SHINING HOPE FOR COMMUNITIES



Shining Hope for Communities

# **TENDER DOCUMENTS**

PROCUREMENT OF

### CONSTRUCTION WORKS FOR THE PROPOSED KIBERA INVESTMENT DELIVERING SAFE WATER (K.I.D.S) PROJECT

### LOT I: WATER SUPPLY NETWORK

### CONTRACT NO: SHOFCO-K.I.D.S.-LOT2-2022

**VOLUME 2 : TECHNICAL SPECIFICATIONS** 

**ISSUED ON:** 

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# Table of Contents

1	SECTION 1 – GENERAL	9
1.1	GENERAL	9
1.2	OFFICE AND ACCOMMODATION FOR PROJECT ENGINEER	9
1.3	PROVISION FOR PROJECT ENGINEER'S OFFICE IN KIBERA	10
1.4	SURVEY EQUIPMENT	13
1.5	OFFICE FOR CONTRACTOR	13
1.6	CONTROL OF TRAFFIC	14
1.7	TEMPORARY DIVERSION OF TRAFFIC	14
1.8	TEMPORARY TRAFFIC SIGNS	14
1.9	PROTECTION OF WORKS	14
1.10	SURVEY BEACONS	14
1.11	DAMAGE TO LAND	15
1.12	RIVERS AND DRAINS	15
1.13	REINSTATEMENT OF ROADS AND FOOTWAYS FOR WATER MAINS	15
1.14	TEMPORARY WORKS	15
1.15	LIGHTING AND GUARDING OF OBSTRUCTIONS	16
1.16	SERVICES	16
1.17	PRIVATELY OWNED OR PUBLIC SERVICES	17
1.18	WATER SUPPLY	17
1.19	ADDITIONAL LAND	17
1.20	USE OF HEAVY PLANT	17
1.21	PROVISION OF INSTRUMENTS AND LABOUR	17
1.22	ACCESS TO SITES	18
1.23	POLLUTION	18
1.24	TREE PROTECTION	18
1.25	GEOLOGICAL DATA	18
1.26	WATCHING, FENCING AND LIGHTING	18
1.27	TIPS	18
1.28	TROPICALISATION	19
1.29	MONTHLY SITE MEETINGS	19
1.30	INSPECTION BY ENGINEER DURING DEFECTS LIABILITY PERIOD	19
1.31	SUBMISSION OF SAMPLES	19
1.32	RESPONSIBILITY FOR ORDERING MATERIALS AND MANUFACTURED ARTICLES AND SAMPLES FOR	
	TESTING	19
1.33	TESTS OF MATERIALS AND MANUFACTURED ARTICLES BEFORE USE	20
1.34	REJECTED MATERIALS	20
1.35	QUALITY OF MATERIALS AND WORKMANSHIP	20
1.36	TEST RUNNING OF THE SCHEME	20
1.37	EQUIPMENT FOR THE PROJECT ENGINEER	20
1.38	OPERATION AND MAINTENANCE MANUAL	21
1.39	CONSTRUCTION PROGRAMME	21
2	CLEARING SITE	23
2.1	CLEARING SITE	23
2.2	VEGETATION	23
2.3	BUSHES AND SMALL TREES	23
2.4	HEDGES	23

2.5	FELLING TREES	23
2.6	GRUBBING-UP ROOTS	24
2.7	WEED CONTROL	24
3	EXCAVATION	25
3.1	DEFINITION AND CLASSIFICATION OF EXCAVATED MATERIALS	25
3.2	STORAGE AND HANDLING OF EXPLOSIVES AND BLASTING	25
3.3	EXCAVATION FOR FILL	
3.4	COMPACTION OF FILL	
3.5	EMBANKMENTS OVER SEWERS	27
3.6	STONE REVETMENTS (STONE PITCHING)	27
3.7	TIPPED REFUSE ON SITE	
3.8	REMOVAL OF INDUSTRIAL WASTE, ETC	28
3.9	LAND SLIPS	28
3.10	CLASSIFICATION OF MATERIAL FROM SLIPS	28
3.11	BORROW PITS	
3.12	STREAMS, WATERCOURSES AND DITCHES	28
3.13	FILLING OLD WATERCOURSES	28
3.14	OPEN DITCHES	28
3.15	CLEARING EXISTING DITCHES	29
3.16	EXCAVATION FOR FOUNDATIONS BELOW OPEN WATER	29
3.17	TRENCHES OF GREATER WIDTH AND DEPTH THAN NECESSARY	29
3.18	SUPPORTS FOR TRENCHES	29
3.19	PROVISION OF SPOIL HEAPS	29
3 20	LISE OF VIBRATORY COMPACTION PLANT	29
5.20		
3.20	WATER IN EXCAVATIONS	
3.20 3.21 <b>4</b>	WATER IN EXCAVATIONS	
3.21 <b>4</b> 4.1	WATER IN EXCAVATIONS	
3.21 <b>4</b> 4.1 4.2	WATER IN EXCAVATIONS	
3.20 3.21 <b>4</b> 4.1 4.2 4.3	WATER IN EXCAVATIONS	
3.20 3.21 <b>4</b> 4.1 4.2 4.3 4.4	WATER IN EXCAVATIONS	30 31 31 31 31 31 31
3.21 4.1 4.2 4.3 4.4 4.5	WATER IN EXCAVATIONS	30 31 31 31 31 31 37 37 39
3.21 4.1 4.2 4.3 4.4 4.5 4.6	WATER IN EXCAVATIONS	30 31 31 31 31 31 31 37 39 39
3.21 4.1 4.2 4.3 4.4 4.5 4.6 4.7	WATER IN EXCAVATIONS	30 31 31 31 31 31 37 39 39 39 39
3.21 4 4.1 4.2 4.3 4.4 4.5 4.6 4.7 4.8	WATER IN EXCAVATIONS	30 31 31 31 31 37 39 39 39 39 39
3.21 4 4.1 4.2 4.3 4.4 4.5 4.6 4.7 4.8 4.9	WATER IN EXCAVATIONS	30 31 31 31 31 31 37 39 39 39 39 39 39 39 39 39 39 39 39 39
3.21 4 4.1 4.2 4.3 4.4 4.5 4.6 4.7 4.8 4.9 4.10	WATER IN EXCAVATIONS         CONCRETE         SCOPE OF SECTION         DEFINITIONS         THE DESIGN OF CONCRETE MIXES         MIXING CONCRETE         HAND-MIXED CONCRETE         TRANSPORT OF CONCRETE         PLACING OF CONCRETE         COMPACTION OF CONCRETE         CURING OF CONCRETE         PROTECTION OF FRESH CONCRETE	30 31 31 31 31 37 39 39 39 39 39 39 39 39 39 39 39 39 39
3.21 4.1 4.2 4.3 4.4 4.5 4.6 4.7 4.8 4.9 4.10 4.11	WATER IN EXCAVATIONS	30 31 31 31 31 37 39 39 39 39 39 43 43 43 43
3.21 4.1 4.2 4.3 4.4 4.5 4.6 4.7 4.8 4.9 4.10 4.11 4.12	WATER IN EXCAVATIONSCONCRETESCOPE OF SECTIONDEFINITIONSTHE DESIGN OF CONCRETE MIXESMIXING CONCRETEHAND-MIXED CONCRETETRANSPORT OF CONCRETEPLACING OF CONCRETEPLACING OF CONCRETECOMPACTION OF CONCRETECURING OF CONCRETEPROTECTION OF FRESH CONCRETEPROTECTION OF FRESH CONCRETECONCRETING IN HOT WEATHERFINISHES ON UNFORMED SURFACES	30 31 31 31 31 37 39 39 39 39 39 39 39 39 39 39 39 39 39
3.21 4.1 4.2 4.3 4.4 4.5 4.6 4.7 4.8 4.9 4.10 4.11 4.12 4.13	WATER IN EXCAVATIONS WATER IN EXCAVATIONS CONCRETE SCOPE OF SECTION DEFINITIONS THE DESIGN OF CONCRETE MIXES MIXING CONCRETE HAND-MIXED CONCRETE HAND-MIXED CONCRETE PLACING OF CONCRETE PLACING OF CONCRETE COMPACTION OF CONCRETE PROTECTION OF FRESH CONCRETE CONCRETING IN HOT WEATHER FINISHES ON UNFORMED SURFACES MORTAR	30 31 31 31 31 37 39 39 39 39 39 43 43 43 43 45 45 46 48
3.21 4.1 4.2 4.3 4.4 4.5 4.6 4.7 4.8 4.9 4.10 4.11 4.12 4.13 4.14	WATER IN EXCAVATIONS	30 31 31 31 31 37 39 39 39 39 43 43 43 43 43 43 43 43 43 43
3.21 4.1 4.2 4.3 4.4 4.5 4.6 4.7 4.8 4.9 4.10 4.11 4.12 4.13 4.14 4.15	WATER IN EXCAVATIONSCONCRETESCOPE OF SECTIONDEFINITIONSTHE DESIGN OF CONCRETE MIXESMIXING CONCRETEHAND-MIXED CONCRETETRANSPORT OF CONCRETEPLACING OF CONCRETECOMPACTION OF CONCRETECURING OF CONCRETEPROTECTION OF FRESH CONCRETECONCRETING IN HOT WEATHERFINISHES ON UNFORMED SURFACESMORTARCONCRETE FOR SECONDARY PURPOSESRECORDS OF CONCRETE PLACING	30 31 31 31 31 37 39 39 39 39 39 39 39 43 43 43 43 43 43 43 43 43 43 43 43 43
3.21 <b>4</b> 4.1 4.2 4.3 4.4 4.5 4.6 4.7 4.8 4.9 4.10 4.11 4.12 4.13 4.14 4.15 4.16	WATER IN EXCAVATIONS         CONCRETE         SCOPE OF SECTION         DEFINITIONS         THE DESIGN OF CONCRETE MIXES         MIXING CONCRETE         HAND-MIXED CONCRETE         HAND-MIXED CONCRETE         PLACING OF CONCRETE         PLACING OF CONCRETE         COMPACTION OF CONCRETE         CONCRETION OF FRESH CONCRETE         PROTECTION OF FRESH CONCRETE         CONCRETING IN HOT WEATHER         FINISHES ON UNFORMED SURFACES         MORTAR         CONCRETE FOR SECONDARY PURPOSES         RECORDS OF CONCRETE PLACING         CONSTRUCTION JOINTS	30 31 31 31 31 37 39 39 39 39 43 43 43 45 45 45 46 48 48 48 49 49
3.21 4.1 4.2 4.3 4.4 4.5 4.6 4.7 4.8 4.9 4.10 4.11 4.12 4.13 4.14 4.15 4.16 4.17	WATER IN EXCAVATIONSCONCRETESCOPE OF SECTIONDEFINITIONSTHE DESIGN OF CONCRETE MIXESMIXING CONCRETEHAND-MIXED CONCRETETRANSPORT OF CONCRETEPLACING OF CONCRETECOMPACTION OF CONCRETECURING OF CONCRETEPROTECTION OF FRESH CONCRETECURING OF CONCRETEPROTECTION OF FRESH CONCRETECONCRETING IN HOT WEATHERFINISHES ON UNFORMED SURFACESMORTARCONCRETE FOR SECONDARY PURPOSESRECORDS OF CONCRETE PLACINGCONSTRUCTION JOINTSEXPANSION AND CONTRACTION JOINTS	30 31 31 31 31 37 39 39 39 39 39 39 43 43 43 43 45 45 45 46 48 48 48 48 48 49 50
3.21 <b>4</b> 4.1 4.2 4.3 4.4 4.5 4.6 4.7 4.8 4.9 4.10 4.11 4.12 4.13 4.14 4.15 4.16 4.17 4.18	WATER IN EXCAVATIONSCONCRETESCOPE OF SECTIONDEFINITIONSTHE DESIGN OF CONCRETE MIXESMIXING CONCRETEHAND-MIXED CONCRETEPLACING OF CONCRETEPLACING OF CONCRETECOMPACTION OF CONCRETECOMPACTION OF FRESH CONCRETEPROTECTION OF FRESH CONCRETECONCRETING IN HOT WEATHERFINISHES ON UNFORMED SURFACESMORTARCONCRETE FOR SECONDARY PURPOSESRECORDS OF CONCRETE PLACINGCONSTRUCTION JOINTSEXPANSION AND CONTRACTION JOINTSWATERSTOPS	30 31 31 31 31 37 39 39 39 39 39 39 39 39 39 39
3.21 <b>4</b> 4.1 4.2 4.3 4.4 4.5 4.6 4.7 4.8 4.9 4.10 4.11 4.12 4.13 4.14 4.15 4.16 4.17 4.18 4.19	WATER IN EXCAVATIONS CONCRETE SCOPE OF SECTION DEFINITIONS. THE DESIGN OF CONCRETE MIXES MIXING CONCRETE. HAND-MIXED CONCRETE TRANSPORT OF CONCRETE PLACING OF CONCRETE PLACING OF CONCRETE COMPACTION OF CONCRETE COMPACTION OF FORSH CONCRETE PROTECTION OF FRESH CONCRETE PROTECTION OF FRESH CONCRETE CONCRETING IN HOT WEATHER FINISHES ON UNFORMED SURFACES MORTAR CONCRETE FOR SECONDARY PURPOSES RECORDS OF CONCRETE PLACING. CONSTRUCTION JOINTS EXPANSION AND CONTRACTION JOINTS WATERSTOPS. GROUTING OF POCKETS AND HOLES AND UNDERPINNING OF BASEPLATES.	30 31 31 31 31 37 39 39 39 39 39 43 43 43 45 45 45 45 45 45 45 45 45 50 50 51
3.21 <b>4</b> 4.1 4.2 4.3 4.4 4.5 4.6 4.7 4.8 4.9 4.10 4.11 4.12 4.13 4.14 4.15 4.16 4.17 4.18 4.19 4.20	WATER IN EXCAVATIONS CONCRETE SCOPE OF SECTION DEFINITIONS THE DESIGN OF CONCRETE MIXES MIXING CONCRETE HAND-MIXED CONCRETE HAND-MIXED CONCRETE PLACING OF CONCRETE PLACING OF CONCRETE COMPACTION OF CONCRETE CURING OF CONCRETE PROTECTION OF FRESH CONCRETE CONCRETING IN HOT WEATHER FINISHES ON UNFORMED SURFACES MORTAR CONCRETE FOR SECONDARY PURPOSES RECORDS OF CONCRETE PLACING CONSTRUCTION JOINTS EXPANSION AND CONTRACTION JOINTS WATERSTOPS GROUTING OF POCKETS AND HOLES AND UNDERPINNING OF BASEPLATES	30 31 31 31 31 37 39 39 39 39 43 43 43 45 46 48 48 49 50 50 51 52

4.22	FIXING REINFORCEMENT	53
5	FORMWORK	55
5.1	FORMWORK FOR CONCRETE Definitions	55
5.2	CONSTRUCTION OF FORMWORK AND FALSEWORK	55
5.3	PREPARATION OF FORMWORK	56
5.4	REMOVAL OF FORMWORK	57
5.5	SURFACE FINISHES ON FORMED SURFACES Classes of finish	58
5.6	TOLERANCES	59
6	MASONRY	60
6.1	GENERAL	60
6.2	WORKMANSHIP	60
6.3	CAST STONEWORK	60
7	MATERIALS	61
7.1	GENERAL	61
7.2	GALVANISED PIPES AND SPECIALS	62
7.3	DUCTILE IRON AND CAST IRON PIPES AND SPECIALS	62
7.4	ASBESTOS CEMENT PIPES AND SPECIALS	63
7.5	STEEL PIPES AND SPECIALS	63
7.6	UNPLASTICISED uPVC PIPES	64
7.7	G.R.P. PIPES AND SPECIALS	65
7.8	GATE VALVES	65
7.9	FIRE HYDRANTS	66
7.10	AIR VALVES	66
7.11	WATER METERS	66
7.12	STOP VALVES	68
7.12 7.13	STOP VALVES CHECK VALVES (DIRECTIONAL VALVES)	68 68
7.12 7.13 7.14	STOP VALVES CHECK VALVES (DIRECTIONAL VALVES) PENSTOCKS	68 68 68
7.12 7.13 7.14 7.15	STOP VALVES CHECK VALVES (DIRECTIONAL VALVES) PENSTOCKS FLANGED JOINTS	68 68 68 68
7.12 7.13 7.14 7.15 7.16	STOP VALVES CHECK VALVES (DIRECTIONAL VALVES) PENSTOCKS FLANGED JOINTS FLEXIBLE JOINTS	68 68 68 68 68
7.12 7.13 7.14 7.15 7.16 7.17	STOP VALVES CHECK VALVES (DIRECTIONAL VALVES) PENSTOCKS FLANGED JOINTS FLEXIBLE JOINTS PRESSED STEEL TANKS AND TOWERS	68 68 68 68 68 69
7.12 7.13 7.14 7.15 7.16 7.17 7.18	STOP VALVES CHECK VALVES (DIRECTIONAL VALVES) PENSTOCKS FLANGED JOINTS FLEXIBLE JOINTS PRESSED STEEL TANKS AND TOWERS PAINTS	68 68 68 68 68 69 70
7.12 7.13 7.14 7.15 7.16 7.17 7.18 7.19	STOP VALVES CHECK VALVES (DIRECTIONAL VALVES) PENSTOCKS FLANGED JOINTS FLEXIBLE JOINTS PRESSED STEEL TANKS AND TOWERS PAINTS MARKER AND INDICATOR POSTS	68 68 68 68 69 70 70
<ul> <li>7.12</li> <li>7.13</li> <li>7.14</li> <li>7.15</li> <li>7.16</li> <li>7.17</li> <li>7.18</li> <li>7.19</li> <li>7.20</li> </ul>	STOP VALVES CHECK VALVES (DIRECTIONAL VALVES) PENSTOCKS FLANGED JOINTS FLEXIBLE JOINTS PRESSED STEEL TANKS AND TOWERS PAINTS MARKER AND INDICATOR POSTS POLYETHYLENE (PALOTHENE, PEH) PIPES	68 68 68 68 68 69 70 70 70
7.12 7.13 7.14 7.15 7.16 7.17 7.18 7.19 7.20 7.21	STOP VALVES CHECK VALVES (DIRECTIONAL VALVES) PENSTOCKS FLANGED JOINTS FLEXIBLE JOINTS PRESSED STEEL TANKS AND TOWERS PAINTS MARKER AND INDICATOR POSTS POLYETHYLENE (PALOTHENE, PEH) PIPES PRECAST CONCRETE UNITS	68 68 68 68 68 69 70 70 70 70
7.12 7.13 7.14 7.15 7.16 7.17 7.18 7.19 7.20 7.21 7.22	STOP VALVES CHECK VALVES (DIRECTIONAL VALVES) PENSTOCKS FLANGED JOINTS FLEXIBLE JOINTS PRESSED STEEL TANKS AND TOWERS PAINTS MARKER AND INDICATOR POSTS POLYETHYLENE (PALOTHENE, PEH) PIPES PRECAST CONCRETE UNITS FILTER MEDIA	68 68 68 68 69 70 70 70 70 72
7.12 7.13 7.14 7.15 7.16 7.17 7.18 7.19 7.20 7.21 7.22 7.23	STOP VALVES CHECK VALVES (DIRECTIONAL VALVES) PENSTOCKS FLANGED JOINTS FLEXIBLE JOINTS PRESSED STEEL TANKS AND TOWERS PAINTS MARKER AND INDICATOR POSTS	68 68 68 68 69 70 70 70 70 72 73
7.12 7.13 7.14 7.15 7.16 7.17 7.18 7.19 7.20 7.21 7.22 7.23 7.24	STOP VALVES	68 68 68 68 69 70 70 70 70 73 73
7.12 7.13 7.14 7.15 7.16 7.17 7.18 7.19 7.20 7.21 7.22 7.23 7.24 7.25	STOP VALVES CHECK VALVES (DIRECTIONAL VALVES) PENSTOCKS FLANGED JOINTS FLEXIBLE JOINTS PRESSED STEEL TANKS AND TOWERS PRESSED STEEL TANKS AND TOWERS PAINTS MARKER AND INDICATOR POSTS POLYETHYLENE (PALOTHENE, PEH) PIPES POLYETHYLENE (PALOTHENE, PEH) PIPES PRECAST CONCRETE UNITS FILTER MEDIA SUBMISSION OF SAMPLES MATERIALS FOR CONCRETE Organic impurities:	68 68 68 68 69 70 70 70 70 72 73 73 75
7.12 7.13 7.14 7.15 7.16 7.17 7.18 7.19 7.20 7.21 7.22 7.23 7.24 7.25 7.26	STOP VALVES CHECK VALVES (DIRECTIONAL VALVES)	68 68 68 68 69 70 70 70 70 72 73 75 80
7.12 7.13 7.14 7.15 7.16 7.17 7.18 7.19 7.20 7.21 7.22 7.23 7.24 7.25 7.26 7.27	STOP VALVES CHECK VALVES (DIRECTIONAL VALVES) PENSTOCKS FLANGED JOINTS FLEXIBLE JOINTS PRESSED STEEL TANKS AND TOWERS PAINTS MARKER AND INDICATOR POSTS POLYETHYLENE (PALOTHENE, PEH) PIPES PRECAST CONCRETE UNITS FILTER MEDIA SUBMISSION OF SAMPLES MATERIALS FOR CONCRETE Organic impurities: BUILDING STONE STONE DUST	68 68 68 68 69 70 70 70 70 73 73 73 80 80
7.12 7.13 7.14 7.15 7.16 7.17 7.18 7.19 7.20 7.21 7.22 7.23 7.24 7.25 7.26 7.27 7.28	STOP VALVES CHECK VALVES (DIRECTIONAL VALVES) PENSTOCKS FLANGED JOINTS FLEXIBLE JOINTS PRESSED STEEL TANKS AND TOWERS PAINTS MARKER AND INDICATOR POSTS POLYETHYLENE (PALOTHENE, PEH) PIPES POLYETHYLENE (PALOTHENE, PEH) PIPES PRECAST CONCRETE UNITS FILTER MEDIA SUBMISSION OF SAMPLES MATERIALS FOR CONCRETE Organic impurities: BUILDING STONE STONE DUST	68 68 68 68 69 70 70 70 70 70 72 73 73 75 80 80 80
7.12 7.13 7.14 7.15 7.16 7.17 7.18 7.19 7.20 7.21 7.22 7.23 7.24 7.25 7.26 7.27 7.28 7.29	STOP VALVES CHECK VALVES (DIRECTIONAL VALVES) PENSTOCKS FLANGED JOINTS. FLEXIBLE JOINTS. FLEXIBLE JOINTS. PRESSED STEEL TANKS AND TOWERS PAINTS. MARKER AND INDICATOR POSTS POLYETHYLENE (PALOTHENE, PEH) PIPES PRECAST CONCRETE UNITS. FILTER MEDIA SUBMISSION OF SAMPLES. MATERIALS FOR CONCRETE Organic impurities: BUILDING STONE STONE DUST	68 68 68 68 69 70 70 70 70 70 73 73 75 80 80 80
7.12 7.13 7.14 7.15 7.16 7.17 7.18 7.19 7.20 7.21 7.22 7.23 7.24 7.25 7.26 7.27 7.28 7.27 7.28 7.29 7.30	STOP VALVES CHECK VALVES (DIRECTIONAL VALVES) PENSTOCKS FLANGED JOINTS FLEXIBLE JOINTS PRESSED STEEL TANKS AND TOWERS PAINTS MARKER AND INDICATOR POSTS POLYETHYLENE (PALOTHENE, PEH) PIPES POLYETHYLENE (PALOTHENE, PEH) PIPES PRECAST CONCRETE UNITS FILTER MEDIA SUBMISSION OF SAMPLES MATERIALS FOR CONCRETE Organic impurities: BUILDING STONE STONE DUST MURRAM WATER FOR CEMENT TREATED MATERIALS	68 68 68 68 69 70 70 70 70 73 73 73 80 80 81 81
7.12 7.13 7.14 7.15 7.16 7.17 7.18 7.19 7.20 7.21 7.22 7.23 7.24 7.25 7.26 7.27 7.28 7.29 7.30 7.31	STOP VALVES	68 68 68 69 70 70 70 70 70 73 73 75 80 80 81 81
7.12 7.13 7.14 7.15 7.16 7.17 7.18 7.19 7.20 7.21 7.22 7.23 7.24 7.25 7.26 7.27 7.26 7.27 7.28 7.29 7.30 7.31 7.32	STOP VALVES CHECK VALVES (DIRECTIONAL VALVES) PENSTOCKS FLANGED JOINTS FLEXIBLE JOINTS PRESSED STEEL TANKS AND TOWERS PRESSED STEEL TANKS AND TOWERS PAINTS MARKER AND INDICATOR POSTS POLYETHYLENE (PALOTHENE, PEH) PIPES PRECAST CONCRETE UNITS FILTER MEDIA SUBMISSION OF SAMPLES MATERIALS FOR CONCRETE Organic impurities: BUILDING STONE STONE DUST MURRAM WATER FOR CEMENT TREATED MATERIALS CEMENT MORTAR HYDRATED LIME CALCIUM CHLORIDE	68 68 68 69 70 70 70 70 70 73 73 73 73 80 80 81 81 81
7.12 7.13 7.14 7.15 7.16 7.17 7.18 7.19 7.20 7.21 7.22 7.23 7.24 7.25 7.26 7.27 7.28 7.27 7.28 7.29 7.30 7.31 7.32 7.33	STOP VALVES CHECK VALVES (DIRECTIONAL VALVES) PENSTOCKS FLANGED JOINTS FLEXIBLE JOINTS PRESSED STEEL TANKS AND TOWERS PAINTS MARKER AND INDICATOR POSTS POLYETHYLENE (PALOTHENE, PEH) PIPES PRECAST CONCRETE UNITS FILTER MEDIA SUBMISSION OF SAMPLES MATERIALS FOR CONCRETE Organic impurities: BUILDING STONE STONE DUST MURRAM WATER FOR CEMENT TREATED MATERIALS CEMENT MORTAR HYDRATED LIME CALCIUM CHLORIDE LIME MORTAR.	68 68 68 69 70 70 70 70 70 73 73 73 80 80 81 81 81 81

7.35	5 CEMENT GROUT	81
7.36	5 CAST STONE	82
7.37	7 REINFORCEMENT FOR CONCRETE	82
7.38	3 STRUCTURAL STEEL FOR WELDED WORK	83
7.39	WATERPROOF UNDERLAY	83
7.40	PREFORMED JOINT FILLER	83
7.41	JOINT PRIMER	83
7.42	2 JOINT SEALING COMPOUND	84
7.43	B CONCRETE PIPES AND SPECIALS	84
7.44	CONCRETE POROUS PIPES	84
7.45	5 CONCRETE DRAIN INVERT BLOCKS	84
7.46	5 CONCRETE SLABS FOR OPEN DRAINS	85
7.47	7 AGRICULTURAL TILES AND PIPES	85
7.48	MANHOLE COVERS AND FRAMES	85
7.49	O GULLY GRATINGS AND FRAMES	85
7.50	PRECAST CONCRETE MANHOLES AND INSPECTION CHAMBERS	85
7.51	PRECAST CONCRETE GULLIES	85
7.52	2 MANHOLE STEP IRONS	85
7.53	3 TIMBER	85
7.54	WATER BARS	86
7.55	5 CONCRETE BLOCKS	86
7.56	5 HDPE PE 100 PIPES MANUFACTURED ISO 4427:2007 STANDARD	86
7.57	7 SUBMERSIBLE PUMPS	87
7.58	3 SURFACE PUMPS	91
-		
8	WORKMANSHIP	
<b>8</b> 8.1	WORKMANSHIP	<b>123</b>
<b>8</b> 8.1 8.2	WORKMANSHIP	<b>123</b> 
<b>8</b> 8.1 8.2 8.3	WORKMANSHIP	<b>123</b> 123 123 123
<b>8</b> 8.1 8.2 8.3 8.4	WORKMANSHIP	<b>123</b> 
8 8.1 8.2 8.3 8.4 8.5	WORKMANSHIP	<b>123</b> 123123123123123123123123
8 8.1 8.2 8.3 8.4 8.5 8.6	WORKMANSHIP	<b>123</b> 123 123 123 123 123 123 123
<ul> <li>8</li> <li>8.1</li> <li>8.2</li> <li>8.3</li> <li>8.4</li> <li>8.5</li> <li>8.6</li> <li>8.7</li> <li>2.2</li> </ul>	WORKMANSHIP	<b>123</b> 123 123 123 123 123 123 123 123 123 123
<ul> <li>8</li> <li>8.1</li> <li>8.2</li> <li>8.3</li> <li>8.4</li> <li>8.5</li> <li>8.6</li> <li>8.7</li> <li>8.8</li> <li>2.2</li> </ul>	WORKMANSHIP HANDLING OF PIPES AND FITTINGS LOADING AND UNLOADING STORAGE TRANSPORT EXAMINATION OF PIPES AND FITTINGS INTERFERENCE WITH FENCES, DRAINS AND OTHER SERVICES METHOD OF EXCAVATION MAIN LAYING DAGVET LINC OF TRENCH	<b>123</b> 123 123 123 123 123 123 123 123 123 123
8 8.1 8.2 8.3 8.4 8.5 8.6 8.7 8.8 8.9	WORKMANSHIP HANDLING OF PIPES AND FITTINGS LOADING AND UNLOADING STORAGE TRANSPORT EXAMINATION OF PIPES AND FITTINGS INTERFERENCE WITH FENCES, DRAINS AND OTHER SERVICES. METHOD OF EXCAVATION MAIN LAYING BACKFILLING OF TRENCH	123           123
8 8.1 8.2 8.3 8.4 8.5 8.6 8.7 8.8 8.9 8.10 8.11	WORKMANSHIP         HANDLING OF PIPES AND FITTINGS         LOADING AND UNLOADING         STORAGE         TRANSPORT         EXAMINATION OF PIPES AND FITTINGS         INTERFERENCE WITH FENCES, DRAINS AND OTHER SERVICES         METHOD OF EXCAVATION         MAIN LAYING         BACKFILLING OF TRENCH         ANCHOR BLOCKS AND SUPPORTS         CHAMPERS AND SUPPORTS	123         124         125         126         127         128
8 8.1 8.2 8.3 8.4 8.5 8.6 8.7 8.8 8.9 8.10 8.11	WORKMANSHIP HANDLING OF PIPES AND FITTINGS LOADING AND UNLOADING STORAGE TRANSPORT EXAMINATION OF PIPES AND FITTINGS INTERFERENCE WITH FENCES, DRAINS AND OTHER SERVICES METHOD OF EXCAVATION MAIN LAYING BACKFILLING OF TRENCH ANCHOR BLOCKS AND SUPPORTS CHAMBERS AND SURFACE BOXES	123           124           125           126           127           127           127
8 8.1 8.2 8.3 8.4 8.5 8.6 8.7 8.8 8.9 8.10 8.11 8.12	WORKMANSHIP         HANDLING OF PIPES AND FITTINGS         LOADING AND UNLOADING         STORAGE         TRANSPORT         EXAMINATION OF PIPES AND FITTINGS         INTERFERENCE WITH FENCES, DRAINS AND OTHER SERVICES         METHOD OF EXCAVATION         MAIN LAYING         BACKFILLING OF TRENCH         ANCHOR BLOCKS AND SUPPORTS         CHAMBERS AND SURFACE BOXES         TESTING	123           125           126           127           127           127           127           127
8 8.1 8.2 8.3 8.4 8.5 8.6 8.7 8.8 8.9 8.10 8.11 8.12 8.13	WORKMANSHIP         HANDLING OF PIPES AND FITTINGS         LOADING AND UNLOADING         STORAGE         TRANSPORT         EXAMINATION OF PIPES AND FITTINGS         INTERFERENCE WITH FENCES, DRAINS AND OTHER SERVICES         METHOD OF EXCAVATION         MAIN LAYING         BACKFILLING OF TRENCH         ANCHOR BLOCKS AND SUPPORTS         CHAMBERS AND SURFACE BOXES         TESTING         CLEANING AND STERILISING THE MAIN	123           125           126           127           127           128           129
8 8.1 8.2 8.3 8.4 8.5 8.6 8.7 8.8 8.9 8.10 8.11 8.12 8.13 8.14 2.5	WORKMANSHIP         HANDLING OF PIPES AND FITTINGS         LOADING AND UNLOADING         STORAGE         TRANSPORT         EXAMINATION OF PIPES AND FITTINGS         INTERFERENCE WITH FENCES, DRAINS AND OTHER SERVICES         METHOD OF EXCAVATION         MAIN LAYING         BACKFILLING OF TRENCH         ANCHOR BLOCKS AND SUPPORTS         CHAMBERS AND SURFACE BOXES         TESTING         CLEANING AND STERILISING THE MAIN         CLEARANCE OF SITE	123         123         123         123         123         123         123         123         123         123         123         123         123         123         123         123         124         125         126         127         127         127         127         128         128         129
8 8.1 8.2 8.3 8.4 8.5 8.6 8.7 8.8 8.9 8.10 8.11 8.12 8.13 8.14 8.15	WORKMANSHIP         HANDLING OF PIPES AND FITTINGS         LOADING AND UNLOADING         STORAGE         TRANSPORT         EXAMINATION OF PIPES AND FITTINGS         INTERFERENCE WITH FENCES, DRAINS AND OTHER SERVICES         METHOD OF EXCAVATION         MAIN LAYING         BACKFILLING OF TRENCH         ANCHOR BLOCKS AND SUPPORTS         CHAMBERS AND SURFACE BOXES         TESTING         CLEANING AND STERILISING THE MAIN         CLEARANCE OF SITE         TESTING OF WATER RETAINING STRUCTURES         STERDING AT ON OF WATER DETAINING STRUCTURES	123         124         125         126         127         127         127         127         128         128         129         120
8 8.1 8.2 8.3 8.4 8.5 8.6 8.7 8.8 8.9 8.10 8.11 8.12 8.13 8.14 8.15 8.16	WORKMANSHIP         HANDLING OF PIPES AND FITTINGS         LOADING AND UNLOADING         STORAGE         TRANSPORT         EXAMINATION OF PIPES AND FITTINGS         INTERFERENCE WITH FENCES, DRAINS AND OTHER SERVICES         METHOD OF EXCAVATION         MAIN LAYING         BACKFILLING OF TRENCH         ANCHOR BLOCKS AND SUPPORTS         CHAMBERS AND SURFACE BOXES         TESTING         CLEANING AND STERILISING THE MAIN         CLEARANCE OF SITE         TESTING OF WATER RETAINING STRUCTURES         STERILISATION OF WATER RETAINING STRUCTURES	123         124         125         126         127         127         127         128         129         129         129
8 8.1 8.2 8.3 8.4 8.5 8.6 8.7 8.8 8.9 8.10 8.11 8.12 8.13 8.14 8.15 8.16 9 0 1	WORKMANSHIP         HANDLING OF PIPES AND FITTINGS         LOADING AND UNLOADING         STORAGE         TRANSPORT         EXAMINATION OF PIPES AND FITTINGS         INTERFERENCE WITH FENCES, DRAINS AND OTHER SERVICES         METHOD OF EXCAVATION         MAIN LA YING         BACKFILLING OF TRENCH         ANCHOR BLOCKS AND SUPPORTS         CHAMBERS AND SURFACE BOXES         TESTING         CLEANING AND STERILISING THE MAIN         CLEARANCE OF SITE         TESTING OF WATER RETAINING STRUCTURES         STERILISATION OF WATER RETAINING STRUCTURES         TESTING OF MATERIALS AND WORKMANSHIP         APPAR ATUS DEQUIDED EOD TESTING ON SITE	123         123         123         123         123         123         123         123         123         123         123         123         123         123         123         123         123         125         126         127         127         127         127         128         129         129         129         120
8 8.1 8.2 8.3 8.4 8.5 8.6 8.7 8.8 8.9 8.10 8.11 8.12 8.13 8.14 8.15 8.16 9.1 9.1	WORKMANSHIP         HANDLING OF PIPES AND FITTINGS         LOADING AND UNLOADING         STORAGE         TRANSPORT         EXAMINATION OF PIPES AND FITTINGS         INTERFERENCE WITH FENCES, DRAINS AND OTHER SERVICES         METHOD OF EXCAVATION         MAIN LA YING         BACKFILLING OF TRENCH         O ANCHOR BLOCKS AND SUPPORTS         CHAMBERS AND SURFACE BOXES         TESTING         CLEANING AND STERILISING THE MAIN         CLEARANCE OF SITE         TESTING OF WATER RETAINING STRUCTURES         STERILISATION OF WATER RETAINING STRUCTURES         TESTING OF MATER RETAINING STRUCTURES         TESTING OF MATERIALS AND WORKMANSHIP         APPARATUS REQUIRED FOR TESTING ON SITE         LOAD TEETING OF EDES	123         124         125         126         127         127         127         127         128         129         129         120         130         130         120
8 8.1 8.2 8.3 8.4 8.5 8.6 8.7 8.8 8.7 8.8 8.10 8.11 8.12 8.13 8.14 8.15 8.16 9.1 9.1 9.2	WORKMANSHIP         HANDLING OF PIPES AND FITTINGS         LOADING AND UNLOADING         STORAGE         TRANSPORT         EXAMINATION OF PIPES AND FITTINGS         INTERFERENCE WITH FENCES, DRAINS AND OTHER SERVICES         METHOD OF EXCAVATION         MAIN LAYING         BACKFILLING OF TRENCH         ANCHOR BLOCKS AND SUPPORTS         CHAMBERS AND SURFACE BOXES         TESTING         CLEANING AND STERILISING THE MAIN         CLEANING AND STERILISING THE MAIN         CLEARANCE OF SITE         TESTING OF WATER RETAINING STRUCTURES         STERILISATION OF WATER RETAINING STRUCTURES         TESTING OF MATERIALS AND WORKMANSHIP         APPARATUS REQUIRED FOR TESTING ON SITE         LOAD TESTING OF PIPES	123         124         125         126         127         127         127         128         129         129         129         120         130         130         120
8 8.1 8.2 8.3 8.4 8.5 8.6 8.7 8.8 8.9 8.10 8.11 8.12 8.13 8.14 8.15 8.16 9 9.1 9.2 10 10	WORKMANSHIP	123         124         125         126         127         127         127         127         128         129         129         120         130         130         130         121
8 8.1 8.2 8.3 8.4 8.5 8.6 8.7 8.8 8.9 8.10 8.11 8.12 8.13 8.14 8.15 8.16 9.1 9.2 10.1 10.2	WORKMANSHIP         HANDLING OF PIPES AND FITTINGS         LOADING AND UNLOADING         STORAGE         TRANSPORT         EXAMINATION OF PIPES AND FITTINGS         INTERFERENCE WITH FENCES, DRAINS AND OTHER SERVICES         METHOD OF EXCAVATION         MAIN LA YING         BACKFILLING OF TRENCH         ANCHOR BLOCKS AND SUPPORTS         CHAMBERS AND SURFACE BOXES         TESTING         CLEANING AND STERILISING THE MAIN         CLEANING AND STERILISING THE MAIN         CLEARANCE OF SITE         TESTING OF WATER RETAINING STRUCTURES         STERILISATION OF WATER RETAINING STRUCTURES         TESTING OF MATER RETAINING STRUCTURES         TESTING OF MATER RETAINING STRUCTURES         TESTING OF PIPES         MISCELLANEOUS         APPARATUS REQUIRED FOR TESTING ON SITE         LOAD TESTING OF PIPES         MISCELLANEOUS         GENERAL         BONDING TIES	123         124         125         126         127         126         127         128         129         129         129         130         130         131         131

10.3	PRECAST LINTELS	131
10.4	BLOCKWORK	131
10.5	DAMP-PROOF COURSE (D.P.C.)	131
10.6	HARDWOOD	132
10.7	PLYWOOD	132
10.8	DOORS	132
10.9	FRAMES AND LININGS	132
10.10	ARCHITRAVES AND STOPS	132
10.11	IRONMONGERY	132
10.12	JOINERY	132
10.13	. FIXING JOINERY	133
10.14	FIXING IRONMONGERY	133
10.15	BOLTS AND NUTS	133
10.16	STRUCTURAL STEELWORK	133
10.17	GALVANISED WORK	134
10.18	ELECTRICAL INSTALLATION	134
10.19	WATER AUTHORITIES REGULATIONS	134
10.20	RAINWATER INSTALLATIONS	134
10.21	TESTING PLUMBER'S WORK	134
10.22	SETTING OUT	135
10.23	COPPER TUBES AND FITTINGS	135
10.24	PLASTIC PIPES, FITTINGS AND ACCESSORIES	135
10.25	SLEEVES	135
10.26	PIPEWORK GENERALLY	135
10.27	BRASSWORK	135
10.28	CISTERNS	136
10.29	SANITARY FITTINGS	136
11 P	LASTERWORK AND OTHER FLOOR, WALL AND CEILING FINISHINGS	137
11.1	GENERAL	137
11.2	METAL LATHING	137
11.3	CEMENT	137
11.4	SANDS	137
11.5	LIME PUTTY	137
11.6	PLASTICISERS	137
11.7	WATER PROOFERS	138
11.8	ANGLE AND CASING BEADS AND RENDER STOPS	138
11.9	GLAZED CERAMIC WALL TILES	138
11.10	ADHESIVE	138
11.11	FIXING WALL TILES	138
11.12	CERAMIC FLOOR TILES	138
11.13	LAYING FLOOK TILES	138
11.14	FIXING METAL LATHING	138
11.15		138
11.16	INTERNAL RENDERING	139
11.17	EXTERNAL RENDERING (TYROLEAN)	139
11.18	EXPANSION JOINTS	139
11.19	PREPARATION	139

11.20	PAINT AND PAINTING	139
11.21	PREPARATION	140
11.22	PROTECTIVE DECORATIVE FINISH	140
11.23	RENDERED PANELS	141
11.24	IRONMONGERY FURNITURE	141
11.25	PREPARATION OF ROAD FORMATION	141
11.26	MURRAM SUB-BASE	141
11.27	WATER-BOUND MACADAM BASE	142
11.28	ROLLED ASPHALT HOT PROCESS WEARING COURSE	142
11.29	BITUMEN MACADAM WEARING COURSE	142
11.30	COMPACTION AND SURFACE FINISH	143
11.31	. PREPARATION OF THE BASE FOR SURFACING OR SURFACE DRESSING	143
11.32	PRIME COAT AND TACK COAT	143
11.33	ROLLING OF SURFACE MATERIALS	144
11.34	TRAFFIC ON NEWLY CONSTRUCTED ROADS	144
11.35	LAYING KERBS, CHANNELS AND EDGING BLOCKS	145
11.36	CONCRETE BLOCK PAVINGS	145
11.37	. LAYING OF BLOCKS	145
11.38	LAYING COURSE	145
11.39	CUTTING BLOCKS	146
11.40	VIBRATION	146
11.41	PREPARATION OF FOOTPATH FORMATION	146
11.42	. PRECAST CONCRETE PAVING	146
11.43	CHASING	147
11.44	DAMP-PROOF COURSES (D.P.C.)	147
11.45	. BITUMINOUS FELT ROOFING	147
11.46	HACKING, ETC.	147
11.47	SURFACES	147
11.48	PRICES FOR PAVING	147
11.49	POLISHED TERRAZZO	148
11.50	ATTENDANCE UPON ENGINEER'S STAFF	148
11.51	TRAINING OF EMPLOYER'S PERSONNEL	148
12 N	IECHANICAL WORKS	149
12.1	GENERAL	149
12.2	TRADE NAMES	149
12.3	SPARE PARTS	149
12.4	STORAGE OF MATERIALS	149
12.5	TESTS ON MATERIALS / EQUIPMENT	150
12.6	DRAWINGS	150
12.7	DESCRIPTION OF SERVICES	151
12.8	MAINTENANCE	151
12.9	INITIAL DEFECTS LIABILITY PERIOD	151
12.10	MAINTENANCE AND SERVICES AFTER COMPLETION OF INITIAL DEFECTS LIABILITY PERIOD	152
12.11	MANUFACTURER'S MAINTENANCE MANUALS	152
12.12	. PRESSURE GAUGES	153
12.13	CHEMICAL DOSERS	153
12.14	AGITATORS	153

### **1** SECTION 1 – GENERAL

### 1.1 GENERAL

All materials, equipment and testing apparatus etc. to be furnished and Works to be executed by the Contractor in this Contract shall conform to the requirements of the latest Kenya Standards, International Standards Organisation (ISO) Standards, DIN, British Standards or other approved applicable Standard in Kenya, unless otherwise specifically stated.

Equipment to be purchased shall be from well recognised manufacturers whose products are standardised and controlled by any recognised Standards Organisation.

All dimensions and measurement units shall be in S.I. units.

The Contractor may propose to the Engineer an alternative Standard other than specified, in which case he shall submit six (6) copies of the English translation of the proposed Standard and all other information for the materials, equipment and testing, together with written proof from a recognised Standards Organisation that the proposed Standard is equivalent in all significant respects to the Standard specified.

The equipment to be employed by the Contractor shall have sufficient performance capacity and durability as to secure the completion of the Works within the construction period stipulated under the Contract. All materials and equipment shall be subject to inspections or tests by the Engineer at any time and in any state of completion both off-site and on-site as he deems necessary. The Contractor shall furnish promptly, without additional charge, all facilities, labour and materials reasonably needed for performing such inspections and tests as may be required by the Engineer.

The Contractor shall make diligent efforts to procure the specified materials, but when the materials specified are unavailable, for reasons beyond the control of the Contractor, substitutes may be used with prior written approval of the Engineer.

### **1.2** OFFICE AND ACCOMMODATION FOR PROJECT ENGINEER

The offices for the Project Engineer on Site will be rented premises or other arrangement provided by the Contractor who will furnish it as specified hereunder.

The Project Engineer's offices shall be regularly and properly cleaned to the satisfaction of the Engineer. A messenger and tea boy / office cleaner shall be provided by the Contractor exclusively for the Project Engineer's offices. Also Security Guards shall be provided for day and night security at these offices. The offices, furniture and equipment shall be insured against fire, theft and natural calamity.

### 1.3 PROVISION FOR PROJECT ENGINEER'S OFFICE IN KIBERA

Furniture	<u>Qty.</u>
Writing Desk with 3 lockable drawers	3 Nr
Writing Desk without Locks	2 Nr
Metal Chairs with arm rests	5 Nr
Wooden Conference Table, 3.0m x 1.2m	1 Nr
Wooden Table, 2.4m x 1.2m	1 Nr
Metal office chairs without arm rests	6 Nr
Plan Chest with 4 lockable drawers suitable for A1 size	1 Nr
Drawing racks suitable for A1 drawings	1 Nr
Lockable Steel Cupboard (Size 1m x 1.8m x 0.5m deep)	1 Nr
Office paper punch	2 Nr
Pin board 2.4m x 1.2m	2 Nr
Whiteboard, 2.4m x 1.2m	1 Nr
Whiteboard, 1.2m x 1.2m	1 Nr
Office Tray (3 tier)	3 Nr
Office Stapling Machines	2 Nr
Heavy Duty Stapler	1 Nr

<u>Furniture</u>	<u>Oty.</u>
Steel File Cabinet with locks / 4 drawers ('Mecol'	2.33
or equivalent approved)	2 Nr
'Casio' or similar small portable scientific electronic	1 Nr
'Casio' or similar small portable electronic calculator	2 Nr
First Aid kit (for 10 persons) in Metal Box	1 Nr
Potable Fire Extinguisher (5 litres)	2 Nr
Small office scissors	2 Nr
Waste paper baskets	2 Nr
Electric kettle (capacity to make 12 cups of tea)	1 Nr
Coffee/Tea making facility including crockery for all supervisory staff 10 Nr. and 12 additional guests	1 Nr
Coffee/Tea making facility including crockery for all supervisory staff 4nr. and 4 additional guests	1 Nr
Pedastal electric fan, size 400mm	1 Nr
'Sanyo' or equivalent approved Refrigerator (0.2	1 Nr
Wooden book shelves with lockable glass frontage	1 Nr
Desktop – "HP" or approved equivalent OptiPlex GX520, Intel (R) Core (TM) i3, 2.4 GH <sub>z</sub> , 500GB HDD, 4 GB RAM, DVD R/CD-RW Optical Drive, with 17" Flat Panel Monitor. Win XP Professional	1 Nr
Laptop – "HP" or approved equivalent Latitude D620 Intel (R) Core (TM) i7-6700 HQ CPU @ 2.60 GHz, 2.6 GHz, 1TB HDD, 8 GB RAM, DVD <u>+</u> RW Optical Drive, 17" Wide Screen, WiFi / 56K Modem, Bluetooth, with Win XP Professional and Microsoft Office 2014 or latest Version	3 Nr
HP LaserJet Printer A4	1 Nr
HP Colour Inkjet Printer A3	1 Nr
HP Colour LaserJet Printer, 1200 x 1200 dpi, 20ppm, with Largest Supported Paper Size – A3	1 Nr
HP Inkjet Compact Printer A4	1 Nr
Photocopier - Nashua or approved equivalent, A3, 18 pages per minute	1 Nr
Petty Cash Box with security lock	1 Nr
Wall Clock	2 Nr
Ibico' or approved equivalent binding machine suitable to bind upto 40mm spirals	1 Nr

<u>Furniture</u>	<u>Oty.</u>
Flashlights (battery powered)	3 Nr
Digital Camera as specified	2 Nr

The Contractor shall provide a Secretary who can speak English and is conversant in the use of above mentioned software for the duration of the Contract.

Stationery required **per month** as follows:

Stationery	<u>Qty.</u>
Photocopy paper A4	3 Reams
A3 paper	1 Ream
Biro pens blue/black	1 Doz.
Clutch Pencils	1 Doz.
Box files	4 Nr
Spring Files	2 Nr
Document Wallets	3 Nr
Spirals (various sizes of Reports)	2 Doz.
Embossed (hardback cover)	2 Doz.
Perspex covers	2 Doz.
Cellotape (medium)	1 Nr
Masking tape (medium)	1 Nr
Staples	2 Pac.
Paper clips (various sizes)	2 Pac.
Pencil leads (0.5/0.7)	2 Sets
C-DR (Pack of 12)	1 Pac.
CD-RW (Pack of 12)	1 Pac.
Highlighters (set of all colours)	2 Sets
A6 hardcover notebooks	2 Nr
Soft Pencil Erasers (Staedtler or equivalent)	3 Nr
Envelopes (all sizes)	3 Doz.
A4 Carbon papers	1 Doz.
Batteries for flashlights	3 Sets

Stationery	<u>Oty.</u>
Colour and Black ink cartridges for the A3 printer	1 Set
Black ink cartridge/ toner for the A3 printer	3 Nr

Supply of clean towels <u>everyday</u>, soap, lavatory paper, disinfectant and cleaning materials is to be provided and maintained throughout the Contract Period.

The cost of all the above services shall be included by the Contractor under item for maintenance and attendance for Project Engineer's offices. Apart from the consumables, the rest of equipment will revert to the Employer at the end of the Contract.

### 1.4 SURVEY EQUIPMENT

Listed below are the principal items of survey equipment to be provided for use during the whole duration of Project Implementation. All equipment shall be as new and with all necessary carrying containers, manuals, insurances, etc. The Equipment to revert to Contractor at completion of all Works.

Equipment	Qty
Precise automatic levels including tripods (Wild or similar)	1 Nr
Total Station including tripods, complete with reflectors, poles and brackets (Wild or similar)	1 Nr
Metric extending levelling staffs with vertical bubble	1 Nr
30m (enamelled or otherwise protected) steel bands	1 Nr
3 metre ranging rods	6 Nr
Survey umbrellas with stand	1 Nr
5 metre steel tapes	2 Nr
Builders spirit levels 1000mm long	1 Nr
Hammers 3 kg each	1 Nr

Supply of pegs, crayons, spray paint, nails and all other items required for setting out and measuring the work.

The Contractor shall provide the services of two Chainmen as and when requested for the sole use of the Engineer and Engineer's Representative for the whole period of the Contract.

### **1.5 OFFICE FOR CONTRACTOR**

The Contractor shall have an office on the site to be approved by the Engineer and which shall be open and attended to at all hours during which work is in progress. Notwithstanding anything contained in Clause 67(1) of the General Conditions of Contract, any notice to be

given to or served upon the Contractor shall be deemed and taken to be efficiently given or served by the delivery thereof at such office on the site.

### **1.6 CONTROL OF TRAFFIC**

In the event of single way traffic becoming necessary on any particular section of the Works, or on the approaches to the Works, the Contractor shall, in maintaining through traffic routes, provide a width of at least 3 metres for single way traffic. He shall also provide approved electrically operated signals for traffic control on each of the affected sections and any additional traffic signs as may be directed in accordance with Clause

106. Signal lights are to be operated by competent operators provided by the Contractor, if and when required by the Engineer. Manually operated "Stop-Go" signs will only be permitted if approved by the Engineer, and shall be of the size, colour and type authorised. The Contractor shall be responsible for liaison with Police.

### **1.7 TEMPORARY DIVERSION OF TRAFFIC**

Temporary diversion ways, including those listed in any schedule to the Bill of Quantities shall be constructed whenever the site is intersected by existing public and private roads, footpaths, cycle tracks, farm accesses, temporary and accommodation roads.

Any diversion way shall be of such a standard of construction that it is suitable in all respects for the class or classes of traffic requiring to use it. It shall be constructed in advance of the taking up of the existing way and regularly maintained for so long as required in a satisfactory condition all to the approval of the Engineer.

### **1.8 TEMPORARY TRAFFIC SIGNS**

The Contractor shall erect and maintain on the Works and at prescribed points on the approaches to the Works, all traffic signs necessary for the warning, direction and control of traffic and the size of all such signs and the lettering and wording thereon shall be reflectorised or adequately illuminated at night by approved means.

### **1.9 PROTECTION OF WORKS**

The Contractor shall carefully protect from injury by weather all work and materials which may be affected thereby.

### **1.10 SURVEY BEACONS**

During the progress of the Works, the Contractor shall not remove, damage, alter or destroy in any way whatsoever, any plot or survey beacons. He shall notify the Engineer of the need to interfere with any beacon. The Engineer shall authorise any removal and reinstatement that he considers necessary. Should any beacon be found to be above or below the level of the finished work, the Contractor shall immediately report the same to the Engineer.

Should any beacon be damaged or destroyed, the Contractor shall forthwith report the damage to the Engineer and to the Director of Surveys and shall be held liable for the cost of reinstatement thereof.

### 1.11 DAMAGE TO LAND

Except where specified for the proper execution of the Works, the Contractor shall not interfere with any buildings (both makeshift & permanent), fence, hedge, tree, land or crops within, upon or forming the boundary of the site or elsewhere. In the event of such interference, the Contractor shall make good to the satisfaction of the owner and the Engineer and shall pay to the owner such damages as the Engineer may determine.

### 1.12 RIVERS AND DRAINS

The Contractor shall at all times maintain the free flow of rivers and drains and prevent excavated material from the Works from being deposited in them.

### 1.13 REINSTATEMENT OF ROADS AND FOOTWAYS FOR WATER MAINS

### Water Mains laid under roads shall be of HDPE and ferrous material.

The Contractor shall allow in his rates for liaison with the relevant Roads Authority and obtain a Road Opening Permit. Statutory fee for road crossings will be paid under relevant Item in the Bills of Quantity.

The road crossings shall be constructed in the following specifications and any other requirement stipulated by the Road Authority:

- Excavated width of the trench shall not be less than 1m to ensure compaction to required standard
- Protective concrete raft slab shall be constructed for sewer pipes as per details given in the drawings.
- Backfilling shall be carried out with suitable selected excavated material upto the top 300mm, in layer thickness not exceeding 150mm at optimum moisture content
- The top 300mm layer shall be backfilled in two layers of 150mm each comprising of well graded stabilized gravel with 3% cement content at optimum moisture content
- Tarmac roads shall be reinstated to the original condition using approved asphalt from a recommended supplier.

The Contractor shall be responsible for all liaison with the Police for traffic control during execution of the works.

### 1.14 TEMPORARY WORKS

The Contractor shall provide, maintain and remove on completion of the Works all temporary Works including roadways, sleeper tracks and stagings etc., over roads, footpaths, suitable in every respect to carry all plant required for the work or for providing access or for any other purpose.

Details of Temporary Works shall be submitted in advance to the Engineer for his approval and the approval shall not relieve the Contractor of complete responsibility for their safety and satisfactory operation.

### 1.15 LIGHTING AND GUARDING OF OBSTRUCTIONS

The details of the method of signing and guarding an obstruction to traffic caused in the course of the execution of the Works shall be submitted to the Engineer for approval before that portion of the Works is commenced.

No greater area of the road than the Engineer considers necessary shall be closed at any one time.

Temporary traffic signs shall comply with Clause 106. Generally the following

precautions will be required:- Signing

An advance warning sign at least 1.22m x 0.92m in size and 70 metres in advance of the obstruction will be required, and where an appreciable change of direction is necessary at the obstruction, a sign (of the arrow or chevron type) at the obstruction itself. At particular danger points more comprehensive signing may be required.

### Guarding

The obstruction shall be marked by posts carrying red flags or reflective red markers and by red lamps. The latter shall be spaced at 6 metres intervals in the direction of traffic flow and at 0.9 metres intervals across this direction. At least 3 lamps shall be placed across this direction of traffic flow. The flags and lamps on the traffic side of the obstruction shall be at least 5 metres from it.

### **Footpaths**

Where a footpath is affected by an obstruction in any way it shall be separated from both obstruction and traffic by effective banners and red lamps spaced at 0.9 metres intervals.

### 1.16 SERVICES

Before commencing Works which include excavation or ground levelling by manual or mechanical excavation the Contractor shall at his own expenses ascertain in writing from the Kenya Posts & Telecommunications Corporation, Kenya Power & Lighting Co. Ltd. and all other Public Bodies, Companies and persons who may be affected, the position and depth of their respective ducts, cables, mains, pipes, or other appurtenances. He shall thereupon search for and locate such services.

The Contractor shall at his own expense arrange to have effectually propped, protected, underpinned, altered, diverted, restored and made as may be necessary, all water courses, pipes, cables or ducts, poles or wires or their appurtenances disturbed or damaged during the progress of the Works, or in consequence thereof.

Except that such services as require to be removed or altered by virtue of the layout of the permanent work and not the manner in which the work is carried out, shall be so removed or altered at the direction and at the expense of the Employer.

The Contractor shall be liable for the cost of repairs to any services damaged as a result of carrying out the Works and execution of these Works.

### 1.17 PRIVATELY OWNED OR PUBLIC SERVICES

If any privately owned or public services passing through the site will be affected by the Works, the Contractor shall provide at his own expense a satisfactory alternative service in full working order to the satisfaction of the owner of the services and the Engineer, before the cutting of the existing service. Any damage to private or public services shall be made good by the Contractor at his cost.

In case the remedial work is not executed promptly by the Contractor, the Engineer may make alternative arrangements for the execution of the work and debit the costs to the Contractor.

### 1.18 WATER SUPPLY

The Contractor shall provide for all purposes of the work, an adequate supply of water from a suitable source or sources approved by the Engineer. He must pay the water charges, if any, and make arrangements for supply, transport and distribution.

### **1.19 ADDITIONAL LAND**

The Contractor shall select and arrange at his own expenses for any temporary occupation of land outside the site which he requires for the efficient execution of the Works. The Contractor must comply fully with all By-laws and Regulations currently in force in the area.

### **1.20** USE OF HEAVY PLANT

In the event of the Contractor desiring to use heavy machinery or plant, he shall first satisfy the Engineer that they will be of such size and used in such a manner as not to cause any disturbance or damage in particular to buildings (both makeshift & permanent), water, electricity, Post Office or other mains, cables and connections or to sewers, culverts etc. or interfere with the line or position of any overhead wires and cables of any sort, telegraph poles, power poles etc.

The Contractor will be held liable for any such damage or disturbance and shall pay the full costs of any reinstatement, relaying, repairing or refixing as may be required, as agreed between the Engineer and the owner affected.

### 1.21 PROVISION OF INSTRUMENTS AND LABOUR

The Contractor shall provide at his own expenses all instruments, materials, tools and other things which the Engineer considers necessary for his proper supervision of the Works and shall maintain the same in good order. He shall also provide materials, an experienced Surveyor and labour for attendance on the Engineer and his representatives in carrying out operations

connected with the supervision of the Works. All charges arising out of such services shall be deemed to be included in his rates in the Bill of Quantities.

### 1.22 ACCESS TO SITES

The Contractor shall construct and maintain all temporary accesses required for the execution of the Works. Access roads shall be constructed and maintained up to the site office and Project / Assistant Project Engineer's houses. The cost of all these Works shall be deemed to be covered by rates and prices quoted by the Contractor.

### **1.23 POLLUTION**

The Contractor shall ensure that during the course of his operations no pollution of the atmosphere, rivers, reservoir catchment areas or groundwater is allowed to take place.

### **1.24 TREE PROTECTION**

Trees within the permanent and temporary easement are the property of owners. Specific trees will be identified by the Engineer, prior to construction, and the Contractor shall neither remove nor cut their roots unless otherwise directed by the Engineer. If the roots of such trees appear within the trench areas, the Contractor shall handle the roots with maximum care so that no portion of the roots will be damaged. During the excavation of the trench, the exposed roots may be removed to a position that will not damage the roots and will not interfere with the pipelaying. During the construction, the roots shall be thoroughly protected by appropriate cover and wetted as directed. After the pipes are laid, the moved roots shall be placed back to the original locations and backfilled carefully by selected soft soil which can support vegetation.

### 1.25 GEOLOGICAL DATA

Any geological data that is made available to the Contractor and is relevant to the Works, will be for his guidance only, and no guarantee is given that other ground conditions will not be encountered. No claims based on the geological data provided shall be entertained by the Engineer. The Contractor shall be deemed to have made any additional investigations required before submission of his Tender.

#### 1.26 WATCHING, FENCING AND LIGHTING

The Contractor shall arrange to employ watchmen to guard the Works both during the day and night from the commencement of the Works until the substantial completion of the Works.

Any excavation or other obstruction likely to cause injury or damage to any person or domestic animals must be fenced off as directed by the Engineer.

#### 1.27 TIPS

The Contractor shall be responsible for provision of all tips, at his own expense, for disposal of all spoil or other rubbish collected during the construction of the Works. Any surplus excavated material not required shall also be carted away to these tips. The site of the tips must be approved by the Engineer.

### **1.28 TROPICALISATION**

In choosing materials and their finishes, due regard shall be given to the tropical conditions of the site to which they will be subjected. The Contractor shall submit details of his practices which have proven satisfactory and which he recommends for application on the parts of the Works which may be affected by the tropical conditions.

### **1.29** MONTHLY SITE MEETINGS

Throughout the project period, site meetings will be held at the Project Engineer's office once every calendar month to discuss the progress of the work, schedule for the ensuing month, methods of construction, procurement, transportation, labours, etc. These meetings can be called at any other time intervals at the request of the Contractor or as directed by the Engineer.

### **1.30** INSPECTION BY ENGINEER DURING DEFECTS LIABILITY PERIOD

The Engineer will give the Contractor due notice of his intention to carry out inspection during the Defects Liability Period and the Contractor shall upon receipt of such notice arrange for a responsible representative to be present at the times and dates named by the Engineer. This representative shall render all necessary assistance and take notice of all matters and things to which his attention is directed by the Engineer.

### 1.31 SUBMISSION OF SAMPLES

Before incorporating in the finished work any materials or articles which he supplies under the terms of the Contract, the Contractor shall submit to the Engineer's Representative for his approval a sample of each respective material or article, and such samples shall be delivered to and kept at his office for reference. All the respective kinds of materials and articles used in and upon the Works, shall be at least equal in quality to the approved samples. Each and every sample shall be a fair average of the bulk material or of the article which it represents. The Engineer's Representative may decide the method by which each sample to be taken from the bulk material shall be obtained.

# **1.32** RESPONSIBILITY FOR ORDERING MATERIALS AND MANUFACTURED ARTICLES AND SAMPLES FOR TESTING

The responsibility for so ordering and delivering materials and manufactured articles and samples that they may be tested sufficiently far in advance of the work as not to delay it, shall rest upon the Contractor, and he shall not be entitled to any time credit for delay occasioned by his neglect to order sufficiently well in advance or to effect payment of any costs he may incur as a result thereof.

With regard to any item in the Bill of Quantities which is the subject of a P.C. Sum, the Contractor shall notify the Engineer of his requirements as early as possible leaving ample time for the Engineer to make any necessary arrangements so that no delay occurs in the progress of the work.

### 1.33 TESTS OF MATERIALS AND MANUFACTURED ARTICLES BEFORE USE

Any or all of the materials and manufactured articles supplied by the Contractor for use on any of the Works throughout this Contract shall be subject in advance to tests as may be specified in the relevant Standard Specification as may from time to time be deemed necessary by the Engineer. Samples of all such materials and manufactured articles, together with all the necessary labour, materials, plant and apparatus for sampling and for carrying out of tests on the site on all such materials and manufactured articles shall be supplied by the Contractor at his own expenses. The cost of special tests ordered by the Engineer to be carried out by an independent person at a place other than the site or place of manufacture or fabrication shall be borne by the Contractor.

### **1.34 REJECTED MATERIALS**

Should any material or manufactured articles be brought on to the site of the Works which are in the judgement of the Engineer unsound or of inferior quality or in any way unsuited for the work in which it is proposed to employ them, such materials or manufactured articles shall not be used upon the Works but shall be branded if, in the opinion of the Engineer, this is necessary and shall forthwith be removed from the site of the Works, all at the Contractor's expense and in each case as the Engineer shall direct.

### 1.35 QUALITY OF MATERIALS AND WORKMANSHIP

The materials and workmanship shall be of the best of their respective kinds and shall be to the approval of the Engineer. In the reading of this Specification the words "to the approval of the Engineer" shall be deemed to be included in the description of all materials incorporated in the Works, whether manufactured or natural and in the description of all operations for the due execution of the Works.

### **1.36 TEST RUNNING OF THE SCHEME**

Upon substantial completion of the scheme and official inspection which agrees to this, the Contractor shall operate the entire scheme for the test period indicated in the Bill of Quantities.

The Contractor shall supply all necessary personnel, electricity, fuels, oils and chemicals for the test running and together with the Project Engineer shall compile a list of detailed operating instructions that shall be incorporated into the Operation and Maintenance Manual. The Contractor shall further bring to the attention of the Project Engineer and of the Employer's operational staff any problem or defects he encounters during this period of test running so that solutions may be found and any necessary alterations made.

### **1.37** EQUIPMENT FOR THE PROJECT ENGINEER

The Contractor shall provide 3 Nr Digital Cameras, Sony or approved equivalent, suitable for Construction Sites with splash and shock proof casing for exclusive use of the Project Engineer and his staff for the purpose of taking record photographs of the progress of the Works. The Camera should have picture capture resolution of 7.1 megapixels or more, both optical and digital zoom capabilities, storage capacity of 128 MB, downloading facility by means of USB port, neck strap and hard cover pouch. The Contractor shall further provide 1 Nr suitable photo printer with necessary photo paper and ink cartridges for prints production. The cost for this service is deemed to be covered by the Contractor in his rates in the Bill of Quantities.

### **1.38 OPERATION AND MAINTENANCE MANUAL**

A draft Operation and Maintenance Manual has been compiled prior to commencement of construction of the Works.

This Manual has to be revised and brought to a final draft state prior to the test running of the scheme. The Contractor is required to provide in triplicate, and in English, details of all the different manufactured plant and components incorporated in the Works including but not limited to all pertinent manufacturers' brochures.

Substantial completion of the scheme will not be considered until such detailed information as is required has been submitted to and accepted by the Engineer.

### **1.39 CONSTRUCTION PROGRAMME**

The Contractor shall submit to the Engineer for approval, a revision of the Construction Programme attached in four (4) copies and after approval to the Employer in two (2) copies in the following manner:

(1) Within thirty (30) days after receiving the Letter of Acceptance, the Contractor shall submit to the Engineer for approval, a detailed programme based on the key date stated hereinafter or other dates which are given in the Letter of Acceptance in the form of a Critical Path Method (hereinafter referred to as CPM Network) showing the order of procedure in which he proposes to carry out the Works including design, manufacture, delivery to the site, transport, storage, survey, construction, commissioning and maintenance. This programme shall indicate clearly all activities and its duration along with the earliest and the latest event, times and the first and last dates of the submission of the Drawings and each date of shop inspection by the Engineer for the section or portion of the Works.

The programme so prepared shall be rearranged in the form of a Time Bar-chart Schedule of which size shall be 841mm x 594mm (A-1 size). This Time Bar- chart Schedule shall be submitted to the Engineer together with the CPM Network.

(2) The CPM Network shall be in accordance with commonly accepted practices and shall show graphically the chain of activities / sub-activities and their sequential relationship with each other from the start of construction to the completion of the Contract. The Time Bar-chart Schedule shown in weeks shall list all main activities and its applicable sub-activities.

(3) In preparing the CPM Network and the Time Bar-chart Schedule the Contractor shall make due allowances for possible delays. Under no circumstances shall the CPM Network or the Time Bar-chart Schedule show a completion in excess of the "Time for Completion" stated in the Form of Tender.

(4) The programme once approved by the Engineer shall thereafter be referred to as the Contractual Programme. The Engineer's approval of such programme shall not relieve the Contractor of any of his duties or responsibilities under the Contract.

The Contractual Programme approved shall supersede all other programmes and shall be deemed to be the programme on which the Contractor has based his Contract Sum and in accordance with which he will undertake the execution of the Works. This Programme shall become part of the Contract.

The Contractor shall ensure that all the Works especially Electrical and Mechanical Works which may be carried out by the Electrical/Mechanical Sub-Contractor, are well coordinated with the overall Works under the Contract for the efficient execution of the Works, and shall clearly indicate them on the construction programme.

The Contractor shall also describe the conditions of working shifts, if necessary, to execute the Works and whether work needs to be carried out at night and/or on Sundays and holidays. The Contractor should also indicate which particular Works are subject to these timings in his construction programme.

Whenever the Contractor proposes to change the Contractual Programme, approval of the revision shall be obtained in writing from the Engineer.

If the Contractor has fallen behind the approved Contractual Programme or can foresee delay(s) therein, he shall, immediately after such default or event occurred or foreseen or at the request of the Engineer submit a revision of the Contractual Programme showing the reasons of such a delay and the proposed measures to recover such delay or to complete the Works on time, for the approval of the Engineer.

### **2** CLEARING SITE

### 2.1 CLEARING SITE

The Contractor shall demolish, break up and remove buildings, walls, gates, fences, advertisements and other structures and obstructions, grub up and remove trees, hedges, bushes and shrubs and clear the site of the works at such time and to the extent required by the Engineer but not otherwise, subject to the provisions of Clause 27 of the Conditions of Contract: the materials so obtained shall so far as suitable be reserved and stacked for further use; all rubbish and materials for use shall be destroyed or removed from the site, as directed by the Engineer.

Where top soil has to be excavated this shall be removed and stacked on site. After completion of construction, it shall be spread over the disturbed ground, any surplus being disposed of as directed by the Engineer.

Underground structures and chambers where required to be demolished, shall be demolished to depths shown on drawings or as directed. They shall be properly cleaned out and backfilled and compacted with suitable material to the direction and approval of the Engineer.

### 2.2 VEGETATION

No allowance will be made for the cutting and removal of crops, grass, weeds and similar vegetation. The cost of all such work will be held to be included in the rates entered in the Bill of Quantities.

### 2.3 BUSHES AND SMALL TREES

All bushes and small trees, the main stem of which is less than 500mm girth at 1 metre above ground level shall be uprooted (unless otherwise directed by the Engineer) and burnt or otherwise disposed off as directed by the Engineer.

### 2.4 HEDGES

Where directed by the Engineer, hedges shall be uprooted and disposed off by burning.

### 2.5 FELLING TREES

Where shown on the drawings or directed by the Engineer, trees shall be uprooted or cut down as near to ground level as is possible. The rates entered in the Bill of Quantities shall include for cutting down, removing branches and foliage, cutting useful timber into suitable lengths, loading, transporting not more than 1 km. and stacking or disposing off all as directed by the Engineer.

For the purpose of measurement trees cut down shall be classified according to their girth at 1 metre above ground level, the cost of grubbing up roots shall be deemed to be covered by the rate for felling trees.

### 2.6 GRUBBING-UP ROOTS

Stumps and tree roots shall, unless otherwise directed, be grubbed up, blasted, burnt or removed and disposed of in approved dumps to be provided by the Contractor. Where directed by the Engineer, the holes resulting from grubbing up shall be filled with approved materials, which shall be deposited and compacted in layers not exceeding 225mm loose depth, to the same dry density as that of the adjoining soil. For the purpose of measurement, tree roots shall be classified according to the mean diameter of the stump measured across the cut.

### 2.7 WEED CONTROL

The Contractor shall take all necessary precautions against the growth on the site of weeds and remove them as necessary throughout the period of works and maintenance.

The finished base of all footways and elsewhere as directed shall be sprayed with an approved persistent total herbicide at the rate recommended by the manufacturer. The application shall be by an even spray in a high volume of water at about 0.7 to 0.11 litres per square metre. After this application the footways shall receive at least two further waterings before the surface is sealed.

### **3** EXCAVATION

### 3.1 DEFINITION AND CLASSIFICATION OF EXCAVATED MATERIALS

Excavation in the Bills of Quantities shall be classified in two categories:-

### <u>Common Excavation</u>

Any material which in the opinion of the Engineer can be excavated by use of pick axes and hand levers shall be classified as common excavation. Water logged material shall be included in this class. Murram in any form shall be classified as common excavation.

### Rock

The decision of the Engineer in classifying rock shall be final and binding. Rock in the Bill of Quantities will

be itemised in three classes:-

### Class 'A'

Soft rock of the type known locally as 'tuff' which in the opinion of the Engineer cannot be considered as hard rock but which considerably increases the amount of labour needed for its removal shall be known as Class 'A' rock.

### Class 'B'

Very weathered phonolite lava containing many fissures and faults shall be known as hard rock. This type of rock contains stones and boulders of unweathered or incompletely formed blacktrap or lava. A boulder or outcrop of hard rock 1.5 cubic metres or less and grey or green building stone in a formation which is massive and geologically homogeneous, will be deemed to be Class 'B' rock.

### Class 'C'

Phonolite in a formation which is massive and geologically homogeneous shall be known as Class 'C' rock.

### 3.2 STORAGE AND HANDLING OF EXPLOSIVES AND BLASTING

The removal of hard materials by use of explosives will normally be permitted subject to compliance by the Contractor in all respects with the Explosives Laws of Kenya.

In the Bill of Quantities hard material is classified as rock where blasting will be permitted subject to this clause.

The Contractor shall provide proper buildings or magazines in suitable positions for the storage of explosives in manner and quantities to be approved; he shall also be

responsible for the prevention of any unauthorised issue or improper use of any explosives brought on the works and shall employ only licensed and responsible men to handle explosives for the purpose of the works.

The shots shall be properly loaded and tamped and where necessary, the Contractor shall use heavy mesh blasting nets. Blasting shall be restricted to such periods and such parts of the works as the Engineer may prescribe. If, in the opinion of the Engineer, blasting would be dangerous to persons or property or to any finished work or is being carried out in a reckless manner, he may prohibit it, and order the rock to be excavated by other means and payment will be made at the rate for rock for excavation where blasting is permitted. The use of explosives by the Contractor in large blasts, as in seams, drifts, pits, or large holes, is prohibited unless authorised in writing by the Engineer. In the event of wasting of rock through any such blasting, the Contractor shall if required by the Engineer, furnish an equivalent amount of approved materials for fill, 1 cubic metre of rock in-situ being taken to equal 1.5 cubic metre of material in embankment.

### 3.3 EXCAVATION FOR FILL

Where excavation reveals a combination of suitable and unsuitable materials, the Contractor shall, wherever the Engineer considers it practicable, carry out the excavation in such a manner that the suitable materials are placed separately for use in the works without contamination by the unsuitable materials.

If any suitable material excavated from within the site is, with the agreement of the Engineer, taken by the Contractor for his use, sufficient suitable filling material to occupy after specified compaction, a volume corresponding to that which the excavated material occupied, shall, unless otherwise directed by the Engineer be provided by the Contractor from his own sources.

No excavated material shall be dumped or run to spoil except on the direction or with the permission of the Engineer who may require material which is unsuitable to be retained on site. Material used for haul roads shall not be re-used without the permission of the Engineer.

### **3.4** COMPACTION OF FILL

All materials used in fill shall be compacted to specification by plant approved by the Engineer for that purpose. Maximum compacted thickness of such layers shall not be more than 200mm.

Work on the compaction of plastic materials for fill shall proceed as soon as practicable after excavation and shall be carried out only when the moisture content is not greater than 2 per cent above the plastic limit for that material. Where the moisture content of plastic material as excavated is higher than this value the material shall be run to spoil and an equal volume of material suitable for filling shall be replaced, unless the Contractor prefers, at his own expense, to wait until the material has dried sufficiently for acceptance again as suitable material. Nevertheless, if with any material the Engineer doubts whether compaction will be obtained within the above moisture limits he may require compaction to proceed only when the limits of moisture content for the compaction of non-plastic materials are within the range of the optimum moisture content and 3 per cent below the optimum moisture content as determined by the laboratory compaction test method described in British Standard 1377: Methods of Test for Soil Classification and Compaction.

If any such non-plastic material on excavation is too wet for satisfactory compaction and the Engineer orders the moisture content to be lowered or raised, such work shall be treated as included in the rates. All adjustments of moisture content shall be carried out in such a way that the specified moisture content remains uniform throughout compaction.

Work shall be continued until a state of compaction is reached throughout the fill, which shall have relative compaction determined according to B.S. 1377 not less than 85% of maximum dry density at optimum moisture contents. For excavation under Roads, House Drives and Car Parks the backfilling shall be compacted in 150mm layer to 100% maximum dry density.

If with non-plastic materials the compacted material has become drier in the interval between the completion of compaction and the measurement of the state of compaction, then the moisture content to be used for the calculation of the air content shall be the mean moisture content for the compaction of such materials as specified above.

### 3.5 EMBANKMENTS OVER SEWERS

In carrying embankments over sewer pipes, care shall be taken by the Contractor to have the embankments brought up equally on both sides and over the top of any such structures. Earth embankments shall be formed and compacted in layers of 200mm as the Engineer may direct. The filling immediately adjacent to structures shall be deposited and compacted in accordance with the drawings and approved by the Engineer. The cost of these works shall be included in the prices entered in the Bill of Quantities for the excavations from which embankments are formed.

### **3.6** STONE REVETMENTS (STONE PITCHING)

Where shown on the drawings, the slopes of embankments, rivers, streams, watercourses and other surfaces shall be protected against water or other action by hand-set stone facing set on end. The larger stones shall be roughly dressed on the bed and face, and roughly square to the full depth of the joints. No rounded boulder shall be used, or stones less than 225mm in depth of 0.05 cubic metre in volume. The stones shall be laid to break bond, and shall be well bedded on to a 75mm layer of gravel or fine rubble rammed to a uniform surface and the whole work finished to the satisfaction of the Engineer. Where required, a trench shall be excavated at the bottom of the slope to such a depth as will ensure a safe foundation for the revetment.

### **3.7** TIPPED REFUSE ON SITE

Tipped refuse other than artificial deposits of industrial waste or shale found on the site shall be removed and disposed off in a spoil heap to be provided by the Contractor.

### **3.8** REMOVAL OF INDUSTRIAL WASTE, ETC.

Artificial deposits of industrial waste or shale found on the site shall be removed and disposed off as directed by the Engineer. Should any particular deposits consist of or contain material which in the opinion of the Engineer is suitable for incorporation in fills, all such material shall be used accordingly and deposited in layers and compacted as specified. The prices entered in the Bill of Quantities for the excavation of the material shall include loading, transportation, disposal and compaction of same as and where directed.

### 3.9 LAND SLIPS

Remedial works and/or the removal of materials in slips, slides or subsidences and overbreaks of rock extending beyond the lines and slopes, or below the levels shown on the drawings or required by the Engineer, will not be paid for.

### 3.10 CLASSIFICATION OF MATERIAL FROM SLIPS

The classification of material from slips or slides will be in accordance with its condition at the time of removal, regardless of prior condition. Measurement of overbreak in rock excavation shall be that of the space originally occupied by the material before the slide occurred and regardless of its subsequent classification.

#### 3.11 BORROW PITS

Where for any reason, it becomes necessary to form borrow pits, these shall be located and the work executed in all respects to the instructions of the Engineer. They shall be regular in width and shape and admit of ready and accurate measurement, and shall be properly graded and drained and finished with neatly trimmed slopes.

### 3.12 STREAMS, WATERCOURSES AND DITCHES

Excavations carried out in the permanent diversion, enlargement, deepening, or straightening of streams, watercourses, or ditches shall be performed as directed by the Engineer. The rates for such excavations shall include for excavated materials and all pumping, timbering works, and materials necessary for dealing with the flow of water.

#### 3.13 FILLING OLD WATERCOURSES

Where watercourses have to be diverted from the sites of embankments or other works, the original channels shall be cleared of all vegetable growths and soft deposits and carefully filled in with approved materials deposited and compacted as directed by the Engineer.

### 3.14 OPEN DITCHES

Open ditches for drainage purposes shall be cut where and of such cross section as the Engineer shall direct and where so required by him they shall be constructed before the cuttings are opened or the embankments begin. The sides shall be dressed fair throughout and the bottom accurately graded so as to carry off the water to the outlet to be provided. The material excavated from the ditches shall be disposed of as directed by the Engineer.

### 3.15 CLEARING EXISTING DITCHES

Where directed by the Engineer, existing ditches shall be cleared by removing vegetable growths and deposits. The sides shall be shaped fair throughout and the bottoms properly graded. Material removed from existing ditches shall be disposed of in tips provided by the Contractor. The rates included in the Bill of Quantities for clearing ditches shall include for maintaining and keeping clean until and up to maintenance period.

### 3.16 EXCAVATION FOR FOUNDATIONS BELOW OPEN WATER

The rates for excavation for foundations below the water level shall include for the cost of all temporary close timbering and shoring, sheet piling, coffer dams, caissons, pumps and other special appliances required and for the draining of any water in the excavation.

### 3.17 TRENCHES OF GREATER WIDTH AND DEPTH THAN NECESSARY

The Contractor shall not be entitled to payment in respect of excavation to any greater extent, whether horizontally or vertically, than is necessary to receive any structure for which the excavation is intended, except where a separate item is provided for additional excavation for working space, timbering, or other temporary work. Excavation to a greater depth or width than directed shall be made good with suitable materials to the satisfaction of the Engineer and at the Contractor's cost.

### **3.18** SUPPORTS FOR TRENCHES

The sides of trenches shall where necessary be adequately supported to the satisfaction of the Engineer by timber or other approved means.

### **3.19 PROVISION OF SPOIL HEAPS**

The Contractor shall provide spoil heaps at his own expense for the disposal of surplus material and all rubbish collected when clearing the site and during the construction of the works. The sites for these shall be approved by the Engineer

### 3.20 USE OF VIBRATORY COMPACTION PLANT

Where vibratory rollers or other vibratory compaction plant is used, the mechanism for vibration shall be kept working continuously during compaction operations, except during periods when the Engineer permits or directs discontinuance of vibration.

Unless otherwise permitted by the Engineer, the frequency for vibration shall be maintained within

the range of amplitude and frequency recommended by the manufacturers of the plant for the material to be compacted. The frequency shall be recorded by a tacheometer indicating speed of rotation of any shaft producing vibrations.

### 3.21 WATER IN EXCAVATIONS

All excavations shall be kept free from water, from whatever source, at all times during construction of works until in the opinion of the Engineer, any concrete or other works therein are sufficiently set. The Contractor's rates are deemed to cover compliance with this requirement.

The Contractor shall construct any sumps or temporary drains that the Engineer may deem necessary and shall be responsible for the removal and disposal of all water entering the excavations from whatever source and shall deal with and dispose of such water in a manner approved by the Engineer so as to ensure that excavations are kept dry.

The Contractor shall provide all plant, labour and materials required for such work and all costs incurred shall be deemed to be included in his rates for excavation.

### **4** CONCRETE

### 4.1 SCOPE OF SECTION

This section covers the materials, design of mixes, mixing, transport, placing, compaction and curing of concrete and mortar required in the Works. It also covers formwork and reinforcement for concrete.

### 4.2 **DEFINITIONS**

Structural concrete is any class of concrete which is used in reinforced, prestressed or unreinforced concrete construction, which is subject to stress.

Non-structural concrete is composed of materials complying with the Specification but for which no strength requirements are specified and which is used only for filling voids, blinding foundations and similar purposes where it is not subjected to significant stress.

A formed surface is a face which has been cast against formwork.

An unformed surface is a horizontal or nearly horizontal surface produced by screeding or trowelling to the level and finish required.

A pour refers to the operation of placing concrete into any mould, bay or formwork, etc. and also to the volume which has to be filled. Pours in vertical succession are referred to as lifts.

### 4.3 THE DESIGN OF CONCRETE MIXES

a) Classes of concrete

The classes of structural concrete to be used in the works shall be those shown on the Drawings and designated in Table 4.1, in which the class designation includes two figures. The first figure is the nominal strength at 28 days expressed in N/mm<sup>2</sup> and the second figure is the maximum nominal size of aggregate in the mix expressed in millimetres.

b) Design of proposed mixes

The Contractor shall design all the concrete mixes called for on the Drawings, making use of the ingredients which have been approved by the Engineer for use in the Works and in compliance with the following requirements:-

Class of	Nominal	Maximum	Maximum Water /		Trial Mixes	Early Works est se	
Concret	Strength	Nominal Size	Cement Ratio		Target Mean	Cubes (Clau	
e	N/mm <sup>2</sup>	of Aggregate mm	A	В	Strength (Clause 401 c) N/mm <sup>2</sup>	Any one Cube N/mm <sup>2</sup>	Average of any Group of 4 Cubes N/mm <sup>2</sup>
10/75	10	75	0.60	0.55	13.5	8.5	13.3
15/75	15	75	0.60	0.50	21.5	12.8	20.0
15/40	15	40	0.60	0.50	21.5	12.8	20.0
15/20	15	20	0.57	0.50	21.5	12.8	20.0
20/40	20	40	0.55	0.48	31.5	17.0	27.5
20/20	20	20	0.53	0.48	31.5	17.0	27.5
20/10	20	10	0.50	0.48	31.5	17.0	27.5
25/40	25	40	0.52	0.46	36.5	21.3	32.5
25/20	25	20	0.50	0.46	36.5	21.3	32.5
25/10	25	10	0.48	0.46	36.5	21.3	32.5
30/40	30	40	0.50	0.45	41.5	25.5	37.5
30/20	30	20	0.48	0.45	41.5	25.5	37.5
30/10	30	10	0.47	0.45	41.5	25.5	37.5
40/20	40	20	0.46	0.43	51.5	34.0	47.5
40/10	40	10	0.45	0.43	51.5	34.0	47.5

Table 4.1 - CONCRETE CLASSES AND STRENGTHS

NOTES: 1. Under water/cement ratio, column A applies to moderate and intermediate exposure, and column B applies to severe exposure. See NOTE after Table 4.2.

2. In case of concrete having a maximum aggregate size of 40mm or less, 150mm cubes should be used.

In case of concrete having a 75mm or larger aggregate, 200mm cubes should be used.

- i) The aggregate portion shall be well graded from the nominal maximum size of stone down to the 150 micron size.
- ii) The cement content shall be such as to achieve the strengths called for in Table 4.1 but in any case not less than the minimum necessary for impermeability and durability shown in Table 4.2.
- iii) The workability shall be consistent with ease of placing and proper compaction having regard to the presence of reinforcement and other obstructions.
- iv) The water/cement ratio shall be the minimum consistent with adequate workability but in any case not greater that that shown in Table 4.1 taking due account of any water contained in the aggregates. The Contractor shall take into account that this requirement may in certain cases require the inclusion of a workability agent in the mix.
- v) The drying shrinkage determined in accordance with BS 1881 shall not be greater than 0.05 percent.

Minimum Cement Content - kg/m <sup>3</sup> of Compacted Concrete							
Class of Concrete	Moderate Exposure	Intermediate Exposure	Severe Exposure				
10/75,15/75	200	220	270				
15/40, 20/40, 25/40, 30/40	240	270	290				
15/20, 20/20, 25/20, 30/20	260	300	330				
40/20	300	320	330				
20/10, 25/10, 30/10	300	340	390				
40/10	310	340	390				

### Table 4.2 - MINIMUM CEMENT CONTENT

<u>Note</u>: the minimum cement contents shown in the above table are required in order to achieve impermeability and durability. In order to meet the strength requirements in the Specification higher contents may be required.

The categories applicable to the Works are based broadly on the factors listed hereunder:

Moderate exposure Surface sheltered from severe rain;

buried concrete, concrete continuously under water

Intermediate

exposure Surface exposed to driving rain; alternate wetting and drying; traffic; corrosive fumes; heavy condensation Severe exposure Surface exposed to sea water, moorland water having a pH of 4.5 or less, groundwater containing sulphates.

c) Trial mixes

At least six weeks before commencing placement of concrete in the Permanent Works trial mixes shall be prepared for each class of concrete specified.

For each mix of concrete for which the Contractor has proposed a design, he shall prepare three separate batches of concrete using the materials, which have been approved for use in the works and the mixing plant which he proposes to use for the Works. The volume of each batch shall be the capacity of the concrete mixer proposed for full production.

Samples shall be taken from each batch and the following action taken, all in accordance with BS 1881:-

- i) The slump of the concrete shall be determined.
- ii) Six test cubes shall be cast from each batch. In the case of concrete having a maximum aggregate size of 40mm or less, 150mm cubes shall be used. In the case of concrete containing 75mm or larger aggregate, 200mm cubes shall be used and in addition, any pieces of aggregate retained on a 53mm BS sieve shall be removed from the mixed concrete before casting the cubes.
- iii) Three cubes from each batch shall be tested for compressive strength at seven days and the remaining three at 28 days.
- iv) The density of all the cubes shall be determined before the strength tests are carried out.

Subject to the agreement of the Engineer, the compacting factor apparatus may be used in place of a slump cone. In this case the correlation between slump and compacting factor shall be established during preparation of the trial mixes.

The average strength of the nine cubes tested at 28 days shall be not less than the target mean strength shown in Table 4.1.

The Contractor shall also carry out tests to determine the drying shrinkage of the concrete unless otherwise directed by the Engineer.

Based on the results of the tests on the trial mixes, the Contractor shall submit full details of his proposals for mix design to the Engineer, including the type and source of each ingredient, the proposed proportions of each mix and the results of the tests on the trial mixes.

If the Engineer does not agree to a proposed concrete mix for any reason, the Contractor shall amend his proposals and carry out further trial mixes. No mix shall be used in the works without the written consent of the Engineer.

- d) Quality control of concrete production
  - i) Sampling

For each class of concrete in production at each plant for use in the works, samples of concrete shall be taken at the point of mixing and/or of deposition as instructed by the Engineer, all in accordance with the sampling procedures described in BS 1881 and with the additional requirements as set out below.

Six number 150mm or 200mm cubes as appropriate shall be made from each sample and shall be cured and tested all in accordance with BS 1881, two at seven days and the other four at 28 days.

Each sample shall be taken from one batch selected at random and at intervals such that each sample represents not more than 20m<sup>3</sup> of concrete unless the Engineer agrees to sampling at less frequent intervals.

Until compliance with the Specification has been established the frequency of sampling shall be three times that stated above or such lower frequency as may be instructed by the Engineer.

- ii) Testing
  - 1) The slump or compacting factor of the concrete shall be determined for each batch from which samples are taken and in addition for other batches at the frequency instructed by the Engineer.

The slump of the concrete in any batch shall not differ from the value established by the trial mixes by more than 25mm or one third of the value, whichever is the greater.

The variation in value of the compacting factor, if used in place of a slump value, shall be within the following limits:

For value of 0.9 or more+0.03For value of between 0.8 and 0.9+0.04 Forvalues of 0.8 or less+0.05

- 2) The water/cement ratio as estimated from the results of (a) above, determined by samples from any batch shall not vary by more than five per cent from the value established during the trial mixes.
- 3) The air content of air entrained concrete in any batch shall be within 1.5 units of the required value and the average value of four consecutive

measurements shall be within 1.0 unit of the required value, expressed as a percentage of the volume of freshly mixed concrete.

4) Until such time as sufficient test results are available to apply the method of control described in (e) below, the compressive strength of the concrete at 28 days shall be such that no single result is less than the value shown in Table
4.1 under the heading early works test cubes' and also that the average value of any four consecutive results is not less than the value shown in Table 4.1 under the same heading.

The 7-day cube result may be used as an early strength indicator, at the discretion of the Engineer.

5) When test cube results are available for at least 20 consecutive batches of any class of concrete mixed in any one plant, the average of any four consecutive results at 28 days shall exceed the nominal strength by not less than half the current margin (Table 4.3) and each individual result shall not be less than 85 per cent of the nominal strength.

The current margin shall be defined as 1.64 times the standard deviation of cube tests on at least 20 separate consecutive batches produced from one plant over a period exceeding five days but not exceeding six months or on at least 50 separate consecutive batches produced from one plant over a period not exceeding 12 months. If both figures are available, the smaller shall be taken.

The current margin shall in any case not be less than the figure given below:-

	Minimum Current Margin for				
	10N/mm <sup>2</sup>	15N/mm <sup>2</sup> & above	20N/mm <sup>2</sup>		
After 20 batches	3.3	5 2 5	7.5 3.8		

#### Table 4.3 - MINIMUM CURRENT MARGIN FOR TEST CUBES

Failure to comply with requirements:

If any one test cube result in a group of four consecutive results is less than 85% of the nominal strength but the average of the group of which it is part satisfies the strength requirement, then only the batch from which the failed cube was taken shall be deemed not to comply with the Specification.

If more than one cube result in a group of four consecutive results is less than 85% of the nominal strength or if the average strength of the group fails to satisfy the strength requirement then all the batches between those represented by the first and last cubes in the group shall be deemed not to comply with the Specification, and the
Specification, and the Contractor shall immediately adjust the mix design subject to the agreement of the Engineer to restore compliance with the Specification. After adjustment of the mix design the Contractor will again be required to comply with sub- clauses 401(b) and 401(c) of this Section of the Specification.

The Contractor shall take necessary action to remedy concrete which does not comply with this Specification. Such action may include but is not necessarily confined to the following:-

- i) Increasing the frequency of sampling until control is again established.
- ii) Cutting test cores from the concrete and testing in accordance with SRN 117.
- iii) Carrying out strengthening or other remedial work to the concrete where possible or appropriate.
- iv) Carrying out non-destructive testing such as load tests on beams.
- v) Removing the concrete.

# 4.4 MIXING CONCRETE

Before any plant for batching, mixing, transporting, placing, compacting and finishing concrete is ordered or delivered to site, the Contractor shall submit to the Engineer full details including drawings of all the plant which he proposes to use and the arrangements he proposes to make.

Concrete for the Works specifically for Treatment Works Units and Storage Reservoirs shall be and mixed using an automatic batching plant in one or more central location. If the Contractor proposes to use ready mixed concrete he shall submit to the Engineer for his approval full details and test results of the concrete mixes. The Engineer may approve the use of ready mixed concrete provided that:

a) the proposed mixes, the material to be used and the method of storage and mixing comply with the requirements of the Specification;

and

b) adequate control is exercised during mixing.

Approval for the use of ready mixed concrete may be withdrawn if the Engineer is not satisfied with the control of the materials being used and control during mixing.

The mixing of concrete shall be carried out at central plant located at a site remote from place of discharge of mixed concrete. The mixed concrete shall be transported from the central plant using transit lorry mixers and/or agitator trucks.

Batching and mixing plants shall be modern efficient equipment complying with the requirements of SRN 118 and capable of producing a uniform distribution of the ingredients throughout the mass. Truck mixes shall comply with the requirements of SRN 121 and shall only be used with the prior agreement of the Engineer. If the plant proposed by the Contractor does

not fall within the scope of SRN 118, it shall have been tested in accordance with SRN 119 and shall have a mixing performance within the limits specified in SRN 118.

All mixing operations shall be under the control of an experienced supervisor.

The aggregate storage bins shall be provided with drainage facilities arranged so that drainage water is not discharged to the weigh hoppers. Each bin shall be drawn down at least once per week and any accumulations of mud or silt removed.

Cement and aggregate shall be batched by weight. Water may be measured by weight or volume.

The weighing and water dispensing mechanisms shall be maintained in good order. Their accuracy shall be maintained within the tolerances described in SRN 118 and checked against accurate weighs and volumes when required by the Engineer.

The weighs of cement and of each size of aggregate as indicated by the mechanisms employed shall be within a tolerance of plus or minus two percent of the respective weights per batch agreed by the Engineer.

The Contractor shall provide standard test weights at least equivalent to the maximum working load used on the most heavily loaded scale and other auxiliary equipment required for checking the satisfactory operation of each scale or other measuring device. Tests shall be made by the Contractor at least once a week or at intervals to be determined by the Engineer and shall be carried out in his presence. For the purpose of carrying out these tests, there shall be easy access for personnel to the weigh hoppers. The Contractor shall furnish the Engineer with copies of the complete results of all check tests and shall make any adjustments, repairs or replacements necessary to ensure satisfactory performance.

The nominal drum or pan capacity of the mixer shall not be exceeded. The turning speed and the mixing time shall be as recommended by the manufacturer, but in addition, when water is the last ingredient to be added, mixing shall continue for at least one minute after all the water has been added to the drum or pan.

The blades of pan mixers shall be maintained within the tolerances specified by the manufacturer of the mixer and the blades shall be replaced when it is no longer possible to maintain the tolerances by adjustment.

Mixers shall be fitted with an automatic recorder registering the number of batches discharged.

The water to be added to the mix shall be reduced by the amount of free water contained in the coarse and fine aggregates. This amount shall be determined by the Contractor by a method agreed by the Engineer immediately before mixing begins each day and thereafter at least once per hour during concreting and for each delivery of aggregates during concreting. When the correct quantity of water, determined as set out in the Specification, has been added to the mix, no further water shall be added, either during mixing or subsequently.

After mixing for the required time, each batch shall be discharged completely from the mixer

before any materials for the succeeding batch are introduced.

Mixers which have been out of use for more than 30 minutes shall be thoroughly cleaned before any fresh concrete is mixed and thereafter the first batch of concrete through the mixers shall contain only half the normal quantity of coarse aggregate. This batch shall be mixed for one minute longer than the time applicable to a normal batch.

Mixers shall be cleaned out before changing to another type of cement.

# 4.5 HAND-MIXED CONCRETE

Concrete for structural purposes shall not be mixed by hand. Where non-structural concrete is required, hand mixing may be carried out subject to the agreement of the Engineer.

The mixing shall be done on a hard impermeable surface. The materials shall be turned over not less than three times dry, water shall then be sprayed on and the materials again turned over not less than three times in a wet condition and worked together until a mixture of uniform consistency is obtained.

For hand mixed concrete the specified quantities of cement shall be increased by 10% and not more than 0.5 cubic metre shall be mixed at one time. During windy weather efficient precautions shall be taken to prevent cement from being blown away during the process of gauging and mixing.

## 4.6 TRANSPORT OF CONCRETE

The concrete shall be discharged from the mixer and transported to the Works by means which shall prevent adulteration, segregation or loss of ingredients, and which shall ensure that the concrete is of the required workability at the point and time of placing. The loss of slump between discharge from the mixer and placing shall not exceed 25mm. The mixed concrete shall be transported using agitator trucks or transit truck mixers. The agitating speed of the drum shall be between 2 and 4 rpm. The interval between feeding of water into the mixer drum and final discharging of the concrete shall not exceed one hour.

The time elapsed between mixing and placing a batch of concrete shall be as short as practicable and in any case not longer than will permit completion of placing and compaction before the onset of initial set. If the placing of any batch of concrete is delayed beyond this period, the concrete shall not be placed in the Works.

# 4.7 PLACING OF CONCRETE

a) Consent for placing

Concrete shall not be placed in any part of the Works until the Engineer's consent has been given in writing, and the Contractor shall give the Engineer at least 1 full working day's notice of his intention to place concrete.

If concrete placing is not commenced within 24 hours of the Engineer's consent the Contractor shall again request consent as specified above.

b) Preparation of surface to receive concrete

Excavated surfaces on which concrete is to be deposited shall be prepared as set out in Section 3 of this Specification.

Existing concrete surfaces shall be prepared as set out in Clause 414. Before deposition of further concrete they shall be clean, hard and sound and shall be wet but without any free-standing water.

Any flow of water into an excavation shall be diverted through proper side drains to a sump, or be removed by other suitable methods which will prevent washing away the

freshly deposited concrete or any of its constituents. Any underdrains constructed for this purpose shall be completely grouted up when they are no longer required by a method agreed by the Engineer.

Unless otherwise instructed by the Engineer surfaces against which concrete is to be placed shall receive a prior coating of mortar mixed in the proportions similar to those of the fines portion in the concrete to be placed. The mortar shall be kept ahead of the concrete. The mortar shall be well worked into all parts of the excavated surface and shall not be less than 5mm thick.

If any fissures have been cleaned out as described in Section 3 of this Specification they shall be filled with mortar or with concrete as instructed by the Engineer.

The amount of mortar placed at any one time shall be limited so that it does not dry out or set before being covered with concrete.

### c) Chutes

In general, transportation of concrete by the use of chutes will not be permitted unless approved by the Engineer. The chute shall have a section with round corners and shall have a proper fixed slope so as to allow the concrete to flow satisfactorily and without segregation. The lower end of chute shall be provided with a drop chute not less than 0.6m in height to avoid segregation of falling concrete. The height of drop shall not exceed 1.5m. Chutes shall be protected from direct sunlight, wind and rain.

d) Concrete pump or placer

The type and capacity of pump shall be determined to meet the specified requirements, taking into account the placing speed, construction schedule, quality of concrete, location to which concrete is poured, etc. Diameter of the delivery pipes shall be not smaller than 3 times of the maximum size of aggregates to be used in the concrete.

Delivery pipes shall be so installed as to permit easy removal. Before starting the pump or placer operation, about one cubic metre of mortar with the same proportion of water, admixture, cement and fine aggregate as designated for the regular concrete mix shall be passed through the pipe. The pipe shall be set as straight and horizontally as possible to prevent clogging of the concrete mix in the pipe. The supports of the pipe line shall be stiff enough to fix the pipes firmly without adverse effect on forms and reinforcing steel already set in position. Care shall be taken to prevent leakage of the concrete mix from the pipe line or any other part.

Air boosters shall not be used except in conditions where the outlet of the pipe is completely embedded at least 2 metres in fresh concrete.

#### e) Placing procedures

The concrete shall be deposited as nearly as possible in its final position. It shall be placed so as to avoid segregation of the concrete and displacement of the reinforcement, other embedded items, or formwork. It shall be brought up in layers approximately parallel to the construction joint planes and not exceeding 500mm in compacted thickness unless otherwise permitted or directed by the Engineer, but the layers shall not be thinner than four times the maximum nominal size of aggregate.

Layers shall be placed so that they do not form feather edges nor shall they be placed on a previous layer which has taken its initial set. In order to comply with this requirement, a layer may be started before completion of the preceeding layer.

All the concrete in a single bay or pour shall be placed in a continuous operation. It shall be carefully worked round all obstructions, irregularities in the foundations and the like so that all parts are completely full of compacted concrete with no segregation or honeycombing. It shall also be carefully worked round and between waterstops, reinforcement, embedded steelwork and similar items which protrude above the surface of the completed pour.

All work shall be completed on each batch of concrete before its initial set commences and thereafter the concrete shall not be disturbed before it has set hard. No concrete that has partially hardened during transit shall be used in the Works and the transport of concrete from the mixer to the point of placing shall be such that this requirement can be complied with.

Concrete shall not be placed during rain which is sufficiently heavy or prolonged as to wash mortar from coarse aggregate on the exposed faces of fresh concrete. Means shall be provided to remove any water accumulating on the surface of the placed concrete. Concrete shall not be deposited into such accumulation of water.

In drying weather, covers shall be provided for all fresh concrete surfaces which are not being worked on. Water shall not be added to concrete for any reason.

When concrete is discharged above its place of final deposition, segregation shall be prevented by the use of chutes, downpipes, trunking, baffles or other appropriate devices, as approved by the Engineer.

Forms for walls, columns and other thin sections of significant height shall be provided with openings or other devices that will permit the concrete to be placed in a manner that will prevent segregation and accumulations of hardened concrete on the formwork or reinforcement above the level of the placed concrete.

When it is necessary to place concrete under water the Contractor shall submit to the Engineer his proposals for the method and equipment to be employed. The concrete shall be deposited either by bottom-discharging watertight containers or through funnel-shaped tremies which are kept continuously full with concrete up to level above the water and which shall have the discharging bottom fitted with a trapdoor and immersed in the concrete in order to reduce to a minimum the contact of the concrete with the water. Special care shall be taken to avoid segregation.

If the level of concrete in a tremie pipe is allowed to fall to such an extent that water enters the pipe, the latter shall be removed from the pour and filled with concrete before being again lowered into the placing position. During and after concreting under water, pumping or dewatering in the immediate vicinity shall be suspended if there is any danger that such work will disturb the freshly placed concrete.

f) Interruptions to placing

If concrete placing is interrupted for any reason and the duration of the interruption cannot be forecast or is likely to be prolonged, the Contractor shall immediately take the necessary action to form a construction joint so as to eliminate as far as possible feather edges and sloping top surfaces and shall thoroughly compact the concrete already placed in accordance with Clause 406. All work on the concrete shall be completed while it is still plastic and it shall not thereafter be disturbed until it is hard enough to resist damage. Plant and materials to comply with this requirement shall be readily available at all times during concrete placing.

Before concreting is resumed after such an interruption the Contractor shall cut out and remove all damaged or uncompacted concrete, feather edges or any other undesirable features and shall leave a clean sound surface against which the fresh concrete may be placed.

If it becomes possible to resume concrete placing without contravening the Specification and the Engineer consents to a resumption, the new concrete shall be thoroughly worked in and compacted against the existing concrete so as to eliminate any cold joints.

g) Dimensions of pours

Unless otherwise agreed by the Engineer, pours shall not be more than two metres high and shall as far as possible have a uniform thickness over the plan area of the pour. Concrete shall be placed to the full planned height of all pours except in the circumstances described in sub-clause 405(d).

The Contractor shall plan the dimensions and sequence of pours in such a way that cracking of the concrete does not take place due to thermal or shrinkage stresses.

h) Placing sequence

The Contractor shall arrange that as far as possible the intervals between placing successive lifts of concrete in one section of the Works are of equal duration. This

duration shall normally be not less than three or more than seven days under temperate weather conditions unless otherwise agreed by the Engineer.

Where required by the Engineer to limit the opening of construction joints due to shrinkage, concrete shall not be placed against adjacent concrete which is less than 21 days old.

When the drawings call for contraction gaps in concrete, these shall be of the widths and in the locations shown on the drawings and they shall not be filled until the full time interval shown on the drawings has elapsed.

## 4.8 COMPACTION OF CONCRETE

The concrete shall be fully compacted throughout the full extent of the placed layer. It shall be thoroughly worked against the formwork and around any reinforcement and other embedded items, without displacing them. Particular care shall be taken at arises and other confined spaces. Successive layers of the same pour shall be thoroughly worked together.

Concrete shall be compacted with the assistance of mechanical immersion vibrators, unless the Engineer agrees to another method.

Immersion vibrators shall operate at a frequency of between 7,000 and 10,000 cycles per minute. The Contractor shall ensure that vibrators are operated at pressures and voltages not less than those recommended by the manufacturer in order that the compactive effort is not reduced.

A sufficient number of vibrators shall be operated to enable the entire quantity of concrete being placed to be vibrated for the necessary period and, in addition, standby vibrators shall be available for instant use at each place where concrete is being placed.

Where the concrete contains aggregate with a nominal size of 75mm or more, vibrators with a diameter of 100mm or more shall be used.

Vibration shall be continued at each point until the concrete ceases to contract, a thin layer of mortar has appeared on the surface and air bubbles have ceased to appear. Vibrators shall not be used to move concrete laterally and shall be withdrawn slowly to prevent the formation of voids.

Vibration shall not be applied by way of reinforcement nor shall vibrators be allowed to touch reinforcement or other embedded items. The vibrators shall be inserted vertically into the concrete to penetrate the layer underneath at regular spacing. The spacing shall not exceed the distance from the vibrator over which vibration is visibly effective.

# 4.9 CURING OF CONCRETE

a) General

Concrete shall be protected during the first stage of hardening from loss of moisture and from the development of temperature differentials within the concrete sufficient to

cause cracking. The methods used for curing shall not cause damage of any kind to the concrete.

Curing shall be continued for as long as may be necessary to achieve the above objectives but in any case for at least seven days or until the concrete is covered by later construction whichever is the shorter period.

The above objectives are dealt with in sub-clause 407(b) and (c) but nothing shall prevent both objectives being achieved by a single method where circumstances permit.

The curing process shall commence as soon as the concrete is hard enough to resist damage from the process, and in the case of large areas or continuous pours, shall commence on the completed section of the pour before the rest of the pour is finished.

Details of the Contractor's proposals for curing concrete shall be submitted to the Engineer before the placing of concrete commences in the Works.

Formed surfaces may be cured by retaining the formwork in place for the required curing period.

If the use of the foregoing methods is inappropriate, surfaces which will not have further concrete bonded to them and which are not to receive an application of a finish may be cured by the application of a curing compound having an efficiency index of at least 90 percent. Curing compounds shall contain a fugitive dye to enable the extent of the spread to be seen easily.

Curing compound is used on surfaces exposed to the atmosphere shall contain sufficient finely divided flake aluminium in suspension to produce a complete coverage of the surface with a metallic finish when applied at the rate recommended by the manufacturer.

Curing compounds shall become stable and impervious to the evaporation of water from the concrete surface within 60 minutes of application. The material shall not react chemically with the concrete surfaces for at least the first four days of the curing period.

If instructed by the Engineer, the Contractor shall, in addition to the curing provisions set out above provide a suitable form of shading to prevent the direct rays of the sun reaching the concrete surfaces for at least the first four days of the curing period.

### b) Loss of moisture

Exposed concrete surfaces shall be closely covered with impermeable sheeting, properly secured to prevent its removal by wind and the development of air spaces beneath it. Joints in the sheeting shall be lapped by at least 300mm.

If for some reason it is not possible to use impermeable sheeting, the Contractor shall keep the exposed surfaces continuously wet by means of a water spray or by covering

with a water absorbent material which is kept wet, unless this method conflicts with subclause 407(c).

Water used for curing shall be of the same quality as that used for concrete mixing as stated in sub-clause 702(g).

c) Limitation of temperature differential

The Contractor shall limit the development of temperature differentials in concrete after placing by any means appropriate to the circumstances including the following:

- i) Limiting concrete temperatures at placing as set out in sub-clause 409(b);
- ii) Use of low heat cement, subject to the agreement of the Engineer;
- iii) Insulation of exposed concrete surface by insulating blankets. Such blankets shall have an insulation value at least equivalent to 50mm of dry mineral wool;
- iv) Leaving formwork in place during the curing period. Steel forms shall be suitably insulated on the outside;
- v) Preventing rapid dissipation of heat from surfaces by shielding from wind;
- vi) Avoiding the use of water sprays when such use would cause rapid cooling of the surface.

### 4.10 PROTECTION OF FRESH CONCRETE

Freshly placed concrete shall be protected from rainfall and from water running over the surface until it is sufficiently hard to resist damage from these causes.

No traffic shall be allowed on any concrete surface until such time as it is hard enough to resist damage by such traffic.

Concrete placed in the Works shall not be subjected to any loading until it has attained at least its nominal strength as defined in Clause 401.

If the Contractor desires to impose loads on newly-placed concrete, he shall make at least three test cubes and cure them in the same conditions as the concrete they represent. These cubes shall be tested singly at suitable intervals in order to estimate the time at which the nominal strength is reached.

### 4.11 CONCRETING IN HOT WEATHER

a) General

The Contractor shall prevent damage to concrete arising from exposure to extreme temperatures, and shall maintain in good working order all plant and equipment

required for this purpose.

In the event that conditions become such that even with the use of the equipment the requirements cannot be met, concrete placing shall immediately cease until such time as the requirements can again be met.

b) Concrete placing in hot weather

During hot weather the Contractor shall take all measures necessary to ensure that the temperature of concrete at the time of placing in the Works does not exceed 30 degrees centigrade and that the concrete does not loose any moisture during transporting and placing.

Such measures may include but are not necessarily limited to the following:-

- vii) Shielding aggregates from direct sunshine.
- viii) Use of a mist water spray on aggregates
- ix) Sun shields on mixing plants and transporting equipment.
- x) Cooling the mixing water. If ice is used for this purpose it should preferably be in flake form. Lump ice shall not be allowed to enter the tank supplying the mixer drum.
- xi) Covering skips closely with polythene sheet so that the latter is in contact with the concrete.

Areas in which concrete is to be placed shall be shielded from direct sunshine and rock or concrete surfaces shall be thoroughly wetted to reduce absorption of water from the concrete placed on or against them.

After concrete in any part of an area has been placed, the selected curing process shall be commenced as soon as possible. If any interval occurs between completion of placing and start of curing, the concrete shall be closely covered during the interval with polythene sheet to prevent loss of moisture.

### 4.12 FINISHES ON UNFORMED SURFACES

Horizontal or nearly horizontal surfaces which are not cast against formwork shall be finished to the class shown on the drawings and defined hereunder.

UF 1 Finish

All surfaces on which no higher class of finish is called for on the drawings or instructed by the Engineer shall be given a UF 1 finish.

The concrete shall be levelled and screeded to produce a uniform plain or ridged surface, surplus concrete being struck off by a straight edge immediately after compaction.

UF 2 Finish

This is a floated finish for roof or floor slabs and other surfaces where a hard trowelled surface is not required.

The surface shall first be treated as a Class UF 1 finish and after the concrete has hardened sufficiently, it shall be floated by hand or machine sufficiently only to produce a uniform surface free from screed marks.

UF 3 Finish

This is a hard trowelled surface for use where weather resistance or appearance is important, or which is subject to high velocity water flow.

The surface shall be floated as for a UF 2 finish but to the tolerance stated below. When the moisture film has disappeared and the concrete has hardened sufficiently to prevent laitance from being worked to the surface, it shall be steel trowelled under firm pressure to produce a dense, smooth uniform surface free from trowel marks.

### Table 4.4 - SURFACE TOLERANCES

Class of	Tolerance in mm. See notes		
Finish	А	В	С
UF 1	N/A	10	+ 20 or - 10
UF 2	Nil	10	+ 20 or - 10
UF 3	Nil	5	+ 12.5 or -7.5

Notes:

1. Col. A is the maximum allowable value of any sudden change of level in the surface.

- 2. Col. B is the maximum allowable value of any gradual irregularity of the surface, as indicated by the gap between the surface and a three metre long straight edge or correctly shaped template placed on the surface.
- 3. Col. C is the maximum allowable value of the difference in level or position between a three metre long straight edge or correctly shaped template placed on the surface and the specified level or position of that surface.

Where dimensional tolerances are given on the drawings or in this Special Specification they shall take precedence over those given in Table 4.4.

### 4.13 MORTAR

This clause covers mortar for use ahead of concrete placing, and other uses not covered elsewhere in the Specification.

Mortar shall be composed of fine aggregate complying with sub-clause 702(c) and ordinary Portland cement complying with SRN 103. The mix proportions shall be as stated on the drawings or elsewhere in this Specification or if not stated shall be one part of cement to two parts of fine aggregate by weight.

Small quantities of mortar may be hand mixed but for amounts over 0.5 cubic metre a mechanical mixer shall be used.

The water content of the mortar shall be as low as possible consistent with the use for which it is required but in any case the water/cement ratio shall not be more than 0.5.

Mortar which is specified as 'dry pack' shall be mixed with sufficient water for the mix to become cohesive but not plastic when squeezed in the hand. Dry pack mortar shall be rammed into the cavity it is required to fill, using a hand rammer with sufficient force to ensure full compaction.

### 4.14 CONCRETE FOR SECONDARY PURPOSES

a) Non-structural concrete (NS concrete) shall be used only for non-structural purposes where shown on the drawings.

NS concrete shall be composed of ordinary Portland cement complying with SRN 103 and aggregates complying with SRN 108-111 including all-in aggregate within the grading limits of SRN 109 and SRN 111.

The weight of cement mixed with 0.3 cubic metres of combined or all-in aggregate shall not be less than 50 kg. The mix shall be proportioned by weight or by volume. The maximum aggregate size shall be 40mm nominal.

The concrete shall be mixed by machine or by hand to a uniform colour and consistency before placing. The quantity of water used shall not exceed that required to produce a concrete with sufficient workability to be placed and compacted where required.

The concrete shall be compacted by hand or by mechanical vibration.

b) No Fines concrete (NF concrete) is intended for use where a porous concrete is required and shall only be used where shown on the drawings or instructed by the Engineer.

The mix shall consist of ordinary Portland cement complying with SRN 115. The aggregate size shall be 40mm to 10mm only. The weight of cement mixed with 0.3 cubic metre of aggregate shall not be less than 50 kg. The quantity of water shall not exceed that required to produce a smooth cement paste which will coat evenly the whole of the aggregate.

### 4.15 RECORDS OF CONCRETE PLACING

Records, in a form agreed by the Engineer, shall be kept by the Contractor of the details of every pour of concrete placed in the Works. These records shall include class of concrete, location of pour, date of pour, ambient temperature and weather conditions during mixing and placing and concrete temperature at time of placing, moisture contents of aggregates, details of mixes, batch numbers, cement batch number, results of all tests undertaken, location of test cube sample points and details of any cores taken.

The Contractor shall supply to the Engineer four copies of these records each week covering work carried out the preceeding week. In addition, he shall supply to the Engineer monthly histograms of all 28-day cube strengths together with accumulative and monthly standard deviations and any other information that the Engineer may require concerning the concrete placed in the works.

# 4.16 CONSTRUCTION JOINTS

Whenever concrete is to be bonded to other concrete which has hardened, the surface of contact between the sections shall be deemed a construction joint.

Where construction joints are shown on the drawings, the Contractor shall form such joints in those positions. The location of joints which the Contractor requires to make for the purpose of construction shall be subject to the agreement of the Engineer. Construction joints shall be in vertical or horizontal planes except in sloping slabs where they shall be normal to the exposed surface or elsewhere where the drawings require a different arrangement.

Construction joints shall be so arranged as to reduce to a minimum the effects of shrinkage in the concrete after placing, and shall be placed in the most advantageous positions with regard to stresses in the structures and the desirability of staggering joints.

Feather edges of concrete at joint shall be avoided and any feather edges which may have formed where reinforcing bars project through a joint shall be cut back until sound concrete has been reached.

The intersection of horizontal or near horizontal joints and exposed faces of concrete shall appear as straight lines produced by use of a guide strip fixed to the formwork at the top of the concrete lift, or by other means acceptable to the Engineer.

Construction joints formed as free surfaces shall not exceed a slope of 20 per cent from the horizontal.

The surface of the fresh concrete in horizontal or near horizontal joints shall be thoroughly cleaned and roughened by means of high pressure water and air jets when the concrete is hard enough to withstand the treatment without the leaching of cement. The surface of vertical or near vertical joints shall be similarly treated if circumstances permit the removal of formwork at a suitable time. Where concrete has become too hard for the above treatment to be successful, the surface whether formed or free is to be thoroughly scrabbled by mechanical means or wet sand blasted and then washed with clean water. The indentations produced by scrabbling shall be not less than 10mm deep and shall not extend closer than 40mm to a finished face.

If instructed by the Engineer the surface of the concrete shall be thoroughly brushed with a thin layer of mortar composed of one part of cement to two parts of sand by weight and complying with Clause 411 all as set out in sub-clause 405(b) immediately prior to the deposition of fresh concrete. The mortar shall be kept just ahead of the fresh concrete being placed and the fresh layer of concrete shall be thoroughly and systematically vibrated to full depth to ensure complete bond with the adjacent layer.

No mortar or concrete may be placed in position on or against a construction joint until the joint has been inspected and passed by the Engineer.

### 4.17 EXPANSION AND CONTRACTION JOINTS

Expansion and contraction joints are discontinuities in concrete designed to allow thermal or other movements in the concrete.

Expansion joints are formed with a gap between the concrete faces to permit subsequent expansion of the concrete. Contraction joints are formed to permit initial contraction of the concrete and may include provision for subsequent filling.

Expansion and contraction joints shall be formed in the positions and in accordance with the details shown on the drawings or elsewhere in the Specifications.

### 4.18 WATERSTOPS

All references to waterstops include grout stops.

Waterstops shall be of the material and form shown on the drawings. No waterstop material shall be brought on the site until the Contractor has submitted full details of the materials he proposes to use, including samples, and these have been tested and approved by the Engineer. All samples shall be of adequate length for testing.

Waterstops shall be made of materials which are resistant to chlorides, sulphates, or other deleterious substances which may be present in the environment of the Works.

Rubber waterstops may be of natural rubber and shall have an elongation at breaking stress of at least 500 percent at 25 degrees centigrade and shall allow a joint movement of at least 50mm.

Polyvinyl chloride (PVC) waterstops shall be extruded from an unfilled plasticised PVC polymer or copolymer which does not contain any reclaimed or scrap PVC. PVC waterstops shall have an elongation at breaking stress of at least 225 percent at 25 degrees centigrade and shall allow a joint movement of at least 10mm.

Low modulus waterstops shall be of rubber or PVC as described above but shall have an elongation of at least 200 percent at 25 degrees centigrade under a tensile stress of 6 N/mm<sup>2</sup> and shall allow a joint movement of at least 50mm.

Waterstops shall be supplied in lengths as long as possible consistent with ease of handling and construction requirements.

In rubber or plastic materials, joints other than butt joints shall be supplied ready made by the manufacturer. Butt joints shall be made on site in accordance with the manufacturer's instructions and with equipment supplied for the purpose by the manufacturer.

Waterstop material shall be stored carefully on site to avoid damage and contamination with oil, grease, or other pollutants. Rubber and plastic waterstops shall be stored in cool well ventilated places away from direct sunlight.

Rubber and plastic waterstops which are embedded in one side of a joint more than one month before the scheduled date of placing concrete on the other side, shall be protected from the sun.

Waterstops shall be firmly fixed in the formwork so that they cannot be displaced during concrete placing and shall be completely free of all dirt, grease, oil, etc., before placing concrete. Where eyelets are provided these shall be fully wired to the reinforcement and be the only means whereby the waterstop is fixed. In no circumstances shall a waterstop be punctured with nails etc. as a means of fixing.

Concrete shall be placed carefully round waterstops so as to avoid distortion or displacement and shall be fully compacted. Where waterstops lie in a horizontal or nearly horizontal plane the Contractor shall ensure that no voids are left on the underside of the waterstop.

Formwork around waterstops shall be carefully removed to avoid damage. If waterstops suffer any damage which cannot be properly repaired in-situ the Engineer may require a section of concrete to be removed and the waterstop replaced.

# 4.19 GROUTING OF POCKETS AND HOLES AND UNDERPINNING OF BASEPLATES

Pockets and holding-down bolt holes shall be thoroughly cleaned out using compressed air and water jet. Holes drilled by a diamond bit shall be roughened. The pockets and holes shall be filled with grout consisting of cement and clean fresh water mixed in proportion of two parts by weight of cement to one part by weight of water. The pouring of liquid grout shall cease as soon as each hole is filled and any excess grout on the surface of the concrete foundation shall be completely removed and the surface dried off before the next operation proceeds.

The space between the top surface of foundation concrete and the underside of the baseplates shall be filled with a special mortar made up in the following proportions:-

- Fine aggregate ..... 50 kg.
- An additive acceptable to the Engineer to counteract shrinkage in proportions

recommended by the manufacturer.

The special mortar shall be mixed with the lowest water-cement ratio which will result in a consistency of mix of sufficient workability to enable maximum compaction to be achieved.

The special mortar shall then be well rammed in horizontally below the baseplate and from one edge only until it is extruded from the other three sides. The mortar which has extruded shall then be rammed back to ensure complete support without voids.

### 4.20 REMEDIAL WORK TO DEFECTIVE SURFACES

If on stripping any formwork the concrete surface is found to be defective in any way, the Contractor shall make no attempt to remedy such defects prior to the Engineer's inspection and the receipt of any instructions which the Engineer may give.

Defective surfaces shall not be made good by plastering.

Areas of honey combing (of a mild nature) which the Engineer agrees may be repaired shall be cut back to sound concrete or to 75mm whichever is the greater distance. In the case of reinforced concrete the area shall be cut back to at least 25mm clear distance behind the reinforcement or to 75mm, whichever is the greater distance. The cavity shall have sides at right angles to the face of the concrete. After cleaning out with water and compressed air, a thin layer of cement grout shall be brushed on to the concrete surface in the cavity and it shall then be filled immediately with concrete of the same class as the main body but with aggregate larger than 20mm nominal size removed. A form shall be used against the cavity, provided with a lip to enable concrete to be placed. The form shall be filled to a point above the top edge of the cavity.

After seven days the lip of concrete shall be broken off and the surface ground smooth.

Surface irregularities which are outside the limits of tolerance set out in Clause 410 shall be ground down in the manner and to the extent instructed by the Engineer.

Severe honeycombing and defects other than those mentioned above shall be dealt with as instructed by the Engineer.

### 4.21 BENDING REINFORCEMENT

Unless otherwise shown on the drawings, bending and cutting shall comply with SRN 129.

The Contractor shall satisfy himself as to the accuracy of any bar bending schedules supplied and shall be responsible for cutting, bending, and fixing the reinforcement in accordance with the drawings. Any discrepancies should be brought to the attention of the Engineer prior to ordering the reinforcement.

Bars shall be bent cold by the application of slow steady pressure. At temperatures below 5 degrees centigrade the rate of bending shall be reduced if necessary to prevent fracture of the steel.

After bending, bars shall be securely tied together in bundles or groups and legibly labelled as set out in SRN 129.

Reinforcement shall be thoroughly cleaned and all dirt, scale, loose rust, oil and other contaminants removed before it is placed in the Works.

### 4.22 FIXING REINFORCEMENT

Reinforcement shall be securely fixed in position within a dimensional tolerance of 20mm in any direction parallel to a concrete face and within a tolerance of 5mm at right angles to a face, provided that the cover is not thereby decreased below the minimum shown on the drawings, or if not shown shall be not less than 25mm or the diameter of the bar, whichever is the greater. Cover on distribution steel shall not be less than 15mm or the diameter of the bar whichever is the greater.

Unless otherwise agreed by the Engineer, all intersecting bars shall either be tied together with 1.6mm diameter soft annealed iron wire and the ends of the wire turned into the body of the concrete, or shall be secured with a wire clip of a type agreed by the Engineer.

Spacer blocks shall be used for ensuring that the correct cover is maintained on the reinforcement. Blocks shall be as small as practicable and of a shape agreed by the Engineer. They shall be made of mortar mixed in the proportions of one part of cement to two parts of sand. Wires cast into the block for tying in to the reinforcement shall be 1.6mm diameter soft annealed iron.

Alternatively another type of spacer block may be used subject to the Engineer's agreement.

Reinforcement shall be rigidly fixed so that no movement can occur during concrete placing. Any fixings made to the formwork shall not be within the space to be occupied by the concrete currently being placed.

No splices (laps) shall be made in the reinforcement except where shown on the drawings or agreed by the Engineer. Splice lengths shall be as shown on the drawings.

Reinforcement shall not be welded except where required by the Contract or agreed by the Engineer. If welding is employed, the procedures shall be as set out in SRN 937 for gas welding or SRN 919 for metal arc welding. Full strength butt welds shall only be used for steel complying with SRN 126, and if used on high yield deformed bars complying with SRN 126 the permissible stresses in the vicinity of the weld shall be reduced to those applicable to plain bars complying with that Specification.

Mechanical splices shall not be used unless the Engineer agrees otherwise.

The Contractor shall ensure that reinforcement left exposed in the Works shall not suffer distortion, displacement or other damage. When it is necessary to bend protruding reinforcement aside temporarily, the radius of the bend shall not be less than four times the bar diameter for mild steel bars or six times the bar diameter for high yield bars. Such bends shall be carefully straightened before concrete placing continues, without leaving residual links or damaging the

concrete around them. In no circumstances will heating and bending of high yield bars be permitted.

Bars complying with SRN 127 or other high tensile bars shall not be bent after placing in the Works.

Before concrete is placed in any section of the Works which includes reinforcement, the reinforcement shall be completely clean and free from all contamination including concrete which may have been deposited on it from previous operations.

The Engineer's approval for concrete placing is to be sought in writing for each pour, leaving adequate time to inspect and rectify any defects noted in the formwork, falsework, reinforcement, scaffolding, concreting arrangements, etc.

# **5** FORMWORK

### 5.1 FORMWORK FOR CONCRETE Definitions

Formwork means the surface against which concrete is placed to form a face, together with all the immediate supports to retain it in position while concrete is placed.

Falsework means the structural elements supporting both the formwork and the concrete until the concrete becomes self supporting.

A formed face is one which has been cast against formwork.

An exposed face is one which will remain visible when construction has been completed.

## 5.2 CONSTRUCTION OF FORMWORK AND FALSEWORK

Before construction begins, the Contractor shall submit to the Engineer, drawings showing details of the proposed formwork and falsework.

Formwork and falsework shall be so constructed that they will support the loads imposed on them by the fresh concrete together with additional stresses imposed by vibrating equipment and by construction traffic, so that after the concrete has hardened the formed faces shall be in the positions shown on the drawings within the tolerances set out in Clause 506.

Ground supports shall be properly founded on footings designed to prevent settlement.

Joints in formwork for exposed faces shall, unless otherwise specified, be evenly spaced and horizontal or vertical and shall be continuous or form a regular pattern.

All joints in formwork including formwork for construction joints shall be tight against the escape of cement, water and fines. Where reinforcement projects through formwork, the form shall fit closely round the bars.

Formwork shall be so designed that it may be easily removed from the work without damage to the faces of the concrete. It shall also incorporate provisions for making minor adjustments in position if required, to ensure the correct location of concrete faces. Due allowance shall be made in the position of all formwork for movement and settlement under the weight of fresh concrete.

Where overhangs in formwork occur, means shall be provided to permit the escape of air and to ensure that the space is filled completely with fully compacted concrete.

Formwork shall be provided for concrete surfaces at slopes of 30 degrees to the horizontal or steeper. Surfaces at slopes less than 20 degrees may be formed by screeding. Surfaces at slopes between 20 degrees and 30 degrees shall generally be formed unless the Contractor can demonstrate to the satisfaction of the Engineer that such slopes can be screeded with the use of special screed boards to hold the concrete in place during vibration.

Horizontal or inclined formwork to the upper surface of concrete shall be adequately secured against uplift due to the pressure of fresh concrete. Formwork to voids within the body of the concrete shall also be tied down or otherwise secured against floating.

The internal and external angles on concrete surfaces shall be formed with fillets and chamfers of the sizes shown on the drawings unless otherwise instructed by the Engineer.

Supports for formwork for non-water retaining structures may be bolted to previously placed concrete provided the type of bolt used is acceptable to the Engineer. If metal ties through the concrete are used in conjunction with bolts, the metal left in shall not be closer than 50mm to the face of the concrete.

Supports for formwork for water retaining structures may be bolted to previously placed concrete provided the type of bolts and positions of fixing are acceptable to the Engineer. After concreting the Contractor shall remove all support bolts and seal all holes with well rammed cement/sand mortar containing approved waterproofing cement additive. Metal ties which would be left in the concrete shall not be permitted.

Formwork shall not be re-used after it has suffered damage which in the opinion of the Engineer is sufficient to impair the finished surfaces of the concrete.

Where circumstances prevent easy access within the form for cleaning and inspection, temporary openings for this purpose shall be provided through the formwork.

Shear keys shall be provided in all construction joints of the size and shape indicated on the drawings.

Where precast concrete elements are specified for use as permanent formwork, or proposed by the Contractor and agreed by the Engineer, they shall comply with the requirements of the Specification. Such elements shall be set true to line and level within the tolerances prescribed for the appropriate class of finish in Clause 506 and fixed so that they cannot move when concrete is placed against them.

### **5.3 PREPARATION OF FORMWORK**

Before any reinforcement is placed into position within formwork, the latter shall be thoroughly cleaned and then dressed with a release agent. The agent shall be either

a suitable oil incorporating a wetting agent, an emulsion of water suspended in oil or a low viscosity oil containing chemical agents. The Contractor shall not use an emulsion of oil suspended in water nor any release agent which causes staining or discoloration of the concrete, air holes on the concrete surface, or retards the set of the concrete.

In order to avoid colour difference on adjacent concrete surfaces, only one type of release agent shall be used in any one section of the works.

In cases where it is necessary to fix reinforcement before placing formwork, all surface preparation of formwork shall be carried out before it is placed into position. The Contractor shall not allow reinforcement or prestressing tendons to be contaminated with formwork release agent. Before placing concrete all dirt, construction debris and other foreign matter shall be removed completely from within the placing area.

Before concrete placing commences, all wedges and other adjusting devices shall be secured against movement during concrete placing and the Contractor shall maintain a watch on the formwork during placing to ensure that no movement occurs.

# 5.4 REMOVAL OF FORMWORK

Formwork shall be carefully removed without shock or disturbance to the concrete. No formwork shall be removed until the concrete has gained sufficient strength to withstand safely any stresses to which it may thereby be subjected.

The minimum periods which shall elapse between completion of placing concrete and removal of forms are given in Table 5.1 and apply to ambient temperatures higher than 10 degrees centigrade. At lower temperatures or if cement other than ordinary Portland are involved, the Engineer may instruct that longer periods be used.

Alternatively, formwork may be removed when the concrete has attained the strength set out in Table 5.1, provided that the attained strength is determined by making test cubes and curing them under the same conditions as the concrete to which they refer.

Compliance with these requirements shall not relieve the Contractor of his obligation to delay removal of formwork until the removal can be completed without damage to the concrete.

Position of Formwork	Min. period for temp over 10 degrees	Strength to be attained
Vertical or near vertical faces of mass concrete	24 hours	0.2 C
Vertical or near vertical faces of reinforced walls, beams and columns	48 hours	0.3 C
Underside of arches, beams and slabs (formwork only)	4 days	0.5 C
Supports to underside of arches, beams and slabs	14 days	С
Arched linings in tunnels and underground works	24 hours	4 N/mm <sup>2</sup>

# Table 5.1 - MINIMUM PERIODS FOR FORMWORK REMOVAL

Note: C is the nominal strength for the class of concrete used

If the Contractor wishes to strip formwork from the underside of arches, beams and slabs before the expiry of the period for supports set out above, it shall be designed so that it can be removed without disturbing the supports. The Contractor shall not remove supports temporarily for the purpose of stripping formwork and subsequently replace them.

As soon as the formwork has been removed, bolt holes in concrete faces other than construction joints which are not required for subsequent operations shall be completely filled with mortar sufficiently dry to prevent any slumping at the face. The mortar shall be mixed in the same proportions as the fine aggregate and cement in the surrounding concrete and with the same materials and shall be finished flush with the face of the concrete.

## 5.5 SURFACE FINISHES ON FORMED SURFACES Classes of finish

The surface finish to be achieved on formed concrete surfaces shall be as shown on the drawings and defined hereunder:-

a) Class F1 finish

This finish is for surfaces against which backfill or further concrete will be placed. Formwork may be sawn boards, sheet metal or any other suitable material which will prevent the loss of fine material from the concrete being placed.

b) Class F2 finish

This finish is for surfaces which are permanently exposed to view but where the highest standard of finish is not required. Forms to provide a Class F2 finish shall be faced with wrought thicknessed tongued and grooved boards with square edges arranged in a uniform pattern and close jointed or with suitable sheet material. The thickness of boards or sheets shall be such that there shall be no visible deflection under the pressure exerted by the concrete placed against them. Joints between boards or panels shall be horizontal and vertical unless otherwise directed. This finish shall be such as to require no general filling of surface pitting, but fins, surface discoloration and other minor defects shall be remedied by methods agreed by the Engineer.

c) Class F3 finish

This finish is for surfaces which will be in contact with water flowing at high velocity, and for surfaces prominently exposed to view where good appearance is of special importance. To achieve this finish, which shall be free of board marks, the formwork shall be faced with plywood complying with B.S. 1088 or equivalent material in large sheets. The sheets shall be arranged in an approved pattern. Wherever possible, joints between sheets shall be arranged to coincide with architectural features or changes in direction of the surface.

All joints between panels shall be vertical and horizontal unless otherwise directed. Suitable joints shall be provided between sheets to maintain accurate alignment in the plane of the sheets. Unfaced wrought boarding or standard steel panels will not be permitted for Class F3 finish. The Contractor shall ensure that the surface is protected from rust marks, spillages and stains of all kinds.

d) Curved surfaces

For curved surfaces where F2 or F3 finishes are called for, the formwork face shall be built up of splines cut to make a tight surface which shall then be dressed to produce the required finish.

Alternatively, single curvature surfaces may be faced with plastic or plywood linings attached to the backing with adhesive or with escutcheon pins driven flush. Linings shall not bulge, wrinkle or

## 5.6 TOLERANCES

All parts of formed concrete surfaces shall be in the positions shown on the drawings within the tolerances set out in Table 5.2.

In cases where the drawings call for tolerances other than those given in Table 5.2 the tolerances shown on the drawings shall take precedence.

Where precast units have been set to a specified tolerance, further adjustments shall be made as necessary to produce a satisfactory straight or curved line. When the Engineer has approved the alignment, the Contractor shall fix the units so that there is no possibility of further movement.

Class of finish	Tolerances in mm (See Note)		
	А	В	С
F1	10	10	+ 25 to - 10
F2	5	10	+ or - 15
F3	2	5	+ or - 10

Table 5.2 - TOLERANCES

Note: The tolerances A, B and C given in the table are defined as follows:

- 1. Column A is an abrupt irregularity in the surface due to misaligned formwork or defects in the face of the formwork.
- 2. Column B is a gradual deviation from a plane surface as indicated by a straight edge 3m long. In the case of curved surfaces the straight edge shall be replaced by a correctly shaped template.
- 3. Column C is the amount by which the whole or part of a concrete face is displaced from the correct position shown on the drawings.

# **6** MASONRY

# 6.1 GENERAL

All masonry work shall be constructed from building stone as specified in Clause 804.

For culvert headwalls and other small works, the stone shall, unless otherwise specified, be rough dressed. For walls, facing and other exposed works the stone shall unless otherwise specified, be medium chiseldressed.

# 6.2 WORKMANSHIP

The Contractor shall provide and use proper setting out rods for all work.

Stones shall be well soaked before use and the tops of walls shall be kept wet as the work proceeds. The stones shall be properly bonded so that no vertical joint in a course is within 115mm of a joint in the previous course. Alternate courses of walling at angles and intersections shall be carried through the full thickness of the adjoining walls. All perpends, reveals and other angles of the walling shall be built strictly true and square.

The stones shall be bedded, jointed and pointed in mortar 1 to 3 in accordance with Clause 707 with beds and joints 9mm thick flushed up and grouted solid as the work proceeds.

All masonry work shall be cured in accordance with the relevant requirements of Clause 409.

### 6.3 CAST STONEWORK

Cast stone shall be as specified in Clause 711. Facing stones shall be brought up in courses to a height not exceeding 1 metre at a time, the concrete backing being then brought up and well incorporated into and round the backs of the stones and the projecting metal ties to ensure a complete bond. The stones shall be bedded and jointed as shown on the drawings.

All materials, moulds, mixing, casting and surface treatment, setting, jointing and pointing, and all centering, scaffolding and labour required to complete the cast stonework specified or as shown on the drawings, shall be included in the rates for such work.

# 7 MATERIALS

# 7.1 GENERAL

The approval in writing or otherwise by the Engineer of any materials shall not in any way whatsoever relieve the Contractor from any liability or obligation under the Contract and no claim by the Contractor on account of the failure, insufficiency or unsuitability of any such materials will be entertained.

- a) All items shall be suitable for water works purposes and for use with cold water installation and operation being in a tropical climate.
- b) All items hereinafter specified shall be to such other Standard or Specification which in the opinion of the Engineer provides for a quality of material and workmanship not inferior to the Standard Reference Number (SRN) quoted. The Standard or Specification must be submitted to the Engineer for approval before commencement of work.
- c) All ferrous pipes and fittings shall be coated with a protective paint suitable for use in and transport through a tropical climate.
- d) The Contractor shall supply to the Employer a certificate stating that each item supplied has been subjected to the tests hereinafter laid down and conforms in all respects to the said Specification.
- e) The Contractor shall provide adequate protection to all piping, flanged items and valves so as to guard effectively against damage in transit and storage and ingress of foreign matter inside the valves.
- f) All pipework and fittings shall be subjected to a works hydrostatic test pressure which shall be not less than twice the maximum operating pressure.
- g) The Contractor should exercise diligence to provide the best material.
- h) Where applicable the manufacturer's Specification should accompany all offers. The name of the manufacturer must in every case be stated.
- j) Where necessary the Contractor shall provide rubber gaskets to comply with SRN 208 and all other bolts, nuts, washers, etc. to undertake jointing at fittings etc.
- k) Any articles required under this Contract which are found to be faulty due to a crack, flaw or any other reason or is not in accordance with the Specification stipulated will not be accepted nor will the Employer be liable for any charges in respect of such an article. Where any such rejected article can, in the opinion of the Engineer, be rendered usable, the Contractor may deal with it accordingly and include it in the Contract at a price to be mutually agreed. Straight pipes which have been cut will be accepted at the discretion of the Engineer, provided the length is not less than 4 metres or two thirds of the standard length

whichever is the lesser and will be priced pro-rata.

I) Wherever possible, samples of pipes and fittings shall be submitted for approval of the Engineer prior to the Contractor obtaining the total requirements.

# 7.2 GALVANISED PIPES AND SPECIALS

All piping shall conform to SRN 823 and SRN 903 for "Medium" Piping. The pipes shall be screwed and socketted, coupled or flanged.

All specials shall be of such dimensions as will mate with the piping supplied. Screw down stopvalves shall conform to SRN 826. Barrel nipples shall conform to SRN 823 and all other specials shall conform to SRN 824.

All pipes supplied shall be certified by the manufacturer to have been tested in accordance with the relevant Standard Specification.

## 7.3 DUCTILE IRON AND CAST IRON PIPES AND SPECIALS

All cast iron piping and fittings shall conform to the requirements of SRN 200.

Ductile iron pipes and fittings shall comply with SRN 202. Where required the pipes shall be protected as specified by the manufacturer of the pipes and shall be used as recommended by the manufacturer of the pipe.

Where the requirements include for the supply of flexible couplings the Contractor shall submit for approval by the Engineer full details of the type of joint offered and a full description of the method of jointing prior to arranging for the delivery of goods on site.

All flexible couplings shall be protected from corrosion by wrapping with Denso paste and tape or by some similar approved material.

The quality of metal used for the manufacture of the pipes shall be of good quality grey cast iron and subject to the various quality control tests as specified in the relevant Standards.

All piping and fittings shall be coated internally with cement mortar lining to SRN 211. Cement mortar lining shall not contain any constituents soluble in water nor any ingredient which could impart any taste or odour whatsoever to the water after sterilization and washing out of the mains. External protection to be as specified in SRN 258.

The flanges of straight pipes shall be at right angles to axis of the pipe and the faces of the flanges shall be parallel and machine finished.

The faces of the flanges of fittings shall be at right angles to the directional axis. The bolt holes shall be concentric with the bore and located symmetrically off the centre line.

In flanged pipework the holes in one flange shall be located in line with those in the other. All flanges shall be

drilled to SRN 207, unless otherwise detailed.

The weights of the pipe and fittings shall comply with the Specification in the relevant Standard.

# 7.4 ASBESTOS CEMENT PIPES AND SPECIALS

All piping and bends shall be plain ended suitable for use with flexible couplings and shall comply with the requirements of SRN 401. Fittings shall be of asbestos cement or cast iron complying with requirements of SRN 201, or mild steel complying with SRN 210.

Where possible, fittings shall have plain ends of an external diameter equal to that of the asbestos cement pipes and shall be suitable for use with asbestos cement, cast iron or mild steel mechanical joints. Where compatible external diameters of fittings and pipes cannot be supplied, suitable stepped couplings of approved manufacturer shall be used.

Flexible couplings shall be supplied complete with bolts, nuts, washers and joint rings as may be required. All metal parts of the joints shall be adequately protected with rust-proof paint.

The couplings shall, if required by the Engineer, be protected from corrosion by wrapping with Denso paste and tape or by some similar approved material.

The Contractor shall submit full details of the type of joint and a full description of the method of jointing.

The lengths of piping supplied shall be in accordance with SRN 401.

All pipes and bends supplied shall be certified by the manufacturer to have been tested in accordance with the relevant clauses of Standard Specification.

Unless specified, the pipes, joints and bends shall be coated internally with cement mortar lining complying with SRN 212. This lining should not impart any taste or odour to the water. External protection for pipes, joints and bends to be as specified in SRN 212.

Precautions shall be taken to avoid damage to the pipes and fittings during handling and storing and during laying, all to the satisfaction of the Engineer.

Where ferrules are tapped into the piping, saddles should be used, otherwise service connections can be incorporated by use of suitable long collar joints.

# 7.5 STEEL PIPES AND SPECIALS

All piping shall be plain ended unless otherwise specified and suitable for use with flexible mechanical couplings. The grade of steel used shall comply with the requirements of SRN 213.

The pipes shall be welded or seamless and shall conform to SRN 210.

All the pipes shall be internally protected with cement mortar lining in accordance with SRN 212. External protection to be as specified in SRN 241.

All joints shall be of the flexible mechanical type and shall be supplied complete with all bolts, nuts, washers and joint rings as may be required. All metal parts of joints shall be adequately protected

with rust-proof paint. The joints shall be protected from corrosion by wrapping with Denso paste and tape or by some similar approved material.

All fittings and specials shall be of such dimensions as will mate up with the piping supplied.

Flanged adaptors shall be pieces suitable for connecting a flanged gate valve etc. to the type of piping supplied and shall be supplied complete with all bolts, nuts, washers and joint rings.

The spigot ends of all Tees shall be suitable for connection to the pipework supplied using the aforementioned flexible mechanical joints. Branches shall be flanged with flanges drilled to NP 16 in accordance with SRN 207, unless otherwise detailed.

All flanges on specials shall conform to NP 16 in accordance with SRN 207, unless otherwise detailed.

All flanged joints shall be protected from corrosion by wrapping with Denso paste and tape or some similar approved material.

### 7.6 UNPLASTICISED uPVC PIPES

Unplasticised PVC piping shall be in accordance with SRN 300.

The maximum sustained working pressures to which the pipes and fittings will be subjected is based on water at a temperature of 20 degrees centigrade.

The Contractor shall submit full details of the pipes he intends to supply.

The pipes upto and including 40mm diameter can be of a solvent weld type. The pipe shall be supplied with interchangeable sockets preformed at the factory and of such internal diameter that it takes the plain end of the pipe with the same nominal diameter.

The joint shall sustain the end thrust to which the pipe shall be subjected. The Contractor shall supply sufficient quantity of the cleaner and adhesive which shall be required to make the joints with the pipes.

The pipes of 50mm diameter and over shall consist of a grooved socket at one end of the pipe. The socket shall be designed to give a clearance fit on the outside diameter of the parent pipe. The sealing medium which shall seat in the groove shall be a rubber ring.

If the formation of the socket and groove results in the thinning of the original wall thickness of the pipe, it shall be compensated for by shrinking on to the outside of the socket area a reinforcing sleeve of the same material as the pipe.

The socket and groove shall incorporate no sharp angles where the stress points are created.

The joint shall take 10% deformation of the spigot at the point where it enters the socket without leakage from the pipe when subjected to the test pressure specified for the pipe. Thermal expansion of the pipe shall be accommodated in the joint. The joint shall be capable of linear deflection upto 3 degrees.

The sealing ring shall be of first grade natural rubber and the physical properties of the mix shall meet the requirements of SRN 222.

The Contractor shall supply sufficient quantity of any lubricant or other material which shall be needed to make the joint which shall be assembled by hand.

The Contractor shall submit full details of the type of joint offered and a full description of the method of jointing.

The fittings shall have the same type of joint as for the pipes to be used. The Contractor shall submit full details of the materials dimensions and test pressures of the fittings offered.

Precautions shall be taken to avoid damage to the pipes and fittings.

In handling and storing the pipes and fittings, every care shall be taken to avoid distortion, flattening, scoring or other damage. The pipes and fittings shall not be allowed to drop or strike objects. Pipe lifting and lowering shall be carried out by approved equipment only.

Special care shall be taken in transit, handling and storage to avoid any damage to the ends.

Pipes and fittings shall be marked at not greater than one metre intervals showing their class and diameter.

## 7.7 G.R.P. PIPES AND SPECIALS

Glass Reinforced Plasting piping shall be in accordance with SRN 317.

### 7.8 GATE VALVES

Gate valves shall comply with the requirements of SRN 501.

The gate valves shall be suitable for use in pipelines and for the operating pressure to a head of 160 metres of water (NP 16).

The gate valves shall be double flanged. The dimensions and drilling of flanges shall be in accordance with SRN 207. Flanges shall be machined flat. Flanges shall be NP 16 complying with SRN 207.

Spindles of the gate valves shall be provided with cast iron caps conforming to the requirements as specified under "Valve Caps" in SRN 501 or handwheels if so specified.

The spindles of the gate valves shall be of the non-rising type and screwed so as to close the valves when rotated in a clockwise direction. The direction of closing shall be clearly cast on the valve cap or handwheel.

The gate valves shall be subject to "Closed End Tests" in accordance with the procedure set out in SRN 501.

The gate valves shall be suitable for opening and closing against an unbalanced head by manual operation.

# 7.9 FIRE HYDRANTS

Fire hydrants shall be in accordance with SRN 509. They shall be for installation underground and shall be in accordance with SRN 509.

The spindle shall be provided with a cast iron cap conforming to dimensions under "Spindle Cap" in SRN 501.

The spindle of the fire hydrant shall be of the non-rising type and screwed so as to close the hydrant when rotated in a clockwise direction viewed from above. The direction of closing shall be clearly cast on the valve cap.

The flanged outlet of the outlet bend shall have a Bayonet Joint Outlet for a 63mm standpipe. The outlet of the hydrant shall be of the hooked type with hooks 112mm apart.

The outlet shall have a gun metal standpipe seating and be covered by a loose cast iron cap which shall be attached to the hydrant by means of a chain.

Both flanges shall be 63mm drilled to requirements of SRN 207.

The outlet bends shall be subject to a hydrostatic test in accordance with procedure set out in SRN 509 and shall be water-tight against a test pressure of 1.85 Pa. head of water.

## 7.10 AIR VALVES

The Contractor shall provide air valves to suit the site on which the main is located and the maximum water pressure specified. The body and cover of air valves shall comply with SRN 906 and SRN 916.

The body, cover, splash cowl and joint support ring of the air valve shall be of mechanite cast iron with flanges drilled to SRN 207.

The internal screwed isolating valve shall have the valve and seating of gun metal, operating screws of bronze, nuts of gun metal, and glands and cap of mechanite.

The large orifice valve shall have a vulcanite covered ball closing on a moulded dexine seat ring. The bush may be in gun metal.

The double orifice type of air valve shall comprise a small and large orifice unit with common connection to the main and screw down isolating valve to permit inspection of the valve. The spindle of the isolating valve shall be screwed so as to close the valve when rotated in a clockwise direction and be provided with a Spindle Cap to dimensions as specified in SRN 501.

Design of the air valves shall be such that the balls do not blow shut under any working or test conditions when large volumes of air are being released.

# 7.11 WATER METERS

All water meters up to 50mm size shall be of the rotary piston positive action type with all moving parts composed of non-corrosive material.

75mm diameter and over meters shall be of the inferential helix full flow type.

The body of the 12mm to 25mm size of meter shall be of brass, the larger sizes in cast iron. The external surface of the brass bodies shall be coated with baked enamel and the cast iron bodies shall be painted to suit.

The working chamber of the rotary type meter shall be made of bronze or similar non- corrosive material and the piston shall be in ebonite or similar material.

The working parts of the Helix type meter shall facilitate removal for repair or replacement without removing the meter body from the pipeline. The working parts shall be inter-changeable and the working chamber so designed as to be full of water under all conditions of flow.

The dial of the meter shall be of the direct reading type registered in cubic metres with suitable lid locking device.

The capacities of the piston type meter shall not be less than the following amounts per month:-

•	12mm meter	250 cubic metres
•	18mm meter	350 cubic metres
•	25mm meter	600 cubic metres
•	38mm meter	1100 cubic metres
•	50mm meter	1700 cubic metres

The Helix type meter shall be capable of continuous working with a head loss not exceeding 300mm at the following rates of flow:-

•	75mm meter	22.5 cu.m./hr
•	100mm meter	45 cu.m./hr
•	150mm meter	90 cu.m./hr

All meters shall be accurate to within + 2% over the range of the meter upwards from the minimum flows given for each size:-

- 12mm 23 litres/hour
- 18mm 28 litres/hour
- 25mm 32 litres/hour
- 38mm 110 litres/hour

•	50mm	190 litres/hour
•	75mm	2.5 cu.m./hr
•	100mm	2.8 cu.m./hr
•	150mm	4.5 cu.m./hr

Meters above 150mm diameter should conform to manufacturer's specifications approved by the Engineer.

The 12mm and 18mm sizes shall be guaranteed to register commencing at 5 litres/hour.

The meters shall be tested to a head of not less than 16 bar.

## 7.12 STOP VALVES

All stop valves shall be in accordance with SRN 826. Samples of valves shall be submitted for test and approval to the Engineer.

### 7.13 CHECK VALVES (DIRECTIONAL VALVES)

Check valves shall comply with the requirements of SRN 505 with cast iron body and cover, gun metal doors with bronze facing rings and flanged connections in accordance with SRN 207, NP 16.

### 7.14 PENSTOCKS

Cast iron penstocks shall be all in accordance with SRN 906 and SRN 916. Seating faces shall be gun metal or bronze.

Spindles shall be threaded as necessary and non-rising unless otherwise specified. Spindles shall be of aluminium bronze, manganese bronze and extension spindles may be of mild steel.

Handwheels shall be of cast iron and words "OPEN" and "SHUT" marked on upper side with appropriate direction arrows.

### 7.15 FLANGED JOINTS

All flanges on fittings and pipework where flanged connections are required must comply with the requirements of SRN 207 and drilled to NP 16, unless otherwise specified.

Inspection gaskets for flanged joints shall be rubber reinforced with cotton, 3mm thick and shall be in accordance with SRN 208. Bolts, washers and nuts for flanged joints shall be of mild steel complying with SRN 914.

### 7.16 FLEXIBLE JOINTS

All flexible couplings (Viking Johnson or other approved type) shall be supplied complete with rubber gaskets, bolts, nuts and washers. All couplings shall be coated with red oxide primer and bituminous composition suitable for use with potable water.

# 7.17 PRESSED STEEL TANKS AND TOWERS

The pressed steel tanks (or similar approved), towers and associated materials and fittings shall comply with SRN 909 and SRN 863.

Detailed drawings of the steel tank should be submitted to the Engineer for approval prior to acceptance.

The pressed steel tank to SRN 909 (B.S. 1564 Type A(2) or similar approved) shall be supplied complete with:-

- a) All stays, cleats, bolts, nuts, washers, jointing compound and associated materials and fittings.
- b) Connections for inlet, outlet, washout and overflow.
- c) Galvanised access ladder 450mm wide.
- d) Steel roof cover to fit the tank complete with access manhole and mosquito- proof cowl ventilators.
- e) Water level indicator.

Jointing material to the tank to be a non-toxic plastic compound which does not impart taste, colour nor odour to the water.

Connections to the tank shall be welded to the outside of the tank plate and drilled and tapped to suit flanges to SRN 207, NP 16 unless otherwise stated.

The cover to the tank shall be of mild steel cambered for external use and adequately supported by rolled steel or pressed steel bearers or trusses and to be surface finished by hot dip galvanizing.

The tank tower shall be supplied complete with:-

- a) Anchor bolts.
- b) Bolts, nuts, washers and associated materials and fittings.
- c) Access ladder 450mm wide extending from ground level to the top of the tank. Safety rings shall be at 1.2m centres.

The supports to the tank shall consist of steel joints designed to carry imposed load under each transverse joint and the two ends of the tank.

The columns of the tank shall consist of rolled steel joist sections or similar. Four such columns shall be provided with adequate bracing.

Internal surfaces of the tank shall be painted with approved non-toxic primer and non-toxic bituminous paint.

External surfaces of the tank and tower shall be painted with approved primer and approved bituminous aluminium paint.

# 7.18 PAINTS

All priming, undercoating and finishing paints shall be in accordance with SRN 877 or SRN 878 as appropriate.

The painting of all building works shall comprise a special paint recommended for external work while all other paints, plastic emulsion coating etc. are to be of an approved manufacturer. All paints, distempers etc. shall be delivered on site intact in the original drums or tins, and shall be mixed and applied in accordance with the manufacturer's printed directions. The only addition which will be allowed to be made will be liquid thinners, driers etc. supplied by the makers for the purpose.

All surfaces must be thoroughly cleaned down prior to painting and decorating work and no external painting shall be carried out in rainy weather. All paint must be thoroughly well worked on and excess of paint in any coat must be avoided.

All colours will be selected by the Engineer from the standard range of colours.

## 7.19 MARKER AND INDICATOR POSTS

Marker posts shall be erected at changes in direction of water mains as directed by the Engineer. Indicator posts shall be erected at valves and other fittings as directed

Marker and indicator posts shall be embedded in concrete as shown on drawings and shall be vibrated precast reinforced concrete as per dimensions shown on drawings. They should be painted in colours as indicated on the drawings.

### 7.20 POLYETHYLENE (PALOTHENE, PEH) PIPES

Polyethylene High Density pipes shall comply with SRN 307 for testing, storage, handling, laying and backfilling. Contractor shall conform to requirement indicated for PVC pipes. Joints shall be required to sustain test pressures similar to which the pipe shall be subjected.

Contractor shall comply with all instructions issued by the manufacturers and shall submit full details of the type, class, dimensions and test pressures of the brass fittings to the Engineer for approval.

### 7.21 PRECAST CONCRETE UNITS

Precast concrete covers to be precast units for use in the works, whether instructed under the Contract or proposed by the Contractor.

a) Formwork for Precast Units

Moulds shall be so constructed that they do not suffer distortion or dimensional changes during use and are tight against loss of cement grout or fines from the concrete. Moulds shall be set up on firm foundations so that no settlement occurs under the weight of the fresh concrete.

Moulds shall be constructed so that units may be removed from them without sustaining any damage.

Release agents used for demoulding shall not stain the concrete or affect its properties in any way.

b) Reinforcement for Precast Units

Reinforcement in precast units shall comply with the requirement of Clauses 736 and 419-420. When preformed cages are used the cages shall be made up on jigs to ensure dimensional accuracy and shall be carefully supported within the could in such a way that they cannot move when concrete is placed. Reinforcement complying with SRN 126 may be tack welded where bars cross to provide rigidity in the cage but reinforcement complying with SRN 127 shall not be welded.

Cover to main reinforcement shall be as shown on the drawings, or if not shown shall be not less than 25mm or the diameter of the bar, whichever is the greater. Cover on distribution steel shall not be less than 15mm or the diameter of the bar whichever is the greater.

Bars shall be spaced so that the minimum clear distance between them is the maximum nominal aggregate size plus five millimetres but in any case not less than the diameter of the bars.

Bars may be placed in pairs provided that there are no laps in the paired lengths.

c) Casting of Units

Concrete for precast units shall comply with Clauses 724 and 401-410 using the class of concrete specified on the drawings.

If lightweight aggregates are specified, they shall comply with SRN 147.

The area in which units are cast shall be adequately protected from the weather so that the process is not affected by rain, sun or drying winds.

d) Curing Precast Units

Requirements for curing shall be generally as set out in Clause 407.

The Contractor shall ensure that units do not suffer any loss of moisture or sudden changes of temperature for at least four days after casting. If a water spray is used for

curing, the water shall be at a temperature within 5 degrees centigrade of the temperature of the unit being cured.

If Contractor proposes curing at elevated temperatures, the method shall be subject to the agreement of the Engineer and shall include means whereby units are heated and subsequently cooled evenly without sudden changes of temperature.

e) Dimensional Tolerances of Precast Units

Units shall be accurately formed to the dimensions shown on the drawings unless closer tolerances are called for by the Engineer.

f) Surface Finish of Precast Units

The formed faces of precast units shall be finished to Class F3 as set out in Clause 505(C) unless another class of finish is specified on the drawings.

Free faces shall be finished to Class UF2 unless another class of finish is specified on the drawings.

In cases where a special finish is required a trial panel shall be constructed by the Contractor which after approval by the Engineer shall be kept available for inspection at the place of casting and production units shall thereafter match the approved pattern.

Those parts of the unit which are to be joined to other units or to in-situ concrete shall be brushed with a stiff brush before the concrete has fully hardened. Alternatively, if the concrete has been allowed to harden, the surfaces shall be roughened by sand blasting or by the use of a needle gun.

g) Handling and Storage of Precast Units

Precast units shall be handled in a manner which will not cause damage of any kind and shall be stored on a hard impermeable base.

Prestressed units and large precast normally reinforced units shall be handled and stored so that no stresses shall be induced in excess of those which they will incur in their final positions in the Works unless they have been designed to resist such stresses.

Units shall be provided with adequate lifting holes or loops, placed in the locations shown on the drawings or agreed by the Engineer and they shall be lifted only by such holes or loops. Where it is not possible to provide holes or loops, suitable sling positions shall be indicated in paint on the units

Units shall be marked indelibly with the reference number and date of casting and shall be stacked on suitable packers which will not damage the concrete or stain the surfaces. Not more than two packers shall be placed under each unit and these shall be located either at the positions of the permanent support
points or in positions such that the induced stresses in the unit will be a minimum.

h) Testing Precast Units

Precast units shall be capable of safely sustaining the loads which they have been designed to carry. The Contractor shall subject units selected by the Engineer to load tests simulating the working conditions. Details of such tests shall be agreed between the Engineer and the Contractor.

In the case of units subject to bending loads the test piece shall be supported at full span and a loading equivalent to 1.25 times the sum of the live and dead loads which were assumed in the design shall be maintained for one hour without the appearance of any signs of distress. The recovery one hour after the removal of load shall be not less than 75 per cent of the full load deflection.

If the unit fails to meet the above requirements, further tests shall be carried out on two more units. If either of these fail the whole batch of units will be rejected.

If the Engineer so requires, a test to destruction shall also be carried out which on units subject to bending shall be as follows:-

The units shall be supported at full span and a load applied in increments instructed by the Engineer up to 95 per cent of the designed ultimate load. This load shall be held for 15 minutes without failure of the unit. The deflection at the end of this period shall be not more than 1/40th of the span. The load shall then be further increased until failure occurs.

If the unit fails to sustain the required load for the prescribed period or if the deflection exceeds the specified amount, the Engineer may order two further tests, and if either of these fail, the batch of units which they represent may be rejected.

# 7.22 FILTER MEDIA

The grading of filter media shall be in accordance to the table of gradings shown on drawings.

Filter media must be free from fines which would clog the air spaces, and free from dirt, silt and all foreign matter.

The media shall be delivered in clean vehicles and if stored it shall be placed on a clean and firm surface and if it is liable to be contaminated, protected with sheets. Different sizes of media shall be kept strictly separate.

The uniformity coefficient as indicated in the drawings should be adhered to and Contractor to submit samples and carry out sieve analysis, organic content, friability tests, etc. to the satisfaction of the Engineer. These tests are to be carried out before the media is placed in filters. All costs arising to be borne by the Contractor.

#### 7.23 SUBMISSION OF SAMPLES

As soon as possible after the contract has been awarded, the Contractor shall submit to the Engineer a list of the suppliers from whom he proposes to purchase the materials necessary for the execution of the Works. Each supplier must be willing to admit the Engineer or his representatives, to his premises during ordinary working hours for the purpose of obtaining samples of the materials in question. Alternatively, if desired by the Engineer, the Contractor shall deliver the samples of the materials to the Engineer's office without charge.

The information regarding the names of the suppliers may be submitted at different times, as may be convenient, but no source of supply shall be changed without the Engineer's prior approval once a supplier, source or material has been approved.

Samples of materials approved will be retained at the Engineer's office until the completion of the contract. Samples may be tested to destruction.

All materials delivered to site must be at least equal in all respects to approved samples, otherwise they shall be rejected. No special payment will be made for compliance with clauses specifying tests etc. to ensure quality control etc. unless specifically itemised in Bills of Quantities.

## 7.24 MATERIALS FOR CONCRETE

a) General

The Contractor shall submit to the Engineer full details of all materials which he proposes to use for making concrete. No concrete shall be placed in the Works until the Engineer has approved the materials of which it is composed. Approved materials shall not thereafter be altered or substituted by other materials without the consent of the Engineer.

### b) Cement

Cement shall comply with the following Kenya Standards:- SRN 103 for Ordinary Portland cement. SRN 103 for Rapid Hardening Portland cement plus all special conditions to its use stipulated by the manufacturer. SRN 104 for Sulphate Resisting or High Alumina cement.

Cement shall be free flowing and free of lumps. It shall be supplied in the manufacturer's sealed unbroken bags or in bulk. Bagged cement shall be transported in vehicles with effective means of ensuring that it is protected from the weather.

Bulk cement shall be transported in vehicles or in containers specially built and equipped for the purpose.

Cement in bags shall be stored in a suitable weatherproof structure of which the interior shall be dry and well ventilated at all times. The floor shall be raised above the surrounding ground level and shall be so constructed that no moisture rises through it.

Each delivery of cement in bags shall be stacked together in one place. The bags shall be closely stacked so as to reduce air circulation but shall not be stacked against an outside wall. If pallets are used, they shall be constructed so that bags are not damaged during handling and stacking. No stack of cement bags shall exceed 3 metres in height. Different types of cement in bags shall be clearly distinguished by visible markings and shall be stored in separate stacks.

Cement from broken bags shall not be used in the Works. Cement

in bags shall be used in the order in which it is delivered.

Bulk cement shall be stored in weatherproof silos which shall bear a clear indication of the type of cement contained in them. Different types of cement shall not be mixed in the same silo.

The Contractor shall provide sufficient storage capacity on site to ensure that his anticipated programme or work is not interrupted due to lack of cement.

Cement which has become hardened or lumpy or fails to comply with the Specification in any way shall be removed from the site.

All cement for any one structure shall be from the same source.

All cement used in the Works shall be tested by the manufacturer or the Contractor in a laboratory acceptable to the Engineer. The tests to be performed shall be those set out in SRN 103 and the Contractor shall supply two copies of each certificate to the Engineer.

Each set of tests carried out by the manufacturer or Contractor shall relate to not more than one day's output of each cement plant, and shall be made on samples taken from cement which is subsequently delivered to the site. Alternatively, subject to the agreement of the Engineer, the frequency of testing shall be one set of tests for every 200 tones of cement delivered to site from each cement plant.

Cement which is stored on site for longer than one month shall be re-tested in the laboratory of the Materials Branch of the Ministry of Transport & Communications or at the Kenya Bureau of Standards or at any other approved laboratory at the rate of one set of tests as shown in SRN 103 for every 200 tonnes, and at monthly intervals thereafter.

Cement which does not comply with the Specification shall not be used in the Works and it shall be disposed off by the Contractor.

The Contractor shall keep full records of all data relevant to the manufacture, delivery, testing and use of all cement used in the Works and shall provide the Engineer with two copies thereof.

#### c) Fine Aggregate

Fine aggregate shall be clean, hard and durable and shall be natural sand, crushed gravel sand or crushed rock sand complying with SRN 108. All the material shall pass through a 5mm standard sieve and the grading shall be in accordance with Zones 1, 2 or 3 of SRN 109. In order to achieve an acceptable grading, it may be necessary to blend materials from more than one source. Fine aggregate for mortar only shall comply with SRN 135.

The fine aggregate shall not contain iron pyrites or iron oxides. It shall not contain mica, shale, coal or other laminar, soft or porous materials or organic matter unless the Contractor can show by comparative tests, on finished concrete as set out in SRN 117, that the presence of such materials does not adversely affect the properties of the concrete.

Other properties shall be as set out below:

Content passing a 75 micron standard sieve shall not exceed 3 per cent for natural or crushed gravel sand or 15 per cent for crushed rock sand.

Chlorides soluble in a 10 per cent solution by weight of nitric acid shall not exceed 0.05 per cent by weight expressed as chloride ion when tested as set out in SRN 107, subject also to the further restriction given in the note on total chloride content in sub- clause 724 (d).

Sulphates soluble in a 10 per cent solution by weight of hydrochloric acid shall not exceed 0.4 per cent by weight expressed as SO3, when tested as set out in SRN 601, subject also to the further restriction given in the note on total sulphate content in sub- clause 724 (d).

Soundness: After five cycles of the test in AASHO T104 or an approved equivalent, the aggregate shall not show a weight loss of more than 10 per cent.

### 7.25 Organic impurities:

If the test for presence of organic impurities in aggregates described below shows that more than a trace of organic impurities is present, the fine aggregate shall not be used in the Works unless the Contractor can show by tests on finished concrete as set out in SRN 117 that the presence of organic impurities does not adversely affect the properties of the concrete.

Test for presence of organic impurities in aggregates:

This test is designed to indicate the presence of organic impurities in aggregates used for making concrete.

A 350 cc graduated bottle shall be filled to the 120 cc mark with a sample of the aggregate to be tested and a 3% solution of sodium hydroxide in water added until the volume of aggregate and liquid after shaking gives a total volume of 200 cc. The bottle shall be stoppered, shaken thoroughly and allowed to stand for 24 hours. If, after 24 hours, the colour of the solution is not darker than a pale brown, the aggregate under test may be

deemed satisfactory.

a) Coarse aggregate

Coarse aggregate shall be clean, hard and durable crushed rock, crushed gravel or natural gravel complying with the requirements of SRN 110. The material shall not contain any iron pyrites, iron oxides, flaky or laminated material, hollow shells, coal or other soft or porous material, or organic matter unless the Contractor can show by comparative tests on finished concrete as set out in SRN 117 that the presence of such materials does not adversely affect the properties of the concrete. The pieces shall be angular, rounded or irregular as defined in SRN 107.

Coarse aggregate shall be supplied in the nominal sizes called for in the Contract and shall be graded in accordance with SRN 111 for each nominal size.

Other properties shall be as set out below:-

The proportion of clay, silt and other impurities passing a 75 micron standard sieve shall not be more than one per cent by weight.

The content of hollow and flat shells shall be such as will not adversely affect the concrete quality when tested as set out in SRN 117. The total content of aggregate shall not be more than the following:

- 40mm nominal size and above 2% of dry weight
- 20mm nominal size 5% of dry weight
- 10mm nominal size 15% of dry weight

Chlorides soluble in a 10 per cent solution by weight of nitric acid shall not exceed 0.03 per cent by weight, expressed as chloride ion when tested as set out in SRN 107 but subject also to the further restriction under the note on total chloride content hereunder. Sulphates soluble in a 10 per cent solution by weight of hydrochloric acid shall not exceed 0.4 per cent by weight expressed as SO<sub>3</sub> when tested as set out in SRN 601 subject also to the further restriction given in the note on total sulphate content hereunder.

*Soundness*: After 5 cycles of the test in AASHO T104, the aggregate shall not show a weight loss of more than 12 per cent.

When tested in accordance with test C289 of the American Society for Testing of Materials, the aggregate shall be non-reactive.

Flakiness Index when tested in accordance with SRN 113 shall be as set out hereunder:

- For 40mm stone and above, not more than 40
- For 20mm stone and below, not more than 35

If the Flakiness Index of the coarse aggregate varies by more than five units from the average value of the aggregate used in the approved trial mix, then a new set of trial mixes shall be carried out if the workability of the mixes has been adversely affected

by such variation.

Impact value: Not more than 45 per cent when tested in accordance with SRN 107.

Ten per cent fines value: Not less than 50kN when tested in accordance with SRN 107.

*Shrinkage*: When mixed with other ingredients in the approved proportions for concrete and tested as set out in SRN 117, the shrinkage factor shall not exceed 0.05 per cent.

*Organic impurities*: If the test for presence of organic impurities in aggregates shows that more than a trace of organic impurities is present, the aggregate shall not be used in the Works unless the Contractor can show by tests on finished concrete as set out in SRN 117 that the presence of organic impurities does not adversely affect the properties of the concrete.

*Water absorption*: The aggregate shall not have a water absorption of more than 2.5 per cent when tested as set out in SRN 112.

Aggregate Crushing Value (ACV): Not more than 35 per cent. Los

Angeles Abrasion (LAA): Not more than 50 per cent.

NOTE: Total chloride and sulphate content:-

The total chloride content, expressed as chloride ion, arising from all ingredients in a mix including cement, water and admixtures shall not exceed the following limits, expressed as a percentage of the weight of cement in the mix:-

For prestressed concrete, steam cured concrete or concrete containing sulphate resisting or super sulphated cement: 0.05 per cent.

For any other reinforced concrete: 0.3 per cent in 95 per cent of all test results provided no result is more than 0.5 per cent.

The total sulphate content expressed as  $SO_3$  of all the ingredients in a mix including cement, water and admixtures shall not exceed 0.4 per cent by weight of the aggregate or 4.0 per cent of the weight of cement in the mix, whichever is the lesser.

#### b) Testing Aggregates

i) Acceptance testing

The Contractor shall deliver to the Engineer samples containing not less than 50 kg of any aggregate which he proposes to use in the Works and shall supply such further samples as the Engineer may require. Each sample shall be clearly labelled to show its origin and shall be accompanied by all the information called for in SRN 107.

Tests to determine compliance of the aggregates with the requirements of sub-

clause 724(c) and (d) shall be carried out by the Contractor in a laboratory acceptable to the Engineer. If the tested materials fail to comply with the Specification, further tests shall be made in the presence of the Contractor and the Engineer and acceptance of the material shall be based on such tests.

A material shall be accepted if not less than three consecutive sets of test results show compliance with the Specification.

ii) Compliance testing

The Contractor shall carry out routine testing of aggregates for compliance with the Specification during the period that concrete is being produced for the Works. The tests set out below shall be performed on aggregates from each separate source on the basis of one set of tests for each day on which aggregates are delivered to site provided that no set of tests shall represent more than 250 tonnes of fine aggregate nor more than 500 tonnes of coarse aggregate, and provided also that the aggregates are of uniform quality. If the aggregate from any source is variable, the frequency of testing shall be increased as instructed by the Engineer.

٠	Grading	SRN 107
٠	Silt and clay contents	SRN 107
•	Moisture content	SRN 107
	C1 1 ''''''	

• Check on organic impurities

In addition to the above routine tests, the Contractor shall carry out the following tests at the frequencies stated:

*Moisture content*: As frequently as may be required in order to control the water content of the concrete as required by the Specification.

*Chloride content*: As frequently as may be required to ensure that the proportion of chlorides in the aggregates does not exceed the limit stated in the Specification.

The Contractor shall take account of the fact that when the chloride content is variable it may be necessary to test every load in order to prevent excessive amounts of chloride contaminating the concrete. For this purpose the Contractor shall use the rapid field test (the Quantab test). In the event of disagreement regarding the results of the field test, the chloride content of the aggregate shall be determined in the laboratory as described in SRN 107 (the Volhard test).

c) Delivery and storage of aggregates

Aggregates shall be delivered to site in clean and suitable vehicles. Different types or sizes of aggregate shall not be delivered in one vehicle.

Each type or size of aggregate shall be stored in a separate bin or compartment having a base such that contamination of the aggregate is prevented. Dividing walls between bins shall be substantial and continuous so that no mixing of types or sizes

occurs.

The storage of aggregates shall be arranged so that as far as possible rapid drying out in hot weather is prevented in order to avoid sudden fluctuations in water content. Storage of fine aggregates shall be arranged so that they can drain sufficiently before use in order to prevent fluctuations in water content of the concrete.

#### d) Water for concrete and mortar

Seawater or brackish water containing more than 1,000 ppm chloride ion or 2,000 ppm sulphate ion shall not be used for mixing or curing concrete.

Water shall be clean and free from harmful matter and shall comply with the requirements of SRN 114.

The Contractor shall carry out tests in accordance with SRN 114 to establish compliance with the Specification.

#### e) <u>Admixtures</u>

i) General

The use of the admixtures in concrete may be required under the Contract to promote special properties in the finished concrete or may be proposed by the Contractor to assist him to comply with the Specification. In all cases the Contractor shall submit to the Engineer full details of the admixture he proposes to use and the manner in which he proposes to add it to the mix. The information provided shall include but not be limited to:-

- a) The typical dosage, the method of dosing and the detrimental effects of an excess or deficiency in the dosage.
- b) The chemical names of the main active ingredients in the admixture.
- c) Whether or not the admixture contains chlorides, and if so the chloride ion content expressed as a percentage by weight of admixture.
- d) Whether the admixture leads to the entrainment of air when used at the manufacturer's recommended dosage, and if so, the extent to which it does so.
- e) Details of previous uses of the admixture in Kenya.

The chloride ion content of any admixture shall not exceed 2 per cent by weight of the admixture nor 0.03 per cent by weight of the cement in the mix.

Admixtures shall not be mixed together without the consent of the Engineer.

Calcium chloride or admixtures containing calcium chloride shall not be used in prestressed concrete.

ii) Workability agents

Workability agents shall comply with SRN 149 and shall not have any adverse effect on the properties of the concrete.

### 7.26 BUILDING STONE

All building stone shall be capable of withstanding when wet a crushing stress of 1.4 kg./sq.mm. he source of stone shall be approved by the Engineer and stone supplied therefrom shall be free from Magadi, overburden, mudstone, cracks, sandholes, veins, laminations or other imperfections.

The stone shall be chisel dressed into true rectangular blocks, with each surface even and at right angles to all adjoining surfaces, to the size specified. For exposed stonework the maximum permissible variation of any of the specified dimensions shall be 6mm provided that cut stone, supplied as 'rock face' stone may be hammer dressed on one face only, or on one face and one end, if in other respects it conforms with this specification. Stones shorter than 375mm will not be accepted.

Unless the Engineer allows otherwise the Contractor shall at his own expense provide and dress four 100mm cubes of stone for testing.

The stone shall be sound when tested in accordance with SRN 870 except that:-

- i) The treatment shall be repeated for 10 cycles only; and
- ii) The second criterion of failure shall be amended to allow for a loss of weight of not more than 20% of its original weight.

#### 7.27 STONE DUST

Stone dust for blinding shall be blacktrap screened to the following grading:-

Passing 10mm sieve	100%
Passing No. 4 sieve	85% - 100%
Passing No. 100 sieve	5% - 25%

#### 7.28 MURRAM

Murram shall be from an approved source quarried so as to exclude vegetable matter, loam, top soil or clay. The California Bearing Ratio of the murram, as determined for a sample compacted to maximum density (as defined under SRN 601) and allowed to soak in water for four days, shall not be less than 30%. This C.B.R. is a guide to quality only and the compaction in the work will be judged by density.

### 7.29 WATER FOR CEMENT TREATED MATERIALS

If water for the works is not available from the Employer's supply the Engineer's approval must be obtained regarding the source of supply and manner of its use. Water to be used with cement or lime shall be free from salt, oil, alkali, organic matter, and other deleterious substances. If the water is required to be tested, this shall be done in accordance with SRN 114 : Tests for Water for Making Concrete, all to the cost of the Contractor.

#### 7.30 CEMENT MORTAR

Cement mortar shall consist of proportions by volume as specified of Portland Cement and natural sand or crushed natural stone or a combination of both as specified in SRN 135 and SRN 136: Building Sands from Natural Sources. The constituent materials shall be accurately gauged and mixed in an approved manner.

Cement mortar shall be made in small quantities only as and when required, and any mortar which has begun to set or which has been mixed for a period of more than one hour shall be rejected.

#### 7.31 HYDRATED LIME

Hydrated lime shall comply with SRN 801 : Building Limes, and shall be of the semi- hydrated type.

### 7.32 CALCIUM CHLORIDE

Calcium chloride shall be of good industrial grade, and shall be obtained from an approved source.

### 7.33 LIME MORTAR

Lime mortar shall consist of proportions by volume as specified of hydrated lime and naturals and/or crushed natural stone or a combination of both as specified for cement mortar in Clause 729. The constituent materials shall be accurately gauged and mixed in an approved manner.

### 7.34 CEMENT-LIME MORTAR

Cement-lime mortar shall consist of Portland Cement, hydrated lime and natural sand or crushed natural stone or a combination of both, as specified for cement mortar in Clause 707. The constituent materials shall be accurately gauged and mixed by volume in an approved manner in the proportions specified.

Cement-lime mortar shall be made only in small quantities as and when required. Any mortar which has begun to set or which has been mixed for a period of more than two hours shall be rejected.

### 7.35 CEMENT GROUT

Cement grout shall consist of Portland Cement and water mixed in the proportion of one part by volume of cement and one and a half parts by volume of water. The grout shall be used within

one hour of mixing.

# 7.36 CAST STONE

Cast stone shall be manufactured by an approved manufacturer to the shapes and dimensions shown on the drawings, and shall conform to the requirements of SRN 871 : Cast Stone. It shall have a dense and even surface of the texture and colour detailed on the drawings or required by the Engineer. Where indicated exposed faces of the stone shall be formed of a specially graded mix. Metal bond ties of approved manufacture shall be cast in with the stone as shown on the drawings. Samples of the completed stone shall be submitted for the Engineer's prior approval.

All stones shall be protected from damage during transport and and erection by means of cement slurry coatings or by other approved methods.

## 7.37 REINFORCEMENT FOR CONCRETE

Reinforcement which shall comply with the following Standards, covers plain and deformed bar reinforcement and steel fabric to be cast into concrete in any part of the Works but does not include prestressing tendons or any other embedded steel.

- SRN 126 for hot rolled plain bar and high yield deformed bar
- SRN 127 for cold worked steel bar
- SRN 128 for steel mesh fabric

All reinforcement shall be from an approved manufacturer and, if required by the Engineer, the Contractor shall submit a test certificate from the manufacturer.

All reinforcement for use in the Works shall be tested for compliance with the appropriate British Standard in a laboratory acceptable to the Engineer and two copies of each test certificate shall be supplied to the Engineer. The frequency of testing shall be as set out in the relevant Standard.

In addition to the testing requirements described above, the Contractor shall carry out additional tests as instructed by the Engineer.

Any reinforcement which does not comply with the Specification shall be removed from site.

All reinforcement shall be delivered to site either in straight lengths or cut and bent. No reinforcement shall be accepted in long lengths which have been transported bent over double.

Any reinforcement which is likely to remain in storage for a long period shall be protected from the weather so as to avoid corrosion and pitting. All reinforcement which has become corroded or pitted to an extent which, in the opinion of the Engineer, will affect its properties shall either be removed from site or may be tested for compliance with the appropriate Standard at the Contractor's expense.

Dowel Bars

Dowel bars and tie bars shall consist of mild steel, or deformed bars of high yield steel all

complying with SRN 126 and they shall be free from oil, paint other than bond-breaking compound, dirt, loose rust and scale.

Dowel bars and tie bars shall be of sizes as shown on the drawings and directed by the Engineer, and shall be straight, free from burred edges, or other irregularities and shall have their sliding ends sawn or, if approved, sheared.

Bond breaking compound for dowel bars shall consist of 66 per cent of 200 pen bitumen blended hot with 14 per cent light creosote oil and, when cold, brought to the consistency of paint by the addition of 20 per cent solvent naphtha or other approved compound meeting the following requirements.

- i) It shall not retard or in any other way affect the setting of concrete.
- ii) The average bond stress on bars coated with the compound with half their length cast into concrete specimens and subject to pull out tests at 7 days shall not exceed 0.14 newtons per square millimetre and the total movement of the dowel bar relative to the concrete shall not be less than 0.25 millimetres at that stress. The concrete specimens shall be 150 millimetres by 150 millimetres in section and 0.45 metre long and made with the same mix proportions as used in the Works.

### 7.38 STRUCTURAL STEEL FOR WELDED WORK

Structural steel for riveted and welded work shall comply with the requirements of SRN 125 : Structural Steel, SRN 126 : The Use of Structural Steel in Building and for Welded Work, SRN 125 : High Yield Stress and High Tensile Structural Steel, High Tensile (Fusion Welding Quality) Structural Steel for Bridges, etc. and General Building Construction.

#### 7.39 WATERPROOF UNDERLAY

Waterproof underlay shall consist of either waterproof paper complying with SRN 856 : Waterproof Building Paper, containing approved fibrous reinforcement, or 500 gauge polythene sheeting as stated in the Bill of Quantities.

#### 7.40 PREFORMED JOINT FILLER

Preformed joint filler shall be of the thickness shown on the drawings or as stated in the Bill of Quantities.

The material comprising joint filler shall be as stated on the drawings or approved by the Engineer.

#### 7.41 JOINT PRIMER

Joint priming compound shall be entirely in accordance with the manufacturer's recommendations for the joint sealant to be used.

### 7.42 JOINT SEALING COMPOUND

Poured joint sealing material shall consist of an approved rubber-bitumen compound, complying with the requirements of SRN 879, or a two component, cold applied compound complying with SRN 879 as stated in the Bill of Quantities. Test Certificates, prepared by an approved testing laboratory, shall be supplied by the Contractor to show that the material does in fact comply in respect of cone penetration, flow and bond with the under-mentioned requirements:

Test Cone Penetration	<u>Hot-poured</u> Materials	<u>Cold-poured</u> Materials	
0.15 kg. For 5 secs. at 25° centigrade using standard grease cone	Penetration not to exceed 9mm	Penetration to be not less than 5mm not more than 27.5mm	
Flow			
On a plane inclined at 75° to the horizontal, 5	Flow not to exceed	Flow not to exceed	
hours at 60° centigrade	5mm	20mm	
Bond			
25mm wide joint extended 12mm at rate of 4mm per hour at 18° centigrade. No more than one specimen in three to develop a crack separation or other opening more than 4mm deep	Five cycles of extension and recompression	Three cycles of extension and recompression	

Approved

hot-poured materials shall also comply with a requirement whereby when heated for a period of 6 hours at a temperature of 80 degrees centigrade above recommended pouring temperature or 30 degrees centigrade below the safe heating temperature whichever is the greater shall still comply with the flow requirements of this clause.

In addition to materials complying with SRN 879, the Engineer may approve the use of alternative materials provided that they meet the requirements of this clause relating to cold- poured joint sealing compounds.

### 7.43 CONCRETE PIPES AND SPECIALS

Concrete pipes and specials shall comply with the requirements of SRN 840. They shall carry the relevant Standards Institution registration certification trade mark, or test certificates shall be furnished by the manufacturers.

### 7.44 CONCRETE POROUS PIPES

Concrete porous pipes shall comply with the requirements of SRN 410 : Concrete Porous Pipes for Underdrainage.

#### 7.45 CONCRETE DRAIN INVERT BLOCKS

Precast concrete invert blocks shall be manufactured to the detail drawings supplied from concrete Class 20/10 as specified in Table 4.2 using maximum 12mm size aggregates. If required, cube test certificates shall be supplied by the manufacturer.

### 7.46 CONCRETE SLABS FOR OPEN DRAINS

Precast concrete slabs for lining open drains shall be manufactured to the detail drawings supplied from concrete Class 20/10 as specified in Table 4.2 using maximum 12mm size aggregates. If required, cube test certificates shall be supplied by the manufacturer.

#### 7.47 AGRICULTURAL TILES AND PIPES

Agricultural tiles and pipes shall be best well-burnt earthenware, true and circular in bore and with an external flat bottom and plain ends suitable for laying with open or butt joints.

### 7.48 MANHOLE COVERS AND FRAMES

Manhole covers and frames shall be in accordance with the requirements of SRN 846: Cast Manhole Covers, Road Gully Gratings and Frames for Drainage Purposes except that the manhole covers shall be constructed of mild steel, concrete filled, in accordance with the standard detail drawings.

Foul water sewer manholes shall have triangular Grade "A" heavy duty covers and frames. Circular manhole covers and frames shall be used on surface water sewer manholes.

#### 7.49 GULLY GRATINGS AND FRAMES

Gully gratings and frames shall be basically in accordance with the requirements of SRN 846, nominal size 500mm x 350mm except that the gully gratings shall be constructed of mild steel concrete filled in accordance with the standard detail drawings.

Where indicated as being kerb inlet type, the gullies shall conform to the shape and dimensions given on the detail drawings supplied, but in respect of materials and workmanship conform to SRN 846.

#### 7.50 PRECAST CONCRETE MANHOLES AND INSPECTION CHAMBERS

Precast concrete manholes and inspection chambers shall comply with the requirements of SRN 854: Concrete Cylindrical Pipes and Fittings including Manholes, Inspection Chambers and Street Gullies, and they shall carry the relevant Standard Institution registered certification trademark, or test certificates shall be furnished by the manufacturer.

#### 7.51 PRECAST CONCRETE GULLIES

Precast concrete gullies shall be unreinforced and shall comply with the requirements of SRN 854: Concrete Cylindrical Pipes and Fittings including Manholes, Inspection Chambers and Street Gullies.

#### 7.52 MANHOLE STEP IRONS

Step irons of general-purpose type shall comply in all respects with SRN 845: Malleable Step Irons.

# 7.53 TIMBER

Timber shall be sound, well seasoned and entirely free from worm, beetle, warps, shakes, splits, and all forms of rot and deadwood.

Where required, all timber shall be treated with creosote, as specified in SRN 872: Coal Tar Creosote for the Preservation of Timber or an alternative approved timber preservative.

# 7.54 WATER BARS

Water bars shall be "Dumbell" type and be of natural or synthetic rubber or extruded PVC. They shall be flexible, tough, elastic and durable and of dimensions detailed. They should be unaffected on contact with dilute acids or alkalis. Joints and junctions shall, when possible, be prefabricated by the manufacturer, but if made at site the manufacturer's instructions including recommended adhesives shall be followed and used. Samples shall be submitted for approval of the Engineer before use of any material.

# 7.55 CONCRETE BLOCKS

Solid and hollow concrete blocks for walling shall comply with SRN 904 in every respect.

All solid and hollow concrete blocks used in the walling must be capable of withstanding a crushing pressure of not less than 0.35 kg per square millimetre after 28 days. The blocks shall be cast in Metric sizes.

# 7.56 HDPE PE 100 PIPES MANUFACTURED ISO 4427:2007 STANDARD

1	Compound Material	The material from which the pipes are made shall be in accordance with ISO 4427-1. All pipes shall be manufactured using <b>pre-compounded carbon black, bimodal, high density polyethylene</b> <b>MRS 10.0 material (PE100)</b> . The use of natural PE100 with a Carbon black master batch is <u>strictly not allowed</u> . Carbon black should be well dispersed to give outstanding UV resistance, and should have a minimum carbon content of 2%.
2	Identification compound	The compound used for identification stripes shall be manufactured from a PE polymer manufactured from the same type of base polymer as used in the compound for pipe production.
3	General appearance	When viewed without magnification, the internal and external surfaces of pipes shall be smooth, clean and free from scoring, cavities and other surface defects such as would prevent conformity of the pipe to ISO 4427. The pipe ends shall be cut cleanly and square to the axis of the pipe.
4	Colour	The pipes shall be black with coloured identification stripes (blue for potable water) with protection from UV light.
5	Test	The HDPE pipes must undergo and pass the following test after manufacturing and test certificates shall be provided
5a	Hydrostatic Pressure Test	Pipes shall withstand without bursting or leakage the hydrostatic stress induced by internal hydrostatic pressure when tested in accordance with ISO 1167-1 using the test conditions specified in section 7.2 (e.g. 124 bars @ 20 degrees Celsius for 100 hours for PE100)

6	Dimensional Classes							
6a	General	The dimensions of the pipe shall be measured in accordance with ISO 3126. Manufacturing shall be to ISO 4427 Standard, as per <b>annexed dimensional chart.</b>						
6b	Lengths and coils	Where coiling is possible, the minimum internal diameter of the coil shall be not less than 18d <sub>n</sub> .						
		The lengths shall be supplied to minimize the number of joints to be done in the field, and the size that is allowed to be legally transported on Kenyan roads by the traffic department. ≤90 mm in 100m length coils; 110mm in 50m length coils; and ≥125mm in 12m length coils or lengths						
7		Markings						
	General	All pipes shall be permanently and legibly marked in such a way that the marking does not initiate cracks or other types of failure and such that normal storage, weathering, handling, installation and use does not affect the legibility of the marking. The colour of the printed information shall differ from the basic colour of the product. The marking shall be such that it is legible without magnification. <b>The frequency of marking shall not be less than once per metre.</b>						

# 7.57 SUBMERSIBLE PUMPS

### Pump make

Preference is for PENTAIR or equivalent.

### Pump set capability

1. Marking should be achieved through engrave printing on corrosion resistant material (e.g., metal plates) appropriate for the local conditions; name plates should be securely attached (riveted name plates) on the pumps and motors. Figures below provide examples of recommended marking on the pumps and motors.



1- Manufacturer's address and LOGO	6- Gross weight
2- Year of supply	7- Speed
3- Serial number	8- Flow rate
4- Head	9- Order number
5- Impeller diameter	10- Designation of the pump set

123 Street Side,	City Country	NOTO P
KimWate M1002-40		2016
3~	Volts 220-240D/380	-415Y
P-No. 77823456-000103	Amps 5.90/3.40	
S.N. 291 56 124	HZ 50	
Gew. 1090 kg	cos φ 0 <b>.8</b> 5-0.79	
N 2840-2870 1/m	Eff. % 94 P 1.	5 kW

1- Manufacturer's address and LOGO	8- Efficiency
2- Year of supply	9- Speed
3- Voltages	10- Gross weight
4- Currents	11- Serial number
5- Frequency	12- Order number
6- Power factor	13- Phase
7- kW	14- Designation of the motor set

- 2. The year of manufacture and serial number must be indicated
- 3. Minimum hydraulic pump efficiency of 70%
- 4. Pump grade 2B for pumps with shaft power >10 kW and  $\leq$ 100 kW
- Hydraulic minimum efficiency index (MEI) ≥ 0.7 according to ErP Directive 2009/125/EC [Commission Regulation (EU) 547/2012]
- 6. Degree of Protection otherwise known as Ingress Protection, minimum IP 68 required.

### Pump – assembly and maintenance

- 1. Fully submersible, multistage, submersible pump with NEMA coupling (6" and 8") or standard connection (10") and radial or semi-axial impellers for vertical or horizontal installation.
- 2. Integrated non-return valve
- 3. Rewindable three-phase AC motor with PVC-isolated winding and a water-glycol filling for direct starting
- 4. Hydraulic connection as NEMA (6" and 8") or standard connection (10") Sealing of motor shaft with a mechanical seal Self-lubricating motor bearing. Thrust bearing with rockers for absorption of high axial thrust Negative axial thrust is absorbed by the rotating seal bearing

- 5. The pump material should be non-toxic, non-contaminating, and biologically inert. (The supplier shall list all the materials used for the pump housing, impeller, lantern, pump shaft, mechanical seal, etc.)
  - a. Impellers made of stainless steel AISI 304
  - b. Motor Housing made of stainless steel AISI 304
  - c. Pump housing made of stainless steel AISI 304L
  - d. Shaft made of AISI 420 stainless steel for direct connection via NEMA coupling
  - e. Motor shaft made of 1.4301 stainless steel.
  - f. Mechanical Seal made of EPDM (EP 851) i.e. B-carbon or silicon carbide (AQIEGG)
- 6. Mechanical seals shall be provided unless approved otherwise.
- 7. If alternative materials are proposed this shall be so stated in the bid submission documents.
- 8. The pump casing, bearing, shaft, impellers and gaskets must be made of materials suitable for 10 years of continuous operation in water system.
- 9. The duty performance curves, efficiency curves, and power demand curves (characteristics curves) shall accompany the tender with clear indications of the capacity and efficiency of the pump with the specified head. The duty chart shall indicate the duty points i.e. proper NPSH curves showing flow, head, impeller size, shaft power and hydraulic efficiency.
- 10. The pump shall be able to operate with water at  $50^{\circ}$ C.

# Motor

- 1. The motor shall, unless otherwise stated, be suitable for 415/240 volts 3 phase 50 cycles (50Hz) 4 wire power supply. The motor shall have a soft starter which shall not exceed 2,900 RPM. The motor shall be foot mounted, squirrel cage, damp proof or totally enclosed suitable for an ambient temperature of 30°C.
- 2. The motor shall be designed for continuous running. Insulation Class 90°C for motor protection from power surges is required. The motor shall be capable of an overload of 10% above its rated output and the rated voltage for a period of one hour without sustaining damage.
- **3**. The motor is cooled by the pumped fluid. Therefore, the unit must always be operated immersed. However, a self-cooling motor is highly preferred and recommended.

# Spare Parts

The sub- contractor shall submit with his tender a list of the recommended spare parts for a period of 10 years. The subcontractor shall provide a guarantee from the supplier that a sufficient number of spare parts for the maintenance of the equipment.

# Maintenance Manual

Upon completion, the sub-contractor shall furnish the Engineer with three copies of a manual size A4 of loose leaf type containing all the following items:

- 1. Description of equipment
- 2. Full operation and maintenance instructions
- 3. Fault finding chart
- 4. Emergency procedures

- 5. Maintenance and service period
- 6. Primary and secondary spares
- 7. Recording drawing size A4

The maintenance manual shall be specially written (in English) and not a standard manufacturers manual unless approved by the Engineer. All instructions shall be written into the manual with reference to the drawings. All valves, terminals, controls of the pump set shall be labelled to correspond with maintenance and operation manual. The work shall not be considered to be complete for purposes of taking over until such instructions and drawings have been supplied to the client.

# Certificates

- The manufacturer of the pump shall hold a certificate for the standard ISO 5199:2012 and should hold certification corresponding to standard Quality System Certificate ISO 9001:2015; the environment standard ISO 14001:2015 and occupational safety and health standard BS OSHAS 18001:2007.
- Additionally, the specific pump/motor model purchased shall be certified according to applicable standards (e.g., ISO 9906:2012 Rotodynamic pumps -- Hydraulic performance acceptance tests -- Grades 1, 2 and
   The acceptance grade shall be as follows: 2B for pumps with shaft power >10 kW and ≤100 kW
- 3. The supplier should provide the specific manufacturer's authorization to sell the products, and the relevant KEBS/ERC Energy Efficiency Label under KS 2449-1:2013 and KS 2449-2:2013 Standards.
  - 4. For any parameter that can't be verified physically, a manufacturer's certificate should suffice

# Performance requirement for Borehole pump

Provide, install and commission a complete submersible pump (including draw pipes, cables, pump protection devices, control panel & sundries) capable of delivering 15.4m<sup>3</sup>/hr against a head of 130 m pre-approved before procurement by Engineer.

A test certificate from the factory should accompany the pump to verify specifications, which cannot be verified physically.

# Equipment

- 1. Lifting equipment/truck
- 2. Light Duty Truck (Pick-up or similar)

# Personnel

Required Key Personnel Position	Required qualifications
Project Manager	<ul> <li>BSc Degree in Mechanical/Electrical Engineering</li> <li>Minimum 5 years relevant experience in water projects</li> </ul>
Technician	Electromechanical technician
	• Minimum 4 years of experience

# 7.58 SURFACE PUMPS

## Pump set capability

Preference is for PENTAIR or equivalent.

### Pump set capability

Marking should be achieved through engrave printing on corrosion resistant material (e.g., metal plates) appropriate for the local conditions; name plates should be securely attached (riveted name plates) on the pumps and motors. Figures below provide examples of recommended marking on the pumps and motors.

123 Street Side,	City Country	BCPUM
		2016
KimWate P1002-40	S.N. 231 51 7	/65
P-No. 77823456-000103		
Q 305 l/s	H 6.3 m	
N 987 1/m	Imp. Dia. 0	.54 m
Gew. 1090 kg	1	
		CM070
123 Street Side, KimWate M1002-40	City Country	2016
123 Street Side,      KimWate M1002-40      3~	City Country	2016 DD/380-415Y
123 Street Side,         KimWate M1002-40         3~         P-No. 77823456-000103	City Country Volts 220-240 Amps 5.90/3	2016 DD/380-415Y
123 Street Side,         KimWate M1002-40         3~         P-No. 77823456-000103         S.N. 291 56 124	City Country Volts 220-240 Amps 5.90/3	2016 2D/380-415Y .40
123 Street Side,         KimWate M1002-40         3~         P-No. 77823456-000103         S.N. 291 56 124         Gew. 1090 kg	City Country Volts 220-240 Amps 5.90/3 HZ 50 cos $\varphi$ 0.85-0.	2016 2016 0D/380-415Y .40
123 Street Side,         KimWate M1002-40         3~         P-No. 77823456-000103         S.N. 291 56 124         Gew. 1090 kg         N 2840-2870 1/m	City Country Volts 220-240 Amps 5.90/3 HZ 50 cos $\varphi$ 0.85-0. Eff. % 94	2016 2016 2017 2016 2016 2016 2016 2016 2016 2016 2016

1- Manufacturer's address and LOGO	8- Efficiency
2- Year of supply	9- Speed
3- Voltages	10- Gross weight
4- Currents	11- Serial number
5- Frequency	12- Order number
6- Power factor	13- Phase
7- kW	14- Designation of the motor set

- 2. The motor MUST be rated and a display plate or engraving for international efficiency (IE) class mounted on the motor (riveted name plate with "punched" information that shows design specs). The year of manufacture must be indicated also as well as the serial number. E.g. IE3 95.8%
- 3. Motors rated below IE 3 are not acceptable. Pump grade 1B for pumps with shaft power >100 kW.
- 4. Motor efficiency lower than 93% or a power factor of 0.93 is not acceptable.
- 5. Hydraulic minimum efficiency index (MEI) ≥ 0.4 according to ErP Directive 2009/125/EC [Commission Regulation (EU) 547/2012]
- 6. Degree of Protection otherwise known as Ingress Protection, minimum IP 55 required.
- 7. The pump shall be coupled to the motor shaft by flexible coupling as per ISO 9905 requirements.

#### Pump – assembly and maintenance

- 1. The pumps shall be of the centrifugal type with cast iron casings. The shaft shall be prepared for direct connection via flexible coupling of the motor.
- 2. The pump material should be non-toxic, non-contaminating, and biologically inert. (The supplier shall list all the materials used for the pump housing, impeller, lantern, pump shaft, mechanical seal, etc.)
  - a. Impellers, stage chambers and pump housing made of 1.4301 (AISI 304 standard) or 1.4404 (AISI 316L standard) stainless steel
  - b. Shaft made of AISI 304 or AISI 316L stainless steel
  - c. Mechanical Seal made of EPDM (EP 851) i.e. B-carbon or silicon carbide (AQIEGG)
  - d. Bearing is preferably tungsten carbide or aluminum oxide
  - e. Pump base aluminium
- **3.** Pump casing shall have interchangeable, bronze wear rings. The impellers shall be of bronze or high grade cast iron dynamically balanced to ensure smooth running.
- 4. The propeller shaft shall be of steel (AISI 316L) and fitted with renewable bronze protecting sleeves wherever it is in contact with the pumped water.
- 5. Mechanical seals shall be provided unless approved otherwise.
- 6. If alternative materials are proposed this shall be so stated in the bid submission documents.
- 7. For this horizontal type pump, the propeller shaft shall be carried by oil or grease lubricated ball or other bearings.
- 8. The pump casing bearing, shaft, impellers and gaskets must be made of materials suitable for many years of continuous operation in water system. In this case a minimum of 10 years.
- **9.** The duty performance curves, efficiency curves, and power demand curves (characteristics curves) shall accompany the tender with clear indications of the capacity and efficiency of the pump with the specified

head. The duty chart shall indicate the duty points i.e. proper NPSH curves showing flow, head, impeller size, shaft power and hydraulic efficiency.

- 10. The pump shall be able to operate with water at  $50^{\circ}$ C.
- 11. An excel sheet showing the life cycle costs of the pump over its life time. 85% of the total life cycle cost of the pump is directly attributed to electricity. (Purchase price 7% and O&M is 8%).

# Motor

- The motor shall, unless otherwise stated, be suitable for 415/240 volts 3 phase 50 cycles (50Hz) 4 wire power supply. The motor shall have a soft starter coupled with a variable speed drive which shall not exceed 2,900 RPM. The motor shall be foot mounted, squirrel cage, damp proof or totally enclosed suitable for an ambient temperature of 30°C.
- 2. The motor shall be designed for continuous running. Insulation Class F for motor protection from power surges is required. The motor shall be capable of an overload of 10% above its rated output and the rated voltage for a period of one hour without sustaining damage.
- **3.** The rated output of the motor shall be the maximum horsepower absolved by the pump under the described conditions of head and discharge plus an allowance for loss of power in the coupling.
- 4. The electrically driven pump shall, unless otherwise stated, be directly coupled via a flexible coupling to the motor. The motor and pump assembly shall be fitted to a common rigid steel frame bolted to a concrete plinth. Proper alignment of motor and pumps must be guaranteed.

# **Spare Parts**

The sub- contractor shall submit with his tender a list of the recommended spare parts for a period of 10 years. The subcontractor shall provide a guarantee from the supplier that a sufficient number of spare parts for the maintenance of the equipment.

# Maintenance Manual

Upon completion, the sub-contractor shall furnish the Engineer with three copies of a manual size A4 of loose leaf type containing all the following items:

- 1. Description of equipment
- 2. Full operation and maintenance instructions
- 3. Valves operation
- 4. Fault finding chart
- 5. Emergency procedures
- 6. Maintenance and service period
- 7. Lubricating instructions
- 8. Primary and secondary spares
- 9. Recording drawing size A4

The maintenance manual shall be specially written (in English) and not a standard manufacturers manual unless approved by the Engineer. All instructions shall be written into the manual with reference to the drawings. All valves, terminals, controls of the pump set shall be labelled to correspond with maintenance and operation manual. The work shall not be considered to be complete for purposes of taking over until such instructions and drawings have been supplied to the client.

# Certificates

- 1. The manufacturer of the pump shall hold the for the standard ISO 5199:2012 for manufacture of pumps, and should also hold certification corresponding to standard Quality System Certificate ISO 9001:2015; the environment standard ISO 14001:2015 and occupational safety and health standard BS OSHAS 18001:2007.
- Additionally, the specific pump/motor model purchased shall be certified according to applicable standards (e.g., ISO 9906:2012 Rotodynamic pumps -- Hydraulic performance acceptance tests -- Grades 1, 2 and
   The acceptance grade shall be as follows: 2B for pumps with shaft power >10 kW and ≤100 kW; and 1B for pumps with shaft power >100 kW.
- **3**. The supplier should provide the specific manufacturer's authorization to sell the products, and the relevant KEBS/ERC Energy Efficiency Label under KS 2449-1:2013 and KS 2449-2:2013 Standards.

Technical Requirement	Description								Evaluation (Requirement fulfilled - Yes/No)	
	-ISO 9001:2008 (ISO 9001:2015 is an added advantage); ISO 14001:2004 (ISO 14001:2015 is an added advantage); BS OHSAS 18001:2007;									
Required Certificates	<ul> <li>Type approval certificate (either according to EN ISO 4064:2014, or OIML R49: 2013) from 28-06-2017 listed OIML Issuing Authorities Laboratories i.e. NMI-Australia; PTB-Germany; KIWA or NMiCertin - Netherlands; FORCE Certification A/S-Denmark; LNE-France; NMIJ/AIST-Japan; NMRO-UK; RISE-Sweden;</li> <li>MID also accepted</li> <li>Manufacturer's Authorization to sell</li> <li>KEBS certificate</li> <li>Manufacturer's Calibration Certificate</li> </ul>									
Type of Water Meter	Single Jet (Mechanical or with AMR enabled * [Smart]); *Automatic Meter Reading or Smart Water Meter									
	The value of the ratio $R=Q_3/Q_1$ shall behave a preferred accuracy of R200 for DN15 and R160 for DN 20, 25, 32 & 40mm.									
Class of Water	(Letter V o if the meter R200-H ar	or H shou r can only 1d R40-V	uld be m y be ope )	arked or erated in	inscril the ver	bed on th tical or h	e meter 10rizoni	for the al posi	R value, tion. e.g.	
Meter	Q <sub>s</sub> = Starting Flow rate.									
		DN	mm	15	20	25	32	40		
	L mm 110 190 260 260 300									

# DN 15,20,25,32 AND 40 SINGLE JET METERS

Technical Requirement	Description					Evaluation (Requirement fulfilled - Yes/No)				
		Q3	m³/h	2.5	4	6.3	10	16		
		Q <sub>3</sub> /Q <sub>1</sub>	R	200	160	160	160	160		
		Qs	l/h	<6	12	20	40	60		
		$\mathbf{Q}_1$	l/h	12.5	25	39.3	62.5	100		
		Q2	l/h	20	40	63	100	160		
		Q4	m³/h	3.125	5	7.875	12.5	20		
			DN	N 15. 20.	25, 32	& 40.			J	
Sizing of Water Meter	The meter size will be designated by the nominal size of its inlet and outlet threaded or flanged connectors. Both the inlet and outlet shall be of the same size and on the same axis. For each meter size designated, the corresponding fixed set of dimensions must correspond to BS 5728/1, ISO 4064-1: 2014 and no deviations from this shall be accepted (DN 15mm, 20, 25, 32 & 40mm) Water Utility request for Accuracy Class 2 water meters The meter manufacturer shall specify the accuracy class ISO									
Meter Application	4064-1:20 Accuracy of 4.2.1 Gen A water m indication) in 4.2.2 or designated requireme 4.2.2 Acco The MPE temperatur 30 °C. The MPE f	14 Section class and eral eter shall do not ex 4.2.3 und a seither nts of 4.2 uracy class for the up res from 0	be desi ceed the er rated · accurated .2 or 4.2 s 1 wate per flow 0,1 °C to wer flow	m permis gned and e maximu operating cy class 1 2.3. er meters v rate zon o 30 °C, a r rate zon	sible end manual m perm condit: l or acc ne ( $Q_2 \le$ and $\pm 2$ e ( $Q_1 \le$	Fror (MPI factured and a single end of the factor of the	E) such that rors (M vater me ass 2, ac is $\pm 1$ % mperatu is $\pm 3$ %	at its er PEs) a: eter sha ccordir 6, for ires gra	rrors (of s defined all be ng to the eater than	

	Yes/No)
regardless of the temperature range.	
4.2.3 Accuracy class 2 water meters A water meter shall be designated as accuracy class 2. This requires the Maximum Permissible Error (MPE) to be $\pm 2$ % (for temperatures from 0.1 °C to 30 °C and $\pm 3$ % for temperatures greater than 30 °C) for the upper flow rate zone. As the temperature in Kenya is greater than 30 °C, a MPE of $\pm 3$ % is acceptable. The MPE for the lower flow rate zone shall be $\pm 5$ %. The MPE for the upper flow rate zone ( $Q_2 \le Q \le Q_4$ ) is $\pm 2$ %, for temperatures from 0,1°C to 30 °C, and $\pm 3$ % for temperatures greater than 30 °C.	
The MPE for the lower flow rate zone $(Q_1 \le Q < Q_2)$ is $\pm 5 \%$ regardless of the temperature range	
The material should be resistant to normal exposures. The meter body shall be UV stabilized (co-) polymer, NOT plastic. <u>The copolymer meter will only have copolymer threads.</u> (The meter body material to be specified in the brochure)	
Threaded meters shall be supplied complete with a set of connectors that are made of copper alloy or equivalent material resistant to corrosion, rust and damage due to shock or vibration. The connectors shall be threaded to the correct male size, comprising cap nuts, linings and fiber sealing washers. The meter linings shall have adequate provisions to safeguard against tampering. Ensure adequate thread tape is provided.	
Only copolymer threads are allowed for co-polymer meters.	
The meters should have thread caps to prevent thread damaging .	
Strainers for DN15, 20, DN25, DN32 and DN40 only	
In-built sieves/strainers shall be incorporated in consumer flow meters.	
All meters shall be provided with effective inlet strainers which shall be of rigid construction, close fitting and designed for easy removal. Inlet strainers shall be of nickel-plated copper, stainless steel or other materials having satisfactory characteristics. The strainer shall have an effective straining area of at least three times that of the meter body inlet diameter. Tenderers shall provide details of the materials of construction, aperture size and design of strainers.Larger size meters are flanged.	
$\mathbf{r}$ $4 \mathbf{A} \mathbf{N} \mathbf{t} \mathbf{r} 9 \mathbf{T} \mathbf{t} \mathbf{t}$ $\mathbf{T} \mathbf{r}$ $\mathbf{T} \mathbf{s} \underline{\mathbf{n}} \mathbf{s}$ $\mathbf{T} \mathbf{n} \mathbf{a} \mathbf{t} \mathbf{v} \mathbf{a}$ $\mathbf{O} \ \mathbf{T} \ \mathbf{S} \ \mathbf{I} \mathbf{r} \mathbf{A} \mathbf{r} \mathbf{s} \mathbf{n} \mathbf{e} \mathbf{c} \mathbf{c} \mathbf{c} \mathbf{f} \ \mathbf{S} \mathbf{I}$	egardless of the temperature range. .2.3 Accuracy class 2 water meters A water meter shall be designated as accuracy class 2. This requires the Maximum Permissible Error (MPE) to be $\pm 2$ % (for temperatures from 0.1 °C o 30 °C and $\pm 3$ % for temperatures greater than 30 °C, a MPE of $\pm 3$ % is acceptable. The MPE for the lower flow rate zone shall be $\pm 5$ %. The MPE for the upper flow rate zone ( $Q_2 \le Q \le Q_4$ ) is $\pm 2^2$ %, for emperatures from 0,1°C to 30 °C, and $\pm 3$ % for temperatures greater han 30 °C. The MPE for the lower flow rate zone ( $Q_1 \le Q < Q_2$ ) is $\pm 5$ % egardless of the temperature range The material should be resistant to normal exposures. The meter body hall be UV stabilized (co-) polymer, NOT plastic. <u>The copolymer</u> neter will only have copolymer threads. (The meter body material to be pecified in the brochure) Threaded meters shall be supplied complete with a set of connectors that are nade of copper alloy or equivalent material resistant to corrosion, rust und damage due to shock or vibration. The connectors shall be threaded o the correct male size, comprising cap nuts, linings and fiber sealing vashers. The meter linings shall have adequate provisions to safeguard gainst tampering. Ensure adequate thread tape is provided. Only copolymer threads are allowed for co-polymer meters. The meters should have thread caps to prevent thread damaging . <i>Ctrainers for DN15, 20, DN25, DN32 and DN40 only</i> n-built sieves/strainers shall be incorporated in consumer flow neters. All meters shall be of nickel-plated copper, stainless steel or other naterials having satisfactory characteristics. The strainer shall have an iffective straining area of at least three times that of the meter body inlet tiameter. Tenderers shall provide details of the materials of construction, aperture size and design of strainers.Larger size meters are langed. Suitable in-built strainer (0.75mm aperture& 2,844 mm <sup>2</sup> mesh (made

Technical Requirement	Description	Evaluation (Requirement fulfilled - Yes/No)
	of stainless steel) area) shall protect the measuring mechanism. For larger sizes, suppliers shall submit the required strainer aperture and mesh sizes	
	Non-return Valves for DN15, 20, DN25, DN32 and DN40 only.	
	All meters shall be supplied with integral non-return valves. Tenderers shall provide details of the materials of construction and design of non-return valves. A sample provided of the Non-return valve is also requested. Larger size meters have no NRV's.	
	End Connectors	
	<u>All meters of size 15 to 40mm</u> diameter shall be supplied complete with a set of copper alloy connectors (linings and cap nuts) threaded to $\frac{1}{2}$ " BSP male containing no less than 57% copper and rubber sealing washers.	
	ISO 4064-1:2014 section 6.1.7A water meter shall be of such design, composition, and construction that it does not facilitate the perpetration of fraud. A visible indicator showing any form of tampering is a requirement	
	The meter shall be delivered calibrated. In addition to the inscription requirement in ISO 4064-1:2014 Section 6.6 (see Annex F, Marks and Inscriptions), the nominal diameter is required to be marked on the meter. As the recommended temperature class, T50, differs from T30, it should be indicated additionally. Furthermore, the abbreviation of the specific WSP shall be engraved to reduce the chance of theft.	
	Marks and inscriptions	
	6.6.2 A water meter shall be clearly and indelibly marked with the following information, either grouped or distributed, on the casing, the indicating device dial, an identification plate or the meter cover, if it is not detachable. These markings shall be visible without dismantling the water meter after the instrument has been placed on the market or put into use.	
	a) Unit of measurement.	
	b) Accuracy class, where it differs from accuracy class 2.	
	c) Numerical value of $Q_3$ and the ratio $Q_3/Q_1$ : if the meter measures reverse flow and the values of $Q_3$ and the ratio $Q_3/Q_1$ are different in the two directions, both values of $Q_3$ and $Q_3/Q_1$ shall be inscribed; the direction of flow to which each pair of values refers shall be clear. The ratio $Q_3/Q_1$ may be expressed as R, e.g. "R160". If the	

Technical Requirement		Evaluation (Requirement fulfilled - Yes/No)				
	meter h both va value re					
	d) Type	approval sign a	ccording to nation	al regulations.		
	e) Nam	e or trademark o	f the manufacturer			
	f) Year month a	of manufacture, t and year of man	the last two digits outputs of the last two digits of the second se	of the year of ma	unufacture, or the	
	g) Seria number code +	al number (as ne r may be engrav serial number) f	ear as possible to yed or laser printe for auto reading of	the indicating d ed in a data mat f the serial num	evice). The serial rix format (article ber.	
	Marking	g of approving la	boratory with app	roval number		
	Indelib tracebil	le marking of Q ity of order from	R data matrix sh n manufacturer.	nowing meter se	erial number, and	
	{Data Matrix code is a two-dimensional barcode consisting of black and white "cells" or modules arranged in either a square or rectangular pattern, also known as a matrix. The information to be encoded can be text or numeric data.)					
	h) Dire	ction of flow, h		row (shown on	both sides of the	
	body or visible					
	i) Maximum admissible pressure (MAP) if it exceeds 1 MPa (10 bar) or 0,6 MPa (6 bar) for DN $\geq$ 500.					
	j) Letter V or H, if the meter can only be operated in the vertical or horizontal position.					
	k) The temperature class will be T50.					
		Class	mAT <sup>0</sup> C	MAT <sup>o</sup> C		
		T30	0.1	30		

Technical Requirement	Description					Evaluation (Requirement fulfilled - Yes/No)
		T50	0.1	50		
		T70	0.1	70		
		T90	0.1	90		
		T130	0.1	130		
		T180	0.1	180		
		T30/70	30	70		
		T30/90	30	90		
		T30/130	30	130		
		T30/180	30	180		
	l) The p	ressure loss class	where it differs f	from $\Delta p63$ .	I	
	m) Tl U0/D0.	ne installation However, U0/D	sensitivity cl 0 is required.	lass where	it differs from	
	A worl indicate A wate Maximu to 30 °C rate zon % is ac					
Engraving	The abbreviation ofWASCO shall be engraved to reduce the chance of theft.					
Packaging	Every s shock-re during	ingle meter mus esistant material transportation, d	t be packed separ (such as bubble- elivery and instal	etely with a rob wrap) to preven lation.	ust shock- proof or t it from damage	
Non-Return	The me meter r	ter shall have inter shall have interes and the second second second second second second second second second s	ouilt Non – Return	Valve to reduce	e the risk of water	
Water Hammer	The me to 100,0 of mini	ter has to be teste 000 cycles. The r mum one year.	ed against the effe neter remains with	ct of water ham in the calibration	ner for up n range for period	

Technical Requirement	Description	Evaluation (Requirement fulfilled - Yes/No)
	Spare parts/after sales service: NO SPARE PARTS! A water meter shall require no spare parts or servicing, except for the removal of silt by from the internal strainer is preferred. This ensures that the metrology of the water meter is preserved, protected and never tampered with. The water meter manufacturer must guarantee that the meter will perform at its optimum accuracy throughout its lifespan with only the removal of silt. Maintenance manuals: Installation manuals, commercial guides and data sheets (in English) shall be provided. The only maintenance will be removal of silt. Warranty: The minimum warranty period shall be two years. Warranty must be from the manufacturer.	
Additional Non- Technical Requirements	For specially designed and manufactured unservicable water meters, the manufacturer should provide <u>a guaranteed lifespan of atleast 8 years</u> . Testing: Before authorizing payments and upon delivery after the award of contract, the company will be sampling 5% of the meters at random. A batch will be considered as failed if one or more meters do not comply with the established technical specifications or have failed the tests. Under these circumstances, the specific batch of meters has to be rejected. A random batch of 5% in every batch of 100 meters will be selected by a representative of the _WASCO's technical department.	
	The tests must be conducted by a Kenya National Accreditation Service (KENAS) Accredited Meter Testing Laboratory such as KEBS or Nyeri Water and Sewerage Company Ltd. The costs for testing shall be taken over by the supplier. Furthermore,	
	the supplier has also to bear the costs for replacement if rejected.	
Metrological requirements	ISO 4064-1:2014 Section 3 $Q_1$ - minimum flow rate - lowest flow rate at which the meter is to operate within the maximum permissible errors	

Technical Requirement	Description	Evaluation (Requirement fulfilled - Yes/No)
	$Q_2$ - transitional flow rate - flow rate between the permanent flow rate and the minimum flow rate that divides the flow rate range into two zones, the upper flow rate zone and the lower flow rate zone, each characterized by its own maximum permissible errors	
	$Q_3$ - permanent flow rate - highest flow rate within the rated operating conditions at which the meter is to operate within themaximum permissible errors	
	$Q_4$ - overload flow rate - highest flow rate at which the meter is to operate for a short period of time within the maximum permissible errors, while maintaining its metrological performance when it is subsequently operating within the rated operating conditions	
	ISO 4064-1:2014 Section 4	
	4.1 Values of $Q_1$ , $Q_2$ , $Q_3$ , and $Q_4$	
	4.1.1 The flow rate characteristics of a water meter shall be defined by the values of $Q_1$ , $Q_2$ , $Q_3$ , and $Q_4$ .	
	4.1.2 A water meter shall be designated by the numerical value of $Q_3$ in m <sup>3</sup> /h and the ratio $Q_3/Q_1$ .	
	4.1.3 The value of $Q_3$ , expressed in $m^3/h$ , shall be chosen from the following list:	
	1; 1,6; 2,5; 4; 6,3; 10; 16; 25; 40; 63; 100; 160; 250; 400; 630; 1000; 1600; 2500; 4000; 6300;	
	The list may be extended to higher or lower values in the series.	
	<b>4.1.4</b> The value of the ratio $Q_3/Q_1$ shall be chosen from the following list: 40; 50; 63; 80; 100; 125; 160; 200; 250; 315; 400; 500; 630; 800; 1000	
	The list may be extended to higher values in the series.	
	NOTE: The values in 4.1.3 and 4.1.4 are taken from ISO 3,[4] R 5 and R 10 lines, respectively.	
	4.1.5 The ratio $Q_2/Q_1$ shall be 1,6.	
	<b>4.1.6</b> The ratio $Q_4/Q_3$ shall be 1,25.	
	Tenderers shall state the meteorological classes of the meters offered.	

Technical Requirement			Evaluation (Requirement fulfilled - Yes/No)		
	ISO 4064-1:2014 Section	6.5			,
	The pressure loss throu, and/or straightener, when meter, shall not be greate				
	Class	Maximum Pressure Loss			
Pressure Loss		MPa	Bar		
	Δ <i>p</i> 63	0.063	0.63		
	Δ <i>р</i> 63	0.040	0.40		
	Δ <i>р</i> 63	0.025	0.25		
	Δ <i>р</i> 63	0.016	0.16		
	Δ <i>p</i> 63 ISO 4064-1:2014 Section	0.010 6.7 Indicating device	0.10		
	6.7.1 General requirement	nts			
	6.7.1.1 Function				
	The indicating device of reliable, and unambigu A combination meter ma provides the indicated vo				
	6.7.1.2 Unit of measurem				
Indicating device	The indicated volume of symbol m <sup>3</sup> shall appear numbered display.	tes. The to the			
	If units of measuremen country's national regu considered acceptable for the officially agreed eq and those of the SI shall	t outside the SI are lations, these units indications in that co uivalents between the be used	e required or allowe of measurement sountry. In internationa these units of measure	ed by a shall be al trade, urement	

Technical Requirement		Evaluation (Requirement fulfilled - Yes/No)		
		Q3	Indicating Range (Minimum Values)	
		m³/h	m <sup>3</sup>	
		$Q_3 \le 6,3$	9 999	
		$6,3 < Q_3 \le 63$	99 999	
		$63 < Q_3 \le 630$	999 999	
		$630 < Q_3 \le 6\ 300$	9 999 999	
	ISO4064- The indica metres gi 6.7.1.4 Co The colou multiples The colou These colou These colou These colou discs, dia Other me multiples in distin displays, 6.7.2 Typ Any of the 6.7.2.1 T The indica a) one or b) one or The value form 10 <i>n</i> zero, ther shall eithe	1:2014 Section 6.7.1.3 Indica ating device shall be able to re- ven in Table above without plour coding for indicating de- ur black should be used to indour shall be applied to either ls or to the apertureframes. eans of indicating the cub smay be used for a water n- guishing between the p- e.g. sub-multiples for verific bes of indicating device e following types shall be used type 1 - Analogue device ated volume is indicated by of more pointers moving relative more circular scales or drum expressed in cubic metres for , where <i>n</i> is a positive or ne eby establishing a system of er be graduated in values exp	ating range ecord the indicated volume in cubic passing through zero. evices dicate the cubic metre and its icate sub-multiples of a cubic me pointers, indexes, numbers, wheele ic metre, its multiples and its s neter provided there is no ambigu- rimary indication and alterna- eation and testing. ed. continuous movement of ve to graduated scales, or s each passing an index. r each scale division shall be of the gative whole number or f consecutive decades. Each scale pressed in cubic metres	tre. s, sub- uity tive

Technical Requirement	Description	Evaluation (Requirement fulfilled - Yes/No)
	<ul> <li>or accompanied by a multiplication factor (×0,001; ×0,01; ×0,1; ×1; ×10; ×100; ×1 000, etc.)</li> <li>Rotational movement of the pointers or circular scales shall be clockwise.</li> <li>Linear movement of pointers or scales shall be left to right. Movement of numbered roller indicators (drums) shall be upwards.</li> <li>6.7.2.2 Type 2 - Digital device</li> <li>The indicated volume is given by a line of adjacent digits appearing in one or more apertures. The advance of a given digit shall be completed while the digit of the next immediately lower decade changes from 9 to 0. The apparent height of the digits shall be at least 4 mm.</li> </ul>	
	<ul><li>For non-electronic devices:</li><li>a) movement of numbered roller indicators (drums) shall be upwards;</li><li>b) if the lowest value decade has a continuous movement, the aperture shall be large enough to permit a digit to be read unambiguously.</li></ul>	
	<ul> <li>For electronic devices:</li> <li>c) either permanent or non-permanent displays are permitted - for non-permanent displays, thevolume shall be able to be displayed at any time for at least 10 s;</li> <li>d) the meter shall provide visual checking of the entire display which shall have the following sequence: <ol> <li>for seven segment type displaying all the elements (e.g. an "eights" test);</li> <li>for seven segment type blanking all the elements (a "blanks" test);</li> <li>for graphical displays an equivalent test to demonstrate that display faults cannot result in any digit being misinterpreted.</li> </ol> </li> </ul>	
	The materials used in the construction shall be designed to withstand raw and treated (potable) water and operate for at least 5 years without normal need for maintenance or repair and without the maximum error exceeding the specified limits.	
Materials and Design	Tenderers shall specify the optimum pH and the water quality for which the meters have been designed.	
2 00.51	They must be constructed throughout of materials which are resistant to internal and external corrosion and if necessary be protected by some suitable surface treatment. All materials of the	

Technical Requirement	Description	Evaluation (Requirement fulfilled - Yes/No)
	water meter which are in contact with the water flowing through the water meter shall be non-toxic and non-tainting. Water temperature variations within the working range shall not adversely affect the materials used in the construction of the water meter.	
	The water meter must be resistance to sand, manganese, lime, 12,000 Gauss magnets, hot needles, G-clamps and condensation on the underside of the window of indicating device.	
	ISO 4064-1:2014 Section 6.1 Materials and construction of water meters	
	6.1.1 A water meter shall be manufactured from materials of adequate strength and durability for the purpose for which it is to be used.	
	6.1.2 A water meter shall be manufactured from materials which shall not be adversely affected by the water temperature variations, within the working temperature range	
	6.1.3 All parts of a water meter in contact with the water flowing through it shall be manufactured from materials which are conventionally known to be non-toxic, non-contaminating, and biologically inert. <i>Attention is drawn to national regulations</i> .	
	6.1.4 The complete water meter shall be manufactured from materials which are resistant to internal and external corrosion or which are protected by a suitable surface treatment.	
	6.1.5 A water meter indicating device shall be protected by a transparent window. A cover of a suitable type may also be provided as additional protection.	
	6.1.6 Where there is a risk of condensation forming on the underside of the window of a water meter indicating device, the water meter shall incorporate devices for prevention or elimination of condensation.	
	z(The units should be permanently sealed and should be frost, moisture and dust proof.)	
	6.1.7 A water meter shall be of such design, composition, and construction that it does not facilitate the perpetration of fraud.	
	6.1.8 A water meter shall be fitted with a metrological controlled display. The display shall be readily accessible to the customer, without requiring the use of a tool.	
	6.1.9 A water meter shall be of such design, composition, and construction that it does not exploit the MPE or favour any party.	

Technical Requirement	Description	Evaluation (Requirement fulfilled - Yes/No)
Dial Counter	The dial should be of dry dial magnetic type in all the water meters. The register is fully – sealed, vacuum filled, with a sample straight – reading presentation. The register is placed in a window inside the meter body in the direction of flow for easy reading.	
Meter Installation Orientation	Letter V or H should be marked or inscribed on the meter, if the meter can only be operated in the vertical or horizontal position. [Velocity Meters]	
	It is recommended that the Manufacturer provides his / her specific preferred installation instructions. The installation instructions shall be guided by the ISO 4064-5:2014 best practice recommendations.	
	ISO 4064-5:2014 - Installation. 6.1 General requirements	
	6.1.1 Every water meter, single or in a group, shall be easily accessible for reading (without the use of a mirror or ladder, for instance), for installation, for maintenance, for removal and for <i>in situ</i> dismantling of the mechanism if required.	
Installation	In addition, for water meters of a mass in excess of 25 kg, there shall be clear access to the installation site to allow the water meter to be brought to, or removed from, its working position, and adequate space around the working position for the installation of lifting gear. The following points should be taken into account:	
Requirements	<ul><li>a) the need for adequate illumination of the installation site;</li><li>b) the need for the floor to be even, rigid, non-slip and clear of obstacles.</li></ul>	
	6.1.2 Associated fittings such as those specified in Clause 5, if fitted, shall also be readily accessible, and the requirements of 6.1.1 relating to large meters are also applicable for the fittings.	
	6.1.3 Measures shall be employed to avoid contamination, especially when the meter is installed in a pit, by mounting the water meter and the fittings at a sufficient height above the floor. If necessary, the pit shall be provided with a sump or drain for water removal.	
	6.2 Installation requirements	
	6.2.1 For correct operation, a water meter shall always be full of	

Technical Requirement	Description	Evaluation (Requirement fulfilled - Yes/No)
Automatic Meter Reading Capability	<ul> <li>Description</li> <li>water. If there is a risk of air entering the meter, an upstream air release valve shall be installed.</li> <li>6.2.2 The meter shall be protected from the risk of damage by shock or vibration.</li> <li>6.2.3 The meter shall not be subjected to undue stresses caused by pipes and fittings. If necessary, it shall be mounted on a plinth or bracket. The water pipe lines and associated fittings shall be adequately anchored to ensure that no part of the installation can be displaced under water thrust when the meter is dismantled or disconnected on one side.</li> <li>6.2.4 The meter shall be protected from the risk of damage from extremes of temperature of the water or ambient air.</li> <li>6.2.5 Where possible, the meter pit shall be protected from flooding and rainwater.</li> <li>6.2.6 The instructions shall give limits on orientation dependent on the meter type.</li> <li>6.2.7 The meter shall be protected from the risk of damage due to external environmental corrosion.</li> <li>6.2.8 In the case where the water meter is part of an electrical earthing, in order to minimize the risk to operational staff, there shall be a permanent shunt for the water meter and its associated fittings.</li> <li>NOTE: Any national or local legislation concerning the use of water pipes for this purpose applies in the country of use.</li> <li>6.2.9 Unfavourable hydraulic conditions, e.g. cavitation, surging and water hammer, should be avoided.</li> <li>The water meter shall be AMR ready or enabled to allow for future Automatic Meter Reading Capabilities. The AMR meter shall conform to the following characteristics so that it can be ready for AMR. For future tasks, the AMR water meter shall also be compatible with an external pulse reader or sensor and can transmit meter readings via a radio frequency reading system or a fixed network pulse transmitter via GPRS / GSM. Characteristics of the Pulse Reader, Radio frequency reading system and fixed network pulse transmitter are detailed below</li> <li>The water</li></ul>	fulfilled - Yes/No)
Technical Requirement	Description	Evaluation (Requirement fulfilled - Yes/No)
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	The pulse emitters will	
	An external pulse reader or sensor that is fixed on the meter and fitted with either a radio frequency reading system or a fixed network pulse transmitter via GPRS / GSM.	
	Properties of Pulse Reader or Sensor:	
	1. Compact radio emitter	
	2. Compatible with a modular meter inductive technology (Ha+Ti or Ti)	
	<b>3</b> . Frequency MHz 868.95 or 434.47 (for mobile mode walk-by or drive- by through radio frequency transmission module) and 868.30 or 433.42 (for fixed Network via GPRS/GSM)	
	4. Transmission power 16mW	
	5. Transmission mode Unidirectional	
	6. Radio range Up to 2000 m depending on the environment with a Bluetooth receiver for transmission of meter readings	
	7. Approval EN 300 220, CE RTTE	
	8. Battery lifetime up to 15 years and a continuous signal emission in programmable seconds.	
	9. Degree of Protection should be IP 68	
	10. Insensitive to magnetic fraud	
	11. Tampering Alarm	
	12. Provision for manual download and/or delete readings directly from the water meter incase the radio frequency module fails.	
	The pulse reader or sensor shall include an electronic circuit that picks up the data sent by an emitter (clipped on a water meter) and stores them in a memory.	
	The pulse reader or sensor transmits the data and other operating information at least every 10 seconds or less on mobile mode walk- by or drive-by through radio frequency transmission module and at least every 20 minutes or lessfor fixed Network via GPRS/GSM.	
	Walk-by/Drive-by :	

Technical Requirement	Description	Evaluation (Requirement fulfilled - Yes/No)
	A handheld unit equipped with an a receiver that collects the reading information and directly transfers them to the central computer system within a certain radius.	
	Fixed network : A fixed GPRS/LAN receiver installed in buildings, will collect the data from all the external pulse readers or sensors, memorize them, and transmit them each day via GPRS/LAN to a centralized server.	
	Can be connected to remote reading or consumption-analysis systems.	
	Comply with ISO 4064-1:2014 Section 5 i.e. "Water Meters equipped with electronic devices"	

DN 50.80	AND	100	SINGLE	JET	METERS
D1100,00		100			

Technical Requirement	Description	Evaluation (Requirement fulfilled - Yes/No)
	<ul> <li>ISO 9001:2008 (ISO 9001:2015 is an added advantage); ISO 14001:2004 (ISO 14001:2015 is an added advantage); BS OHSAS 18001:2007;</li> </ul>	
<b>Required</b> Certificates	<ul> <li>Type approval certificate (either according to EN ISO 4064:2014, or OIML R49: 2013) from 28-06-2017 listed OIML</li> <li>Issuing Authorities Laboratories i.e. NMI-Australia; PTB-Germany; KIWA or NMiCertin - Netherlands; FORCE Certification A/S-Denmark; LNE-France; NMIJ/AIST-Japan; NMRO-UK; RISE-Sweden;         <ul> <li>MID also accepted</li> <li>Manufacturer's Authorization to sell</li> <li>KEBS certificate</li> <li>Manufacturer's Calibration Certificate</li> </ul> </li> </ul>	
Type of Water Meter	Single Jet (Mechanical or with AMR enabled * [Smart]); *Automatic Meter Reading or Smart Water Meter	
Class of Water Meter	The value of the ratio $R=Q_3/Q_1$ shall behave a preferred accuracy of R315 for DN50 and DN65 and R630 for DN 80 & 100mm. $Q_s = Starting$ Flow rate.	

Technical Requirement	Description						Evaluation (Requirement fulfilled - Yes/No)		
		DN	mm	50	65	80	100		
	ľ	L	mm	300	300	350	350		
		<b>Q</b> <sub>3</sub>	m³/h	25	40	63	100		
		$Q_3/Q_1$	R	315	315	630	630		
		Qs	l/h	15	25	25	40		
		<b>Q</b> 1	l/h	80	127	100	158		
		Q2	l/h	127	203	160	254		
		<b>Q</b> 4	m³/h	31.25	50	78.75	125		
			DN	50, 65, 8	<u>80, 100</u>	mm.			
	The meter	size will	be desig	gnated by	the no	minal siz	te of its	inlet and outlet	
	threaded or	flanged	connect	ors. Both	the inle	t and out	let shal	l be of the same	
Sizing of Water	size and or	n the sam	ne axis.						
Meter	For each m	eter size	designs	ted the	orregn	onding f	ived se	t of	
	dimensions	must cor	respond	to BS 57	$\frac{28}{1.15}$	50 4064-	1: 2014	and no	
	deviations	from this	s shall b	e accept	ed				
	(DN 50mm	, 80, 100	mm)	1					
	·		,						
	Water Util	ity requ	est for A	Accuracy	Class	2 water	meters		
	The meter	manufac	cturer s	hall speci	ify the	accuracy	class l	ISO	
	4064-1.201	14 Sectio	on 4 2						
	Accuracy of	class and	l maxim	um perr	nissible	error (I	MPE)		
	4.2.1 Gen	eral		<b>r</b>		(-	)		
	A water me	eter shall	be desi	gned and	lmanut	factured	such th	at its errors (of	
	indication)	do not ex	ceed the	e maximu	m perm	issible ei	rors (N	IPEs) as defined	
	in 4.2.2 or 4	4.2.3 und	er rated	operating	conditi	ions. A w	ater m	eter shall be	
Meter	designated	as either	accura	cy class 1	l or acc	uracy cl	ass 2, a	ccording to the	
Application	requiremen	its of 4.2	.2 or 4.2	2.3.					
	4.2.2 Accu	iracy cla	ss 1 wat	er meter	s				
	The MPE f	or the up	per flow	v rate zor	$ie (O_2 <$	$< O \leq O_4$	) is $\pm 1$ 9	%, for	
	temperatur	es from (	0,1 °C t₀	o 30 °C, a	and $\pm 2$	% for te	mperat	ures greater	
	than 30 °C						-	-	
	The MPE for	or the low	ver flow	rate zone	$e(Q_1 \leq$	$Q < Q_2$ ) is	s ±3 % ;	regardless of	
	the tempera	ature ran	ge.						
	4.2.3 Accu	racy cla	ss 2 wat	er meter	S				
	A water me	ter shall	be desig	nated as	accurac	cy class 2	. This 1	requires	
	the Maximu	ım Permi	ssible E	rror (MP	E) to be	±2 % (fe	or temp	eratures from 0.1	
	°C to 30 °C	C and $\pm 3$	% for te	emperatur	es grea	ter than .	30 °C)		

Technical Requirement	Description	Evaluation (Requirement fulfilled - Yes/No)
	for the upper flow rate zone. As the temperature in Kenya is greater than 30 °C, a MPE of $\pm 3$ % is acceptable. The MPE for the lower flow rate zone shall be $\pm 5$ %. The MPE for the upper flow rate zone ( $Q_2 \le Q \le Q_4$ ) is $\pm 2$ %, for temperatures from 0,1°C to 30 °C, and $\pm 3$ % for temperatures greater than 30 °C. The MPE for the lower flow rate zone ( $Q_1 \le Q$ $) is \pm 5 % regardless of the temperature range.The material should be resistant to normal exposures. The meter body$	
Material Requirements	shall be brass. <u>The brass meter shall be flanged. Rotating</u> flanges are an <u>added advantage.</u> (The meter body material to be specified in the brochure)	
	The meter shall be delivered calibrated. In addition to the inscription requirement in <b>ISO 4064-1:2014 Section 6.6</b> (see Annex F, Marks and Inscriptions), the nominal diameter is required to be marked on the meter. As the recommended temperature class, T50, differs from T30, it should be indicated additionally. Furthermore, the abbreviation of the specific WSP shall be engraved to reduce the chance of theft. <b>Marks and inscriptions</b> <b>6.6.2</b> A water meter shall be clearly and indelibly marked with the following information, either grouped or distributed, on the casing, the indicating device dial, an identification plate or the meter cover, if it is not detachable. These markings shall be visible without dismantling the water meter after the instrument has been placed on the market or put into use. a) Unit of measurement. b) Accuracy class, where it differs from accuracy class 2. c) Numerical value of $Q_3$ and the ratio $Q_3/Q_1$ are different in the two directions, both values of $Q_3$ and $Q_3/Q_1$ shall be clear. The ratio $Q_3/Q_1$ may be expressed as R, e.g. "R160". If the meter has different values of $Q_3/Q_1$ in horizontal and vertical positions, both values of $Q_3/Q_1$ shall be clear. d) Type approval sign according to national regulations. e) Name or trademark of the manufacturer. f) Year of manufacture, the last two digits of the year of manufacture, or the month and year of manufacture.	

Technical Requirement		Evaluation (Requirement fulfilled - Yes/No)			
	g) Serial number (as no number may be engra- code + serial number) t				
	Marking of approving la	aboratory with app	proval number		
	Indelible marking of ( tracebility of order from	QR data matrix s n manufacturer.	howing meter s	erial number, and	
	{Data Matrix code is a white "cells" or modu pattern, also known as or numeric data.)	i two-dimensiona ules arranged in a matrix. The info	el barcode const 1 either a squa prmation to be e	isting of black and are or rectangular ncoded can be text	
	<ul> <li>h) Direction of flow, by or on one side only prounder all circumstances</li> <li>i) Maximum admissible or 0,6 MPa (6 bar) for D</li> <li>j) Letter V or H, if the</li> </ul>				
	horizontal position.	will be <b>T50</b>			
	Class	$mAT^0C$	MAT °C		
	T30	0.1	30		
	T50	0.1	50		
	T70	0.1	70	]	
	T90	0.1	90		
	T130	0.1	130	-	
	T180	0.1	180		
	T30/70	30	70	-	
	T30/90 T20/120	30	90	-	
	1 30/130 T20/190	<u> </u>	150	-	
	$\frac{130/100}{100}$	SU s where it differe	100	-	
	m) The installation sense	itivity class where	e it differs from		
	-,				

Technical Requirement	Description	Evaluation (Requirement fulfilled - Yes/No)
	U0/D0.However, U0/D0 is required.	
	A working pressure of $1,600 \ kPa$ is recommended. This should be indicated on the meter as well. $1 \ bar = 100 \ kPa$	
	A water meter shall be designated as accuracy class 2. This requires	
	the Maximum Permissible Error (MPE) to be $\pm 2$ % (for temperatures	
	from 0.1 °C to 30 °C and $\pm 3$ % for temperatures greater than 30 °C)	
	for the upper flow rate zone. As the temperature in Kenya is greater than 30 °C, a MPE of $\pm 3$ % is acceptable. The MPE for the lower	
	flow rate zone shall be $\pm 5$ %.	
Engraving	The abbreviation of MAWASCO shall be engraved to reduce the chance of theft.	
Packaging	Every single meter must be packed separately with a robust shock- proof or shock-resistant material (such as bubble-wrap) to prevent it from damage during transportation, delivery and installation.	
Water Hammer	The meter has to be tested against the effect of water hammer for up to 100,000 cycles. The meter remains within the calibration range for period of minimum one year.	
	Spare parts/after sales service: NO SPARE PARTS! A water	
	meter shall require no spare parts or servicing, except for the	
	removal of silt by from the internal strainer is preferred. This ensures	
	that the metrology of the water meter is preserved, protected and	
	never tampered with.	
	The water meter manufacturer must guarantee that the meter will	
	perform at its optimum accuracy throughout its lifespan with only the removal of silt.	
Additional Non-	Maintenance manuals: Installation manuals, commercial guides and	
Technical	data sheets (in English) shall be provided. The only	
Requirements	maintenance will be removal of silt.	
	Warranty: The minimum warranty period shall be two years.	
	For specially designed and manufactured unservicable water meters	
	the manufacturer should provide a guaranteed <b>lifespan</b> of atleast 8	
	years. Testing:	
	Before authorizing payments and upon delivery after the award of	
	contract, the company will be sampling 1% of the meters at random.	

Technical Requirement	Description	Evaluation (Requirement fulfilled - Yes/No)
	A batch will be considered as failed if one or more meters do not comply with the established technical specifications or have failed the tests. Under these circumstances, the specific batch of meters has to be rejected. A random batch of 1% in every batch of 100 meters will be selected by a representative of the MAWASCO's technical department. The tests must be conducted by a Kenya National Accreditation Service (KENAS) Accredited Meter Testing Laboratory such as KEBS or Nyeri Water and Sewerage Company Ltd. The costs for testing shall be taken over by the supplier. Furthermore, the supplier has also to bear the costs for replacement if rejected. <b>ISO 4064-1:2014 Section 3</b>	
	$Q_1$ - minimum flow rate - lowest flow rate at which the meter is to operate within the maximum permissible errors $Q_2$ - transitional flow rate - flow rate between the permanent flow rate and the minimum flow rate that divides the flow rate range into two zones, the upper flow rate zone and the lower flow rate zone, each characterized by its own maximum permissible errors	
	$Q_3$ - <b>permanent flow rate</b> - highest flow rate within the rated operating conditions at which the meter is to operate within the maximum permissible errors	
Metrological requirements	$Q_4$ - <b>overload flow rate</b> - highest flow rate at which the meter is to operate for a short period of time within the maximum permissible errors, while maintaining its metrological performance when it is subsequently operating within the rated operating conditions	
	ISO 4064-1:2014 Section 4	
	<ul> <li>4.1 Values of Q<sub>1</sub>, Q<sub>2</sub>, Q<sub>3</sub>, and Q<sub>4</sub></li> <li>4.1.1 The flow rate characteristics of a water meter shall be defined by the values of Q<sub>1</sub>, Q<sub>2</sub>, Q<sub>3</sub>, and Q<sub>4</sub>.</li> <li>4.1.2 A water meter shall be designated by the numerical value of Q<sub>3</sub> in m<sup>3</sup>/h and the ratio Q<sub>3</sub>/Q<sub>1</sub>.</li> <li>4.1.3 The value of Q<sub>3</sub>, expressed in m<sup>3</sup>/h, shall be chosen from the following list:</li> </ul>	

Technical Requirement		Evaluation (Requirement fulfilled - Yes/No)					
	1; 1,6; 2,5; 4; 6,3; 10; 10 1600; 2500; 4000; 6300 <i>The list may be extended</i> 4.1.4 The value of the r 40; 50; 63; 80; 100; 125 1000 The list may be extende <i>NOTE: The values in 4.</i> <i>10 lines, respectively.</i> 4.1.5 The ratio Q <sub>2</sub> /Q <sub>1</sub> s 4.1.6 The ratio Q <sub>4</sub> /Q <sub>3</sub> s Tenderers shall state <b>ISO 4064-1:2014 Section</b>	6; 25; 40; 63; 100; 160; 2 ; d to higher or lower value atio $Q_3/Q_1$ shall be chose ; 160; 200; 250; 315; 400 d to higher values in the 1.3 and 4.1.4 are taken from hall be 1,6. hall be 1,25. the meteorological class on 6.5	50; 400; 630; 1000; es in the series. n from the following I ; 500; 630; 800; series. om ISO 3,[4] R 5 and esses of the meters o	ist: R ffered.			
	The pressure loss through a water meter, including its filter or strainer and/or straightener, where either of these forms an integral part of the water meter, shall not be greater than 0,063 MPa (0,63 bar) between $Q_1$ and $Q_3$ .						
Drossura Loss	Class	Maximum Pressure Loss MPa	Bar				
rressure Loss	<u>Λn63</u>	0.063	0.63				
	<u>Δ</u> ρου Λn63	0.000	0.00				
	Δρ03 Δρ63	0.040	0.40				
	Δρ03	0.025	0.25				
	Δρ03 Δρ63	0.010	0.10				
Indicating device	ISO 4064-1:2014 Secti 6.7.1 General require 6.7.1.1 Function The indicating device of reliable, and unambiguindicated volume. A cor sum of which provides	on 6.7 Indicating device ements of a water meter shall pro- ous visual indication of nbination meter may have the indicated volume.	ovide an easily reada the two indicating devic	ble, es, the			

Technical Requirement	Description	Evaluation (Requirement fulfilled - Yes/No)
	<b>6.7.1.2 Unit of measurement, symbol, and its placement</b> The indicated volume of water shall be expressed in cubic metres. The symbol m <sup>3</sup> shall appear on the dial or immediately adjacent to the numbered display. If units of measurement outside the SI are required or allowed by a country's national regulations, these units of measurement shall be considered acceptable for indications in that country. In international trade, the officially agreed equivalents between these units of measurement and those of the SI shall be used	
	The Q <sub>3</sub> Indicating Range (Minimum Values)	
	$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$	
	$\begin{array}{c cccc} 6,3 < Q_3 \le 63 & 99 \ 999 \\ \hline 63 < Q_3 \le 630 & 999 \ 999 \\ \hline 630 < Q_3 \le 6 \ 300 & 9 \ 999 \ 999 \end{array}$	
	<ul> <li>indicating device shall be able to record the indicated volume in cubic metres given in Table above without passing through zero.</li> <li><b>6.7.1.4 Colour coding for indicating devices</b> The colour black should be used to indicate the cubic metre and its multiples. The colour red should be used to indicate sub-multiples of a cubic metre. These colours shall be applied to either pointers, indexes, numbers, wheels, discs, dials or to the aperture frames. Other means of indicating the cubic metre, its multiples and its sub- multiples may be used for a water meter provided there is no ambiguity in distinguishing between the primary indication and alternative displays, e.g. sub-multiples for verification and testing. </li> <li><b>6.7.2 Types of indicating device</b> Any of the following types shall be used. <b>6.7.2.1 Type 1 - Analogue device</b> The indicated volume is indicated by continuous movement of a) one or more pointers moving relative to graduated scales, or b) one or more circular scales or drums each passing an index. The value expressed in cubic metres for each scale division shall be of the form 10<i>n</i>, where <i>n</i> is a positive or negative whole number or zero, thereby establishing a system of consecutive decades. Each scale shall either be graduated in values expressed in cubic metres</li></ul>	

Technical Requirement	Description	Evaluation (Requirement fulfilled - Yes/No)
Materials and Design	<ul> <li>or accompanied by a multiplication factor (×0,001; ×0,11; ×0,1; ×1; ×10; ×100; ×1 000, etc.)</li> <li>Rotational movement of the pointers or circular scales shall be clockwise.</li> <li>Linear movement of pointers or scales shall be left to right. Movement of numbered roller indicators (drums) shall be upwards.</li> <li><b>6.7.2.2 Type 2 - Digital device</b></li> <li>The indicated volume is given by a line of adjacent digits appearing in one or more apertures. The advance of a given digit shall be completed while the digit of the next immediately lower decade changes from 9 to 0. The apparent height of the digits shall be at least 4 mm.</li> <li><b>For non-electronic devices:</b> <ul> <li>a) movement of numbered roller indicators (drums) shall be upwards;</li> <li>b) if the lowest value decade has a continuous movement, the aperture shall be large enough to permit a digit to be read unambiguously.</li> </ul> </li> <li><b>For electronic devices:</b> <ul> <li>c) either permanent or non-permanent displays are permitted - for non-permanent displays, thevolume shall be able to be displayed at any time for at least 10 s;</li> <li>d) the meter shall provide visual checking of the entire display which shall have the following sequence: <ul> <li>1) for seven segment type blanking all the elements (e.g. an "eights" test);</li> <li>2) for seven segment type blanking all the elements (a "blanks" test);</li> <li>3) for graphical displays an equivalent test to demonstrate that display faults cannot result in any digit being misinterpreted.</li> </ul> </li> <li>The materials used in the construction shall be designed to withstand raw and treated (potable) water and operate for at least 5 years without normal need for maintenance or repair and without the maximum error exceeding the specified limits.</li> <li>Tenderers shall specify the optimum pH and the water quality for which the meters have been designed.</li> <li>They must be constructed throughout of materials which are resistant to internal and external corrosion and if neces</li></ul></li></ul>	Yes/No)

Technical Requirement	Description	Evaluation (Requirement fulfilled - Yes/No)
	<ul> <li>water meter shall be non-toxic and non-tainting. Water temperature variations within the working range shall not adversely affect the materials used in the construction of the water meter.</li> <li>The water meter must be resistance to sand, manganese, lime, 12,000 Gauss magnets, hot needles, G-clamps and condensation on the underside of the window of indicating device.</li> <li>ISO 4064-1:2014 Section 6.1 Materials and construction of water meters 6.1.1 A water meter shall be manufactured from materials of adequate strength and durability for the purpose for which it is to be used.</li> <li>6.1.2 A water meter shall be manufactured from materials which shall not be adversely affected by the water temperature variations, within the working temperature range</li> <li>6.1.3 All parts of a water meter in contact with the water flowing through it shall be manufactured from materials which are conventionally known to be non-toxic, non-contaminating, and biologically inert. Attention is drawn to national regulations.</li> <li>6.1.4 The complete water meter shall be manufactured from materials which are protected by a suitable surface treatment.</li> <li>6.1.5 A water meter indicating device shall be protected by a transparent window. A cover of a suitable type may also be provided as additional protection.</li> <li>6.1.6 Where there is a risk of condensation forming on the underside of the window of a water meter indicating device, the water meter shall incorporate devices for prevention or elimination of condensation. (<i>The units should be permanently sealed and should be frost, moisture and dust proof.</i>)</li> <li>6.1.7 A water meter shall be of such design, composition, and construction that it does not acilitate the perpetration of fraud.</li> <li>6.1.8 A water meter shall be of such design, composition, and construction that it does not exploit the MPE or favour any party.</li> </ul>	
Dial Counter Meter	The dial should be of dry dial magnetic type in all the water meters. The register is fully – sealed, vacuum filled, with a sample straight – reading presentation. The register is placed in a window inside the meter body in the direction of flow for easy reading. Letter V or H should be marked or inscribed on the meter, if the meter can only be operated in the vertical or horizontal position.	

Technical Requirement	Description	Evaluation (Requirement fulfilled - Yes/No)
Installation Orientation	[Velocity Meters]	
	It is recommended that the Manufacturer provides his / her specific preferred installation instructions. The installation instructions shall be guided by the ISO 4064-5:2014 best practice recommendations.	
	ISO 4064-5:2014 - Installation. 6.1 General requirements	
	<b>6.1.1</b> Every water meter, single or in a group, shall be easily accessible for reading (without the use of a mirror or ladder, for instance), for installation, for maintenance, for removal and for <i>in situ</i> dismantling of the mechanism if required.	
Installation Requirements	<ul> <li>In addition, for water meters of a mass in excess of 25 kg, there shall be clear access to the installation site to allow the water meter to be brought to, or removed from, its working position, and adequate space around the working position for the installation of lifting gear.</li> <li>The following points should be taken into account:</li> <li>a) the need for adequate illumination of the installation site;</li> <li>b) the need for the floor to be even, rigid, non-slip and clear of</li> </ul>	
	<ul><li>6.1.2 Associated fittings such as those specified in Clause 5, if fitted, shall also be readily accessible, and the requirements of 6.1.1 relating to large meters are also applicable for the fittings.</li></ul>	
	<b>6.1.3</b> Measures shall be employed to avoid contamination, especially when the meter is installed in a pit, by mounting the water meter and the fittings at a sufficient height above the floor. If necessary, the pit shall be provided with a sump or drain for water removal.	
	6.2 Installation requirements	
	<b>6.2.1</b> For correct operation, a water meter shall always be full of water. If there is a risk of air entering the meter, an upstream air release valve shall be installed.	
	<ul><li>6.2.2 The meter shall be protected from the risk of damage by shock or vibration.</li><li>6.2.3 The meter shall not be subjected to undue stresses caused by</li></ul>	

Technical Requirement	Description	Evaluation (Requirement fulfilled - Yes/No)
Automatic Meter Reading Capability	<ul> <li>pipes and fittings. If necessary, it shall be mounted on a plinth or bracket. The water pipe lines and associated fittings shall be adequately anchored to ensure that no part of the installation can be displaced under water thrust when the meter is dismantled or disconnected on one side.</li> <li><b>6.2.4</b> The meter shall be protected from the risk of damage from extremes of temperature of the water or ambient air.</li> <li><b>6.2.5</b> Where possible, the meter pit shall be protected from flooding and rainwater.</li> <li><b>6.2.6</b> The instructions shall give limits on orientation dependent on the meter type.</li> <li><b>6.2.7</b> The meter shall be protected from the risk of damage due to external environmental corrosion.</li> <li><b>6.2.8</b> In the case where the water meter is part of an electrical earthing, in order to minimize the risk to operational staff, there shall be a permanent shunt for the water meter and its associated fittings.</li> <li><b>NOTE:</b> Any national or local legislation concerning the use of water pipes for this purpose applies in the country of use.</li> <li><b>6.2.9</b> Unfavourable hydraulic conditions, e.g. cavitation, surging and water hammer, should be avoided.</li> <li>The water meter shall be AMR ready or enabled to allow for future Automatic Meter Reading Capabilities. The AMR meter shall conform to the following characteristics so that it can be ready for AMR. For future tasks, the AMR water meter shall also be compatible with an external pulse reader or sensor and can transmitt meter readings via a radio frequency reading system or a fixed network pulse transmitter via GPRS / GSM.</li> <li>Characteristics of the Pulse Reader, Radio frequency reading system and fixed network pulse transmitter are detailed below</li> <li>The water meter will be equipped with pulse emitters which can manage the flow values in both directions and also features alarms. The pulse emitters will</li> <li>An external pulse reader or sensor that is fixed on the meter and fitted with either a radio frequency reading sy</li></ul>	Yes/No)

Technical Requirement	Description	Evaluation (Requirement fulfilled - Yes/No)
	2. Compatible with a modular meter inductive technology (Ha+Ti or Ti)	
	<b>3</b> . Frequency MHz 868.95 or 434.47 (for mobile mode walk-by or drive- by through radio frequency transmission module) and 868.30 or 433.42 (for fixed Network via GPRS/GSM)	
	4. Transmission power 16mW	
	5. Transmission mode Unidirectional	
	6. Radio range Up to 2000 m depending on the environment with a Bluetooth receiver for transmission of meter readings	
	7. Approval EN 300 220, CE RTTE	
	8. Battery lifetime up to 15 years and a continuous signal emission in programmable seconds.	
	9. Degree of Protection should be IP 68	
	10. Insensitive to magnetic fraud	
	11. Tampering Alarm	
	12. Provision for manual download and/or delete readings directly from the water meter incase the radio frequency module fails.	
	The pulse reader or sensor shall include an electronic circuit that picks up the data sent by an emitter (clipped on a water meter) and stores them in a memory.	
	The pulse reader or sensor transmits the data and other operating information atleast every 10 seconds or less on mobile mode walk- by or drive-by through radio frequency transmission module and atleast every 20 minutes or less for fixed Network via GPRS/GSM.	
	<b>Walk-by/Drive-by</b> : A handheld unit equipped with a receiver that collects the reading information and directly transfers them to the central computer system within a certain radius.	
	<b>Fixed network:</b> A fixed GPRS/LAN receiver installed in buildings, will collect the data from all the external pulse readers or sensors, memorize them, and transmit them each day via GPRS/LAN to a centralized server.	
	Can be connected to remote reading or consumption-analysis systems.	

Technical Requirement	Description	Evaluation (Requirement fulfilled - Yes/No)
	Comply with ISO 4064-1:2014 Section 5 i.e. "Water Meters equipped with electronic devices "	

# 8 WORKMANSHIP

# 8.1 HANDLING OF PIPES AND FITTINGS

The Contractor shall exercise care in the handling of all pipes, specials, valves etc., to prevent damage to the structure surfaces and to the ends of the pipes.

# 8.2 LOADING AND UNLOADING

Normally loading and unloading of small diameter pipes and fittings can be undertaken by hand; where mechanical means are used care should be exercised to ensure that the handling methods do not damage the pipes and fittings.

# 8.3 STORAGE

The Contractor shall comply with the manufacturer's specification regarding the storage of pipes, fittings and valves. Where storage dumps are to be provided along the route of the pipeline, these will be subject to the Engineer's approval. The cost of so providing shall be borne by the Contractor and deemed to be covered by his rates in the Bill of Quantities.

# 8.4 TRANSPORT

The Contractor shall provide such transport arrangements as will effectively cater for the lengths of pipes provided and the material of the piping. Adequate support shall be provided so as to ensure that the piping and fittings are not subject to excessive movement.

## 8.5 EXAMINATION OF PIPES AND FITTINGS

The Contractor shall examine all pipes, valves, fittings and other materials to ascertain that they are in perfectly sound condition before commencing to lay the pipes, valves etc.

## 8.6 INTERFERENCE WITH FENCES, DRAINS AND OTHER SERVICES

The Contractor shall ensure the proper reinstatement of fences, drains, telephone lines, KP&L cables etc. where affected by his work. All services shall be adequately protected and propped to the satisfaction of the Engineer. The Contractor shall be liable for any damage caused to the services due to his failure to provide adequate protection.

## 8.7 METHOD OF EXCAVATION

The Contractor is deemed to have covered in his excavation rates all the work that is necessary in order to comply with the provisions of the Specifications in general and this Clause in particular.

a) The Contractor shall excavate the pipe trenches in the line and to the depths indicated on drawings or as indicated by the Engineer. Except where otherwise indicated on the drawings or directed by the Engineer, it is intended that the trench shall be excavated to such a depth as will allow of a minimum cover of 600mm over the top of the barrel of the pipe when laid. All trenches shall be excavated in open cuttings and for trenching to uPVC piping, shall not be opened too far in advance of pipe laying.

b) For the purpose of measurement, the width of trench shall be taken as the nominated width for the particular size of sewer, irrespective of the width of trench the Contractor may choose to excavate.

Nominated trench width for	or:
75mm main	0.5m
100mm main	0.6m
150mm main	0.6m
200mm main	0.6m
225mm main	0.6m
250mm main	0.6m
300mm main	0.7m
400mm main	0.8m
500mm main	0.9m
600mm main	1.0m
700mm main	1.1m
800mm main	1.2m

For two or more pipes in the same trench, the nominated width shall be the distance between the centres of the outer pipes plus the internal radii of the outer pipes plus 400mm.

- c) Where the trench passes through grassland, arable land or gardens, whether enclosed or otherwise, the turf, if any, shall be carefully pared off and stacked, and the productive soil shall be carefully removed for a width of 600mm greater than the nominated trench width, or equal to the overall width of track of excavating machine, whichever is greater, and laid aside to be subsequently used in reinstating the surface of the ground after the trench has been refilled.
- d) The bottom of the trench shall be properly trimmed off, and all low places or irregularities shall be levelled up with fine material. Where rock or large stones are encountered, they shall be cut down to a depth of at least 100mm below the level at which the bottoms of the barrel of the pipes or flanges are to be laid, and covered to a like depth with fine material, so as to form a fine and even bed for the pipes. The bottom of trenches to accommodate uPVC piping shall be hardened by tamping in gravel or broken stone in all soft spots. The bedding shall consist of soil, which can be properly compacted to provide support for the pipe and to comply with Clause 809 b).
- e) Joint holes shall be excavated to suit minimum dimensions as will allow the joints to be well and properly jointed.
- f) The pipe trench shall be kept clear of water at all times as per Clause 321 of this Specification.

- g) The Contractor shall, wherever necessary, by means of timbering or otherwise, support the sides of the trench so as to make them thoroughly secure, and afford adequate support to adjoining roads, land, buildings and property, during the whole time the trench remains open and shall remove such timbering when the trench has been backfilled. The cost of such timbering or other work shall be deemed to be included in the rates for excavation. In case the Contractor is instructed by the Engineer to leave any portion of such timber in position after backfilling the trench, he will be paid for it accordingly.
- h) The clear width inside the timbering shall be at least 150mm in excess of the external diameter of the pipe being laid, in order to allow it to be freely lowered into position, in the trench without damage to the external protection.
- i) Should the excavation be taken out to a greater depth than is specified the bottom shall be made good to the correct level with Class 15/20 concrete or other material approved by the Engineer. No payment shall be made for any over excavation carried out by the Contractor nor for the cost of filling up to required levels.
- j) If a mechanical excavator is used by the Contractor, he shall indemnify the Employer against all claims for damage which in the opinion of the Engineer, may be caused by the use of this plant.
- k) The Contractor shall fix Sight Rails for use with boning rods at intervals of not more than 30 metres and temporary Bench Marks related to the Survey of Kenya Datum shall be provided at such intervals as directed by the Engineer.

# 8.8 MAIN LAYING

a) Mains shall be laid in straight lines and/or smooth curves as indicated on the drawings. The vertical profile of the pipe shall be to even gradients. Any pipes not so laid shall be removed if so directed by the Engineer, and re-laid in proper manner at the Contractor's expense.

In laying the pipes and specials care shall be taken not to damage the protective linings and the pipes shall be handled with tackle if so directed by the Engineer.

The pipes and specials shall be checked for flaws before they are lowered into the trench. After the pipes or specials have been checked they shall cleaned and set to proper gradient and line so that there is a continuous rise from each washout to air valve.

When laying uPVC pipes, final connection at any fixed joints shall be deferred until the majority of the pipeline has been covered with backfill.

- b) Large diameter curves to mains shall wherever possible be formed by allowing for deflection at flexible joints, not exceeding 3 degrees, or as specified by the manufacturers.
- c) In jointing of the pipes and specials the Contractor shall comply with the standards adopted for the various types of joints as specified.

d) In laying pipes and specials with flanged joints, flanges shall be brought together and bolted with the faces absolutely parallel. A rubber jointing gasket ring 3mm thick shall be used in each flange joint and one washer with and not provided for each bolt.

The bolts shall be tightened up gradually and equally in the customary manner in order to distribute the stress evenly over the flange. If it is found necessary to deviate slightly from the normal run of the flanged piping, the deflection shall be obtained by means of a bevelled gun metal ring washer between the flanges.

- e) The Contractor shall fix the gate valves, air valves and washout pipes all in accordance with the drawings.
- f) The Contractor shall, subject to approval of the Engineer, cut pipes to such lengths as directed. Pipes should be cut off clean and square with the axis. Cuts should be made with an approved cutting device dependant on the type of pipe specified. Ends of pipes should be tapered by means approved by the Engineer if mechanical joints are to be used.
- g) Equipment for tapping off the mains under pressure may be employed in the making of service or branch connections. The Contractor is required to choose a suitable method for fixing of the ferrule to the type of pipe specified, to the Engineer's approval.

# 8.9 BACKFILLING OF TRENCH

- a) When a section of the main has been jointed, the ends shall be temporarily closed with caps, plugs or flanges to prevent ingress of foreign matter into the pipe to the satisfaction of the Engineer. The trench shall be properly backfilled and rammed for its whole length so that the soil cover to the main shall not be less than 600mm except at joint holes which shall be kept clear of all backfilling, if necessary, by the use of timbering, so that each joint is left fully exposed for the Engineer's inspection. Special care shall be exercised when using surround to A.C. and uPVC pipes which shall be free from any stones and well compacted in layers to not less than 100mm above the crown of the pipe.
- b) The Contractor's attention is drawn to the special requirements for bedding and sidefill to uPVC pipes. Clay should not be used. Soils which are of a granular nature and provide adequate support after compaction shall be used. If unavailable from excavated material the Contractor should provide suitable material for which an item in the Bill has been included.

With flexible pipes it is important that the sidefill should be firmly compacted between the pipe and the soil sides of the trench. The bedding material shall be placed in 75mm layers up to the crown of the pipe with adequate compaction and then to a minimum height of 100mm or two thirds of the pipe diameter. The progress of filling and tamping should proceed equally on either side of the pipe so as to maintain an equal pressure on both sides.

c) Where a main is laid across a road or is in such a position as to interfere seriously with the normal use of the road, the Contractor may, with the consent of the Engineer and at his own risk, fill such holes as may be necessary. Due consideration is to be given to

compaction of section of the trench across the road to prevent undue settlement. In the event of damage at this section the Contractor is required to re-excavate and repair the pipeline all at his own expense.

### 8.10 ANCHOR BLOCKS AND SUPPORTS

Concrete Class 15/20 shall be placed in anchor blocks at all changes of direction of the pipeline exceeding 6 degrees and wherever else required to withstand thrust resulting from internal water pressure e.g. at blank ends. Concrete in plinths shall be placed where specified.

#### 8.11 CHAMBERS AND SURFACE BOXES

Gate valves, air valves and fire hydrants etc. shall be provided with suitable chambers or surface boxes in accordance with detailed drawings. In roads and footpaths the boxes shall have metal covers laid flush with the surface. Indicator posts to suit shall also be provided.

## 8.12 TESTING

- a) The Contractor shall test as long a section of main as possible subject to the maximum length of open trench approved by the Engineer. The test shall be carried out within 12 working days of the completion of such section of the main.
- b) The pipeline shall be adequately anchored during the test at stop ends or valves to prevent movement under the test pressures.
- c) The test section shall be filled with water and great care should be taken to drive out all air through air valves, ferrules etc. The test pressure is to be at least 1.5 times the nominal working pressure for the class of pipe being tested and is to be applied for at least 2 hours.
- d) The leakage from the mains and connections from each section tested shall be according to SRN 316, i.e. not exceeding 0.02 litres per millimetre of nominal bore per kilometre of pipeline per 24 hour per bar of applied pressure head.

The determine the rate of leakage, the Contractor shall furnish a suitable hydraulic test pump, pressure gauge, connections and water meter or other appliance, for measuring the amount of water pumped. The pressure shall be raised to the amount required and specified by the Engineer, and shall be so maintained for a period of not less than two hours or whatever longer period as required by the Engineer to examine every joint to satisfy himself that they are sound.

If the leakage is at a greater rate than that specified, the Contractor shall re- excavate the trench where necessary and shall re-make the joints and replace defective work until the leakage shall be reduced to the allowable amount.

e) The Employer shall charge the Contractor the cost of any couplings required to join up tested lengths of main if, in the Engineer's opinion, greater lengths could reasonably have been tested or if failure under test, requires the pipe to be cut, or other methods of laying

should have been adopted.

Water used in testing the main shall be supplied by the Contractor. The Contractor shall carry out all work which may be necessary for making temporary connections to the existing mains to obtain water for testing at his own expense.

In carrying out the test for water tightness the Employer only shall authorise the operation of all valves, but the Contractor shall provide all the necessary labour to assist in the opening and closing of the valves to the Engineer's instructions, and he shall allow in his prices for all his expenses in connection with testing on completion.

The Engineer shall be the sole judge of water tightness.

#### 8.13 CLEANING AND STERILISING THE MAIN

- a) When a pipeline is complete and where applicable, has successfully passed the test, it shall be thoroughly washed out, using if possible, an open end. Thereafter it shall be sterilised by being filled with a suitable solution containing not less than 20 p.p.m. of free available chlorine or such other sterilising agent as the Engineer shall approve. After standing for 24 hours the main shall again be washed out and refilled with mains water prior to the taking of bacteriological samples. The Contractor shall provide all necessary stop-ends, fittings and chemicals for this work.
- b) Emptying and washing out of the pipes shall be done in such a manner as not to damage the trench or cause undue flooding of the vicinity, and the Contractor shall supply and use piping, specials and/or hose as may be necessary to facilitate the flow of water to the nearest drain or watercourse. Water used for washing out and sterilising may be supplied by the Employer when a suitable supply is available but all expenses should be payable by the Contractor.

Before any section of the main is put into use, a bacteriological sample or samples will be taken by the Engineer's Representative and only on receipt of a satisfactory certificate from a Medical Research Laboratory or similar organisation will the main or section of main be permitted to be put into supply and be considered as having been substantially completed.

Any expenditure involved in providing facilities or materials for the taking of samples shall be included in the Contractor's tendered rates and the Engineer will specify and shall be the sole judge as to the number of samples required and the points at which they are to be taken.

The cost of the bacteriological examination will be borne by the Employer but if the sample or samples are not satisfactory, the cost of any subsequent analysis will be borne by the Contractor.

#### 8.14 CLEARANCE OF SITE

The Contractor shall remove all surplus pipes, specials and other fittings from the site as directed by the Engineer. The site of works shall be levelled and all surplus excavation, debris, cut trees or bushes shall be carted to approved tip sites.

## 8.15 TESTING OF WATER RETAINING STRUCTURES

As soon as possible after completion of water retaining structures viz. storage reservoirs etc. they shall be tested for water retention by filling to the normal maximum level with water at a uniform rate of not greater than 2m in 24 hours.

When first filled, the water level should be maintained by adding of further water for a stabilizing period while absorption and antogenous healing take place. This period may be 7 days after which the level of the water surface should be recorded at 24 hour intervals for a test period of 7 days. The structure shall be considered satisfactory if, during this period the total permissible drop in level, after making due allowance for rainfall and evaporation, should not exceed 1/500th of the average water depth of the full tank, 10mm or another specified amount all in accordance with SRN 102. Water used in testing the structures shall be supplied by the Contractor. <u>Sterilisation of the structures is to be done as specified by the Engineer and sampling of water carried out similar to Clause 813.</u>

This test shall be carried out before any backfilling has taken place.

In the event of any water retaining structures failing to pass the test, the Contractor shall make good and re-test at his own expense.

#### 8.16 STERILISATION OF WATER RETAINING STRUCTURES

A strong chlorine solution (about 200 milligrams per litre) shall be sprayed on all interior surfaces of the hydraulic structure. Following this, the structure shall be partially filled with water to a depth of approximately 30 centimetres. During the filling operation, a chlorinewater mixture shall be injected by means of a solutionfeed chlorinating device. The dosage applied to the water shall be sufficient to give a chlorine residual of at least 50 milligrams per litre upon completion of the partial filling operation. Precaution shall be taken to prevent the strong chlorine solution from flowing back into the lines supplying the water. After the partial filling has been completed, sufficient water shall be drained from the lower ends of the appurtenant piping to insure filling the lines with the heavy chlorinated water.

Chlorinated water shall be retained in the hydraulic structure and in the associated piping long enough to destroy all non-spore-forming bacteria and, in any event, for at least 24 hours. After the chlorine-treated water has been retained for the required time, the chlorine residual shall be at least 25 milligrams per litre. All valves shall be operated while the lines are filled with the heavily chlorinated water.

# **9** TESTING OF MATERIALS AND WORKMANSHIP

# 9.1 APPARATUS REQUIRED FOR TESTING ON SITE

Apparatus for testing shall be, if directed by the Engineer, made available on site of the works, for as long a period as required by the Engineer, and regarded as constructional plant. The Contractor to allow for this provision in his rates. The following may be required:-

- a) A set of sieves complying with British Standard 410 : Test Sieves, or the following nominal sizes:-
  - <sup>I</sup> Fine mesh wire cloth 200, 100, 72, 52, 36, 25, 18, 14, 10 and 7.
  - Medium mesh wire cloth 3mm.
  - Perforated plate 5mm, 6mm, 9mm, 12mm, 20mm, 38mm, 50mm, 65mm and 75mm.
- b) A suitable balance, a pycnometer and a stove or other approved apparatus for determining the moisture content of the aggregate. The methods of test shall be as described in Part Four of British Standard 812 : Sampling and Testing of Mineral Aggregates, Sands and Fillers.
- c) A 200 ml. graduated cylinder in accordance with British Standard 604 : Graduate Measuring Cylinders, for the use in the field settling test for clay and fine silt in aggregates.
- d) Two 0.34 kg. graduated clear glass medicine bottles for use in the test of organic impurities in sand.
- e) Apparatus required for testing soils in accordance with British Standard 1377 : Methods of Test for Soil Classification and Compaction, and British Standard 1924 : Methods of Test for Stabilised Soils.
- f) Apparatus for testing concrete in accordance with British Standard 1881 : Methods of Testing Concrete, Parts 1 to 7.
- g) A straight edge 3 metres long and measuring wedge or other approved apparatus for testing the accuracy of surfaces.
- h) Additional testing equipment as stated in the Bill of Quantities or as required by the Engineer.

# 9.2 LOAD TESTING OF PIPES

The Engineer may instruct the Contractor to make a Loading Test (Three-Edge Bearing or Sand Bearing) on pipes to be used to construct the sewer. Payment for Load Tests will be entirely in accordance with the General Conditions of Contract.

# **10 MISCELLANEOUS**

# 10.1 GENERAL

The Contractor is referred to the drawings as to the general character of the works and he shall allow in his rates for any extra costs he may consider incurred by reason of the work being in detached positions, in small quantities, difficulty of access or for any other cause. He should also make due allowance for specialist installations taking place during the currency of this contract.

This section of the Specification refers to miscellaneous items. Clauses elsewhere in the Specification shall also be followed where relevant.

# **10.2** BONDING TIES

Bonding ties shall be 75mm wide x 250mm long galvanised bitumen-coated expanded metal strip, cast 100mm into concrete surfaces in contact with block work. The bonding tie used shall be approved by the Engineer's Representative.

# **10.3 PRECAST LINTELS**

All precast items shall be marked with the date of casting and shall not be built into the works until they have matured for 28 days. Ends of bar reinforcement shall be hooked or bent as required. The cover for reinforcement shall be 25mm from internal faces and 38mm from external exposed faces. The 'top' of lintels shall be numbered for identification.

Lintels shall have timber or pre-formed inserts cast in for fixing metal windows where required and shall have fair face finish on all surfaces exposed to view and hacked surfaces where plastered.

# **10.4 BLOCKWORK**

Building blocks shall be dense concrete blocks complying with the requirements of B.S. 2028, 1364, with faces for plastering and having a compressive strength of 14 N/sq.mm. (Table 2, Type A14).

Blocks shall be obtained from an approved manufacturer and shall be equal to sample blocks previously approved by the Engineer's Representative.

Blocks shall be carefully handled and stored on site and protected from the weather at all times.

Surfaces on which blockwork is to be built shall be kept clean. Blocks shall be well wetted before being laid and the tops of walls where blockwork has been left shall be well wetted before re- commencing. Blockwork shall be built plumb, true to line and level, with all perpends vertical and in line. Blocks shall be built in half bond and alternate courses shall be block bonded at all junctions, no cut block shall be less than half a block. Joints in concrete blockwork shall be well filled with gauged mortar and shall not exceed 10mm in width.

# **10.5** DAMP-PROOF COURSE (D.P.C.)

Hessian based metal cored bitumen for damp-proof courses shall be lead cored, complying with

B.S. 743 paragraph 4, type D, weighing not less than 4.4 kg. per square metre. Damp-proof course shall be bedded horizontally in mortar as for blockwork with 115mm laps in length and full laps at angles.

### 10.6 HARDWOOD

Hardwood for joinery shall be sound, well conditioned and seasoned Mvuli complying with the requirements of B.S. 1186 Part 1, Class 1. A sample of each representative section for use in the work shall be previously submitted by the Contractor for approval by the Engineer's Representative. Moisture content shall be 12% (+ or - 2%).

#### 10.7 PLYWOOD

Plywood generally shall comply with B.S. 1455. That from sources not included in B.S. 1455 shall be of corresponding grades of veneers and types of bonding. Plywood for flush doors shall be Grade I Mvuli veneered.

#### 10.8 DOORS

Internal doors shall be hardwood framed solid cored flush doors constructed in accordance with B.S. 459 Part 3, faced both sides with 3mm thick Mvuli veneered plywood and lipped all round with matching hardwood lipping. Moisture content at delivery shall be 12% (+ or - 2%).

### **10.9** FRAMES AND LININGS

Door frames and linings shall be Class 1 Mvuli mortice and tenon jointed at angles. Sub- frames for internal doors shall be Class 1 Mvuli tongued at angles.

#### **10.10** ARCHITRAVES AND STOPS

Architraves and stops shall be Class 1 Mvuli matching to the frames and linings.

#### **10.11 IRONMONGERY**

All ironmongery shall be obtained from a source approved by the Engineer's Representative. Samples shall be submitted before ordering and the articles ordered shall match up with the approved samples. Screws of a like metal shall be used for all fittings.

#### **10.12 JOINERY**

All exposed joiner's work shall have wrought faces. The prices of all joiner's work shall include for slightly rounded arises.

Where the term 'framing' or 'framed' is made use of, it shall be understood to mean all halvings, dovetails, tenons and hardwood pins and the best known means of putting the work together.

All framed work shall be put together loosely and stacked under cover where a free current of air can circulate and is not to be wedged and glued until it is required for fixing.

All joinery, when brought on the works, shall be stacked under cover.

The Engineer or his representative, shall have full right of access to the joinery works and power to condemn any work not approved and any approval expressed or implied is not to relieve the Contractor from his responsibility and liability to make good any shrinkage or other defects that may appear after the work is fixed.

All joinery to be painted shall be knotted and primed.

The Contractor shall provide all materials, labour, framing, fixing, etc., nails, screws and everything necessary for the proper execution and completion of the work.

#### **10.13** . FIXING JOINERY

Doors shall be hung on one or one and a half pairs of butt hinges to give a maximum even tolerance of 2mm all round.

Sub-frames shall be fixed to blockwork with three fixing clamps per side and one dowel let 50mm into the floor and 50mm into the foot of each leg. Linings shall be fixed after completion of other finishings by means of screwing and pellating to sub-frames with matching hardwood pellates. Architraves and stops shall be pinned on, heads punched and filled with tinted filler.

#### **10.14** FIXING IRONMONGERY

The rates for supplying and fixing ironmongery shall include for all sinking, cutting, boring, mortising etc., making good, replacing damaged screws, oiling, adjusting and leaving in good working order and for mastering all keys.

#### **10.15** BOLTS AND NUTS

Bolts and nuts shall comply with the relevant requirements of the British Standards as set out below:-

Black Hexagon Bolts, Screws and Nuts	B.S. 4190, Grade 4.6
Metal Washers for General Purpose	B.S. 4320
Black Cup and Countersunk Head Bolts and Screws,	, with Nuts B.S. 4993

the items shall preferably have coarse metric threads but items with B.S.W. threads may be used. Bolt lengths shall be sufficient to ensure that nuts are full threaded when tightened in their final position.

#### **10.16 STRUCTURAL STEELWORK**

The whole of the structural steelwork and testing shall comply with the relevant clauses of B.S. 449. The Contractor shall include for the preparation of all shop details from the drawings supplied by the Engineer. All such details shall be approved in writing by the Engineer before the work is put in

hand. Every drawing shall show the number and sizes of all rivets and bolts, complete details of welds, type of electrodes, welding procedure, whether the welds are to be made in the shop or elsewhere and any other relevant information. The Contractor shall be responsible for the accuracy of his shop details and for shop fittings and site connections.

The Contractor shall take the dimensions from the structure and he shall verify all dimensions given on the drawings before the work is put in hand.

Any damage to materials on the site due to inadequate precautions being taken during the erection of the steelwork shall be made good to the satisfaction of the Engineer's Representative at the Contractor's expense.

The fabrication and erection of the steelwork shall be carried out in accordance with Part 5 of B.S. 449.

## **10.17** GALVANISED WORK

Iron and steel, where galvanised, shall comply with B.S. 729, entirely coated with zinc after fabrication by complete immersion in a zinc bath in one operation and all excess carefully removed. The finished surface shall be clean and uniform.

## **10.18** ELECTRICAL INSTALLATION

The electrical installations will be carried out by Licensed Electrician and complying with the following:-

- a) Regulations for Electrical Equipment of Buildings issued by the Institution of Electrical Engineers.
- b) Electric Power Act.
- c) The K.P. &L. Co.'s Bye-Laws.
- d) Relevant current British Standards and Codes of Practice.
- e) All the relevant clauses in this Specification, particularly the clauses in Sections 13 and 14.

#### **10.19** WATER AUTHORITIES REGULATIONS

The internal plumbing work shall be carried out to the satisfaction of and in accordance with the regulations of the local Water Authority.

#### **10.20** RAINWATER INSTALLATIONS

Rainwater installation shall be in grey PVC pipework with 'O' ring joints.

#### **10.21 TESTING PLUMBER'S WORK**

The plumbing work and sanitary fittings shall be tested at such times as the Engineer's Representative shall direct and to his entire satisfaction. Gutters and rainwater pipes shall be tested with water to satisfy the Engineer's Representative that gutters are to correct falls, pipes are unobstructed and joints are sound.

#### **10.22** SETTING OUT

The positions of all pipe runs, including joints and connections, shall be agreed with the Engineer's Representative before work is commenced.

#### **10.23** COPPER TUBES AND FITTINGS

Light gauge copper tubes shall comply with B.S. 2871 Part 1, Table X.

Fittings: Fittings and couplings for jointing pipes shall comply with B.S. 864, Part 2 for capillary and compression type A fittings.

Fixing: Tubes shall be fixed clear of walls or soffits with two piece copper spacing clips complying with B.S. 1494 Table 8d, but in metric sizes to suit tubes spaced at not more than 1.2m horizontally and 1.5m vertically for 15mm diameter pipes 2.0m horizontally and 2.5m vertically for 22mm and 28mm diameter pipes.

#### 10.24 PLASTIC PIPES, FITTINGS AND ACCESSORIES

uPVC soil and ventilating pipes and fittings shall comply with B.S. 4514. Waste pipes and fittings shall be modified unplasticised polyvinyl chloride (MuPVC). Waste traps shall comply with B.S. 3943. Balloon gratings shall be plastic coated steel wire.

#### 10.25 SLEEVES

Where sleeves are required for pipes passing through concrete or blockwork they shall be of galvanised steel heavy gauge tube of sufficient diameter to give a space of 3mm all round the pipe.

## **10.26 PIPEWORK GENERALLY**

Pipes shall be in the maximum lengths possible to avoid unnecessary jointing and fixed to sufficient falls to prevent air locks and to enable the system to be drained down.

## 10.27 BRASSWORK

Ball Valves: Piston type ball valves shall comply with B.S. 1212, Part 1 for high or low pressure as described. Floats to break feed cisterns shall be copper type complying with B.S. 1968, Class C.

Bib-taps shall comply with B.S. 1010 and shall be of brass with fixed jumpers, chromium plated and colour coded for hot and cold.

Pillar valves shall comply with B.S. 1010 and shall be of brass with fixed jumpers, chromium plated and colour coded for hot and cold.

Stop valves shall comply with B.S. 1010 and shall be of brass with crutch handles.

## 10.28 CISTERNS

Storage cisterns and break feed cisterns shall be galvanised steel cisterns complying with B.S. 417, Grade A.

### **10.29** SANITARY FITTINGS

Sanitary fittings shall be manufactured from glazed vitreous china complying with the requirements of B.S. 3402. They shall be supplied by an approved firm and shall pass the requirements of the local Water Authority.

# 11 PLASTERWORK AND OTHER FLOOR, WALL AND CEILING FINISHINGS

# 11.1 GENERAL

All branded materials shall be delivered in the manufacturer's packages bearing the manufacturer's name and the name of the material concerned. Cement, lime, plaster etc., shall be stored separately off the ground in dry conditions. All surfaces shall be properly prepared for plastering, rendering and screeding and brushed or cleaned free from dust and all traces of efflorescence and contamination removed. Concrete surfaces shall be thoroughly cleaned free from all traces of mould oil or other formwork coatings and hacked to provide a key.

Surface to receive plastering, rendering, screeding etc. shall be wetted sufficiently in advance to ensure the correct conditions for adhesion. Undercoats shall be thoroughly scratched to allow for keying and allowed to dry sufficiently before application of further

coats. Dubbing out shall be in the same mix as the subsequent coat and shall not exceed 20mm in thickness in one application.

# **11.2** METAL LATHING

Metal lathing shall be light galvanised expanded metal weighing not less than 1.2 kg. per square metre and complying in all other respects with B.S. 1369.

## 11.3 CEMENT

Cement shall be Ordinary Portland Cement and shall comply with KS 02-21. White and coloured cements shall comply with KS 02-21 and shall be obtained from an approved manufacturer.

## 11.4 SANDS

Sand for cement and lime shall comply with B.S. 1199, Table 1 for undercoats and Table 2 for finishing coats. Sand for floor screeds shall comply with B.S. 1199, Table 1.

# 11.5 LIME PUTTY

Lime putty shall be prepared from hydrated lime complying with B.S. 890, Table 2. Hydrated lime shall be added to water, stirred to a creamy consistency and left to mature for at least sixteen hours before use. Alternatively, ready slaked lime may be obtained from an approved manufacturer. The lime putty shall be protected from drying out.

## 11.6 PLASTICISERS

Plasticisers shall be of the resin type and shall be used only with the approval of the Engineer's Representative in accordance with the manufacturer's instructions.

#### **11.7 WATER PROOFERS**

Water proofers shall be approved integral water proofers and shall be used in accordance with the manufacturer's instructions.

#### 11.8 ANGLE AND CASING BEADS AND RENDER STOPS

Galvanised steel angle and casing beads and render stops shall be as manufactured by "Expamet" or other equal and approved.

#### **11.9 GLAZED CERAMIC WALL TILES**

Glazed and eggshell ceramic wall tiles shall comply with B.S. 1218 and shall be of the colours described. Samples of tiles shall be submitted to the Engineer's Representative for approval.

#### 11.10 ADHESIVE

Adhesive for fixing wall tiles shall be approved adhesive.

## **11.11 FIXING WALL TILES**

Tiles shall be wiped clean and fixed dry with the approved adhesive all in accordance with manufacturer's recommendations with straight joints 1.6mm wide, pointed in white cement.

#### **11.12** CERAMIC FLOOR TILES

Ceramic floor tiles shall be fully vitrified clay tiles complying with B.S. 1286 and having a water absorption not exceeding 0.3%.

#### **11.13 LAYING FLOOR TILES**

For laying of floor tiles, the surface of the compacted bedding shall be spread with a 3mm thick cement and sand (1:1) slurry. Floor tiles shall be wiped clean, laid dry, in a square pattern with 3mm wide joints, and tapped into the grout. Pointing shall be in an approved proprietory tile grout, tinted to match floor tiles.

## 11.14 FIXING METAL LATHING

At junctions of blockwork and concrete where rendering continues over both surfaces a 100mm wide strip of expanded metal lath shall be fixed, centred on the joint.

# 11.15 FINISH

Cement-lime-sand undercoats shall be allowed to dry out thoroughly before a further coat is applied and scratched to provide an adequate key for the next coat. The finishing coat shall be finished with a steel float. A neat cut shall be made with the edge of the trowel through all coats of the wall plaster at junctions with concrete columns and soffits.

#### 11.16 INTERNAL RENDERING

The internal rendering on concrete block panels shall be two coat work, total 20mm finished thickness. The undercoat to be 1:1:5 cement, lime putty, sand by volume, 9mm to 12mm thick and scratched for key. The finishing coat to be 1:1:6 cement, lime putty, sand by volume, 6mm to 9mm thick, trowelled smooth. At junctions of panels to concrete columns and beam soffit, finish the rendering with a clean trowel cutting through both coats of rendering.

# 11.17 EXTERNAL RENDERING (TYROLEAN)

The external rendering on concrete blockwork and outer face of in-situ concrete frame shall be two coat work, total 15mm finished thickness. Clean and prepare block and concrete surfaces, shot pin metal lath strip 100mm wide at concrete/blockwork junctions

and apply undercoat 10mm finished thickness of 1:1:6 cement, lime putty, sand by volume, floated smooth. The finishing coat shall be approximately 6mm thick off white Culamix Tyrolean open honeycombed texture machine applied to the required thickness by skilled operatives strictly in accordance with the manufacturer's recommendations, manufactured and supplied by Blue Circle Industries Ltd., agents in Kenya, Kencem, P.O. Box 14267, Nairobi, Kenya or other approved alternative. The undercoat surface shall be sound and clean and free from any loose material. All window and door frames shall be protected by suitable masking.

## **11.18 EXPANSION JOINTS**

Expansion joints in clay ceramic tile flooring shall be 6mm wide x 50mm deep, unless otherwise described, formed with 6mm wide x 38mm deep butyl rubber or other equal and approved compressible strip pointed with 6mm wide x 12mm deep polysulphide compound to match colour of tiling. All surfaces of concrete or screed in contact with the butyl rubber shall be primed.

Expansion joints shall be formed at perimeters and at not less than 4.5 metre centres both ways in the tiled areas.

## **11.19 PREPARATION**

Concrete floors to receive screeds shall be raked where necessary to remove concrete, plaster or mortar droppings and well brushed to remove all loose particles and dirt. Concrete floors shall be well wetted before the screeds are laid.

## **11.20** PAINT AND PAINTING

All paint, including primers, undercoats and finishings, polish, emulsion etc., to be used shall be obtained ready for use from the manufacturer approved by the Engineer.

The Contractor shall order direct from the manufacturer and only fresh paint will be allowed to be used.

All paints shall be of the qualities, i.e. exterior, interior etc., types and colours scheduled. All coats of paint system shall be obtained from the same manufacturer, shall be ordered for use together

and as far as practicable, shall be ordered on one order in sufficient quantity for the whole of the work, particularly in the case of the finishing colour. Where more than one of the three systems (gloss, semi-gloss or flat) is in use, these paints shall be used in strict accordance with their accompanying printed instructions.

The Contractor shall use only paints delivered to the site in original sealed containers, not exceeding five litre capacity, stamped and bearing the manufacturer's name of mark, the specification number, method of application (e.g. brushing) colour, quantity, batch number and date of manufacture, and expiry.

Contractor's stocks shall not be accepted unless expressly approved by the Engineer's Representative.

The paint, which will be subject to sampling and testing, shall be used exactly as received, after adequate stirring, without the addition of thinners, driers, or adulterating materials of any kind.

All tints and shades (including colours of undercoats) shall be selected and approved by the Engineer's Representative and the Contractor shall allow in his prices for executing the painting work in colour schemes, to be prepared from a wide range of colours.

All paints described as oil paint shall be alkyd paint.

No painting on exterior work shall be carried out in wet weather or upon surfaces which are not thoroughly dry. Painting shall not proceed in dusty conditions. Each coat of paint shall be thoroughly dry and shall be rubbed down with glass paper before a subsequent coat is applied. Adequate care must be taken to protect surfaces of paintwork, still wet.

Lead based priming paints for steelwork shall conform to B.S. 2521 and 2523.

#### **11.21 PREPARATION**

Copper pipes shall be washed with soap and water, roughened with abrasive paper and washed with white spirit.

Metalwork - remove all scale from unprimed iron and steelwork, degrease using proprietary solution compatible with paint finish, remove all dirt and rust by brushing with a steel wire brush. Clean all steel delivered primed, of dirt and dust and touch up any damage to primed surfaces in transit or erection.

Hardwood - rub down and brush off all dirt and dust, stop any holes or other imperfections with stopping tinted to match pigment finish.

#### **11.22 PROTECTIVE DECORATIVE FINISH**

The protective decorative finish on hardwood joinery shall be PX65 (Pinotex) and Holdex as manufactured and supplied by Sadolins Paints (E.A.), or other equal and approved finish.

External frames and doors shall be treated with two coats PX65 (Pinotex) Pigmented before

fixing and one coat PX65 (Pinotex) Top Coat after fixing.

Internal frames and doors shall be treated with two coats PX65 (Pinotex) Pigmented before fixing and one coat after fixing and finished with two coats of Holdex, Silk Matt Interior Lacquer.

Application shall be strictly in accordance with the manufacturer's recommendations.

Not more than three months should separate the initial (before fixing) and final (after fixing) coats.

### **11.23 RENDERED PANELS**

The internal rendered blockwork panels shall be painted with two coats Sandtex Matt resin- based surface coating or other equal and approved coating.

Rendered wall surface shall be cleaned down and Sandtex coats laid on by brush or roller in accordance with the manufacturer's recommendations. Spraying wall surfaces will not be allowed.

#### **11.24 IRONMONGERY FURNITURE**

The rates for painting shall include for taking down and refixing ironmongery furniture, kicking plates etc., as necessary.

#### **ROADS AND FOOTPATHS**

#### **11.25 PREPARATION OF ROAD FORMATION**

After excavation or filling has been completed the road formation shall be shaped to the required contour and compacted with an 8 - 10 tonne roller.

If any soft places develop in the formation during compaction they shall be excavated to such depths as the Engineer may direct, refilled with hardcore or other approved granular material, levelled and recompacted before the sub-base is laid.

#### **11.26** MURRAM SUB-BASE

The murram sub-base will be constructed only in poor soil conditions where directed by the Engineer. The murram shall be from an approved source quarried so as to exclude vegetable matter, loam, topsoil or clay. The California Bearing Ratio (C.B.R.) of the murram, as determined for a sample compacted to maximum density as defined under

B.S. 1377 and allowed to soak in water for four days, shall not be less than 30. This

C.B.R. is a guide to quality only and the compaction in the work will be judged by density.

The murram sub-base shall be of the thickness as shown on drawings or stated in the Bill of Quantities.

The sub-base shall be evenly spread and compacted using an 8-10 tonne roller for road construction and a 2-4 tonne roller for footpath construction. The Contractor will be required to maintain the selected material at its optimum moisture content to achieve maximum compaction. The roads

and footpaths shall be finished to the grades and levels shown on the drawings.

#### 11.27 WATER-BOUND MACADAM BASE

The base shall consist of crushed building stone mechanically laid in one or more separate layers, so as to give a total compacted thickness as shown on the drawings, or stated in the Bill of Quantities. The first layer shall be placed to produce a thickness of 75mm to 150mm after compaction as specified. Where a greater thickness than 150mm of base is specified the material shall be laid in separate layers each not less than 75mm or more than 150mm in thickness after compaction.

lowing gradings:-
% by Weight Passing
100
25 - 80
0 - 20
0 - 5

Alternatively, a stone base may be placed by hand. In this case the first stones in each layer, which shall be of a cubical nature, shall be placed to the approximate height of the layer. When an area has been covered in this way a second placing of stones of smaller size shall be positioned by eye in the spaces between these first placed, and wedged home by hammering. A third placing of stones shall follow the second and so on until in the opinion of the Engineer the voids are sufficiently filled to permit compaction.

Thorough watering shall be carried out at all stages of compaction. Initial compaction shall be with a light roller. The surface shall then be blinded with quarry dust so as to fill the interstices completely and again rolled, this time using a heavy roller. The base shall then be well watered and brushed and permitted to dry. Further rolling with a heavy roller, blinding with quarry dust, watering and brushing shall be carried on until the whole presents a homogeneous surface and no movement is visible under the action of the heavy roller. On completion of the base, and before any surfacing is laid, the finishing surface shall be maintained free from potholes, ruts and undulations, irregularities, depressions, loose material or other defects, and shall remain true to cross-section, line and level.

# 11.28 ROLLED ASPHALT HOT PROCESS WEARING COURSE

Rolled asphalt wearing course shall be made and laid in accordance with British Standard 594 : Rolled Asphalt (Hot Process) and the thickness after compaction shall be as shown on the drawings or stated in the Bill of Quantities. Except where impracticable, the rolled asphalt shall be laid using an approved paver.

Where a base course has been used as part of the surfacing, the wearing course shall be laid thereon as soon as practicable, care being taken that the latter is thoroughly clean. In any case the wearing course should be laid within 3 days of the laying of the base course, unless the Engineer allows otherwise, and no construction or other traffic shall be allowed on the base course.

## **11.29 BITUMEN MACADAM WEARING COURSE**

Bitumen macadam wearing course shall be made and laid in accordance with British Standard 1621 : Bitumen Macadam with Crushed Rock or Slag Aggregate, using the appropriate Table and Section(s) thereof, other than those for Dense Bitumen Macadam, and nominal size of aggregate all as shown on the drawings or stated in the Bill of Quantities. Except where impracticable the bitumen macadam shall be laid using an approved paver. The maximum mixing temperature for straight run bitumen of penetration 85-100 is 155 degrees centigrade. For other penetration bitumens the mixing temperature shall be as determined by the Engineer.

## **11.30** COMPACTION AND SURFACE FINISH

As soon as rolling can be effected without causing undue displacement of the material, and while the material is above the minimum temperature stated in Table 6.3, it shall be uniformly compacted by an 8-10 tonne roller having a width of roll not less than 18 inches.

## 11.31 . PREPARATION OF THE BASE FOR SURFACING OR SURFACE DRESSING

Before any binder or coating material is applied to a base the latter shall have been freed from all extraneous material by brushing with mechanical sweepers or stiff brooms.

Macadam or murram bases shall normally receive a priming coat in accordance with the following clause.

Concrete, bitumen bound or rolled asphalt bases shall normally receive a tack coat in accordance with the following clause.

# **11.32 PRIME COAT AND TACK COAT**

When a base is to be sealed before surfacing by means of a prime coat, the surface shall first be prepared in accordance with the preceding clause.

Unless otherwise stated in the Bill of Quantities or ordered by the Engineer, the prime coat material shall be bitumen grade M.C.O. at a rate of application of 1.2-1.5 lit./sq.m. It shall be applied with a mechanical bitumen distributor complying with the requirements of British Standard 1707 : Binder Distributors for Road Surface Dressing.

The prime coat shall be cured for 48 hours. This period may be relaxed at the discretion of the Engineer who shall be informed and shall give his consent before any surfacing works are commenced.

The Contractor shall not permit traffic to run on a prime coat. Where this is unavoidable the Engineer shall order an application of medium sand at a rate of 6 kg./sq.m. which item shall be measured and paid for separately.

Where adhesion on an existing surface is to be improved before surfacing by means of a tack coat, the surface shall first be prepared in accordance with the preceding clause.
Unless otherwise stated in the Bill of Quantities or ordered by the Engineer, the tack coat material shall be approved bitumen emulsion in accordance with British Standard 434 : Bitumen Road Emulsion containing not less than 55% of bitumen. It shall be mechanically applied at a rate of 0.38 - 0.43 lit./sq.m.

The tack coat shall be allowed to cure to a tacky condition and the Engineer's consent obtained before any surfacing works are commenced. Any ponding which has occurred must be brushed out to bring the coverage within the limits specified.

The Contractor shall not permit traffic under any circumstances to run on a tack coat.

# 11.33 ROLLING OF SURFACE MATERIALS

The type and weight of roller to be employed on each course of surfacing shall be approved before hand by the Engineer. Notwithstanding this, the Engineer may call for a certified weighbridge ticket in respect of any roller at any time.

Roller wheels shall always be clean and even. An adequate water tank shall be provided together with a fully operating roller sprinkler system. The roller shall be operated by a person fully trained and experienced in rolling technique.

Rolling shall be generally carried out in a longitudinal direction, working from the edge of the carriageway to the crown or, in the case of a super elevated carriageway, from the low to the high side. The second pass should be precisely on the path of the first, before the roller shifts transversely. Heavy drive wheels should approach the freshly laid material. Reversing should be carried out slowly and smoothly and the reversing points staggered across the carriageway to avoid any wave effect. Rolling should be continued until all rollmarks are eliminated and there is no perceptible movement under the roller wheels.

Idle standing on freshly laid material is not permitted.

If the total surfacing to be compacted exceeds 3,300 sq.m. Per day, the Contractor shall provide a second roller.

In confined areas where normal rolling is not possible, mechanical tamping will be permitted. The tampers must be employed systematically to give a smooth "as-rolled" finish.

No traffic will be permitted on a surfacing course until it has been compacted and in the opinion of the Engineer has acquired a sufficient set.

# 11.34 TRAFFIC ON NEWLY CONSTRUCTED ROADS

The Contractor will not be permitted to use a new carriageway at any stage of construction without the written permission of the Engineer's Representative. Notwithstanding any conditions which the Engineer's Representative may stipulate at the time of giving his permission, the Contractor will be solely responsible for maintaining the new carriageway, keeping the surface clean and for making good at his own expense any damage or wear so caused.

# 11.35 LAYING KERBS, CHANNELS AND EDGING BLOCKS

Kerbs, channels and edging blocks shall be bedded true to line and level in cement mortar on a concrete foundation Grade 15. They shall be haunched with concrete Grade

15. The foundation and haunch shall be laid before the approved sub-base is laid to the dimensions shown on the drawings.

# 11.36 CONCRETE BLOCK PAVINGS

The precast concrete blocks have to be manufactured to the following requirements:-

- i) Depth of block to be 60mm and 80mm.
- ii) The concrete used shall have a maximum aggregate size of 20mm, high workability, and shall be designed to have a 20-day characteristic cube strength of 45 N/sq.mm.
- iii) To ensure that the surface does not polish but retains a micro texture to give good low speed skidding resistance, sands containing more than 25% acid soluble material must not be used.
- iv) To ensure interlock between blocks, they must be manufactured to accurate dimensions, which allows them to be laid with only small spaces between the joints. When laid, the spaces between blocks should not exceed 2 to 3mm.

# 11.37 . LAYING OF BLOCKS

The blocks should be laid in such a way so as to develop interlock. The surface course comprises closely fitting paving blocks, the spaces between them being filled with dust and sand particles.

The finished surface level shall be within 5mm of the design level. The maximum deformation within the completed surface measured by a 3m straight edge placed parallel to the centre line of the road in parts of the carriageway where vertical curves necessitate a greater deviation.

The level of any two adjacent blocks should not deviate by more than 2mm.

# 11.38 LAYING COURSE

The laying course shall consist of 40mm sand as specified containing not more than 3% of silt and clay by weight, and, with no more than 10% retained on a 5mm sieve. It is spread to give a thickness when compacted of 40mm. The profile of the uncompacted sand should be similar to that of the final surface. The required thickness of uncompacted sand forming the laying course will depend upon its moisture content grading, and degree of pre-compaction. The laying course sand needs to be spread to a greater depth than the target compacted depth of 40mm. The amount of surcharge will be of the order of 10 to 15mm but the exact value is best determined by trial. To avoid any need to adjust the surcharge during construction, it is helpful to keep the sand grading and moisture content sensibly constant.

Once spread the sand should be screed smooth to level. For roads less than 4.5m wide, the kerbs may be used as screeding guides, but on wide pavements, it is necessary to set temporary screed rails for striking off the laying course. During spreading and screeding, operatives must not stand in the sand, otherwise uneven pre- compaction will occur causing irregularities in the final road surface. To minimise the risk of disturbance, it is advisable to avoid screeding sand long distances in front of the block laying face.

# 11.39 CUTTING BLOCKS

Awkward shapes at edges or obstructions, like gulleys manholes are filled by cutting blocks with a block splitter or by using a bolster chisel and hammer.

#### 11.40 VIBRATION

When the laying of concrete blocks has been completed, then blocks should be vibrated with a plate vibrator. The vibrator should have a centrifugal force of 0.35 to 0.50 sq.m. A frequency of 75 to 100 Hz is recommended.

The required number of passes of the plate depends upon a variety of factors and is best determined by site trial. It should be sufficient to provide an even riding surface and prevent vehicles from causing further compaction. Normally two or three passes will suffice. Vibration should not be carried out within about 1m of unrestricted blocks; on the other hand, as little surface course as possible should be left unvibrated overnight.

Finally, sand should be brushed over the surface and two or three further passes of the vibrator made, to complete interlock and fill the joints.

As soon as vibration has been completed, the road can be used.

# 11.41 PREPARATION OF FOOTPATH FORMATION

After the excavation of filling has been completed as specified the footpath formation shall be regulated to an even and uniform surface, and compacted with a roller weighing not less than 2.5 tonnes.

If any soft places develop in the formation during compaction they shall be excavated and backfilled with approved granular material, levelled and re-compacted.

# **11.42** . PRECAST CONCRETE PAVING

Precast concrete paving slabs shall be to B.S. 368 : 1971 and shall be laid with 1:3 lime mortar using five pats not less than 150mm diameter for each slab. They shall be laid at a level not exceeding 4mm above the top of the kerb or concrete edging. The joints shall be thoroughly cleaned out and grouted with cement mortar well brushed in and flushed off. No cracked or broken slabs shall be used.

#### 11.43 CHASING

Chasing in load-bearing walling for pipes, etc., is to be kept to a minimum size of cut and the positions and runs of chases are to be approved by the Engineer before any cutting is commenced.

#### 11.44 DAMP-PROOF COURSES (D.P.C.)

Damp-proof courses shall be 1000 gauge polythene free from tears and holes and be laid with 150mm minimum laps on and including a levelling screed of cement mortar.

#### 11.45 . BITUMINOUS FELT ROOFING

Bituminous felt roofing shall be carried out complete by an approved Specialist Sub- Contractor.

Felt roofing shall be executed in accordance with British Standard Code of Practice C.P. 114/101 and strictly in accordance with the manufacturer's instructions, laps shall be 100mm minimum and falls 100mm minimum in 3 metres for flat roofs, and the minimum specification shall be as follows (Felt to B.S. 747):-

- a) One layer of asphalt saturated felt (weighing 6.8 kg. per 10 square metres) laid loose to screed or random and lap nailed to the boarding.
- b) One layer of asphalt saturated felt but weighing 9 kg. per 10 square metres and bedded to underlayer with hot bituminous compound.
- c) One layer of white mineral surfaced roofing felt (weighing not less than 23 kg. per 10 square metres) bedded to underlayer with hot bituminous compound.

# 11.46 HACKING, ETC.

The prices for all pavings and plastering, etc., shall include for hacking concrete surfaces and for raking out joints of walls 12mm deep and for cross scoring undercoats to form a proper key.

Plastering on walls generally shall be taken to include flush faces of lintels, beams, etc., in the walls.

#### 11.47 SURFACES

All surfaces to be paved or plastered must be brushed clean and well wetted before each coat is applied. All cement pavings and plaster shall be kept continually damp in the interval between application of coats and for seven days after the application of the final coat.

# **11.48 PRICES FOR PAVING**

Prices for paving are to include for adequate covering and protection during the progress of the Works to ensure that the floors are handed over in perfect condition on completion.

# 11.49 POLISHED TERRAZZO

Polished terrazzo shall be laid by an approved Sub-Contractor and shall consist of a screed or backing coat and a finishing coat of "Snowcrete" and marble chippings (1:2) mixed with "Cemantone No. 1" colouring compound in accordance with the manufacturer's instructions in the proportions of 10 lbs. compound to 100 lbs. cement. Overall thicknesses are to be as specified.

The finishing coat shall be a minimum of 12mm thick for pavings trowelled to a smooth and even finish and well rubbed and polished with carborundum.

# 11.50 ATTENDANCE UPON ENGINEER'S STAFF

The Contractor is to provide the necessary support staff, as and when requested by the Engineer, to assist in some of the duties on site. These staff may include but not be limited to chainmen and other short term staff required for quality control monitoring. An allowance for these is made in the Bill of Quantities.

# 11.51 TRAINING OF EMPLOYER'S PERSONNEL

On commissioning of all the Works, the Contractor will be responsible for the operation and maintenance of the Works for 4 weeks, during which period training of Staff will be done.

During the above training period, the Contractor will deploy specialised persons capable of giving theoretical and practical training to the Staff in the following fields:

- operation and maintenance
- treatment process and laboratory tests
- mechanical / electrical units

After the training period, the Plant Manager(s) or other Designated Staff will take over the operation of the Works.

# **12 MECHANICAL WORKS**

# 12.1 GENERAL

The workmanship and materials covered by this section shall include for the supply, installation and commissioning of all mechanical equipment like pumps, compressors, agitators, chemical solution feeders and ancillary equipment required at Treatment Works. It shall also include submission of shop and working drawings, testing and test connections, and operation manuals as specified.

All materials and equipment shall be obtained from reputable manufacturers, who have well established agent(s) in Kenya. The local agent(s) shall be able to provide an efficient service for the equipment and shall have ample stocks of all expendable items such as packings, impellers, fuses, etc.

The Engineer reserves the right to reject manufacturer(s) or agent(s) not fulfilling the above requirements.

It is the responsibility of the Contractor to provide evidence that the equipment is in compliance with the Bills of Quantities, Specifications herein, and as shown on the drawings, and that the equipment will operate satisfactorily under the conditions under which it is installed. The work shall comprise complete installation such as anchor bolts, base plates, gaskets, painting, etc., all to the satisfaction of the Engineer.

# 12.2 TRADE NAMES

Where trade names or manufacturers' catalogue numbers are mentioned in the Specification herein or shown on the drawings, the references are intended as a guide to the type of equipment or quality of materials required. The Contractor may propose any equipment or materials in type or quality to those described herein or shown on the drawings subject to prior approval of the Engineer and at his absolute discretion. The Contractor shall guarantee that the quality of the equipment he proposes are equal to or higher than that indicated herein or as shown on the drawings.

# **12.3** SPARE PARTS

The Contractor shall supply sufficient amount of spare parts to properly operate and maintain all the equipment furnished and installed under this Contract for over three (3) years period. The Contractor shall, as recommended by the manufacturer supply the quantities of such spare parts, the list of which must be submitted with the Tender, and costs thereof shall be covered by the Contractor's rates.

# **12.4** STORAGE OF MATERIALS

The Contractor shall provide weather-proof lock-up sheds for safe storage and custody of materials for the works. The sheds shall be removed upon completion of the works, and the site shall be restored to the original conditions to the satisfaction of the Engineer.

# **12.5** TESTS ON MATERIALS / EQUIPMENT

The Engineer reserves the right to inspect, examine and test materials and workmanship, from time to time during the period of manufacturing, all equipment to be supplied under the Contract at manufacturer's factories. Such inspections and testing, however, will not in any way relieve the Contractor from any obligation under the Contract.

The Contractor shall carry out any tests on the quality of materials and workmanship of equipment as directed by the Engineer. Performance tests shall be carried out by the Contractor for all mechanical equipment to ensure that the equipment complies with the requirements of the Specification.

All tests shall be carried out in the presence of the Engineer or such personnel as appointed by the Engineer for this purpose.

The Contractor shall provide all necessary labour and instruments for carrying out these tests, and he shall be responsible for the use and discharge of any water and chemicals during these tests.

The Contractor shall give to the Engineer, a written notice of the date after which he will be ready to conduct the tests as required in the Contract. Unless otherwise agreed, the test shall take place within 14 days after the said date on such day or days as the Engineer shall notify the Contractor.

If the Engineer fails to appoint a time after having been asked to do so, or does not attend at the time and place appointed, the Contractor shall be entitled to proceed with the tests in his absence. The tests shall then be deemed to have been made in the presence of the Engineer and the results of the tests shall be accepted as accurate. The Engineer shall give the Contractor 7 days' notice in writing of his intention to attend the tests.

# 12.6 DRAWINGS

The works as shown on the drawings are prepared for tendering purposes only, and it is the Contractor's responsibility to provide promptly, detailed shop drawings of the equipment he proposes to use. It is also the Contractor's responsibility to see that all openings, recesses, channels, conduits, etc., in structures are so located and installed as to fit and function properly with mechanical and electrical works.

The Contractor shall prepare all necessary detailed or workshop drawings required for manufacturing and erecting the equipment. Such drawings shall be submitted to the Engineer for approval prior to the commencement of manufacture and installation of the equipment. Upon completion of the works, the Contractor shall prepare and submit information on as-built drawings to the Engineer for his retention.

The Contractor shall be responsible for any discrepancies, errors, or omissions in the Contractor's drawings unless they are due to incorrect drawings or other written information supplied by the Employer or the Engineer. Approval by the Engineer of the Contractor's drawings shall not relieve the Contractor from any responsibility under this section

#### **12.7 DESCRIPTION OF SERVICES**

The Contractor shall supply, transport, deliver, install, connect, commission and hand over all equipment and materials specified in the Specifications, Drawings, Bills of Quantities, in a clean complete and in every detail working condition. He shall carry out all tests specified herein to Kenyan or other International Standards together with any tests which might be requested by the Engineer with respect to the use of these materials or equipment.

All costs accruing due to preparation of the above drawings, manuals, tests and other obligations including all necessary labour, overheads and profits, duties, sales taxes, etc., shall be deemed to be included in the Contract Price.

#### **12.8 MAINTENANCE**

The Contractor shall be liable for all defects and shall maintain all Mechanical and Electrical Equipment for a period of one (1) calendar months from the date the works are taken over by the Employer. All such expendable items necessary for the maintenance of the works as gaskets, filters, fuses, indicator lamps, relays, coils, switches, oils, etc., are to be supplied by the Contractor.

In case permanent power supply is not made available in time for testing equipment, the Contractor, if he intends to clear out of the site, shall make his own arrangement for testing equipment and again return to the site for final testing when permanent power supply is made available. No extra payment will be made for such arrangement.

The Contractor shall be responsible for making good any defect in or damage to any part of the works which may appear or occur during the Defects Liability Period. The Defects Liability Period for the works shall not end until all defects which occurred or appeared during the period have been satisfactorily rectified.

The Defects Liability Period for the works shall be extended by a period equal to the period during which the works cannot be used by reason of a defect or damage of equipment. If only part of the works is affected the Defects Liability Period shall be extended only for that part.

#### **12.9 INITIAL DEFECTS LIABILITY PERIOD**

During the one month Defects Liability Period, the Contractor shall carry out all necessary adjustments and repairs, cleaning and lubricating, etc., required for maintaining the equipment in good working condition. A report of any work executed with respect to such maintenance shall be submitted to the Engineer and incorporated in Maintenance Records.

The Contractor shall inform the Employer his schedule of any routine maintenance inspection work before the work commences. Any items of materials found to be defective shall be replaced by the Contractor within seven (7) days after the receipt of such notice by the Employer or his representative. If the defect or damage is such that repairs cannot be expeditiously carried out on the site, the Contractor may with the consent of the Engineer

remove from the site for the purposes of repair any part of the works which is defective or damaged.

The Contractor shall bear all the costs required for maintenance and inspection services of the equipment and provide for all labour, tools, instruments and plant, and the transportation thereof, as required for the satisfactory execution of these obligations and for the provision, use and installation of all materials such as fuses, expendable items, oils, greases, etc., and such parts which are periodically renewed as relay contacts or parts which are faulty for any reason.

# **12.10** MAINTENANCE AND SERVICES AFTER COMPLETION OF INITIAL DEFECTS LIABILITY PERIOD

The Contractor shall, if required by the Employer, enter into a Maintenance and Service Agreement with the Employer for a period of up to five (5) years from the last day of the Initial Defects Liability Period. Such an Agreement shall offer the same services as specified under "Initial Defects Liability Period". The Contractor shall be entitled to be paid the cost for such additional maintenance and services which will be determined by negotiation between the Employer and the Contractor.

# 12.11 MANUFACTURER'S MAINTENANCE MANUALS

Upon completion of the works, the Contractor shall furnish to the Engineer six (6) copies of Manufacturer's Maintenance Manuals for the equipment installed in A-4 size loose leaf type binding containing information on the following items:

- a) Description of Equipment
- b) Full Operation and Maintenance Instructions
- c) Valve Operations
- d) Fault-finding Charts
- e) Emergency Procedures
- f) Maintenance and Service Periods
- g) Lubricating Instructions
- h) Colour Code Legend
- i) Spares List
- j) Record Drawings in size A-4 / A-3
- k) Any other relevant information.

The Manual shall be specifically written for this Contract and not be the manufacturer's standard manual unless otherwise approved by the Engineer.

All instructions in the Manual shall be written with reference to the drawings. All valves, terminals and controls in the plant and other sites be labeled to correspond with the Operation and Maintenance Manual.

The Works will not be considered completed for the purpose of taking over until such Manual containing instructions and the drawings have been supplied to the Employer.

#### **12.12** . PRESSURE GAUGES

Pressure gauges shall be wall mounted, in metric units complete with connection to delivery side of pumps, and copper pipe from pipe to gauge supplied with isolating cock. If proposed and instructed, the gauges can be directly mounted on the delivery pipework.

#### 12.13 CHEMICAL DOSERS

Dosers shall be of gravity solution feeder type and shall consist of constant level tank with level regulator, inlet valve with hose connection, outlet regulator unit, funnel with outlet hose connector and pipes, as shown on the drawings.

Constant level tanks shall be of hard chemical resistant rubber lined aluminium or steel tank, and be sufficiently large to contain an expanded PVC float of ample area.

Float shall be connected to a valve consisting of a PVC body with soft rubber or PVC seat which gives sensitive and accurate control of the liquid level in the tank.

Outlet regulator unit shall be of a needle valve type and fixed to the constant level tank. Flow shall be controlled easily by adjusting a knob rotation. Type of discharge orifice in the outlet regulator unit shall be such that it can always be drained so as to avoid crystallisation of chemicals.

Regulator shall be so fixed as to discharge the contents into a plastic funnel from which it is led to reinforced flexible chemical resistant pipe or reinforced polyethylene tube to a point of application.

All valves shall be made of materials that resist chemical attack of any sort.

# **12.14 AGITATORS**

Agitator, to be used for mixing, shall be of vertical shaft, paddle or impeller type. The assembly shall be of such construction that it can be operated both manually and electric motor.

It shall consist of an impeller mounted on a vertical shaft, a speed reducing device, a clutch selector for selection of manual or electric operation, bearings, couplings, motor and base frame.

Length and diameter of shaft and impeller shall be for proper mixing of chemicals without causing vibration, and spilling.

Anti-friction type thrust and guide bearings shall be located above liquid level for supporting and guiding shaft and impeller and to resist all hydraulic loading on the shaft. Drive assembly shall include a vertically mounted motor, clutch selector and speed reducer to provide the speed necessary. Speed reducers shall be of vertical type, adequate capacity for transmitting the required power and torque output. Reducer shall be equipped with a cast iron or steel construction pedestal. Shaft and impeller shall be made of chlorinated rubber or neoprene lined steel or other materials accepted by the Engineer. All materials used must be

resistant to chemical reaction of any kind and approval of the Engineer is a must before fabrication or ordering of the Agitators. Agitators shall be provided with a removable handle for manual operation.

In the Tender, the Contractor shall outline his proposal for training. An item for such training is allowed for in the Bills of Quantities. Prior to Commissioning of the Works, a detailed training programme shall be submitted to the Engineer for approval. The training shall be divided into four different levels:

- Training of Management Staff and Department Heads: Theoretical and Practical Seminar(s)
  Training of Skilled Personnel: Short theoretical introduction and practical seminar(s) The laboratory personnel shall be trained in analysing various parameters and handling of laboratory equipment. Include for training of Plant Operators especially in operation and maintenance of electro/mechanical equipment
  Training of Unskilled Personnel: Familiarisation with various appurtenances of the Works and daily and routine works associated with maintenance work
- 4. General Operation and Maintenance of all the Works i.e. daily, weekly, monthly and yearly procedures to be followed, recording of observations, and reporting action plan for any remedial works, etc.