



Specification No. MP-477

STEAM GENERATING EQUIPMENT

BOILER NO. 12

ASTORIA STATION

CONSOLIDATED EDISON COMPANY OF NEW YORK, INC.

4 IRVING PLACE, NEW YORK 3, N. Y.

Mechanical Engineering Department - Mechanical Plant Engineering Bureau

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## A - GENERAL

### 1. Purpose and Intent

The Contractor shall furnish, deliver and erect one (1) steam generating unit, complete, including furnace, boiler, superheater, reheater, economizer, air heater, flues and ducts, fuel preparation, transporting and burning equipment, insulation, integral supporting steel and boiler plant accessories as hereinafter specified; and shall provide all of the necessary superintendence, labor and equipment to place the units in satisfactory operating condition. Two proposals are desired. The first will cover a steam generating unit with the furnace operating at a slight draft. The alternate proposal will cover a steam generating unit with the furnace operating under sufficient pressure to permit the elimination of the induced draft fans.\* All work shall be done in accordance with the standard "General Conditions" of the Company.

These specifications shall be a part of the contract.

### 2. Abbreviations

A table of abbreviations used throughout this specification is appended hereto.

### 3. Exceptions to Specifications

It is not intended to specify designs which depart from the Contractor's standards, provided the latter are the equivalent of the specific provisions made herein. Where the Contractor does not wish to meet the provisions of these specifications, he shall submit with his proposal a "Statement of Exceptions" covering the points of variation between his proposal and these specifications, together with the reasons therefor. If there is any inconsistency between the design data specified herein and the required performance, the Contractor should take exception to it in his "Statement of Exceptions".

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\* For the pressurized boiler, the necessary observation of the interior shall be possible through glass or other transparent material. Means shall be provided to keep the glass clean and the parts free of ash or slag. If the glass is a part of a door, the door shall be interlocked with aspirating air nozzles to preclude blow-back.

#### 4. Material Handling and Site Conditions

The equipment herein specified shall be erected on property of the Consolidated Edison Company of New York, Inc. at 20th Avenue and 21st Street, Astoria, N. Y. Delivery of material may be made directly by truck, or by lighter to the Company's dock at the property, or to the Harold Avenue Yard of the Long Island Railroad and from that point to the Astoria Station by truck. The Contractor will note that Astoria is located outside the lighterage limit.

No field work shall be started by the Contractor unless he is advised to do so in writing or by an authorized representative in the field.

The Contractor shall so carry on his work that it shall at no time interfere with regular station operation outside of the area of his work. Cooperation between the Contractor and the Company is necessary in this connection.

The Contractor shall protect his equipment against damage during transportation and storage.

The Company will furnish sources of electric power for the erection of the equipment called for in these specifications. Others will make electrical connections to the Contractor's erecting equipment and will install, maintain and remove all temporary lighting required.

Service voltages available to the Contractor for operation of electric power-driven equipment and electric lighting during his erection work, will be 208/120 volts, 60-cycles, 3-phase, 4-wire for 208-volt supply to motors, and 120 volts for lighting and electrically-driven hand tools.

#### 5. Shop and Field Inspection

Free access shall be allowed the Company's representative to the Contractor's and Sub-contractor's shops, and to the work in the field.

The Contractor shall keep the Company advised at all times regarding the progress of the work in shops and field. The Company reserves the right to inspect any material at any reasonable time.

If the specifications or drawings, or the Company's instructions, or any law or ordinance, or any public or other authority having jurisdiction, require any of the work to be specially inspected, tested and approved, the Contractor shall give the Company due and timely notice of readiness for such inspection. Failure to give such notice will place the burden of uncovering and removing the work by the Contractor, if so required by the Company.

All materials or work rejected by the Company as not in accordance with the drawing and specifications, shall be removed immediately by the Contractor at his own expense, and replaced with other materials or work in accordance with the specifications.

The fact that any material or workmanship has been approved by the Company shall not release the Contractor from the responsibility of making good any defects developing after such approval.

With the boiler, the Contractor must submit a certificate of a job inspection in accordance with paragraphs P-331 to P-334 inclusive of the latest A.S.M.E. Code, Power Boilers.

In cases where others are furnishing equipment such as soot blowers, piping, valves and fittings to the Contractor, the Company shall have the right to have a representative witness hydrostatic and operating tests before such equipment is shipped from the Subcontractor's shop.

In the event the Company waives the requirement that test shall be conducted in the presence of its representative, the Contractor shall conduct such tests and send the Company two (2) copies of a report certifying the successful passing of those tests.

#### 6. CONTRACTOR'S DRAWINGS

Within three months after the contract has been awarded the Contractor shall submit for the Company's approval six (6) blueprints of general outline drawings covering the major components of equipment which he is furnishing and their loadings, which will permit the Company to start design of the supporting steel.

As soon thereafter as possible the Contractor shall submit for the Company's approval, six (6) blueprints of all detailed drawings and electrical diagrams necessary to completely illustrate the design, construction physical location and size of the equipment and material he is furnishing.

When a drawing is approved or approved with comments by the

ing is approved with comments by the Company, the Contractor shall revise the tracing as required and transmit to the Company six (6) blueprints of the revised tracing. This Revised drawing will then be commented on or approved by the Company as the case may be. After a drawing is approved, the Contractor shall furnish one (1) positive brownline Van Dyke print of the approved tracing. The Company will then print from these Van Dykes all necessary copies for its distribution and records. The Van Dyke prints shall be rolled, not folded, for transmittal.

Fabrication shall not be begun by the Contractor on any piece of equipment until receipt from the Company of an approved print or drawing for the same, unless the Contractor is otherwise advised in writing.

An approval of drawings by the Company, however, shall not release the Contractor from any responsibility for errors thereon, or from any of his obligations under the contract.

### B - OPERATING CONDITIONS

#### 1. Capacity

The steam generating unit shall be capable of producing 1,200,000 lbs of steam per hour continuously delivered to the turbine throttle valve at a pressure of 1800 psig and a temperature of 1000 F when burning any of the fuels listed herein. The unit shall also be capable of being shut down and started up daily. The pressure drop from superheater outlet to turbine inlet shall be assumed to be 50 psi. The data tabulated below gives approximate expected conditions at the reheater at various loads:

| Boiler Output - M #/hr   | 1200 | 1050 | 790  |
|--------------------------|------|------|------|
| Reheat Data              |      |      |      |
| psia out of turbine      | 509  | 445  | 342  |
| Temp. F       "       "  | 683  | 751  | 635  |
| psia reentering turbine  | 451  | 395  | 304  |
| Temp. F       "       "  | 1000 | 1000 | 1000 |
| Reheater Steam Flow M/hr | 1117 | 990  | 740  |

## 2. Temperature Control

A superheat temperature of 1000°F plus or minus 10°F is to be maintained at the high pressure turbine inlet valve at all steam flows between the maximum continuous flow of 1,200,000 lbs per hour and 65% of this load, i.e. 780,000 lbs per hour, when using Bunker C oil as the fuel.

A reheat temperature of 1000 F plus or minus 10 F is to be maintained at the low pressure turbine inlet valve at all steam flows between the maximum continuous flow of 1,120,000 lbs per hour and 75% of this load; i.e. 840,000 Lbs per hour, when using Bunker C oil as the fuel.

At least as great a range of superheat and reheat control shall be maintained within the same limits when either coal or natural gas is used as the fuel. The superheat and reheat temperature control equipment shall be furnished by the Contractor. The Contractor shall state the size and power consumption of any power operated temperature control equipment.

The controls shall be so designed that the controlled temperature may be set or changed remotely, and the controlling medium shall be designed for a maximum of flexibility.

Interconnecting control piping and wiring between the temperature measuring element and the control board and between the control board and the positioning or actuating devices will be provided by the Company.

## 3. Feedwater

The temperature of feedwater entering the economizer will be as follows:

462 F at 1,200,000 lbs per hour

450 F at 1,050,000 " " "

424 F at 790,000 " " "

The feedwater is expected to be condensate. The soluble solids concentration of the water entering the boiler is expected normally to be below 10 ppm.

## 2. Fuel

It is the Company's desire that this unit be designed to burn coals of as wide a variety of characteristics as is practicable with a minimum of trouble due to deposits on heating surfaces. Appended to this specification is a tabulation of analyses of coals, illustrating the range of coal characteristics, which the Company intends to burn in this unit. The characteristics of the test coal are given under Section G-Performance.

The Company desires to burn oils of the analysis given on Page 35 of this specification.

The Company desires to burn Natural Gas of the analysis given on Page 36 of this specification.

It is the Company's desire to be able to obtain the full continuous capacity out of this unit when burning any of the fuels referred to above.

## C - DESIGN AND BOUNDARIES OF CONSTRUCTION WORK

### 1. General

The furnace shall be of the dry bottom type. The bottom shall be so designed as to form a water wall ash hopper integral with the furnace, thus obviating the need for a separate refractory bottom hopper. This hopper should be protected from radiant heat either by a narrow throat or a shaded throat. The hopper shall include an inclined ash gate, hydraulically operated. That portion of the hopper subjected to sliding action of the ash shall be adequately protected against erosion. The Hopper shall have 800 cubic feet of usable bottom ash storage capacity.

The boiler shall be so designed and surfaces so proportioned that a minimum of cleaning and maintenance will result from the type of operation outlined herein. The steam generating unit shall be arranged to facilitate operation and maintenance. Further, the design and arrangement of the furnace and burners, and the circulating rates in the wall tubes, should be such that a concentration of burning in proximity to the wall tubes is avoided.

The Company desires a design having the following limits on furnace heat absorption, when operating at 1,200,000 lbs per hour steam flow, with any of the fuels listed herein:

The heat absorption per square foot of projected furnace area shall be below 50,000 Btu per hour.

Local heat absorption at any point shall be less than 65,000 Btu per hour per square foot.

The Contractor shall state his expected average heat absorption and his expected maximum local heat absorption.

The projected furnace area used above shall be limited by the centerline of the hopper throat and shall include the projected tube area of the first row of screen tubes ahead of the superheater.

The absorption rates noted above shall be measured within one week following an acid wash. The method of determination of the absorption rates shall be mutually agreed on before the contract is signed.

The Company's intent in the above section is to obtain a furnace with a local heat absorption rate low enough to avoid the burning or blistering of wall tubes and the avoidance of solids build-up due to excessive temperature on the water side of the furnace tube walls.

Attached to this specification is our Proposition Drawing No. 14274, showing the location of the proposed unit.

#### HIDE-OUT

The Company desires a guarantee that the steam generating unit will be substantially free from hide-out of phosphate or sulphate when operating with concentrations within the standards prescribed by the American Boiler and Affiliated Industries Standards Committee and when operating on sodium equilibrium.

For the purpose of this Specification hide-out is defined as the increase in concentration of phosphate or sulphate or both in boiler water when the boiler is taken off the line, as described in the "Behavior of Highly Concentrated Boiler Water" by Kaufman, Marcy and Trautman, Proceedings of Sixth Annual Water Conference, Engineers' Society of Western Pennsylvania, October 22-23, 1945.

This boiler shall be considered substantially free from hide-out when such increase in concentration does not exceed 10 ppm of either  $\text{Na}_3\text{PO}_4$  or  $\text{Na}_2\text{SO}_4$ . Phosphate and sulphate shall be determined by Consolidated Edison Company procedures.

## 2. Accessibility

All parts of the steam generating unit shall be properly accessible for inspection and maintenance. A minimum vertical clearance of 12" shall be maintained between economizer, superheater, or reheater supports and the adjacent tube surfaces.

## 3. Air Heaters

Ljungstrom air preheaters are preferred by the Company. However, if the bidder desires, he may submit an alternate bid covering other types of air heaters.

The air heaters shall be supplied complete, including air and gas inlet and outlet flanges, cleaning devices as needed, supports, insulation and motors. Air heaters shall be of such design and materials as to operate with a minimum amount of fouling and corrosion. An air by-pass, suitably dampered, shall be provided for use during starting up and low load periods. The cold elements shall be basketed for ease in removal, and a spare set of basketed elements furnished with each air heater. Basketed elements, radial and circumferential seals shall be of non-corrosive materials. The layout of the heaters shall be such that the cold air inlet shall be at the bottom of the air heater. All bearings shall be air cooled. Necessary instrument and draft connections shall be provided. The Contractor shall design his ducts and flues to insure an even distribution of flow through the air heater.

## 4. Air Vents

Adequate air vents with valves shall be provided on all parts of the generating unit at which air is likely to be pocketed during filling. The top drum vents shall be 2 1/2" to allow rapid filling or emptying of the boiler.

### 5. Baffles

The Contractor shall furnish and install any necessary baffles, installed so as to be permanently tight. The design of all baffles shall take into consideration ease of replacement.

### 6. Blowdown and Drains

All mud drums and lower water wall headers shall be provided with 2 1/2" drains in tandem, with a 1" valve and orifice by-passing the outboard 2 1/2" drain valve to be used for controlled mass blow-off. These combination drain and blow-off connections should be located to afford ample sludge cleaning facilities at all points of settlement and also should be located to afford complete drainage. A minimum of 1 connection per header is required if the header or header system is less than 20 feet in length and 2 connections per header, or header system are required if greater than 20 feet in length. Also teed off between the two 2 1/2" drain valves will be a 2 1/2" valve for use in acid washing the boiler.

The boiler shall be provided with a continuous blowdown system complete with internal collection header.

All other drainable portions of the unit such as the superheater, reheater and economizer shall have adequate drain connections with 2 1/2" valves in tandem.

### 7. Casings

The Company desires boilers with a minimum of steel casing. In effect this means a cap on the top of the unit and a partial cap over the bottom whenever the bottom is readily accessible. Uncased boilers shall consist of the required thicknesses of refractory and insulating materials covered with galvanized

expanded metal lath or wire mesh, as the physical construction dictates, and plastered with a finish coat of suitable hard finish cement applied in two layers. Finish coats to be grooved into panels for full depth and to present a smooth, even, uniform surface. Doors, soot blower and other openings shall be fastened to the metal parts of the unit. Exterior corners shall be metal reinforced against breakage and interior corners reinforced against cracking. Expanded metal and metal lath shall be tied at close intervals to the metal parts of the unit and the entire enclosure designed to accommodate expansion and reduce air leakage to a minimum.

All connections to which the Company connects shall project a suitable distance through the casings with the proper seals and provision made for movement by expansion. Such connections to the boilers and furnaces as are required for the installation of instruments or other measuring devices shall be supplied by the Contractor. These, in general, will consist of a pipe extending from the inner face of the wall to a point approximately 6 inches from the outside face of the casing. These connections shall be designed and located in accordance with drawings submitted by the Company.

### 8. Combustion Control

Complete operating characteristics of each of the combustion controlling points shall be described to the Company by the successful bidder.

The Company will install automatic combustion control equipment furnished by others.

### 9. Drum

Boiler drums shall be fusion welded in accordance with the latest A.S.M.E. Code, Power Boilers.

Drum shall be equipped with an access manhole on each end, and shall be equipped with suitable nozzles, installed as required by the latest A.S.M.E. Code, Power Boilers. The number of nozzles shall be determined later, but shall include the following:

Steam outlets, safety valves, feed, one continuous blow-down, four nozzles for two gage glasses, soot blower, one chemical feed, one steam gage, two vents, two for water sampling, two for water level recorder, and regulator, two for remote level indicator and two spares. Tandem valves shall be furnished where applicable.

In addition to the foregoing, the Contractor shall furnish drum hangers, a pressure gage, safety valves, and two gage glasses per steaming drum complete with illuminators, shut-off valves, and operating chains and drain valves.

The interiors of the drums shall be reasonably clean. Chemical cleaning by washing with acid is contemplated prior to placing the unit on the line. Gaskets shall be of such material as to withstand the cleaning agents.

The drum internals shall be designed to accommodate sudden load changes without carryover.

#### 10. Ducts and Flues

The Contractor shall furnish; Air ducts between air heaters and burners, including cold air by-passes with dampers around air heaters and dampers at air heater inlets, primary air-take-off for mills, common duct for mill tempering air supply, hangers, seal welding, insulation, approved screwed cap or blind flange instrument connections and dampers. Gas flues between economizer outlet and air heater inlets, including hangers, seal welding, insulation dampers, and approved cap or blind flange instrument connections.

All duct and flue work shall be gas and air-tight and shall be welded throughout with the exception of joints provided at other pieces of equipment furnished by either the Contractor or the Company. Duct and flue plate shall be at least 1/4 inch thick.

Expansion shall be properly taken care of and no excessive loads shall be placed on connection flanges. Anchors shall be suitably designed and installed to eliminate such reaction where advisable.

Such parts as are subject to erosion and corrosion shall be properly designed to withstand these actions and shall be so designed as to be conveniently and safely maintained.

Where ducts or flues are subject to wash water collection, drain basins and valved drains shall be provided. Ducts or flues shall be pitched to this drain basin.

All ducts and flues shall be properly insulated by the use of blanket and/or plastic insulation with no exposed stiffeners.

A reasonable number of test, meter and control openings will be requested by the Company and will in general consist of pads four inches square and one inch thick, welded to the ducts; these, in turn, drilled, tapped and plugged for a one inch pipe connection.

#### 11. Dust Handling Equipment

The dust collected in the steam generator parts shall be brought to convenient points, for disposal by the Company. Where possible, self-draining hoppers shall be provided, and in case the hopper is not self-draining, it shall be provided with some suitable device with drive such as shaker, vibrator, screw conveyor, etc. Access doors shall be provided into all hoppers. If shakers or vibrators are motor driven, the driving mechanism shall be designed to prevent transmission of shocks directly to the motor shaft. Any device which is directly driven by a motor shall incorporate means to prevent thrust on the motor shaft.

#### 12. Fuel Preparation and Burning Equipment

##### Coal

a. The Contractor shall furnish coal feeding, preparation, transporting and burning equipment, complete, starting at the raw coal inlet flange of the feeder and including raw coal feeders, coal pipe to mills, mills, primary air fans, coal piping, burners, burner controls, bedplates, dampers and controls, approved screw cap or blind flange instrument and control connections, hangers

and insulation. Mill and mill fan motors will be furnished by the Company without bedplates but erected by the Contractor. The Contractor shall furnish Fast flexible couplings or equivalent as approved by Company with guards completely, enclosing the shaft and coupling between the motors and the drive equipment.

b. Coal feeders shall be assigned in a manner to handle high moisture content coal without sticking and also to minimize any undesired retardation of coal flow. Coal inlet connections shall be of generous size. Provision shall be made to prevent damage to the feeder by foreign objects and the feeder shall be easily accessible and replaceable.

c. Coal piping between feeders and mills will be as short and as near to vertical as design conditions permit. Coal piping to the burners shall be designed so as to minimize any coal settlement at pockets, and where necessary shall have means for inspection and cleaning. Coal splitters in these lines, if used, shall be easily renewable. Any other parts of the lines at which erosion is expected shall be designed in a manner intended to reduce the cost of maintenance. The arrangement of the piping shall be such that stable furnace conditions are maintained at all load and mill combinations.

d. The mills shall be of sufficient size to properly prepare the coals listed herein required for the continuous production of 1,200,000 lbs of steam per hour at 1000 F and 1800 psig at the turbine inlet. The Contractor shall state in his proposal what maximum moisture can be handled without loss of boiler load. The Contractor shall furnish the Company with complete information as to mill characteristics, capacities and loads under all operating conditions. The design of mills shall contemplate easy removal and replacement of wearing parts. Coal pulverizing mills and their primary air fans shall be arranged for direct coupled drive from the drive motors. The Company will not permit any drive arrangement which requires double and drive motors, and will not accept any design in which the mill and primary air fan drive motors are

subjected to a radial load, thrust load, overturning load, or heat absorption from the primary air fans. The Company contemplates the disposal of mill rejects by means of a hydraulic sluice. The design of the mill reject system will be such as to automatically discharge the mill rejects from each mill into a hopper with a discharge gate suitable for manual opening to a sluice.

a. Primary air fans or exhausters shall be designed so that noise and vibration are minimized. All wearing parts shall be fitted with wearing plates, easily replaceable. The design shall provide for easy removal of the impeller. The Contractor shall give the operating characteristics and horsepower required of the fans. One fan shall be given a shop test which will be witnessed by a Company representative. Tempering air to all primary air fans will be taken from a common duct to facilitate air flow measurements.

#### Oil

Oil burning equipment, complete, starting at an oil supply point at the burner box, and including a solenoid quick shut off valve, steam atomized oil burners, and necessary burner box construction.

#### Gas

Gas burning equipment, complete, starting at a gas supply point at the burner box and including a solenoid quick shut off valves, gas burners, and necessary burner box construction.

#### Ignition

Gas fuel ignition system, complete, starting at a gas supply point at the burner box and including separate gas pilot torches complete with spark plug type ignition, transformers; and solenoid valves for remote manual operation. Tandem valves shall be provided for shut-off, with atmospheric vent valve between, interlocked so that the vent valve is open when control valves are shut and vice-versa.

The ignition system should be designed to ignite any of the fuels listed in this specification when using natural gas or when using manufactured

gas of 540 Btu per cubic foot and .7 s.g. as a fuel for the ignition torches.

### Burners

The burners, burner control and burner piping shall be of a design which will insure stable furnace conditions when burning the fuels listed in this specification and under all operating conditions, and shall be complete with ignition system as described. Firing from each will shall be symmetrical about the furnace centerline. Parts of the burners requiring replacement shall be designed for ease of removal and installation. The design shall be such that intimate mixing and uniform distribution of fuel and air can be maintained, with avoidance of tube impingement and furnace atmosphere tending toward "sulphiding" or other form of water wall corrosion. The design shall be such that continuous full load operation can be obtained when burning any of the fuels listed in this specification. The dampers for all burners supplied from one mill shall be capable of operation from one control arm. Remote control equipment will be provided by others. The torque and movement of each control arm shall be furnished by the Contractor.

### 13. Guards

All moving parts such as coupling shafts, chains, belts, etc., shall be completely protected by suitable metal guards, approved by the Company.

### 14. Insulation

In general, the equipment by the Contractor shall be provided with such insulation, furnished and installed by the Contractor, that with an ambient air temperature of 80 F the surface temperature will not exceed 127 F. Where danger from personal contact exists the maximum temperature of the surface shall not exceed 135 F with an ambient air temperature of 100 F and 5 miles per hour air current. Insulation subject to walking or injury due to location shall be steel lagged. Pipe insulation shall include expansion joints in the covering preferably of the sectional type. No rosin sized paper or any other flammable type of paper shall be used. Asbestos paper shall be used in their place.

15. Lubrication

Lubrication shall be provided at all points where necessary, and means for such lubrication shall be provided at accessible locations. Where grease fittings are used, same shall be of the type "Button Head" No. A-1236, manufactured by the Alemite Corporation.

16. Oil Coolers

Where oiling systems are required, the design shall contemplate the use of salt water for cooling with tubes of aluminum bronze, Monel or equal. Tubes will be not less than 5/8" O.D. The coolers shall be rugged in construction and built to withstand the corrosive nature of the water used. Coolers shall be separately mounted.

17. Paint

The Contractor will furnish shop paint on all equipment. Field coats of paint will be furnished and applied by the Company.

18. Piping

(a) General

The main steam piping from the superheater outlet to the turbine inlet and the reheater piping between the reheater and the turbine will be furnished by others. The Contractor shall terminate his work with welded ends at the superheater outlet and at the reheater inlet and outlet. These terminal points will be outside the casing and accessible for welding. The welding will be done by others.

All piping shall be in accordance with the A.S.M.E Code requirements, including its latest revisions.

All safety valve connections shall be flanged. All valves on nozzles shall be welded and shall terminate with welded ends.

19. Pressure Gages

High pressure gages furnished by the Contractor shall

## 20. Pressure Parts

All pressure parts of the generating equipment, including boilers, water walls, superheater, reheater, and economizer, pipe, valves and fittings furnished by the Contractor shall conform in all respects with the latest revision of the A.S.M.E. Boiler Construction Code, the Industrial Code of the State of New York, together with regulations of the Department of Housing and Buildings of the City of New York. All internal surfaces of pressure parts shall be reasonably free from mill scale. All external surfaces shall be reasonably free of scale and other imperfections.

## 21. Sampling

Each steam, water and mud drum shall be fitted with two sampling connections and tandem valves at least 1 inch in size from which representative samples of boiler water can be obtained. Each sample point shall be internally piped to the middle of a suitable collection manifold, drilled with holes no smaller than 1/8 inch in diameter. These holes are to be arranged to obtain an average sample of water throughout most of each drum length.

Means shall be provided for obtaining samples of saturated steam leaving the boiler of at least 6 points across the width of the boiler. Each sampling connection shall be at least 3/4" in size and shall be provided with tandem valves. The sampling tubes shall be designed so as to be easily removed and replaced.

One 1" sampling connection with tandem valve is required at the economizer inlet.

At least one 1" sampling connection with tandem valves is required at the superheater outlet.

One 1" sampling connection with tandem valves is required at the reheater inlet and one 1" sampling connection with tandem valves is required at the reheater outlet.

## 22. Setting

The Contractor shall furnish and install all masonry which may be required to complete the entire apparatus.

The design shall omit refractory material unless it is impracticable to avoid its use. All masonry must be designed with a view to reducing to a minimum the cost of normal maintenance.

The Contractor shall install a sufficient number of single doors to permit convenient access to all parts of each boiler, superheater, reheater, economizer, water walls and furnace required for inspection, cleaning or removal and replacement of tubes. All doors shall be lined with a refractory material not less than two inches thick. This refractory shall be approved by the Company. Forged steel clamps or latches shall be furnished with each door which will permit closing the door tightly enough to seal against air leakage into the boiler. All access doors except those in the furnace shall be capable of opening from either inside or outside. All doors shall be air cooled.

The Contractor shall provide a sufficient number of observation doors; the number, type and location of these doors to be agreed upon later.

## 23. Soot Blowers

A complete soot blowing system necessary for the adequate cleaning of the generating units shall be provided by the Contractor as hereinafter outlined. Retracting type blowers shall be used wherever possible.

The complete blowing system will be designed to use either air or steam as the blowing medium. The changeover to either shall be capable of accomplishment by a single valving operation. The Contractor shall state the necessary quantities and pressures of air and steam required for blowing and control for both air and steam blowing.

In connection with steam blowing, the Contractor shall furnish a complete system from drum to blower including supports, piping, valves, pressure reducing station, safety valve, control equipment, hangers and insulation. Should

the contractor feel that additional soot blowing units may be required after the original installation (but not including the furnace), the design of piping, casing, etc. shall contemplate these additions. The Contractor's work on the air blowing system will stop with a tee in the line to the blower at a point suitable for the introduction of the air. The air compressors and piping to the tee will be furnished by others.

All soot blowing shall be completely automatic, controlled by sequence from a single control panel, and shall be air actuated. The control panel shall include lights on other devices to indicate the blower operation. It shall also include a flow meter, steam pressure gage, air pressure gage, and the necessary alarms to indicate malfunctioning of the equipment.

The Company will supply air and electric power to one point at the control panel. The Contractor shall furnish and erect all wiring and piping at the control panel and all control and power piping and wiring to the blowing units. The system shall be designed to permit individual blowers to be by-passed during the blowing cycle. All soot blower drains shall be brought to a single point by the Contractor. The Company will furnish and install piping from this point to point of disposal. Suitable orifices, solenoid or air operated valves, and traps shall be furnished and installed by the Contractor to provide for minimum loss of steam or air.

#### 24. Steel

The Contractor will furnish all supporting members including castings, lugs, hangers and structural supports which are primarily parts of the steam generating equipment. The Company will furnish in place all building steel and structural supports not part of the steam generating equipment. In general, all supports at boiler hanger level, framing at intermediate levels to support sidewalls, and framing to support furnace bottom if same is not hung from sidewalls, will be classed as building steel. The Contractor shall detail all this boiler supporting steel; the Company will purchase and erect same.

## 25. Superheater, Reheater and Economizer

Each superheater, reheater and economizer shall be cleanable while in operation and shall be baffled and designed to obtain proper heat distribution. They shall be accessible for element replacement. The reheater shall be of the convection type. Necessary instrument connections with valves shall be supplied.

The superheater shall include the necessary safety valves and an extra safety valve with a gate valve under it to be used in lieu of a power controlled safety valve.

The reheater shall include the necessary safety valves at its inlet and outlet.

The economizer shall include a stop valve and non-return valve.

## 26. Tools

One (1) complete set of new tube expanding equipment, together with the necessary gear boxes, special pins, complete are to be furnished at the conclusion of erection under these specifications. A complete new set of any other special tools required for proper maintenance of the generating unit shall be furnished by the Contractor at the conclusion of erection. The Contractor shall mark each tool and furnish the Company with information showing where each tool is used.

## 27. Tubing

Tubing shall be of proper materials to conform to the A.S.M.E. Boiler Code for the service required. Tubing should be as scale-free as best mill practice will permit. Tube ends shall be counterbored, reamed, or otherwise finished to insure concentricity and remove all uneven surface conditions to facilitate inspection and rolling.

## 28. Valves

It is the intent of these specifications that the entire generating unit, in so far as pressure parts are concerned, shall be furnished and erected up

to and including the stop valves on all connections. The superheater and reheater outlets are not included in the above statement and are covered elsewhere in this specification.

All gate, globe and check valves shall be in accordance with the Company's Specifications No MP-902 latest revision with welding ends. All Scott Blower valves shall be flanged. All valves shall conform to the requirements of the A.S.M.E. Boiler Code for the steam and water conditions applying for this installation.

#### 29. Water Level Control and Metering Equipment

The design of the steam generating unit shall be such that water level can be satisfactorily controlled by hand as well as with automatic regulation. The Contractor shall furnish a complete feed water control system to regulate the feed water to the boiler in response to water level, water flow and steam flow changes including steam flow, air flow and steam pressure recorder, water level recorder, feed water flow and feed water pressure recorder, flow nozzles and accessories (except piping and valves) necessary to provide automatic, local hand and remote manual operation. Interconnecting piping and valves will be furnished and erected by the Company. The Contractor shall provide the feed water control valve and valve positioner.

#### 30. Water Walls

Water walls in so far as practically possible shall be such as to exclude the use of any refractory walls. Vibration of the walls shall be minimized. Observation doors shall be provided in sufficient quantity and at locations to enable suitable inspection while the generating units are in operation. Openings shall be provided in the roof of the furnace to permit the support of internal rigging. All water wall coverings shall be designed to permit convenient removal and replacement of tubes. Headers shall all be arranged so that each and every tube may be properly removed, and properly replaced. Gas-tight seals shall be provided at such points where water walls meet one another and where wall tubes

comes outside the furnace to meet the headers. Tube spacing shall be such that there will be no erosion of the walls by slag. Tube rolling holes shall be closed with either rolled or welded caps. Gasketed master handholes shall be installed at the ends of each header and on each side of header division plates. The Contractor should give consideration to a wider gasket seat than has been customarily used in an attempt to reduce failures at this point. Any design which offers a solution to the problem of handhole gasket leakage will be given preference by the Company.

### 31. Test Connections

The Contractor shall provide all high pressure connections that may be necessary to check equipment performance, up to and including suitable shutoff valves.

## D. ELECTRICAL EQUIPMENT

### 1. General

All wiring and connections external to the equipment furnished under these specifications will be provided by the Company. The Company will provide all switching, control and protection devices for motors which are not an inherent part of automatic regulating or control equipment furnished by the Contractor.

All motors shall conform to ASA Standard C-50-1943 and accessory electrical equipment shall conform to the latest applicable AIEE, ASA and NEMA standards.

All accessory equipment containing electrical circuits and devices shall be constructed so that all electrical features will be enclosed within NEMA type 4 water-tight housings. The housings shall be provided with rigid conduit fittings threaded for attaching 3/4" rigid threaded metal conduits carrying the external circuits.

Control panels such as for soot blowers, reheat, etc. shall be furnished completely assembled, piped, and wired, and arranged to provide free

accessibility for maintenance, testing, and replacements. All pipe and wire terminations shall be permanently identified by stamped, slip-proof, metal tags adjacent to the terminals. All wires shall terminate with cup washers and lock nuts, or equivalent means, on States Company or equal, sliding link type terminal blocks having marking strips and covers. Terminal blocks shall be selected to provide at least 10% spare terminal positions, and they shall be located as determined later by the Company. Wiring shall be not smaller than #12 AWG stranded single conductor Rockbestos 600 volt class asbestos covered varnished cambric insulated switchboard wire, or approved equivalent. The design of these panels shall be coordinated, as required by the Company, to suit the requirements for installing them in centralized boiler control boards which the Company will provide.

## 2. Service Voltages

Service voltages upon which the electrical equipment shall be designed to operate are as follows:

- (a) 440 volts 60 cycles 3 phase wye connected, grounded neutral system for all motors, 1/6 hp and larger, except valve motors.
- (b) 120 volts 60 cycles 1 phase with one leg grounded for recorder motors, lighting, boiler automatic regulating devices, and boiler electric ignition equipment.

## 3. Boiler Electric Ignition Equipment

Each igniter shall be of the high tension spark ignition type with one side grounded, and shall include all necessary equipment except the high voltage ignition cable which the Company will provide. All electrical equipment and connections outside the boiler casing shall be protected by NEMA type 4 water-tight enclosures with threaded entrances for metal conduit connections.

The ignition transformer shall be 60 cycle single phase of ample capacity and proper design to withstand being energized continuously without injury. The spark plug shall be constructed of a ceramic or similar material which will withstand the temperature inside the boiler. A straight solid rugged conductor, firmly held by insulators, shall be used for the connection from the spark gap to a terminal outside the boiler casing where the Company's high voltage cable will be attached.

#### 4. Electrically Operated Valves

Motors and control equipment for electrically operated valves shall conform to Section F of the Company's specification MP-3902, latest revision, with current characteristics as follows:

The power supply for valve motors will be 208 volts, 60 cycles, 3 phase; for the control circuits, including solenoids, 208 volts, 60 cycles, single phase; voltage range for all equipment 180 to 215 volts.

#### 5. Instruments

All indicating and recording instruments which have a 120 volt 60 cycle supply circuit shall be equipped with fuses and cut-off switch inside the case in the supply circuit. Internal lighting for instrument charts and scales shall be fluorescent type with "4500 white" tubes.

Recorder mechanisms shall be driven by Warren, or equal, self-starting synchronous type motors. Circular chart recorders shall be for 24 hour charts. Strip chart recorders shall be equipped with an automatic chart reroll device driven by a metal coiled spring type belt from the synchronous motor drive mechanism. In all recorders which employ a horizontal "writing table" the record shall be visible immediately as it is traced.

#### 6. Other Motors

All other motors not included in above items 4 and 5 shall be totally enclosed (or totally enclosed fan-cooled) dust-tight construction squirrel

cage induction, line start-low starting current type with water-tight terminal boxes having threaded conduit entrances. Air preheater drive motors shall be silicone insulated 75°C rise, and all other motors shall be Class B insulated 55°C rise. All motors shall be continuous rated.

Sleeve bearings are preferred on motors from 1 hp to 5 hp inclusive. Sleeve bearings are required on motors larger than 5 hp. In all cases bearing construction shall be such as to prevent entry of dust and loss of lubricant. A drain plug shall be provided in the bearing housing so the bearing well can be flushed out and completely drained.

In all cases the motor shall develop, at rated voltage, locked rotor torque not less than 125% of the torque required at the motor shaft to start the driven machine from standstill under the maximum starting load to which the motor can be subjected, and bring it up to speed promptly.

The rated horsepower of each motor shall be not less than the maximum horsepower required, at the motor shaft, to drive the fully loaded machine.

#### E - PROPOSAL DATA

##### 1. Drawings

The Contractor shall submit with his proposal five (5) sets of general outline prints showing the approximate dimensions and the space required for the equipment he proposes to furnish. These prints should be complete enough to give the Company a fair conception of the proposed equipment and will include at least the following:

- (a) General arrangement of the equipment in the space available.
- (b) General arrangement of cross-sections at important levels.
- (c) Detail cross-sections through main pieces of equipment and such portions of design as are featured in the proposal under trade-marked names.
- (d) Loading diagrams of main pieces of equipment.
- (e) Typical cross-sections through all heating surfaces showing tube spacings, seals, baffles, expansion joints, refractory, insulation and casings.
- (f) Schematic arrangements indicating locations of soot blowers, lancing and poke hole doors, and access doors.

## 2. Description

The proposal shall contain sufficient descriptive matter regarding the design and operation to give the Company an adequate conception of the proposed equipment. Where any exceptions are made a "Statement of Exceptions" as described under A-3 - EXCEPTIONS TO SPECIFICATIONS must be included.

The Contractor shall also include:

- (a) Separate prices on each type of soot blower, which prices the Contractor would deduct in event of cancellation of specific soot blowers by the Company.
- (b) ASTM-ASME Specification number for materials proposed for pressure parts.
- (c) The speed of response of the boiler to load changes, and the rate of load change without carryover in excess of that guaranteed.
- (d) The loads at which the boiler and water walls may be blown intermittently.
- (e) The drum design pressure.
- (f) The Contractor's proposal shall contain, for all motor-driven machines or devices, exclusive of motor-driven recorders:
  - (1) List of machines by name or function.
  - (2) Maximum torque in lbs-ft at the motor shaft required to start the driven machine or device from standstill under the maximum starting load to which the motor can be subjected.
  - (3) Maximum horsepower required at the motor shaft to drive the fully loaded machine or device.

## 3. Electrical Proposal Data

The proposal shall be in accordance with this specification and it shall contain a complete description of all electrical equipment, including the following specific data:

- (a) Boiler Ignition Equipment
  - 1. List of all items stating quantity and function.
  - 2. Name of manufacturer, type, rating, catalog number & complete description.
  - 3. Description of interlocking

(b) Electrically Operated Steam and Water Valves

Complete information and data as required by Specification MP-302.

(c) Recorders

1. Name of manufacturer, type and complete rating data.
2. Description of construction and operation.
3. Performance guarantees of accuracy and sensitivity.
4. Recorder motor make, type and complete rating.
5. Description of internal lighting.

(d) 440 Volt Motors

1. Name of manufacturer, type, rated hp, voltage, frequency, phase, speed and temperature rise guarantee.
2. Full load current and rpm.
3. Guaranteed minimum values of power factor and true efficiency at 1/2, 3/4 and full load.
4. Locked rotor torque, current and power factor at rated voltage.
5. Breakdown torque at rated voltage.
6. Class of winding insulation.
7. Type of bearings.
8. Dimensioned outline drawing.

F - EVALUATION

bids:

The following factors will be used in the evaluation of the

1. The general design and its relation to the intent and purpose outlined in these specifications.
2. The bid price.

3. The efficiency of the unit. The capitalized value of each percent of efficiency when operating on the test coal or Bunker "C" oil, is as follows:

\$183,000 at 1,050,000 lbs. per hour steam flow  
\$41,000 at 790,000 lbs. per hour steam flow

4. The reheater pressure drop. \$9,000 is the capitalized value of each pound of pressure drop in the reheater at 1,050,000 lbs per hour steam flow at the superheater outlet.
5. The auxiliary equipment power charges. The capitalized value of auxiliary power when operating with a steam flow of 1,050,000 lbs. per hour at the superheater outlet is as follows:

\$570 per pound of pressure drop in the superheater and economizer.

\$35,500 per inch of draft loss.

\$18,700 per inch of air pressure loss.

\$300 per horsepower input to all equipment furnished by the Contractor.

#### G - PERFORMANCE

The Contractor shall state in his proposal the expected performance at 1,050,000 lbs per hour and 790,000 lbs. per hour steam flow for coal, oil, and gas. The successful bidder shall also furnish performance data at 510,000 lbs. per hour at a later date. The Contractor shall base his coal performance and guarantees on 14.8 percent CO<sub>2</sub> at the economizer outlet and on the use of a Fairmont coal having the following characteristics:

|                           | <u>Proximate Analysis</u> |            |
|---------------------------|---------------------------|------------|
|                           | <u>As Received</u>        | <u>Dry</u> |
| Moisture, % by wt.        | 4.1                       | -          |
| Volatile Matter, % by wt. | 37.8                      | 39.4       |
| Fixed Carbon, % by wt.    | 50.1                      | 52.3       |
| Ash, % by wt.             | 8.0                       | 8.3        |
| Sulphur, % by wt.         | 3.16                      | 3.29       |
| Btu per Pound             | 13,253                    | 13,820     |
| Btu per Pound, as free    | 15,071                    |            |
| Fusibility of Ash         |                           |            |
| Initial Def. Temp.        | 1896 F                    |            |
| Softening Temp.           | 2056 F                    |            |
| Fluid Temp.               | 2272 F                    |            |
| Iron Oxide, % by wt.      | 36.5                      |            |
| Hardgrove Grindability    | 64                        |            |

Ultimate Analysis

|          |      |
|----------|------|
| Carbon   | 74.7 |
| Oxygen   | 7.23 |
| Hydrogen | 5.23 |
| Ash      | 8.3  |
| Sulphur  | 3.29 |
| Nitrogen | 1.25 |

For the foregoing two (2) steam outputs, the following performance figures shall be stated in the proposal:

|                                                                             |                  |
|-----------------------------------------------------------------------------|------------------|
| 1. * Steam flow . . . . .                                                   | 1,000 Lbs per hr |
| 2. Heat absorbed by unit . . . . .                                          | 1,000 Kb per hr  |
| 3. Fuel as fired . . . . .                                                  | 1,000 Lbs per hr |
| 4. Weight of primary air (from secondary) . . . . .                         | 1,000 Lbs per hr |
| 5. Weight of primary air (from atmosphere) . . . . .                        | 1,000 Lbs per hr |
| 6. Weight of secondary air out of forced draft fan . . . . .                | 1,000 Lbs per hr |
| 7. Weight of secondary air out of air heater . . . . .                      | 1,000 Lbs per hr |
| 8. Weight of gas entering economizer . . . . .                              | 1,000 Lbs per hr |
| 9. CO <sub>2</sub> in gas at economizer outlet Per Cent                     |                  |
| 10. Weight of gas entering air heater . . . . .                             | 1,000 Lbs per hr |
| 11. Air leakage into gas side of air heater . . . . .                       | 1,000 Lbs per hr |
| 12. * Air leakage into unit between burners and air heater inlet . . . . .  | 1,000 Lbs per hr |
| 13. Weight of gas leaving air heater (including leakage) . . . . .          | 1,000 Lbs per hr |
| 14. *Drum pressure . . . . .                                                | Lbs per sq. in.  |
| 15. *Superheater pressure drop . . . . .                                    | Lbs per sq. in.  |
| 16. *Economizer water pressure drop (not including recirculation) . . . . . | Lbs per sq. in.  |
| 17. *Total steam temperature . . . . .                                      | Deg F            |
| 18. Gas temperature - economizer inlet . . . . .                            | Deg F            |
| 19. Gas temperature - air heater inlet . . . . .                            | Deg F            |
| 20. Gas temperature - air heater outlet (including leakage) . . . . .       | Deg F            |
| 21. Water temperature entering economizer . . . . .                         | given            |
| 22. Water temperature leaving economizer . . . . .                          | Deg F            |
| 23. Air temperature entering air heater . . . . .                           | 140 F (given)    |

\*See H - GUARANTEES

|     |                                                                               |                     |
|-----|-------------------------------------------------------------------------------|---------------------|
| 24. | Air temperature leaving air heater . . . . .                                  | Deg. F              |
| 25. | Primary air pressure at fan outlet . . . . .                                  | In H <sub>2</sub> O |
| 26. | Air draft loss through air heater . . . . .                                   | " "                 |
| 27. | Air draft loss through ducts from heater<br>to burner . . . . .               | " "                 |
| 28. | Secondary air pressure at burners . . . . .                                   | " "                 |
| 29. | *Total air pressure required at inlet of air<br>heater . . . . .              | " "                 |
| 30. | Gas draft loss through boiler and superheater . . . . .                       | " "                 |
| 31. | Gas draft loss through economizer . . . . .                                   | " "                 |
| 32. | Gas draft loss through air heater . . . . .                                   | " "                 |
| 33. | Gas draft loss through ducts from economizer<br>to air heater inlet . . . . . | " "                 |
| 34. | *Total gas draft loss from furnace to air<br>heater outlet . . . . .          | " "                 |
| 35. | Power required for coal feeders . . . . .                                     | H.P.                |
| 36. | Power required for milling and exhausting . . . . .                           | " "                 |
| 37. | Power required for air heater drive . . . . .                                 | " "                 |
| 38. | Power required for other equipment furnished<br>by manufacturer . . . . .     | " "                 |
| 39. | Power required - total . . . . .                                              | " "                 |

The following temperatures should be indicated for the 1,050,000 lbs per hour output condition, based on expected equilibrium slag deposits as maintained by the cleaning equipment furnished and when using coal, oil or gas.

|     |                                                                     |        |
|-----|---------------------------------------------------------------------|--------|
| 40. | Temperature of gas leaving primary furnace . . . . .                | Deg. F |
| 41. | Temperature of gas entering first convection<br>tube bank . . . . . | Deg. F |
| 42. | Temperature of gas entering superheater . . . . .                   | Deg. F |

For the 1,050,000 and 790,000 lbs per hour output conditions and when burning the test coal the distribution of ash discharged from the unit should be indicated. Items 43 and 44 should total 100%.

\* See H - GUARANTEES

43. Percentage of total ash discharged through furnace  
---bottom (By weight) . . . . . %
44. Percentage of total ash leaving boiler with the  
flue gas (By weight) . . . . . %
45. Percentage of carbon (by weight) in ash leaving boiler  
with flue gas . . . . . %
46. Maximum dissolved solids content of incoming feed  
water which can be allowed without impairment of  
guaranteed performance in Section "E" . . . . . Ppm

The heat balance of the unit shall be given, using the same outputs as above. Air conditions shall be assumed to be as follows:

Temperature . . . . . 80 F      Humidity . . . . . 60%

The following items are to be included in the heat balance:

1. Heat input in fuel as fired . . . . . 1,000 kB
2. Heat loss due to unconsumed combustible in ash  
pit . . . . . Per Cent
3. Heat loss due to unconsumed combustible in flue  
dust . . . . . " "
4. Heat loss due to incomplete combustion of carbon  
(CO Loss) . . . . . " "
5. Heat loss due to dry gas at boiler outlet . . . . . " "
6. Heat loss due to unconsumed hydrogen and hydro-  
carbons at boiler outlet . . . . . " "
7. Heat loss due to moisture in air and water from  
combustion of hydrogen . . . . . " "
8. Heat loss due to radiation and unaccounted for shall  
be assumed to be . . . . . 2.0%
9. Total losses . . . . . Per Cent
10. \*Efficiency of steam generating unit . . . . . " "
11. Heat absorbed by steam generating unit . . . . . 1,000 kB

\* See H - GUARANTEES

H - GUARANTEES

The Contractor shall guarantee the performance of the generating units for 1,050,000 lbs per hour and 790,000 lbs per hour steam flow operation as covered by the items under G - PERFORMANCE that are marked with an asterisk, and when burning either coal, oil, or gas.

The Contractor shall guarantee the ability of the generating unit to produce a steam output of 1,200,000 lbs per hour continuously.

The Contractor shall guarantee, in accordance with the operating conditions stated in these specifications, including the 1,200,000 lbs. per hour output condition, that the saturated steam shall have a maximum solid concentration of one ppm when the boiler concentration is equal to 1000 ppm. The moisture content of steam entering the superheater shall be no greater than 1/2 of 1% when the boiler water concentration agrees with that stated above.

The Contractor shall specify in his proposal the method of measuring the solids concentration in the steam.

I - ACCEPTANCE TESTS

After the steam generating equipment has been placed in operation it shall be tested by the Company in accordance with the latest A.S.M.E. Test Code for Stationary Steam Generating Units, at a time mutually agreed on between Contractor and Company.

The basis of all heat calculations shall be the 1936 edition of "Thermodynamic Properties of Steam" by Keenan and Keyes.

ABBREVIATIONS

| <u>Symbol</u> | <u>Designation</u>                         |
|---------------|--------------------------------------------|
| F             | Temperature, degrees Fahrenheit            |
| C             | Temperature, degrees Centigrade            |
| Lb.           | Weight in pounds                           |
| psi           | Pressure, pounds per square inch, gage     |
| ppm           | Parts per million                          |
| Btu           | British thermal units                      |
| KB            | 1,000 Btu per hour                         |
| deg.          | degrees                                    |
| in.           | Inches                                     |
| Kw            | Kilowatts                                  |
| Kwh           | Kilowatt hours                             |
| Hp or hp      | Horsepower                                 |
| ntp           | Normal temperature and pressure            |
| rpm           | Revolutions per minute                     |
| S.A.E.        | Society of Automotive Engineers            |
| A.I.E.E.      | American Institute of Electrical Engineers |
| A.S.M.E.      | American Society of Mechanical Engineers   |
| A.S.T.M.      | American Society for Testing Materials     |
| A.S.A.        | American Standards Association             |
| cu. ft.       | Cubic feet                                 |
| lbs. ft.      | Pounds feet                                |

**Analysis of Liquid Fuels Showing Characteristics of Typical Gas Oils,  
Bunker "C" Oil (Heavy)**

**For Proposed Boiler No. 10 - Astoria Station**

|                                        |                   |
|----------------------------------------|-------------------|
|                                        | <u>Bunker "C"</u> |
| A.P.I at 60 F                          | 13.0 - 14.5       |
| Viscosity, Saybolt Universal, at 100 F | -                 |
| Furol at 122 F                         | 150 - 300         |
| Carbon residue, % by Wt                | 10.5 - 13.00      |
| Water and sediment, %                  | 0.80 - 1.50       |
| Four point, F                          | +65               |
| Flash point, F                         | 200               |
| Btu/gal.                               | 149,000           |

**Ultimate Analysis**

|                 |       |
|-----------------|-------|
| Carbon, % by wt | 86.30 |
| Hydrogen        | 11.30 |
| Sulphur         | 2.30  |
| Nitrogen        | 0.30  |
| Ash             | 0.10  |

**Distillation**

|             |      |
|-------------|------|
| I.B.P. F.   | 482  |
| 360 - 400 F | 0.0  |
| 400 - 500   | 1.0  |
| 500 - 600   | 6.8  |
| 600 - 700   | 24.2 |
| Residuum    | 68.2 |

**Expected range of characteristics of Oils**

|                                        | <u>Light</u> |             | <u>Heavy</u> |             |
|----------------------------------------|--------------|-------------|--------------|-------------|
|                                        | <u>Min.</u>  | <u>Max.</u> | <u>Min.</u>  | <u>Max.</u> |
| Gravity, A.P.I at 60 F                 | 30           | 33          | 12           | 14.5        |
| Specific at 60 F                       | 0.860        | 0.876       | 0.969        | 0.986-1.052 |
| Viscosity, <del>Saybolt</del> Univ. at |              |             |              |             |
| 122 F                                  | 35           | 150         |              |             |
| Saybolt Furol at                       |              |             | 150          | 300         |
| 122 F                                  |              |             |              |             |
| Carbon Residue, % by Wt.               | 0.20         |             | 10.5         | 20          |
| Water and sediment, %                  | 0            | 0.50        | 0.80         | 2.00        |
| Four Point, F                          | Below - 30   |             | 50           | 100+        |
| Btu per gal                            | 141,000      |             | 149,000      | 151,000     |
| Sulfur                                 | 0.75         | 1.00        | 2            | 6           |

Data on Natural Gas  
For Proposed Boiler No. 10, Astoria Station

This natural gas is from Texas and Louisiana Fields.

It will contain between 950 and 1100 Btu per cubic foot.

It will contain less than 1 grain of Hydrogen Sulfide per 100 cubic feet.

It will contain not more than 9 grains of total Sulfide per 100 cubic feet.

The specific gravity will be 0.65.

The delivered temperature will be between 0 and 90 F.