour. The crushed stone is elevated to a rotary screen, passed on to a belt conveyor and discharged into three concrete storage silos. From underneath these it is carried by a belt conveyor and bucket elevator to the hopper at the raw mill. Over-size stone from the rotary screen is returned to a roller crusher and elevated again to the silos.

The feed to the kiln is regulated by means of a rotary spoon feeder which delivers the slurry into a feed spout entering the kiln. In its passage down the kiln the slurry is lifted by steel spoons and dropped through the hot gases and dried. Passing into the burning zone it is "clinkered" at a temperature of about 1450 degrees C., the fuel being powdered coal. The kiln is of the parallel type, 160ft. long x 8ft. diameter, and driven through a reduction gear by a 40 h.p. variable speed motor. The speed of the kiln can be varied from one revolution in 60 seconds to one in 120 seconds. The lining consists of highly refractory bricks. The kiln hood is removable, being mounted on wheels and a short track. It is fitted with a special deflecting nozzle for adjusting the direction of the flame.

The fuel is drawn from a feed hopper by a twin screw feeder, and discharged into the delivery pipe of a high pressure fan, which blows the fuel and necessary air for combustion to the firing nozzle.

All controls for the regulation of the kiln speed, slurry and coal feeds, and fan shed are on the firing platform close to the kiln.
View looking down on Kiln from above firing platform, showing Cooler underneath.
General view of Kiln from Firing Platform, showing Speed and Feed Controls to left and Pulverised Coal Fan to right, with Twin Spiral Fuel Feeder above.
Combination Tube Mill for grinding Cement Slurry.
On its discharge from the kiln, the clinker enters a rotary cooler. This cooler is 60ft. x 6ft., and is driven by a 15 h.p. motor. Inside are steel channel irons which lift the clinker as the cooler revolves and drop it through the incoming air. The discharge end is fitted with a bar screen which rejects oversize clinker, coating, etc., from the kiln.

The cooler discharges into a steel "torpedo" conveyor of tray type, which in turn discharges into an automatic weighing machine. This machine empties the clinker into a vertical bucket elevator which lifts the material on to another torpedo conveyor running across four concrete silos. This conveyor is fitted with slides for the discharge of the clinker into each of the silos.

The kiln is fired with powdered coal which is dried and pulverised at the Works. The raw coal is discharged from the hopper wagons into a track hopper; thence carried by a steel apron conveyor to a set of crushing rolls which reduce the coal to 1in mesh. It is then elevated and distributed into two concrete storage silos, by screw conveyors. From these silos it is taken by screws and elevator to the feed hopper of the dryer. This dryer is similar in construction to the cooler, and is encased in brickwork. The drying is done by means of the hot gases from a coal fired furnace alongside the dryer. From the dryer the coal is delivered by elevator and screw conveyor to the feed hopper of the grinding mill. Regulation of the feed to the mill is secured by a rotary feed table. The mill is of the combination type, three-chambered, 28ft. x 5ft., and driven by a 150 h.p. motor. The powdered coal falls into a screw conveyor and is delivered by elevator and another screw to the hopper on the kiln floor. Provision is made for powdered coal storage by the erection of a large concrete silo.

The gypsum is discharged from the trucks into a small jaw crusher. It is reduced to a 1in. mesh and elevated by bucket elevator and discharged into a 150-ton storage bin; whence it is drawn for use.

The clinker is discharged from the storage silos on to belt conveyors, which in turn discharge it into the boot of an elevator, and thence lift it to a large feed hopper at the feeding end of the cement mill. The cement mill is 32ft. 6in. long x 6ft. diameter, and is of the combination type similar to the mill used for the wet grinding. It is driven by a 350 h.p. motor. This mill grinds the clinker to the fineness required. The clinker is fed from feed hopper on to a rotary feeding table, and the requisite amount of gypsum required for the "set" of the cement is there added and ground in conjunction with the clinker.

From the grinding mill the cement is conveyed, elevated and distributed mechanically into ten concrete silos. These silos are each fitted with four special testing tubes, arranged so that the cement can be tested at almost any point in the depth of the material. The cement is drawn off as required into a screw conveyor and delivered into a hopper placed over a Bates bagging machine, which automatically fills two bags at once. From the bagger the bags are conveyed either to railway trucks or to the large cement store.

The Corporation has an extensive private railway system connecting with the main Sydney-Newcastle and Northern lines, near Cockle Creek station. This provides splendid railway facilities for connecting with the chief markets for cement, and, as Newcastle is only 10 miles by rail, cement can be despatched by steamer from Newcastle without difficulty.

The testing laboratory is situated close to the raw materials department, at the entrance to the cement plant. It is equipped with all modern apparatus for the testing of cements. The machinery includes a 60-ton Amsler hydraulic press for the compression tests, and this machine is also fitted for transverse tests on concrete beams etc.

The tensile strength machine is an "Adie," single lever, with a beam about 5ft. long, having graduations showing the breaking strain in lbs. per square inch.
Loading Cement from Bates' Bagging Machine.
Loading Cement for despatching.
The briquettes and cubes for testing purposes are moulded by means of a Boehme Hammer machine. This machine delivers a standard number of blows to the cement in the moulds, thus securing uniformity in moulding and ramming.

The testing plant also comprises a "Vicat" apparatus and "Gilmore" needles for setting time, "La Chatelier" expansion moulds, and a "Bauschinger" expansion measuring apparatus for soundness tests; screens of 32,400, 14,400 and 5,776 holes per square inch for fineness tests; a "Boehme" Hammer machine for standardized making of the tensile briquettes and compression cubes, and a constant temperature hot water bath. A recording thermograph gives the room temperature. There is also installed an electric muffle for determination of sulphur, balances of various types, and a very complete system of earthenware trays for the storage of briquettes in water.

Any analyses required are carried out in the main assay office. This is an up-to-date chemical laboratory, fully equipped to cope with the varying demands of the different industries.

**LIMESTONE QUARRIES.**

The limestone, which is the principal raw material, comes from the Corporation's quarries at Attunga, near Tamworth. The deposit consists of three distinct hills, containing millions of tons of limestone of remarkable purity, and having practically no over-burden. The stone is blasted from the face and loaded by skips into railway trucks.

For blasting purposes a compressor house has been erected, in which are three air compressors, each driven by a crude oil engine, with the usual accessories and air receiver. This plant supplies air at high pressure to the air drills at the quarry face, and has sufficient power for an output of 3,000 tons of limestone per week.

Adjacent to the quarry a large number of cottages has been erected by the Corporation for the use of the employees.

The quarry is connected by a private line to the Tamworth-Barraba Branch line.

The stone is railed to Cockle Creek and discharged at the cement plant into a reinforced track hopper over a 40 x 42 in. jaw crusher.

**CLAY AND SHALE.**

The clay and shale deposits are on the works property close to the cement plant. These deposits are of very consistent chemical composition, the percentage of the chief constituents varying not more than two per cent. A steam shovel is employed for excavating the clay. The clay is loaded into hoppers and discharged into the works storage bins behind the clay wash mill.
# CEMENT TEST CERTIFICATE

Mr. H. A. Evans, Manager of Sulphide Corporation Ltd., having applied to the Department of Public Works for a test of 3,000 bags of Cockle Creek B.C. Brand of Portland Cement, manufactured by Sulphide Corporation Ltd., Boolaroo, New South Wales, ex Store, which were stored at Cockle Creek Works, Boolaroo. Samples were, on the 13th May, 1925, selected by Mr. Gaite, a Departmental Officer, and tested with results as follows—

<table>
<thead>
<tr>
<th>Ref. No.</th>
<th>Description of Tests.</th>
<th>Standards Required</th>
<th>Results of Tests</th>
<th>Details of Setting</th>
<th>Method of Conducting Test</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>FINENESS</td>
<td>Maximum, 13 per cent...</td>
<td>3.3</td>
<td>1 hr. min. 5.0, 15.0, 29.0, 4.30</td>
<td>4. Solution 20 per cent.</td>
</tr>
<tr>
<td></td>
<td>1 Residue on a sieve of 14,400 meshes per square inch</td>
<td>Minimum, 5 per cent.</td>
<td>2.0</td>
<td>2 hr. min. 16.0, 5.0, 30.0, 5.0</td>
<td>5. Estimated with a needle 0.039&quot; diameter, loaded with 10 lb. oz. bearing on a disc of neat cement 40 Min. thick. Gaged for one minute with 50 turns of mixing machine. 6. Temperature of water in cold bath, 65° to 72° Fahl.; in hot bath, 175° to 200° Fahl.</td>
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<tr>
<td></td>
<td>2 Residue on a sieve of 32,400 meshes per square inch</td>
<td>Minimum, 2 per cent.</td>
<td>1.75</td>
<td>4 hr. min. 18.0, 5.0, 32.0, 5.0</td>
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<tr>
<td>2</td>
<td>SPECIFIC GRAVITY</td>
<td></td>
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<tr>
<td>3</td>
<td>SULPHURIC ANHYDRIDE</td>
<td>Minimum, 3,000</td>
<td>3.105</td>
<td></td>
<td></td>
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<tr>
<td>4</td>
<td>RESIDUE INSOLUBLE IN HYDROCHLORIC ACID</td>
<td>Maximum, 2 per cent.</td>
<td>1.75</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>Minimum, 5 per cent.</td>
<td>19.0</td>
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<tr>
<td>5</td>
<td>TIME OF SETTING.</td>
<td>Minimum, 1 hour</td>
<td>1 hour 30 mins.</td>
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<td></td>
<td>At a temperature of 60° Fahl. (commencement)</td>
<td>Minimum, 3 hrs. max. 12 hrs.</td>
<td>4 hrs 30 mins.</td>
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<tr>
<td></td>
<td>With 25.5 per cent. of water (set hard)</td>
<td>Consistency = 20</td>
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<tr>
<td>6</td>
<td>TENSILE STRENGTH.</td>
<td>Minimum, 565 lb. per sq. in.</td>
<td>1,107 lb. per sq. in.</td>
<td>11 hr. min. 25.0, 5.0, 39.0, 4.30</td>
<td>The percentage of water used is based on the amount absorbed by the next cement under a pressure of 5,000 lb. per square inch. The Miehle's shot machine is used for breaking the briquettes. The speed with which the weight is applied is at the rate of 100 lb. in 12 seconds. The standard sand used is Neppe River sand, washed, dried, and sifted through a sieve of 400 meshes per square inch, and caught on a sieve of 900 meshes per square inch.</td>
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<td>Neat Cement with 15.5 per cent. of water, After 1 day in air and 6 days in cold water of from 65° to 72° Fahl. After 1 day in air and 6 days in Devlin's Hot Bath of from 175° to 200° Fahl.</td>
<td>Cement 1 part, Sand 3 parts, with 7.9 per cent. of water, After 1 day in air and 6 days in cold water After 1 day in air and 6 days in Devlin's Hot Bath</td>
<td>Minimum, 710 lb. 1,115 lb. 167 lb. 230 lb.</td>
<td>10 hr. min. 34.0, 34.0, 4.30, 5.0</td>
<td>8. As measured by Bauchinger's Standard Expansion Apparatus.</td>
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<td>7</td>
<td>COMPRRESSIVE STRENGTH.</td>
<td>Cement 1 part, Sand 3 parts, with 8.1 per cent. of water, After 1 day in air and 27 days in cold water After 1 day in air, 6 days in water, and 21 days in air</td>
<td>2,250 lb. 6,067 lb. 3,570 lb.</td>
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<td>8</td>
<td>EXPANSION OF NEAT CEMENT.</td>
<td>After 6 days in Hot Bath</td>
<td>Maximum, 0.10 per cent.</td>
<td>0.08</td>
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<td>After 7 days in cold water; after 7 days in air; after 1 day in air, and 1 day in Devlin's Hot Bath</td>
<td>To show no signs of cracking, crumbling, or alteration of form</td>
<td>Constant</td>
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<td>9</td>
<td>SOUNDNESS.</td>
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These Standards were adopted by the Board of Reference on 2nd December, 1910.

A. MORRISON, Asst. Supt. of Testing and Inspection,