CONSTRUCTION OF THE JATIBARANG MULTIPURPOSE DAM

PACKAGE 1: JATIBARANG MULTIPURPOSE DAM INCLUDING APPURTENANT STRUCTURES

SPECIFICATION

SECTION 4. TUNNELLING

TABLE OF CONTENT

SECTION 4. TUNNELLING

4.1 UNDERGROUND EXCAVATION

4.1.1 General

a. The Contractor shall carry out all tunnelling for the diversion tunnel and for the outlet tunnel as shown on the Drawings or directed by the Engineer. The term tunnelling means all required underground excavation performed by tunnelling methods including excavation, support of excavation and stockpiling and disposal of excavated materials.

b. The Contractor shall retain an Engineer, to be approved by the Engineer, expert in underground excavation who shall be resident permanently on site during all underground excavation work. The Contractor shall include in his tender the curriculum vitae of the Engineer he purpose to employ for this purpose.

c. The Contractor shall ensure at all times that all aspects of his excavation methods and equipment comply with the regulations of the relevant Indonesian authorities and the full cost of satisfying these requirements shall be included in the rates for the applicable items in the Bill of Quantities.

d. The methods of tunnelling shall be as proposed by the Contractor in his Tender and approved in the Letter of Acceptance or as subsequently approved by the Engineer.

e. The Contractor shall submit detailed working drawings with pertinent descriptions, schedules of operation, equipment to be utilised and methods statements of all underground excavation. Items shall include drilling, mucking, transporting and hoisting equipment, methods of disposal, tunnel ventilation, lighting and drainage, groundwater control methods; steel rib and steel lagging installation procedure and shotcrete placement details. Procedures shall be in accordance with Clause 1.4 and 1.5 of the Specification.

f. A daily report, incorporating a blasting journal, shall be submitted to the Engineer each day covering the previous days work. This report shall include as a minimum:

(i) Advance of face;

(ii) Complete description of the progress of tunnelling operations including:

- Date, time and limits of significant events.
- Average rate of advance for tunnelling operations, excluding downtime.

(iii) Cross-sections and all results of any kind of survey made;

(iv) Details of rock support installed, including rock bolts, steel mesh and reinforcing fabric, steel ribs, shotcrete, reinforced concrete and any other materials used.

(v) Number and classification of men and plant engaged in each operation.

(vi) Lapsed time for moving and setting up, drilling, loading, blasting, ventilation, scaling, installation of supports, excavation and non productive work;

(vii) unusual occurrences, rock falls, zones of instability inflows of water, occurrence of gas, and details of any accident sustained by workmen.

4.1.2 Shape and Limits of Excavation

a. All underground excavation shall be made to the lines, grades and dimensions shown on the Drawings or directed by the Engineer.

b. No unexcavated material of any kind will be permitted to remain within the lines shown on the drawings.

c. The overbreak lines indicated on the drawings are the limits to which payment will be made regardless of how far the limits of the actual excavation fall outside of the overbreak lines.

d. The nature of the materials being excavated could, for subsequent excavation, make it necessary, as determined by the Engineer, to move the payment line for excavation to provide for increased thickness of concrete. The Contractor shall not be entitled to any additional compensation because of such changes other than resulting from the increased quantities due to the new positions of the payment line for excavation.

e. Any and all over-excavation performed by the Contractor for any purpose or reason, except as may be directed, and due to the fault of the Contractor, shall be at the expense of the Contractor. Unless otherwise directed or approved by the Engineer, all such over-excavation shall be backfilled with concrete or shotcrete and the cost of furnishing and placing this backfill shall be at the expense of the Contractor.

f. For each advance in the tunnels the Contractor shall survey the actual excavated profile after scaling to ensure that the profile conforms with the minimum excavation requirements and to determine the extent of overbreak. The method of survey shall be as proposed by the Contractor and approved by the Engineer. Results of all such survey shall be submitted to the Engineer.

g. The Contractor shall not carry out local widening of any excavation for his own purposes without prior approval. Where such approval is granted it will be on the express condition that the resulting over-excavation shall be completely backfilled with concrete, in an approved manner, at the expense of the Contractor. Any required support shall also be at the expense of the Contractor.

4.1.3 Classification of Rock

The rock encountered in all underground excavations shall not be classified for payment purposes.

4.1.4 Blasting

a. Blasting shall not be used for any tunnelling unless otherwise approved by the Engineer.

4.1.5 Safety

a. The safety provisions of clause 1.10 of the Specification shall apply to tunnelling

b. Work shall be performed in a manner to avoid hazards and exposure of personnel and equipment to hazardous and potentially hazardous conditions.

c. Following machine excavation, the roof and walls shall be inspected for loose material which shall be removed.

d. Support of the excavation following the completion of each drive shall be carried out in accordance with the approved method statement.

e. The Contractor shall take note that flammable and toxic gases may be present and he shall take all necessary precautions to ensure that these gasses do not become a danger.

4.1.6 Heading and Bench Excavation

a. The excavation of the diversion tunnels shall be performed using the heading and bench method of excavation unless otherwise approved by the Engineer.

b. The permitted maximum lengths of headings and benches will be as proposed by the Contractor and approved by the Engineer depending upon the need to provide close support to the tunnel crown and the maximum lengths of advance determined during tunnelling.

4.1.7 Tunnel Markers

The Contractor shall maintain an up-to-date system of chain ages marked on the tunnel walls every 25 m. The markings shall be clear and painted in an approved colour and shall not lag more than 50 m behind the tunnel face.

4.1.8 Measurement

Measurement, for payment, of Underground Excavation for Diversion Tunnel and Underground Excavation for Outlet Tunnel (Items D 1.1 and D 1.2) shall be made of the in-situ volume of actual material excavated up to the limit of the overbreak line for excavation shown on the Drawings and will be made along the centreline of the excavation between the limits of excavation shown on the Drawings or directed by the Engineer.

4.1.9 Payment

a. The rates in the Bill of Quantities for Underground Excavation shall include all labour, equipment and materials required for excavation within the specified limits, removal and disposal of excavated materials, water control, ventilation, heading and benching, the development and testing excavation methods and all other work necessary for excavation in the tunnels as shown on the Drawings. These rates shall also include for excavation cycles times to suit the installation of support required in the various sections of each of the tunnels.

b. Payment for Underground Excavation for Diversion Tunnel (Items D 1.1) will be made at the rate per cubic meter tendered therefor in the priced Bill of Quantities

c. Payment for Underground Excavation for Outlet Tunnel (Items D 1.2) will be made at the rate per cubic meter tendered therefor in the priced Bill of Quantities

4.2 LIGHTING AND VENTILATION UNDERGROUND

4.2.1 Lighting Underground

a. Lighting shall be in accordance with the requirements of Sub-Clause 1.10.2.4 of the Specification.

4.2.2 Ventilation Underground

a. The air breathed by persons in underground excavations shall contain not less than 17 percent of oxygen and shall not contain a concentration of contaminants such as gases, vapours and dust greater than is safe for their health, having regard to the effects of time, temperature, humidity and the combined effects of several contaminants. The air shall not contain more than 5 mg/L of nitrous fumes, measured as nitrous oxide, for longer than 10 minutes after each blast, 30 mg/L of nitrous fumes as an absolute maximum, 100 mg/L of carbon monoxide as an absolute maximum or 5,000 mg/L of carbon dioxide as an absolute maximum. Concentrations of fumes in excess of 5 mg/L of nitrous fumes, 100 mg/L of carbon monoxide and 5,000 mg/L of carbon dioxide will be allowed within a distance of 3 m of the point of discharge of fumes from internal combustion engines provided that no plant operator or workman strays within range of the excess concentrations.

b. The Contractor shall be responsible for obtaining all information necessary to determine what concentrations of contaminants are harmless and his attention is directed to the Committee on Threshold Limits (American Conference of Governmental Industrial Hygienists).

c. The ventilation system shall be of sufficient capacity to maintain an air velocity of not less than 15 m/min in the underground excavations. Particular care shall be taken to prevent the stagnation of air. The design of the ventilation system shall provide for the size and design of all equipment to be used as well as for the safe hygienic limits for exposure of employees to any multiple toxic and objectionable gases that may occur in the underground excavations. The design of the system shall be submitted, for approval, at least 60 days before its installation.

d. During excavation, the ventilation system shall be an exhaust system. The ventilation pipe, or fan lines, shall terminate not more than 30 m from the face. Intermediate fans attached to the main exhaust line shall be provided as required to ensure satisfactory removal of contaminated air. During mucking, muck piles shall be continuously watered to prevent dust hazards.

e. For each person working within the underground excavations, a minimum amount of 3 m^3/min of fresh air shall be provided.

f. If diesel-powered equipment is used in underground excavations, the minimum quantity of fresh air to be supplied shall be 3 m^3/min for each kW of power employed within the underground excavation in addition to the requirements for personnel.

g. Underground use of internal combustion engines burning gasoline or liquefied petroleum gases (propane, butane, propylene, butylene) is expressly forbidden.

h. The Contractor shall submit, for approval, proof from prospective suppliers of diesel-powered equipment for use underground that the proposed equipment conforms to the requirements of the U.S. Bureau of Mines, or equal approved requirements.

i. The Contractor shall use at least 2 instruments which indicate continuously on a dial the concentration of hydrogen sulphide in locations within 150 mm of the invert of the underground excavation. These instruments shall sound a horn alarm, within hearing distance of personnel in the underground excavation, to warn when the concentration of hydrogen sulphide exceeds 10 parts per million by volume.

j. The Contractor shall provide separate instrumentation for monitoring the concentration of flammable gases within 300 mm of the crown of the underground excavation. The Contractor shall also provide at least two instruments which indicate continuously on a dial the percentage concentration of flammable gases prevailing in at least two locations within the underground excavation as determined by the Engineer. An alarm horn and danger light system shall be provided to warn personnel at working areas in the underground excavation when the concentration of flammable gases reaches or exceeds the lower explosive limit. The lower explosive limit for methane shall be taken as 5 percent.

k. All instruments for the monitoring of gas concentration within the underground excavation shall be provided by the Contractor and shall be certified and calibrated by an approved testing laboratory.

l. The Contractor shall install, outside each portal in use as access to a working face during drilling and blasting operations, an approved automatic lightning detection and alarm system. When atmospheric electrical activity in the vicinity of the portals reaches danger levels and the alarm is activated, all blasting operations shall be suspended until such electrical activity again reaches safe levels.

4.2.3 Payment

The cost of all work required by this Sub-Clause shall be included in the rates tendered in the Bill of Quantities for the items for underground excavation.

4.3 CONTROL AND REMOVAL OF WATER FROM UNDERGROUND EXCAVATIONS

4.3.1 General

a. The requirements of Section 2, Water Control shall apply to tunnelling work in addition to the following.

b. The Contractor shall be deemed to have familiarised himself with the groundwater conditions in the general area of the underground excavations.

c. The Contractor shall construct and maintain such intercepting works, including pumps, as may be necessary to prevent surface water from entering the underground excavations.

d. The Contractor shall supply, install, maintain and operated all necessary diversion, pumping and other equipment to remove water from the underground excavations, and shall discharge diverted and pumped

water to the surface in accordance with the drainage provisions of the Water Control Plan in accordance with Clause 2.2.

e. Where water bearing seams or broken ground yield any considerable quantity of water, the Engineer may direct that these seams or broken ground be grouted to reduce the flow of water into the underground excavations, and the Contractor shall not be entitled to any change in the rates for excavation or to extension of time on account of such a direction.

f. Where water bearing seams or broken ground occur, a means of relieving or controlling the flow of water into the tunnel, such as relief hoses, shall be provided before shotcreting or installation of concrete lining. Care shall be taken to avoid plugging relief hoses or other diversion elements during shotcreting or concreting operations.

g. The Contractor shall make every effort throughout the excavation of the tunnels and construction of the lining to prevent water from flowing, ponding or coming in contact with the excavated rock formations, some of which may be sensitive to moisture change causing deterioration. All softened rock in the invert shall be removed and replaced by concrete.

4.3.2 Payment

Separate payment will not be made for removing water from underground excavations and all costs incurred to meet the requirements of this Clause shall be included in the rates tendered in the Bill of Quantities for underground excavation.

Payment for grouting to control water as directed or approved by the Engineer will be paid for in accordance with Section 5.

4.4 DISPOSAL OF EXCAVATED MATERIAL

Materials excavated from tunnel excavations shall be disposed of, used for embankment or other construction or stockpiled in accordance with Sub-Clause 3.4.2.

4.5 SUPPORT OF UNDERGROUND EXCAVATION

4.5.1 General

a. The underground excavations for the diversion and outlet tunnels shall be supported in the manner shown on the Drawings or as directed or approved by the Engineer.

b. The methods of support shall be in accordance with this clause 4.5

c. Reinforced concrete lining is specified elsewhere in the Specification.

4.5.2 Support of Underground Excavations

a. The method of support of underground excavations shall be as shown on the Drawings and as approved or directed by the Engineer and shall consist of shotcrete, steel ribs, steel mesh, rock bolts and, in the case of the diversion tunnel, reinforced concrete lining.

b. The construction of the support system shall not lag behind the face by more than the distance in the approved method statements for each tunnel.

c. The Contractor shall maintain, on the site, an adequate supply of the various support elements for the execution of the work.

d. General requirements for support of underground excavations shall be in accordance with Clause 7..1

e. Shotcrete shall comply with the requirements specified in Clause 7.2

f. Rock Bolts shall comply with the requirements specified in Clause 7.3

g. Steel Mesh Reinforcement shall comply with the requirements specified in Clause 7.5

h. Steel Ribs shall comply with the requirements specified in Clause 7.7

4.5.3 Payment

Payment for the various elements of support used will be made under the respective payment clauses in Section 7.

4.6 CONCRETE WORK IN TUNNELS

Concrete work in the tunnels, including concrete lining, placement of concrete plug in diversion tunnel, placing concrete around steel conduit in outlet tunnel, is specified in Section 9.

CONSTRUCTION OF THE JATIBARANG MULTIPURPOSE DAM

PACKAGE 1: JATIBARANG MULTIPURPOSE DAM INCLUDING APPURTENANT STRUCTURES

SPECIFICATION

SECTION 5. DRILLING AND GROUTING

TABLE OF CONTENTS

SECTION 5. DRILLING AND GROUTING

5.1 GENERAL

a. The Contractor shall perform drilling and grouting operations of the types and in the locations as generally described below and as directed by the Engineer:

   (i) Curtain Grouting below the dam embankments, abutments and the spillway and around the diversion tunnel and the outlet tunnel

   (ii) Blanket Grouting under the impervious zone of the dam embankment

   (iii) Consolidation Grouting under the spillway and for the diversion tunnel and outlet tunnel.

b. Drilling and curtain grouting shall be performed from the internal gallery for the zone below the dam body and from the surface for the abutments and spillway.

c. Drilling for curtain grouting and consolidation grouting for diversion and outlet tunnels shall be performed from within the respective tunnels.

d. Drilling and grouting of other areas shall be carried out from the ground surface. Blanket grouting shall be carried out prior to removing the final 1 m depth of surface excavation as specified in Clause 3.4

e. Curtain grouting shall be carried out after the progress of the construction of the dam embankment has reached a height of more than 10 m.

f. Drilling and grouting works shall be carried out as specified in this Section 5.

5.2 DRILLING - GENERAL

5.2.1 Requirement for Drilling

a. The Contractor shall perform the following drilling operations in the locations shown on the Drawings or directed by the Engineer :

   (i) Drilling for curtain, blanket and consolidation grouting for the parts of the works as generally described in Clause 5.1, as shown on the Drawings and elsewhere as directed;

   (ii) Drilling investigation holes;

   (iii) Drilling at other locations as shown on the Drawings or directed.

b. During the course of the work, the Engineer will direct the Contractor to core drill vertical and sloping holes in accordance with Clause 5.3. Such core holes shall, where directed by the Engineer, be water tested in stages as the drilling progresses in accordance with Clause 5.7.

5.2.2 Location and Method of Drilling for Grout Holes

a. The location, direction, angle and length of holes and their reference numbers will be as shown on the Drawings or as determined by the Engineer who may at any time increase or decrease the number of holes or instruct drilling to a greater or lesser depth or instruct drilling to a

different angle and direction. The order and timing in which holes are drilled shall be as instructed or approved by the Engineer.

b. If foundation rock conditions as revealed by the excavation, drilling, testing and grouting operations, indicate that grouting at greater depths or closer spacing or in other locations than those shown on the Drawings is necessary, the Contractor shall drill holes to such depths and spacings as directed by the Engineer.

c. The quantity of grout hole drilling that will be required is uncertain and the Contractor shall not be entitled to any extra compensation above the unit rates and prices tendered in the Bill of Quantities by reason of the location and timing of the required drilling or by reason of changes in angles and directions of the required drillings.

d. All drilling shall be carried out by rotary drilling. Pilot and check drilling holes shall have a minimum diameter of 66 mm. Other grout holes shall have a minimum diameter of 46 mm or as otherwise shown on the Drawings or directed.

e. The diameters specified shall be obtained at the maximum depth required. The equipment shall be capable of drilling holes to a maximum of 100 m depth. The drilling equipment shall be capable of drilling at any angle and be capable of being set to an accuracy of one degree.

f. Holes shall be drilled to an accuracy of three degrees of the angle of that specified but the Engineer may require certain holes to be drilled within two degrees of the specified direction. Holes shall be drilled from positions shown on the Drawings or directed with a tolerance of 250 mm.

g. All holes shall be drilled without mud-support and without the use of grease, rod-dope or other non water soluble material or the lubrication of the drill rods. The Engineer may permit the use of an additive in the drilling water. A sample of the additive shall be submitted to the Engineer for approval at least 7 days prior to its being used. The concentration of the approved additive shall not exceed the manufacturer's recommendation.

h. The Contractor shall take appropriate measures to minimize the amount of foreign matter and drill cuttings in the drill hole and from entering the hole.

i. Unless otherwise ordered by the Engineer, all holes shall, immediately after drilling, be thoroughly washed out with water under pressure from the bottom. Water flushing shall continue until the waste water runs clear.

5.2.3 Drilling Sequence for Grout Holes

a. Drilling for grouting shall be carried out only with the approval of the Engineer and after all shotcrete or concrete grout cap, if necessary, has been completed and has gained sufficient strength in each area approved for grouting.

b. Unless otherwise directed by the Engineer, when drilling blanket and curtain grout holes the first holes drilled shall be widely spaced and shall be drilled and grouted before intermediate holes are drilled and grouted, and in this manner the drilling and grouting of holes shall be completed to such final spacing as shown on the Drawings or directed by the Engineer.

c. Unless otherwise directed by the Engineer, all drilling and grouting of blanket grouting holes in an area shall be completed to such final spacing as shown on the Drawings or directed by the Engineer before drilling and grouting of curtain grout holes commence.

d. After holes in an area have been drilled and grouted, it may be found necessary to drill additional grout holes or core recovery check holes in accordance with Clause 5.3 or both. Such core recovery drilling shall be performed as may be required to determine the condition of the rock foundation prior to grouting and evaluate the effectiveness of the grouting operations.

e. The location, angle, direction and depth of these additional grout holes or core recovery check holes shall be as directed by the Engineer or as shown on the Drawings. These holes will be drilled, cleaned, water tested and grouted in the manner similar to that of the curtain grout holes. No allowance above the unit rates and prices tendered in the Bill of Quantities will be made for the drilling and grouting of such additional grout holes and core recovery holes nor for the expense of moving equipment to other locations and returning it to a previously drilled area.

f. When the drilling of each hole has been completed, it shall be protected from becoming clogged or obstructed by capping it temporarily or otherwise until grouting operations require it to be opened. Any hole that becomes obstructed before it is grouted shall be completely cleared by and at the expense of the Contractor.

g. Re-drilling required because of the Contractor's failure to clean out a hole before grout has set shall be performed at the Contractor's expense. When the grout has been allowed to set in a hole by a direction of the Engineer, the required re-drilling will be paid for at the rate of 50 percent of the unit price per linear meter tendered in the Bill of Quantities for drilling the applicable grout holes regardless of depth.

5.2.4 Drilling Holes Through Concrete

a. Except as specified elsewhere, where holes are required below or behind concrete they shall be drilled through the concrete. The grout hole drilled through concrete shall be suitably capped until the hole is grouted and any hole which becomes obstructed before being grouted shall be cleared by and at the expense of the Contractor.

b. Except as otherwise approved, contact grouting work for the spillway shall be commenced 3 weeks after placing concrete for the base of the spillway.

c. Additional grout holes and core check holes directed by the Engineer after placing concrete structures shall be drilled through the concrete, The Contractor shall make allowance for drilling through concrete and reinforcement when drilling these holes and no additional payment will be made above the applicable rates for drilling in the Bill of Quantities.

d. Where required, casing pipes shall be supplied and installed in accordance with Clause 5.9.

5.2.5 Measurement

Measurement, for payment, of Rotary Drilling Holes for Grouting (46 mm dia.) will be made of the length of holes actually drilled (i) from within the gallery, (ii) from the Surface or (iii) from within Tunnels and of the length of any grout column re-drilled at the direction of the Engineer. Holes which

cannot be used because of cave-ins, lost drill stems or packers will not be measured for payment.

5.2.6 Payment

a. Payment for Rotary Drilling Holes for Grouting (46 mm dia.) for will be made at the rate per linear meter, applicable to the situation from which the drilling was made, tendered therefor in the Bill of Quantities (Items E 2.1, E 2.2 and E 2.3). The rates shall include the cost of drilling through shotcrete or concrete as applicable

b. Payment for drill set-up will be made in accordance with the provisions of Clause 5.4

c. Payment for any required re-drilling where the grout has been allowed to set in a hole at the direction of the Engineer, will be made at the rate of 50 percent of the rate per linear meter tendered in the Bill of Quantities for drilling the applicable grout holes.

d. Payment will not be made for re-drilling required because of the Contractor's failure to wash out a hole before grout has set.

e. Additional allowance above the applicable rate tendered in the Bill of Quantities for drilling grout holes will not be made on account of the requirement for washing out holes before further drilling.

f. These rates shall include the cost of furnishing all labour, materials, plant and operations required for drilling the holes, flushing the holes at all stages maintaining the holes free from obstruction until grouted, disposal of drill cuttings and waste water all incidental works connected therewith. The rates for core drilling shall also include all works in accordance with Clause 5.3.

5.3 CORE DRILLING

5.3.1 General

a. The Contractor shall, where and as directed by the Engineer, core drill such holes as may be required for pilot holes for curtain grouting, to determine the effectiveness of the grouting operations and for surface investigation drilling as directed.

b. All core drilling shall be performed with rotary-type hydraulic feed core-drilling equipment, 66 mm minimum hole size, bottom discharge diamond bits and triple tube, swivel inner tube type core barrels. The core holes will be required to be drilled at any angle and direction and to varying depths with a maximum depth of 100 m. All equipment shall be capable of being operated in the confined and limited-access regions of the gallery, the diversion tunnel and the outlet tunnel. The Contractor shall ensure that all core drilling is performed in a workmanlike manner, by competent and experienced workmen and that cores obtained are in as good a condition as possible from all holes.

c. Drilling lifts shall be terminated and the cores removed from the barrel as often as considered necessary to secure the maximum possible amount of core. Drilling lifts shall not be longer than the length of core barrel.

5.3.2 Records

a. Within 24 hours of completing drilling of a cored hole, the Contractor shall submit in duplicate a complete log of the hole in a form approved by the Engineer. The log shall include the following data;

   (i) Location

   (ii) Borehole number

   (iii) Type and diameter of boring

   (iv) Ground level

   (v) Immediate, intermediate and equilibrium water levels with times and dates, note on colour and losses, etc

   (vi) Description and state of weathering of rock and the levels of its boundaries

   (vii) Percentage core recovery

   (viii) Fracture log

   (ix) The results and levels of all in-situ testing

   (x) A record of the driller's observations on progress of boring, rate of penetration, type of bit and speed of rotation of bit

   (xi) Water pressure test results.

b. The logging of rock cores shall be based upon the Geological Society Engineering Group Working Party Report "The Logging of Rock Cores for Engineering Purposes", Quarterly Journal Engineering Geology Vol. 3, 1970, London.

c. Cores should be logged by an approved person. The fact that the Engineer may be present and keeping a record of the drilling shall not relieve the Contractor from the requirement for keeping an accurate log as described in this Sub-Clause unless specifically approved in writing by the Engineer.

d. The Contractor shall provide strong 1.05 m long galvanized metal core boxes to the approval of the Engineer. Each box shall hold cores from 5 m of hole and they shall be provided with fastenable galvanized metal lids.

e. The Contractor shall place the cores in the core box in the correct sequence after extraction from the core barrel. The core at the bottom of each lift shall be marked immediately it has been placed in the box and a corresponding mark shall be printed on the side of the core box and on the rock core. When a core is not recovered, timber blocks of square cross-section shall be placed in the box by the Contractor. These timber blocks shall be cut to the same length as the core losses and placed in the positions from which the core was lost. If these positions cannot be determined, the blocks shall be placed at the top of the lift. A box shall not contain cores from more than one hole. Designating marks, hole numbers and elevations shall be placed on the boxes and along the line of cores as directed by the Engineer. The covers shall be fastened securely to the core boxes and the boxes shall be delivered to the Engineer's store room at the Site unless otherwise directed.

f. Cored holes shall be grouted in accordance with the requirements of Clause 5.6.

5.3.3 Measurement

a. Measurement, for payment, of Rotary Core Drilling (66 mm dia.) will be made of the length of holes actually drilled (i) from within the gallery, and (ii) from the Surface.

5.3.4 Payment

a. Payment for Rotary Core Drilling (66 mm dia.) will be made at the rate per linear meter, applicable to the situation from which the drilling was made tendered therefor in the Bill of Quantities (Items E.1.1 and E.1.2). Such rates shall include the cost of furnishing all labour, materials and equipment required for drilling the cored holes, removing cores, keeping accurate core logs, boxing, labelling and transporting the cores and all incidental work connected therewith.

b. Payment for drill set-up, water pressure testing and grouting will be made in accordance with Clauses 5.4, 5.5 and 5.6 respectively.

5.4 SET-UP FOR DRILLING HOLES

5.4.1 Measurement

Measurement, for payment, for Drill Set-Up shall be made on the basis of the number of times a drill is set up in accordance with the following provisions:

a. Where drilling and grouting is carried out by the upstage method, measurement, for payment, for drill set-up shall be made once only for each hole regardless of any additional set-ups which may be carried out by the Contractor.

b. Where drilling and grouting is carried out by the downstage method, or a combination of upstage and downstage methods, measurement, for payment, shall be made once only for each separate stage of drilling which is directed by the Engineer.

c. Where core drilling is carried out to determined the effectiveness of the grouting operations and for surface investigation drilling, measurement, for payment, for drill set-up shall be made once only for each hole regardless of any additional set-ups which may be carried out by the Contractor.

5.4.2 Payment

a. Payment for Drill Set-Up will be made at the rate per set-up tendered therefor in the Bill of Quantities (Item E.3). Such rate shall include the cost of all labour, materials and equipment and operations for the movement of drilling equipment and the setting-up of drilling equipment over the grout hole or core drill hole at the specified angle and direction.

5.5 WATER PRESSURE TEST

5.5.1 General

a. A water pressure test shall be carried out in each stage of each grout hole after washing and prior to grouting unless otherwise directed by the Engineer. Water pressure tests shall be carried out in all holes to be grouted.

b. Water pressure tests shall be carried out in stages of depth not exceeding 5 m, unless otherwise approved by the Engineer, with clean water and the rate of flow shall be determined to an accuracy of 10 percent for flows exceeding 1 litre/minute using an air vessel to smooth out fluctuations of pressure. The results shall be expressed in Lugeon units. One (1) Lugeon unit is determined by a water pressure test where a leakage occurs of 1 litre of water per minute per meter length of hole under a pressure of 10 kgf/cm².

c. Prior to carrying out the water pressure test the hole shall be washed out in accordance with Sub-Clause 5.6.5.

d. The water pressure test shall be carried out between a packer and the bottom of the hole or between packers in depth stages to suit the variation of jointing of rock.

e. For each water pressure test the pressure shall be maintained for 5 minutes at each of five pressures, which shall be 0.10 kgf/cm², 0.20 kgf/cm², 0.30 kgf/cm², 0.20 kgf/cm², 0.10 kgf/cm² per meter of depth to the bottom of the stage measured from the top of the hole at the surface or such lower figure as the Engineer may instruct. The pressure shall be determined to an accuracy of 10 per cent.

f. Should the flow be too great to hold the specified pressure, the flow shall be held constant at the maximum discharge of the pump and the pressure shall be observed at one minute intervals over a period of 10 minutes. If the results do not give an adequate indication of the required grouting, the tests shall be repeated using two or more shorter stage lengths.

5.5.2 Measurement and Payment

a. Measurement, for payment, of Wash and Water Pressure Testing shall be made once only for each water pressure test of a stage of a hole for which water testing is directed by the Engineer regardless of the number of times that water under pressure is applied to the hole or reapplied following caulking surface leaks or because of any other reason which prevents a satisfactory test being completed at the first attempt.

b. Payment for Wash and Water Pressure Testing of each stage of a hole will be made at the rate per test tendered therefor in the Bill of Quantities (Item E.4). This rate shall include the cost of all labour, materials and equipment required to perform the work set out in this Clause and the cost of provision of water testing records as set out in Clause 5.7.

c. Payment for hook-ups to holes for water pressure testing will be made in accordance with Clause 5.8.

5.6 PRESSURE GROUTING

5.6.1 Requirement for Grouting

a. The Contractor shall carry out all of the grouting operations as described in Clause 5.1.

b. The operations, including the type of drilling and grouting equipment, shall be in accordance with the proposals submitted by the Contractor in his tender and approved in the Letter of Acceptance or with such other modifications as may be approved from time to time.

c. The Contractor shall carry out approved laboratory tests on the proposed grout mixes to determine viscosity, cohesion, sedimentation and strength of the grout at various times after setting. The testing will be carried out in consultation with and in the presence of the Engineer. The results of the testing shall be submitted to the Engineer and only approved mixes shall be used.

d. Drilling and grouting operations shall be performed in accordance with the Drawings, the requirements of this Section of the Specification and with procedures developed by the Contractor during testing and with regard to experience as the work proceeds. The procedures shall be submitted to the Engineer for approval.

e. These procedures shall embody the Contractor's recommendations on both the type and composition of the grout and the injection pressures to be used after determination by the Contractor of the basic parameters of the rock including permeability and jointing pattern.

f. It is anticipated that the majority of the grout will be of the cement and water type.

g. The Engineer may direct the addition of fine aggregate to cement grout where rock is disturbed or contains large voids.

h. The Contractor shall use grout proportions and injection pressures as nominated in the procedures approved by the Engineer and the Contractor shall be responsible for control of those grout proportions and injection pressures.

5.6.2 Mixing and Pumping Equipment

a. Grouting shall generally be carried out from stations which shall contain stores for grouting materials, batching plant, grout mixers, holding tanks, and grout pumps. Such stations may be relocated from time to time depending on site conditions and the location of grouting operations.

b. The arrangements shall be such as to ensure the continuous and uninterrupted flow of grout to the hole being injected and shall include standby equipment capable of being brought into use immediately in the event of a breakdown. The grouting shall be carried out by a return flow system to ensure continuous circulation of grout to the hole being injected and return surplus which is not accepted by the hole to the holding tank.

c. Each grouting unit, including the mixing equipment, pump, hoses and pipelines shall be capable of delivering not less than 150 litres of liquid grout per minute to each hole being injected up to a maximum pressure of 30 kgf/cm² and shall include a water storage tank of adequate capacity to be used for pressure testing and for flushing out the pumps.

d. Two compartment, high-speed, colloidal mixers shall be used. The grout shall be mixed in one compartment and be discharged into a holding tank. A screen shall be inserted between the holding tank and the suction of the pump. The grout in the holding tank shall be continuously agitated. A water meter shall be provided for the accurate measurement of the water to be used for mixing. The holding tank shall be provided with a volume measure indicator to enable a record of grout take to be made.

e. All grout shall be pumped with a screw or other approved type of pumping equipment arranged with interconnecting pipes and valves in

such a way as to permit a standby pump to be brought into immediate service. The pumping equipment shall be capable of forcing grout into the holes or grout connections in a continuous, uninterrupted flow at any specified pressure up to a maximum of 30 kgf/cm² with only minimum fluctuations in pressure during the pump cycle being permissible. The grouting equipment shall be arranged to provide a supply line and a return line from the grout pump to the grout hole. Provision shall be made to permit accurate control of grouting pressures and of grout flow into the grout holes and continuous circulations of grout within the grouting system. The grouting pipeline shall be provided with an automatic recorder for monitoring the flow quantity, pressure and time of discharged grout at the pump and at each grout connection to the grout hole. The Contractor shall provide and keep at the site spare charts for the automatic recording equipment equal to thirty percent (30%) of the required number for ordinary daily operation.

f. Pressure gauges shall have an accuracy of plus or minus 3 percent.

g. A standardised gauge shall be provided for calibrating working gauges. Working gauges shall be used for no longer than two shifts after which time they shall be cleaned and calibrated. All working gauges, water meters and automatic recorders shall have permanently inscribed reference numbers for identification. Tests on gauges, meters and automatic recorders used in connection with drilling and grouting shall be carried out by the Contractor as required by the Engineer.

h. The Contractor shall arrange to have available on Site an adequate number of water meters, pressure gauges and automatic recorders correctly calibrated so that water pressure testing and grouting operations are not held up at any time due to the lack of accurate calibrated equipment.

i. Packers shall be such that they seal drill holes at the specified level and shall be capable of withstanding water pressure exceeding the maximum grout or water pressure to be used at the level without leakage. The Contractor shall have available on site an adequate supply of packers of a size and type to suit the different holes being used.

j. The total length of pipe and hose between the hole being grouted and the pump shall be kept to a minimum and shall not exceed 60 m without approval.

k. A valve, bypass valve on the return line, bleeder valve, and pressure gauge shall be fitted at the collar of a hole being grouted in conjunction with the automatic recorder.

l. Communication facilities between the grout plant and the grout holes or grout connections being grouted shall be furnished by the Contractor.

5.6.3 Materials for Pressure Grouting

a. Cement used in pressure grouting shall comply with the requirements of Clause 9.3.

b. Fine aggregate for grout shall be clean and of such fineness that 100 percent will pass a No. 8 (2.5 millimeter) screen, not less than 50 percent will pass a No. 30 (0.6 millimeter) screen and not more than 5 percent will pas a No. 200 (0.074 millimeter) screen. The ratio of cement to fine aggregate shall be directed by the Engineer.

c. The grout mixtures will be as selected by the Engineer but will generally consist of a water cement slurry with the water cement ratio by mass varying from 10, 8, 6, 4, 2, 1 and 0.5.

d. Water having a temperature above 30°C shall not be used in grouting operations. The use of water at a temperature not exceeding 30°C is designed to limit the temperature rise in the grout during the grouting operation. The Contractor's attention is drawn to the need to provide shelter from effects of hot weather and wind for the stored cement, water and grout lines and the other equipment handling the grout. Recommendations for hot weather concreting are contained in ACI 305 Title No. 74-33 and the Contractor shall adopt any of these recommendation applicable to grouting.

e. The Contractor shall use only stable grouts and injection pressures as approved or directed by the Engineer and the Contractor shall be responsible for control of grout proportions and injection pressures.

f. Cement grout which is not injected within two hours shall not be used for grouting.

g. Cement grout without chemicals (other than water) shall be measured on the basis of the actual quantities injected excluding waste due to leakages or other reasons.

5.6.4 Grouting Methods

a. Drilling and grouting of the foundations shall be performed as follows:

   (i) Consolidation grouting holes shall be carried out in one (1) stage with a packer (or a sealed nipple) installed at the surface of the concrete. If the geological conditions require, the grouting of some holes will be carried out in stages.

   (ii) Curtain and blanket grouting shall be carried out using either upstage or downstage grouting methods or a combination of these two methods with a packer installed within the hole at the top of the stage being grouted or with either a packer (or a sealed nipple) installed within the concrete grout cap or shotcrete and rock. The maximum length of each stage shall be 5 m

b. Grouting each sequence of blanket grouting holes in an area shall be carried out from the outer most rows, upstream and downstream, and be completed progressively row by row towards the axis of the dam.

c. Blanket grouting and curtain grouting shall be started by the drilling of the pilot holes as shown on the Drawings or directed. Secondary, tertiary and quaternary holes or where a further series of closure holes are necessary shall be as shown on the Drawings or directed by the Engineer. No holes of subsequent series shall be drilled until grouting has been completed to full depth in adjacent holes of a previous series.

d. The one stage grouting shall be performed by connecting the grout supply pipe to the connecting coupling on the packer or nipple.

e. For the upstage method the drilling and grouting of the foundations shall be performed in successive operations consisting in each case of:

   (i) drilling the hole to its required final depth;

   (ii) washing under pressure;

(iii) installing a packer into the hole at the top of the lowest stage, water testing and grouting that stage;

(iv) allowing the packer to remain in place until there is no back pressure and then installing the packer at the top of the next stage;

(v) and thus successively water testing and grouting the hole in stages until the hole is completely grouted.

f. Wherever the downstage method is considered appropriate by the Engineer, the drilling, cleaning, water testing and grouting shall be performed in successive operations consisting in each case of drilling the hole to a limited depth, washing under pressure, water testing and grouting that section, cleaning out the grout hole by washing or other suitable means before the grout in the hole has set, sufficiently to require re-drilling, allowing the grout surrounding the grout hole to attain its initial set, drilling the hole to an additional depth, washing under pressure, water testing and grouting by seating a packer near the end of the previously grouted stage, and thus successively drilling, cleaning, water testing and grouting the hole in stages at various depths until the required depth of hole is completely drilled, cleaned, water tested and grouted. Where necessary the Engineer may direct that the grout in the hole be allowed to set before drilling the next stage. On completion of grouting the last stage the hole will then be filled by grout using the upstage grouting method without water testing.

g. Pressure grouting of any part of the foundations shall not be carried out until all excavation and drilling has been completed within 30 meters of the holes to be grouted, and any concrete or shotcrete through which the grout holes extend is at least 14 days old.

h. The composition of the grout, the time of grouting and all other details of the grouting operations shall be as approved or determined by the Engineer. In general the grouting of each stage shall commence with a lean grout of a type most likely to penetrate the rock, according to the jointing, etc. of the rock and the result of the water pressure test, with the grout pressure being increased toward the maximum grout pressure prescribed below.

i. Pressure as high as practicable but which, as determined by trial, are safe against concrete, shotcrete or rock displacement, shall be used in the grouting. Except as specifically ordered by the Engineer, the grouting pressure shall not exceed 20 kgf/cm² and the grouting speed shall be 2 to 6 litres/minute/meter of grout hole.

j. All pressure grouting operations shall be performed in the presence of the Engineer.

k. The grout supply pipes and packers shall be furnished by the Contractor. The packers shall consist of expandable tubes or rings of rubber, leather or other suitable material attached to the end of the grout supply pipe. The packers shall be so designed that they can be expanded to seal the drill hole at the specified elevations and, when expanded, shall be capable of withstanding, without leakage, water pressure equal to the maximum grout pressure to be used.

5.6.5 Washing and Testing

a. Immediately before the pressure grouting of each of any hole is commenced, the hole shall be thoroughly washed with water or air or both under pressure and pressure-tested. When washing, at least the nearest two holes of the same sequence in advance and the adjacent holes of next sequence, if any, shall be completely drilled for the same stage, and completely cross-washed to facilitate washing and flushing out of any intervening clay-filled seams, fractures, or shear zones.

b. All holes sufficiently tight to build up the required test pressure shall be washed at the test pressure and the washing shall continue as long as there is any increase in the rate at which water is taken. Holes in which the required test pressure cannot be reached shall be washed for as long as there is any increase in the rate of flow or drop in pressure when the pump is delivering a full capacity flow. Open holes in which no pressure can be built up shall be washed for such period of time as fracture-filling material is being removed, as determined by the escape of muddy water through surface openings or other grout holes or as directed by the Engineer.

c. Routine water testing of grout holes shall be made prior to grouting in accordance with Clause 5.5.

5.6.6 Leakage Control

a. If, during the grouting, grout is found to flow from adjacent grout holes or connections in sufficient quantity to interfere seriously with the grouting operation or to cause appreciable loss of grout, such grout holes or connections shall be capped temporarily. When grouting is being done with packers and grout returns from adjacent holes, the pressure of the returning grout shall be measured by seating packers in the adjacent holes and such pressures shall be kept below the allowable pressures for that stage of that hole. Where such capping is not essential, ungrouted holes shall be left open to facilitate the escape of air and water as the grout is forced into other holes. Before the grout has set, the grout pump shall be connected to adjacent capped holes and to other holes from which grout flow was observed and grouting of all holes shall be completed at the pressure directed by the Engineer.

b. If, during the grouting of any hole, grout is found to flow from points in the rock surface, or joints in or adjacent to concrete or shotcrete grout cap or other locations, such flows or leaks shall be plugged or caulked by the Contractor. As a safeguard against rock, concrete or shotcrete, displacement, or while grout leaks are being caulked, the Engineer may require the reduction of the pumping pressure, or the discontinuation of pumping.

5.6.7 Grouting Time and Pressure

a. The general targets for permeability of the grouted foundation of the dam, embankments and spillway are 10 Lugeons for blanket grouting and 5 Lugeons for current grouting.

b. The grouting operation shall start by employing a thin dilution of grout mixture of W/C by mass = 10, unless otherwise specified or directed by the Engineer, at the required pump speed and continue until the quantity of grout as mentioned below is injected or the injection pressure does not increase at all for 20 minutes.

W/C ratio by mass	10	8	6	4	2	1
Quantity of Grout per Stage (litre)	400	400	400	400	400	1000

c. When the specified grout is injected without reaching the maximum pressure for the stage of the hole, the injection shall be continued using the next thicker grout.

d. The grouting of any hole or stage of any hole shall be a continuous operation until the hole, stage, or grout connection takes grout at the rate of less than 5 liters of grout mixture in twenty minutes if pressures of 3.5 kg/cm² or less are being used; in fifteen minutes if pressures between 3.5 and 7 kg/cm² are being used; in ten minutes if pressures between 7.0 and 14.0 kg/cm² are being used, and in five minutes if pressures in excess of 14.0 kg/cm² are being used. However, as a safeguard against rock, shotcrete or concrete displacement, excessive grout travel, or while grout leaks are being caulked, the Engineer may require the reduction of the pumping pressure and pumping speed of the discontinuance of pumping. In such case, the specified maximum grouting pressure may be changes by the Engineer. The Engineer may order the establishment of level reference points, upheavel gauges, etc to be observed as a check against uplift. Any possible movement shall be taken as an indication that the grouting pressure being used is excessive and it shall be immediately relieved.

e. Where the grout hole or holes take a large amount of grout, the Engineer may require that pumping be done intermittently, waiting for some period of time before resuming the grouting operation so as to allow grout in the formation to set, or require that fine aggregate be added to the grout mix. The requirements for fine aggregate in such case shall be in accordance with Clause 5.6.3.

f. After the grouting of each stage of every hole is completed, the pressure shall be maintained by means of grout hole valves or other suitable valve or other suitable valve devices until the grout has set sufficiently so that it will be retained in the hole, stage or connections being grouted.

5.6.8 Measurement

a. Measurement, for payment, of blanket, consolidation and curtain grouting will be made on the basis of the mass of cement and of fine aggregate before mixing with water, actually forced into the holes. In case of fine aggregate, the mass shall be the oven dry mass.

5.6.9 Payment

a. Payment for cement and fine aggregate used in pressure grouting will be made at the applicable rate per tonne tendered in the Bill of Quantities (Items E.5 and E.6) and shall include all costs for supplying, mixing and injecting cement, and fine aggregate in accordance with this Clause and carrying out all testing of grout mixes as specified herein and sampling and recording as required by Clause 5.7.

b. Payment for water testing grout holes will be made as provided in Clause 5.5.

c. Payment for setting up for drilling and hooking up for grouting grout holes will be made as provided for in Clauses 5.4 and 5.8 respectively.

d. Payment will not be made for grout lost due to improper anchorage of grout pipes, packers, casings or connections, for grout rejected by the Engineer on account of improper mixing, for grout wasted in excessive length of grout lines or for grout lost by leakage due to the failure of the Contractor to immediately and effectively caulk leaks, and payment will not be made for materials used in such grout.

e. Separate payment will not be made for supply and installation at level reference points, upheaval gauges, etc. and measurements associated therewith and such costs shall be deemed to be included in the applicable rates for grouting tendered therefor in the Bill of Quantities.

5.7 RECORDS FOR GROUTING AND WATER TESTING

5.7.1 General

a. The Contractor shall, within 24 hours of completion of water pressure tests or grouting of any hole, submit in duplicate and in a form approved by the Engineer a record of the grouting and water pressure tests. The record shall include the following data:

(i) The location and reference number of holes grouted and the lengths of stages, level of grout pump and collar of holes;

(ii) Water pressure test results including details of pressures, volumes of water used, timing of each operation, permeability values and graphical records of the tests;

(iii) Details of grout injections, pressures, consistencies, quantities, Marsh cone type test result for viscosity determination and timing for each stage of the grouting;

(iv) Proportions of the grout materials;

(v) General remarks on the procedure of the grouting, surface leaks and connections to other holes, if any, and heaving, if any.

b. When directed by the Engineer, the Contractor shall supply grout samples 0.5 kg in mass taken from any point in the grouting system.

c. Within 30 days of completing grouting of a section of the Works, the Contractor shall submit a report in duplicate, complete with record drawings in approved form showing details of the grouting in that section and any conclusions which he or his subcontractor may have reached regarding the methods used and the effectiveness of the grouting including all additional grout holes and core recovery check holes directed.

5.7.2 Measurement and Payment

Separate payment will not be made for the preparation and submission of records for grouting and water testing in accordance with the requirements of this clause and the costs of completing the work shall be included in other rates and lump sum prices in the Bill of Quantities.

5.8 HOOK-UP TO HOLES FOR GROUTING

5.8.1 Measurement and Payment

a. Payment for hook-up to holes and connections for grouting will be made at the rate per hook-up tendered therefor in the Bill of Quantities (Item E.7).

b. Except as provided in Sub-item c below, payment will be made once only for each stage of a hole actually hooked onto at the direction of the Engineer for the purposes of washing, pressure testing and grouting.

Payment will be made, regardless of the volume of grout or water actually injected into the hole or stage for the connection. Payment will be made for any stage water tested but not grouted from that stage. Payment will be made for each separate stage of a hole whether upstage or downstage methods are used.

b. Should the Engineer defer the grouting of any stage following a water test, then payment for an additional hook-up will be made for any subsequent packer setting and grouting regardless of the number of stages that may be grouted from the one packer setting.

c. Connections to cracks, crevices or seams in the rock when directed by the Engineer, will be considered as grout holes and will be paid for as such.

5.9 CASING PIPES

5.9.1 General

a. The Contractor shall furnish and install standard black pipe for casing pipes to support the loose ground where required to drill through overburden of common or unsound rock and shall supply drilling equipment suitable for such drilling purpose.

b. Pipes for grouting shall also be set over springs, crevices in the rock, faults or other defects wherever directed by the Engineer.

5.9.2 Materials

a. Casing pipe shall be standard black pipe conforming to ASTM A 120 Schedule 40, JIS G 3452 or approved equivalent.

b. Pipe fittings shall be malleable iron. The pipe shall be cut, threaded if necessary, fabricated as required, and placed by the Contractor.

5.9.3 Installation

a. The diameter of casing pipes for consolidation and curtain grouting shall have an inside diameter adequate to accommodate the drill bit size necessary to drill holes of the specified diameter.

b. The lengths of pipes shall be equal to the depth of overburden encountered or as directed. Generally the pipes shall be from the surface of the ground as existing or as excavated to the level of non-collapsing rock.

c. Each casing pipe shall be sealed in the ground with grout or mortar.

d. Care shall be taken to avoid clogging or obstructing the pipes before performing grouting operations. Any pipe that becomes clogged or

obstructed from any cause shall be cleaned in an approved manner or replaced by and at the expense of the Contractor.

5.9.4 Measurement and Payment

a. Measurement, for payment, for furnishing and placing casing pipes for drilling and grouting shall be made of the mass of pipe installed at the direction or approval of the Engineer. Fittings for connections of grout lines will not be measured for payment.

b. Payment for casing pipes used in drilling for grouting will be at the rate per tonne tendered in the Bill of Quantities (Item E.8) and shall include all costs for supplying, fabricating and installing during drilling and all other works connected therewith.

5.10 TUNNEL PLUG GROUT SYSTEM

5.10.1 General

a. The grouting of the joints between concrete placements in the diversion tunnel plug and the existing concrete lining shall be performed as soon as possible after the final concrete placement in each tunnel plug has cooled to the temperature specified in Sub-Clause 9.11.1 but not less than 30 days. Cooling shall be carried out in accordance with the provision of Sub-Clause 9.11.1.

b. A system of pipes, fittings and special grout outlets shall be installed before placing concrete for the diversion tunnel plugs at the locations shown on the Drawings or directed. The special grout outlets shall be pipes set in holes drilled into the existing tunnel concrete lining to the diameter and depth shown on the Drawings or directed.

c. The system of pipes and fittings shall be checked before and after each lift of the concrete placements at the tunnel plug. Any pipe that has become clogged at any inspection shall be cleaned and opened or repaired before the subsequent concrete lift is placed. The completed system of pipes and fittings shall be checked before grouting and any pipe that becomes clogged due to any cause shall, if practicable, be cleaned or opened. If the Contractor fails to clean or open a plugged contraction joint system pipe, the Engineer will direct alternative work to be carried out by the Contractor to ensure that the system of pipes and connections operates satisfactorily. The Contractor shall not be entitled to any additional payment or extensions of time on account of alternative work so directed.

5.10.2 Materials

a. All standard black pipe and fittings for grouting, header, return, riser and air outlet pipes and special joint grout outlets, all nails, tie wire, wooden plugs, mastic material or sponge rubber for sealing purposes, temporary supports and other accessories required for installation of the grouting system, as described in this Clause, shall be furnished by the Contractor. The pipe shall be cut and shall be placed by the Contractor.

b. The pipe shall be standard black pipe conforming to ASTM A 120 Schedule 40, JIS G 3452 or approved equivalent.

c. The pipe fittings shall malleable iron suitable for the pressure to be applied grouting, as approved by the Engineer.

d. All grout materials, mixing and other equipment shall be in accordance with this Section of the Specification. The grout mixture shall be to the approval of the Engineer.

5.10.3 Grouting Procedure

a. The grouting of each tunnel plug shall be completed before the grout takes its initial set in the grout pipe system but shall not be grouted so rapidly that the grout will not settle in the joint as determined by the Engineer.

b. Before any joint is grouted it shall be thoroughly washed and tested with air and water under pressure and left filled with water for at least 24 hours. Immediately prior to being grouted the water shall be drained.

c. The grout shall be pumped into the bottom headers of the piping system for the joint and the air outlet pipe shall be left open until the joint is filled with grout of the proper consistency for retention in the joint, thereupon the air outlet pipe shall be closed and pressure up to 5 kg/cm² applied. This pressure shall be maintained until the grout has set and there is no back pressure.

d. All accessible leaks discovered during the grouting operations shall be caulked or stopped by approved means.

e. All other details of the grouting operations shall be in accordance with this Specification and as directed by the Engineer.

f. After completion and approval of the joint grouting all exposed ends of pipes shall be cut back below the surface of the concrete and repaired in accordance with Clause 9.17.

5.10.4 Measurement and Payment

a. No measurement, for payment, shall be made for grouting joints in the diversion tunnel plug.

b. Measurement, for payment, of furnishing and installing metal pipe and fittings for the tunnel plug grouting system shall be made of the mass of pipes and fittings actually installed as approved and includes all metal pipe, fittings and special grout outlets and air outlet pipes for pressure grouting. This measurement shall be made only for the metal pipe, fittings and special grout outlets actually installed and left in place and the computed mass for payment will not include the mass of nails, tie wire, wooden plugs, temporary supports, mastic materials or other accessories.

c. Direct payment will not be made for pressure grouting the diversion tunnel plug joints and all costs shall be deemed to be included in the rate per cubic meter tendered in the Bill of Quantities for the concrete placed on the diversion tunnel plugs.

d. Payment for furnishing and installing metal pipes and fittings for grouting of diversion tunnel plugs will be made at the rate per tonne tendered therefore in the Bill of Quantities. (Item K.4.1)

5.11 ADIT GROUT SYSTEM

5.11.1 General

a. The grouting of the joints between the concrete placement in the abandoned exploration adits and the adit surfaces shall be carried out following the sufficient cooling of the concrete as advised by the Engineer.

b. A system of pipes, fittings and special grout outlets shall be installed before placing concrete for each adit as directed. The special grout outlets shall be pipes set in place prior to placing the concrete plugs.

c. The system of pipes and fittings shall be checked before and after each lift of the concrete at any inspection shall be cleaned and opened or repaired before the subsequent concrete lift is placed. The completed system of pipes and fitting shall be checked before grouting and any pipe that becomes clogged due to any cause shall, if practicable, be cleaned or opened. If the Contractor fails to clean or open a plugged contraction joint system pipe, the Engineer will direct alternative work to be carried out by the Contractor to ensure that the system of pipes and connections operates satisfactorily. The Contractor shall not be entitled to any additional payment or extensions of time on account of alternative work so directed.

5.11.2 Materials

a. All standard black pipe and fittings for grouting pipes and special joint grout outlets, all nails, tie wire, wooden plugs, mastic material or sponge rubber for sealing purposes, temporary supports and other accessories required for installation of the grouting system, as described in this Clause, shall be furnished by the Contractor. The pipe shall be cut and shall be placed by the Contractor.

b. The pipe shall be standard black pipe conforming to ASTM A 120 Schedule 40, JIS G 3452 or approved by the Engineer.

c. The pipe fittings shall malleable iron suitable for the pressure to be applied grouting, as approved by the Engineer.

d. All grout materials, mixing and other equipment shall be in accordance with this Section of the Specification. The grout mixture shall be to the approval of the Engineer.

5.11.3 Grouting Procedure

a. The grouting of each adit shall be completed before the grout takes its initial set in the grout pipe system but shall not be grouted so rapidly that the grout will not settle in the joint as determined by the Engineer.

b. Before any joint is grouted it shall be thoroughly washed and tested with air and water under pressure and left filled with water for at least 24 hours. Immediately prior to being grouted the water shall be drained.

c. The grout shall be pumped into the bottom headers of the piping system for the joint and the air outlet pipe shall be left open until the joint is filled with grout of the proper consistency for retention in the joint, thereupon the air outlet pipe shall be closed and pressure up to 5 kg/cm² applied. This pressure shall be maintained until the grout has set and there is no back pressure.

d. All accessible leaks discovered during the grouting operations shall be caulked or stopped by approved mean.

e. All other details of the grouting operations shall be in accordance with this Specification and as directed by the Engineer.

f. After completion and approval of the joint grouting all exposed ends of pipes shall be cut back below the surface of the concrete and repaired in accordance with Clause 9.17.

5.11.4 Measurement and Payment

a. Direct payment will not be made for pressure grouting the adit plugs and all costs shall be deemed to be included in the rate per cubic metre tendered in the Bill of Quantities for the concrete placed in adits (Item I.12.4)

b. Payment for furnishing and installing metal pipes and fittings for grouting of diversion tunnel plugs will be made at the rate per tonne tendered therefore in the Bill of Quantities. (Item K.4.2)

5.12 CONTACT GROUTING FOR STEEL CONDUIT

5.12.1 General

a. Not earlier than 30 days after completing any section of concrete embedment of the steel conduit in the outlet tunnel, the conduit shall be inspected by the Contractor in the presence of the Engineer to determined the extent of voids or cavities between the steel and the concrete.

b. Based on this inspection the Contractor shall drill and tap the steel if the existing grout plugs prepared in the conduit are considered to be insufficient. The Contractor shall plug all holes in the steel on completion of grouting by approved methods.

c. If an approved external grout system has been installed by the Contractor, the inspection in paragraph a. of this Sub-Clause shall be repeated after grouting and the works in paragraph b. of this Sub-Clause shall be undertaken where directed by the Engineer and additional grouting performed.

5.12.2 Materials

a. All materials and equipment shall be in accordance with this Section of the Specification.

b. The grout mix shall be to the approval of the Engineer.

5.12.3 Procedure

a. The contact grouting procedure shall be submitted to the Engineer for approval but must be done in such a manner that all voids and cavities are completely filled with grout.

b. The grouting pressure shall not exceed 2 kg/cm² unless otherwise approved by the Engineer.

c. The grouting of each section shall be continued uninterruptedly until holes or pipes cease to take grout. Grout holes or pipes adjacent to a grout hook-up shall be left open during grouting operation to facilitate the

escape of air and water from the voids and cavities surrounding the steel. When grout is found to flow from adjacent grout connections in sufficient quantity to interfere seriously with the grouting operations or to cause appreciable loss of grout, such grout connections may be temporarily capped.

d. After all grout holes or connections in a section are flowing with grout of the same consistency as the inflowing grout, the grout holes can be capped under the specified pressure and maintained at that pressure until grout has set.

5.12.4 Payment

a. Direct payment will not be made for grouting of steel conduit and all costs shall be deemed to be included the applicable rate per cubic meter tendered therefor in the Bill of Quantities for the concrete surrounding the steel conduit. Such rates shall include cleanup and removal of grout inside the conduit, and provision of an external grout system if proposed and approved.

b. Payment for provision of grout holes and plugs in the steel conduit including additional holes drilled and tapped in the steel, as directed, and all plugging and repair of the grout holes and all repair painting shall be deemed to be included in the applicable lump sum prices tendered therefor in the Bill of Quantities for the Water Control Plant.