



المملكة الأردنية الهاشمية

سلطة منطقة العقبة الاقتصادية الخاصة
Aqaba Special Economic Zone Authority



المواصفات الفنية

العطاء رقم ()
والخاص بتطوير وتنفيذ البنية التحتية ضمن المنطقة
التجارية الثانية (منطقة التقسيم) في مدينة العقبة

ركن الهندسة
مهندسون مستشارون



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أولاً: اعمال الحفريات والطعم للجدار الاستنادي.

1. قبل المباشرة باعمال الحفريات على المقاول تزويد المهندس المشرف بمخطط كنتوري يبين مناسيب الارض الطبيعية قبل الحفر وضمن فترات لا تتعدى (5) متر لكل فترة، وعليه ان يأخذ موافقة المهندس على هذا المخطط.
2. تتم اعمال الحفريات بالاليات المناسبة لنوعية التربة ولانجاز الاعمال دون تأخير.
3. عند الوصول الى مناسيب التأسيس المطلوبة على المخططات يجب استشارة المختصين للتأكد من الوصول الى قوة التحمل المنصوص عليها في فحص التربة المعتمد للموقع لأخذ التوصيات المناسبة.
4. في حالة عدم الوصول الى قوة التحمل المطلوبة يجب على المقاول ابلاغ المهندس بذلك خطيا ليقوم باتخاذ الاجراءات التي يراها مناسبة ، واية تعليمات او اعادة تصميم للاساسات او اعمال اضافية تطراً على ذلك يتم التعامل مع هذه التعديلات والأعمال الاضافية حسب العقد.
5. يجب ان يتم تدعيم الحفريات بالدعم المناسب وحسب المواصفات بند (211) وموافقة المهندس لضمان السلامة العامة وسلامة العمل والعاملين اثناء عمليات الحفر وصب الخرسانة للجدار ويكون ذلك دون علاوة وحسب تعليمات المهندس المشرف المسبقة حول طريقة اسناد جوانب الحفر المقترحة من قبل المقاول.
6. يتم الكيل وشمولية الاسعار حسب الباب الثاني (اعمال الحفريات) من كتاب المواصفات الفنية العامة للمباني المجلد الاول ما لم يرد خلاف ذلك في جدول الكميات.
7. لا تنص هذه المواصفات على وجود مسافة عمل حول جوانب الحفريات وعليه فان كيل الحفريات يكون كيلا هندسيا حسب المخططات، دون احتساب لمسافة عمل "Working space".
9. طعم من خارج الموقع من مواد مختارة وناجحة مخبريا يوافق عليها المختبر مطابقة لاشتراطات وتدرج مواد الطرق حسب مواصفات الطرق الصادرة عن وزارة الاشغال العامة لعام 1991. مع الالتزام بما ورد في النقطة (10) من تعميم رقم (141) لسنة 2017 .
10. المواصفات الفنية للطعم والمواد المختارة المستخدمة في مشاريع الابنية والساحات:
 أ. المواصفات للطعم من المواد المختارة:
 - التصنيف المجموعي يكون (A2-5, A2-4, A1-b, A1-a) بمعامل لدونة لا يزيد عن (10%)
 - ان لا يزيد الحجم الاكبر عن 3 انش (التدرج الحجمي)
 ب. مواصفات الطعم ناتج الحفريات:
 يعتبر ناتج الحفريات صالحا لاعمال الطعم اذا حقق الخصائص التالية:-
 - ان لا يكون ذو تصنيف مجموعي "A7.A6"
 - ان لا تقل الكثافة الجافة العظمى عن 1.6 غم/سم3
 وبناءا عليه فان تحديد الخصائص اعلاه يشمل اجراء تجارب التدرج الحجمي اضافة الى فحص البوركتور.
 ج. اما الحدود الدنيا للمواصفات المتبقية في تحديد التصنيف بناء على نتائج الفحوص المخبرية فيمكن الاستعانة بجدول تصنيف التربة ومجموعات التربة والحصى حسب مواصفات جمعية مهندسي الطرق الاميركية (AASHTO).

ثانياً: أعمال الخرسانة العادية والمسلحة.

حسب متطلبات المواصفات القياسية الاردنية 1-1651/2022 بأجزائها - و/ أو الأحدث، 2023/498 و/ أو الأحدث.

1. يتعين على المقاول استخدام الواح الطوبار الجديدة من الخشب المعاكس سماكة 18 مم (New Plywood) للخرسانة الوسيمة وبدون علاوة بحيث تكون خالية من العيوب والنتوءات، والسعر يشمل اصلاح اوجه الخرسانة وتعبئة الفتحات ب مواد اسمنتية خاصة (Non shrinkage grout) وحسب تعليمات الشركة الصانعة ويكون ذلك محمل على سعر البند.

2. يكون الغطاء الخرساني للعناصر الإنشائية كالتالي:-

أ- الزنانير الارضية وجدران التعلية وخرسانة تحت المنسوب 5 سم.

ب- العناصر المعرضة للعوامل الخارجية 3 سم.

ج- الجدران الاستنادية غير المعرضة للعوامل الخارجية والاعمدة والجدران الاستنادية والخرسانة الوسيمة 4 سم.

د- القواعد والاساسات 5 سم.

3. يجب اضافة مواد مميعة لجميع الخلطات الخرسانية العادية والمسلحة ومونة مواد البناء والبلاط والقضارة من مصدر معتمد يوافق عليه المهندس وكذلك اضافة مادة مانعة للنش لخرسانة الجدران التي تكون تحت منسوب مدة الحماية.

4. يجب أن يتم دمك جميع العناصر الخرسانية بواسطة الرج الميكانيكي وبواسطة رجاكات ذات قياسات مناسبة.

5. جميع أعمال الخلط للخرسانة يجب أن تكون بواسطة الخلاطات المركزية او خلاطات تعمل بالوزن ويمنع منعاً باتاً الخلط اليدوي مهما كانت الاسباب.

6. تكون جميع المكونات للخلطة الخرسانية من ركام او رمل أو إسمنت أو ماء خاضعة للفحوص المخبرية التي تنص عليها المواصفات العامة وحسب تعليمات المهندس المشرف.

7. تكال جميع أعمال الخرسانة سواء العادية او المسلحة كيلا هندسيا وحسب الأبعاد والأعماق والمناسيب الواردة على المخططات ولا يؤخذ بعين الاعتبار أية كميات زائدة ناتجة عن أخطاء في الحفريات أو خلافه.

8. يجب مراعاة عمل الفتحات المناسبة في الجدران لأية أعمال ميكانيكية او كهربائية أو تفصيلات معمارية لاحقة وفي الوقت المناسب وبدقة كبيرة ، حيث توضع الأكمام المناسبة (Sleeves) ويمنع منعاً باتاً التكسير سواء في الجدران أو العناصر الخرسانية.

9. يعدل الحد الأدنى لمحتوى الاسمنت والوارد في الجدول رقم (8/3) من الباب الثالث صفحة (34/3) درجات الخرسانة واستعمالاتها في كتاب المواصفات العامة للمباني والصادرعام 1996 ولتصبح كالتالي :

أ. خرسانة درجة (15) محتوى الاسمنت الأدنى (225) كغم/م³.

ب. خرسانة درجة (20) محتوى الاسمنت الأدنى (300) كغم/م³.

ج. خرسانة درجة (21) محتوى الاسمنت الأدنى (300) كغم/م³.

د. خرسانة درجة (25) محتوى الاسمنت الأدنى (325) كغم/م³.

هـ. خرسانة درجة (30) محتوى الاسمنت الأدنى (350) كغم/م³.

و- خرسانة درجة (35) محتوى الاسمنت الأدنى (375) كغم/م³.

10. المخططات التنفيذية لحديد التسليح:

على المقاول تقديم الجداول الخاصة بتنفيذ مخططات التسليح (Bar-Schedule Bending) مبينا فيها اطوال واوزان حديد التسليح لممثل المهندس بغرض اعتمادها قبل التنفيذ.

11. تؤخذ عينات من الحديد المورد للموقع ابتداءً من الشحنة الاولى وكل شحنة تصل الى الموقع لجميع الاقطار وبمعدل (6) عينات فحص لكل (100) طن او حسب تعليمات المهندس المشرف.

12. استخدام مواد خاصة (Form release agent) لخشب الطوبار (الطوبار الغشيم والفيرفيس) لمنع التصاقها بالخرسانة عند فكها والمحافظة على الحواف سليمة.

13. يجب عمل تجميعات خرسانية (8x8) سم محاذية للجدران على المدات الارضية بجميع أنواعها وأشكالها، وتكون محملة على سعر المدات الأرضية.

ثالثاً: أعمال حديد التسليح.

تكون المتطلبات والخواص المطلوبة لأعمال حديد التسليح وفقاً لما ورد في المواصفات الفنية العامة فقرة 305 مع الأخذ بعين الاعتبار ما يلي:

- 1 - يتم وصل القضبان بطريقة التراكب وحسب الشروط والتعليمات الخاصة بذلك فقرة 4/305 من المواصفات الفنية العامة.
- 2 - على المقاول تقديم الجداول الخاصة بتنفيذ مخططات حديد التسليح (Bar Bending Schedules) مبيناً فيها أطوال وأعداد وأشكال وأوزان الحديد لاعتمادها والموافقة عليها من المهندس لأغراض التنفيذ وحساب الكميات.
- 3 - ضرورة الالتزام بالتعليمات والشروط المبينة على مخطط الملاحظات العامة من المخططات الإنشائية للمشروع والتعليمات الواردة في هذا المخطط لها الأولوية في التطبيق على ما سواها.
- 4 - جميع قضبان فولاذ التسليح المستخدمة في المنشأ ومن مختلف الأقطار (High Tensile Grade 60) ومطابق للمواصفات القياسية الأردنية م ق أ (2016/2126) و/او الاحدث.
- 5 - يقوم المقاول إجراء فحص لكل إرساله حديد يتم توريدها للموقع و/أو حسب تعليمات المهندس ويشمل الفحص إجراء الفحوصات التالية:
 - 1- تحديد إجهاد الخضوع ومقاومة الشد.
 - 2- الاستطالة.
 - 3- أقل قطر للثني.
- 6 - يكون فولاذ التسليح شد عالي المقاومة MPa 420 بالأطوال والأقطار المبينة على المخططات
- 7 - شمولية السعر: تشمل كافة الاعمال من اسلاك التزبيط قطر 1.5 ملم والقص والدرس والكراسي والتنظيف والتكريب والنجف وتنظيف الحديد القائم والتشريك للجدران القائمة جميع مايلزم حسب المخططات والمواصفات وتعليمات المهندس المشرف.

رابعاً: أعمال العزل لقاعدة الجدار الاستنادي.

تكون الزفته المستعمله لعزل الاساسات من الزفته الباردة عاليه المرونه دهان اسفلتي مطاطي (High Build elastomeric rubberized Bitumen coating) وجهين متعامدين وبسماكة كلية لا تقل عن (1) ملم ومطابقه للمواصفات القياسية العالميه وتدهن الاسطح على طبقتين بعد التنظيف وتترك لتجف تماما وبعد الجفاف تدهن الاسطح بالطبقة الثانيه بسماكة كلية لا تقل عن 1 ملم ، ولا يجوز وضع الطمم الا بعد التأكد من جفاف الزفته.

خامساً: أعمال بلاط الارضيات.

تشمل اعمال بلاط الارضيات على البلاط الاسمنتي والانتزلوك ويتم التقيد بالمواصفات وتنفيذ الاعمال حسب ما هو وارد في الباب الثامن من المواصفات الفنية العامة للمباني / المجلد الاول ويتم التقيد بالمواصفات وتنفيذ الاعمال حسب ما هو وارد في الباب الخامس من المواصفات الفنية العامة للمباني / المجلد الاول مع مراعاة ما يلي :

بلاط ذوي الاعاقة البصرية الاسمنتي (Cement tactile tiles):

يكون البلاط الاسمنتي_صنف (1) مطابقاً للمواصفات القياسية الأردنية رقم (45- 2 /2010) بمعدل مقاومة الكسر بالإحناء لا يقل عن (3.5) نيوتن/ مم² ولا يزيد التاكل السطحي عن (23) ملم ويحقق

المواصفات الواردة في المجلد الأول من المواصفات العامة للمباني المادة (804) على أن يقوم المقاول بتقديم العينات وبألوان مختلفة لاختيار الانسب للمشروع.
ويكون مزود ببروزات (نتوءات أو خطوط موجهة) يستخدم كأداة تحذيرية أو توجيهية للأشخاص ذوي الإعاقة البصرية في الأرصفة والممرات وينقسم لقسمين:
أ- بلاط تحذيري (Warning/Attention type): مكون من بلاط اسمنتي ذو سطح يحتوي على نتوءات بقطر (2±25 مم) نصف كروية بارتفاع (4-5 مم)، وتباعد 5±60 مم.
ب- بلاط توجيهي (Directional type): مكون من بلاط اسمنتي ذو سطح يحتوي على خطوط بارزة متوازية بعرض (2±25 مم) باتجاه السير، يستخدم لتوجيه المشاة على مسار محدد، والمسافة بين الخطوط (5±60 مم).

الانترلوك :

يكون بلاط الانترلوك من خرسانة درجة 25 جاهزة الصنع متداخل (Precast brick Interlocking tiles) بسماكة لا تقل عن 6.5 سم من اللونين الاسمنتي والقرميدي صنف (ب) حسب المواصفة القياسية الاردنية الواردة في التعميم (141) لعام 2017.

وقاية اعمال البلاط:

بعد تركيب اعمال البلاط يجب وقايته من مرور العمال واية امور اخرى وذلك بالطريقة المناسبة حسب تعليمات المهندس المشرف (وذلك محمل على سعر البند) والمقاول مسؤول عن تغيير اي من القطع التي لحقتها تلف اثناء العمل دون مقابل.

الكيل وشمولية السعر :

أ. تعتبر الاسعار الافرادية لاعمال البلاط على اختلاف انواعه شاملة لعموم التكاليف اللازمة لانجاز العمل على اكمل وجه من تقديم البلاط والمونة واجور المصانعة للتركيب والقص والجلي والطمر تحت البلاط (رمل السيلكا) والترويب والعدة بانواعها المختلفة والسقايل وجميع ما يلزم لانجاز العمل حسب المخططات وتعليمات المهندس ولا يدفع اية علاوة للتشريك او الضياع.
ب. يكال بلاط الارضيات بانواعه المختلفة كيلا هندسيا صافيا لواقع المساحات التي يجري تبليطها فعلا وتؤخذ الابعاد طولا وعرضا مع مراعاة ما ورد في البند 4/817.
ج. يكال بلاط الارضيات كيلا هندسيا صافيا بعد حسم الفراغات ولا يعطي علاوة للتشريك وكما ورد في البند (ب).

سادسا": الفحوصات اللازمة لمواد الطرق

Minimum Tests Required

Earth Works

Work Item	(A) Tests at source of material	Frequency for all tests mentioned under (A)	(B) Tests at Road Site	Frequency for all tests mentioned under (B)
Embankment 2-1	1) Soil Classification (AASHTO) Any other tests as 2) required in technical specs and drawings 3) C.B. R	Tests for each - borrow pit Test for each cut - area having suitable material When materials - quality - change	Maximum Dry 1- Density (modified) Soil 2- Classification (AASHTO) 3- Field Density Any other tests 4- as required by technical specs and drawings	Test for each 1000 lineal m - and for each layer - When materials quality Change - Test for each 1500 m ² or 100 lineal m whichever be less, and for each layer
Subgrade 2-2 and shoulders	1- Granular Gradation 2- Plasticity Index 3- C.B. R Any other tests as 4- required in technical specs and drawings	Test for each - borrow pit Test for each cut - area having suitable material Test for each 4000 - m ³ When materials - quality - change	1- Modified proctor Granular 2- Gradation 3- Plasticity Index Soil 4- Classification (AASHTO) 5- C.B. R 6- Field Density Any other tests 7- as required by technical specs and drawings	Test for each 1000 lineal m - and for each layer When materials quality - change - Test for each 1500 m ² or 100 lineal m for each layer

Minimum Tests Required
Earth Works (cont'd)

Work Item	(A) Tests at source of material	Frequency for all tests mentioned under (A)	(B) Tests at Road Site	Frequency for all tests mentioned under (B)
Selected 2-3 Topping	1- Granular Gradation 2- Plasticity Index 3- C.B. R Any other tests as 4- required in technical specs and drawings	Test for each - source When materials - quality Change	1- Modified proctor Granular 2- Gradation 3- Plasticity Index 4- C.B. R	Test for each 500 lain m, - and for each layer When materials quality - change
			5- Field Density 6- Layer thickness Any other tests 7- as required by Technical specs and drawings	- Test for each 1500 m2 or 100 lain m for each layer
Structural 2-4 Backfill			Maximum Dry 1- Density mod proctor) Granular 2- Gradation 3- Plasticity Index	- Test for each structure When materials quality - change - As request
			4- Field Density Any other tests 5- as required By technical specs and Drawings	- 50% of the layers or to the satisfaction of the Engineer

Minimum Tests Required

Base & Subbase Courses

Work Item	(A) Tests at source of material	Frequency for all tests mentioned under (A)	(B) Tests at Road Site	Frequency for all tests mentioned under (B)
Base & 3-1 Subbase	1- Granular Gradation 2- Plasticity Index 3- Abrasion 4- C.B. R 5- Sand equivalent 6- Fractured faces for bases) 7- Any other tests as required technical specs and Drawings	- Test for each source - Test for each 2000 m3 When materials - quality Change	Modified 1- proctor Granular 2- gradation Plasticity 3- Index 4- C.B. R 5- Abrasion Sand 6- equivalent	-Test for each 500 lain m and for each layer -When materials quality change
			7- Field Density Layer 8- thickness Any other tests as 9- required by technical specs and drawings Clay lumps & friable 10- particles	-Test for each 750 m2 and for each layer

Minimum Tests Required
Asphalt Mixes

Work Item	(A) Tests at source of material	Frequency for all tests mentioned under (A)	(B) Tests at Road Site	Frequency for all tests mentioned under (B)
4-1 Materials in Asphalt mix. (At Batching Plant)	1- Specific gravity and water absorption 2- Abrasion test 3- Chert content 4- Clay lumps and friable particles 5- Flaky and elongated particles 6- Soundness	Test for each - source When materials - quality change - As required		
4-2 Materials used in Asphalt mix (from hot bins)	1- Gradation 2- Specific gravity and water absorption 3- Plasticity index 4- Sand equivalent 5- Stripping with asphalt	Test for each - source When materials - quality change - As required		

Minimum Tests Required
Asphalt Mixes (Cont'd)

Work Item	(A) Tests at source of material	Frequency for all tests mentioned under (A)	(B) Tests at Road Site	Frequency for all tests mentioned under (B)
Asphalt mix 4-3 design each layer (At Batching Plant)	1- Complete mix design in accordance with American Asphalt Institute (MS2) 2- Loss of stability	For each project - When materials quality change - When results are not consistent with the mix design results - As required		
Asphalt mix 4-4 for each layer	At Batching plant		Behind spreader	
	1- Stability 2- Flow 3- Extraction (binder content and gradation) 4- Air voids 5- Voids in mineral aggregates 6- Daily marshal density 7- Loss of stability	Test each working Day - Test for each batching plant - As request - Once per week	1- Stability 2- Flow Extraction (binder content and Gradation) 3- and 4- Air voids Voids in mineral aggregates 5- aggregates Daily marshal density 6- density Road density 7- and thickness (after final compaction) 8- Loss of stability	Test each working days - Test for each batching plant - As request - Test for each 200 m per lane and for each layer - As request

Minimum Tests Required
Concrete Materials, Concrete, Reinforcing Steel

Work Item	(A) Tests at source of material	Frequency for all tests mentioned under (A)	(B) Tests at Road Site	Frequency for all tests mentioned under (B)
5-1 Fine aggregate for Concrete	Gradation and 1- fineness modulus Specific gravity and 2- water Absorption 3- Sand equivalent Organic and harmful 4- materials As requested in the 5- special specs. and drawings Sulphates & 6- chlorides	Test for each - source Test for each - 2000 m ³ When materials - quality change	Gradation and fineness 1- modulus Specific gravity and 2- water absorption 3- Sand equivalent Organic impurities & 4- deleterious substances Any other tests as 5- required in the special specs and drawings 6- Sulphates & chlorides 7- Soundness test	- Test for each source - Test for each 300 m ³ - When materials quality change
5-2 Coarse aggregate for Concrete	1- Gradation Specific gravity and 2- water Absorption 3- Abrasion Harmful materials 4- and organic Impurities Clay lumps & friable 5- materials 6- Elongated and flaky particles Index Any other tests as 7- required in technical specs and drawings	Test for each - source Test for each - 2000 m ³ When materials - quality change	Same tests mentioned under (A) in addition to 1- Abrasion test Percentage of clay 2- lumps and friable particles Flakiness index & 3- Elong, index	- Test for each source - Test for each 300 m ³ - When materials quality change

Minimum Tests Required
Concrete Materials, Concrete, Reinforcing Steel (Cont'd)

Work Item	(A) Tests at source of material	Frequency for all tests mentioned under (A)	(B) Tests at Road Site	Frequency for all tests mentioned under (B)
Combined 5-3 aggregates for concrete	Must satisfy fine and 1- coarse aggregate requirements 2- Gradation	- Test for each source - Test for each 4000 m3 Test quality change - materials	Must satisfy fine - and coarse aggregate requirements - Gradation	- Test for each source - Test for each 500 m3 - Test at change of material
5-4 Water for concrete	1- PH Sulphates & 2- chlorides Water effect 3- in concrete strength and properties Greuze and 4- oil	- Test for each source - When source changes	Some tests mentioned under - (A)	- Test for each source - When source changes
Concrete 5-5 admixtures	Manufacturer 1- certificate	- One for each type or manufacture	Trial mixes to - check suitability and percentages to be used based on site conditions, materials and manufacturer's recommendation Any other tests as - required in the special spec. and drawings	- One for each type of manufacture

Minimum Tests Required
Concrete Materials, Concrete, Reinforcing Steel (Cont'd)

Work Item	(A) Tests at source of material	Frequency for all tests mentioned under (A)	(B) Tests at Road Site	Frequency for all tests mentioned under (B)										
Concrete 5-6 (fresh) 5-6-1 Trial Mix Design			1- Slump test Cubes or 2- cylinders for crushing strength as specified 3- Workability	- Test for each class of concrete - Test for change in any material										
5-6-2 Ready Mix	1- The concrete and all its constituents shall satisfy all concrete and materials requirements as specified 2- Workability 3- Any other tests as required in technical secs and drawings	- For each source - When any material is changed	1- Slump test Compression 2- Tests (cubes or cylinders) Any other tests 3- as required in technical specs and drawings	- For each transit mixer <table><tr><td>No. of Transit Mixers</td><td>No. of samples</td></tr><tr><td>1</td><td>6</td></tr><tr><td>2-5</td><td>12</td></tr><tr><td>6-10</td><td>18</td></tr><tr><td>11-12</td><td>24</td></tr></table> - For each 10 additional transit mixes take 6 additional samples (Half of the samples to be tested after one week and the second half after 28 days).	No. of Transit Mixers	No. of samples	1	6	2-5	12	6-10	18	11-12	24
No. of Transit Mixers	No. of samples													
1	6													
2-5	12													
6-10	18													
11-12	24													

Minimum Tests Required
Concrete Materials, Concrete, Reinforcing Steel (Cont'd)

Work Item	(A) Tests at source of material	Frequency for all tests mentioned under (A)	(B) Tests at Road Site	Frequency for all tests mentioned under (B)
5-6-3 Concrete Tests			Compression 1- tests	6 specimens for every 80 - m3 or less 6 specimens for each - casting day
			2- Workability 3- Slump	- Test for each transit mixer at casting location
Hardened 5-7 Concrete			1- Core samples Any other test 2- as required in the technical specs and drawing	- 3 cores for each part of a structure which does not satisfy the compression test requirements after 28 days If samples are not taken - during casting 3 cores shall be taken for each part of a structure

Minimum Tests Required
Concrete Materials, Concrete, Reinforcing Steel (Cont'd)

Work Item	(A) Tests at source of material	Frequency for all tests mentioned under (A)	(B) Tests at Road Site	Frequency for all tests mentioned under (B)
Reinforcing 5-8 steel	1- Tensile strength 2- Yield point 3- Elongation 4- Bending 5- Dimensions 6- Any other tests as required in the technical specs and drawings	- For each source 3 specimens of each diameter (Specimens to be taken from different bars)	1- Tensile strength 2- Yield point 3- Elongation 4- Bending 5- Dimensions Any other tests 6- as required in the technical specs and drawings	Shipment <u>Load tons</u> <u>Specimens</u> <10 10 - 50 51 - 100 101 - 500 501 - 1000 Over 1000 tons divide shipment into the above mentioned ranges in accordance with Jordanian Specifications.
Concrete 5-9 pipes (Plain / reinforced Plant)	1- Abrasion 2- Proof & Ultimate loads 3- Materials used in pipes shall satisfy each individual material requirement as specified 4- Any other tests as required in the technical specs and drawings	- Specimen for each pipe diameter	1- Abrasion Proof & 2- Ultimate loads Any other tests 3- as required in the technical specs and drawings	Pipes of <u>diameter in (mm)</u> <u>specimens</u> 100 - 500 501 - 1000 1001 - 1500

سابعا: المواصفات الفنية الخاصة لإنشاء الطرق وشبكة تصريف مياه الامطار

1- مرجعية المواصفات الفنية للطرق:

تنفذ كافة أعمال الطرق والعبارات وينود الأعمال الخاصة بها الواردة في جداول كميات العطاء طبقا للمواصفات الفنية الخاصة والمواصفات الفنية العامة لإنشاء الطرق والجسور الصادرة عن وزارة الأشغال العامة والإسكان والمواصفات الفنية العامة للمباني الصادرة عن وزارة الأشغال العامة والإسكان وتعتبر هذه المواصفات الخاصة والمواصفات العامة جزء لا يتجزء من وثائق العطاء.

2- حق صاحب العمل في الإلغاءات والاستحداثات:

يحق لصاحب العمل إجراء أي تعديل على مناسيب الشوارع و العبارات ، كما يحق لصاحب العمل الغاء أو استحداث أي عبارة أو عبارات ضمن موقع المشروع ، كما يحق لصاحب العمل استحداث أي أعمال يراها مناسبة للتماشي مع ما قد يتقرر من قبل وزارة الأشغال العامة أو المهندس المشرف.

3- الفحوصات المطلوبة في المشروع:

تنفذ كافة الفحوصات لأعمال الطرق والعبارات على حساب المقاول من قبل مكتب فحص تربة معتمد من قبل المهندس وتكون الفحوصات الموقعية والمخبرية طبقا لهذه المواصفات الفنية الخاصة ومتطلبات المواصفات الفنية العامة لإنشاء الطرق والجسور الصادرة عن وزارة الأشغال العامة والإسكان ومتطلبات المواصفات الفنية العامة للمباني الصادرة عن وزارة الأشغال العامة والإسكان وتعتبر هذه المواصفات الخاصة والمواصفات العامة جزء لا يتجزء من وثائق العطاء.

4- أعمال حفريات وطعم الطرق:

قبل بدء الطمم ، تجري أعمال فتوح وتسوية الأرض الطبيعية وتحديد عمق طبقات الطمم اللازمة أسفل منسوب طبقة (Sub-base) حسب المناسيب والميول والعروض المبينة في المخططات لمنطقة الطمم.

أ- اذا كان عمق طبقة الطمم أسفل منسوب طبقة (Sub- base) يزيد عن (20) سم يتم تنظيف الأرض الواقعة عند قاع الطمم من الجذور والأعشاب وحرثها ورشها بالماء ودخلها لدرجة رك بحد أدنى (95%) من كثافة بروكتور المعدل لتهيئتها لاستقبال طبقات الطمم وبسماكة (20) سم لكل طبقة.

ب- اذا كان عمق طبقة الطمم أسفل منسوب طبقة (Sub- base) أقل من 20 سم يتم إزالة الطبقة أسفل طبقة (Sub-base) بسماكة 20 سم ويتم إجراء ما يلي:

1. اذا كانت نتيجة فحص مواد الطبقة أسفل طبقة (Sub- base) بسماكة 20 سم ذات C.B.R أكبر من 25% وتصنيف لا يقع تحت A-6 أو A-7 يتم تنظيف الأرض من الجذور والأعشاب وحرثها ورشها بالماء ودخلها لدرجة رك بحد أدنى (97%) من كثافة بروكتور المعدل وبسماكة 20 سم لتهيئتها لاستقبال طبقات Sub- base والـ base.

2. اذا كانت نتيجة فحص مواد الطبقة أسفل طبقة (Sub- base) بسماكة 20 سم ذات C.B.R أقل من 25% أو تقع تحت A-6 أو A-7 ، فيتم إجراء ما يلي :

أ- يتم حفر وإزالة هذه الطبقة بسماكة 20 سم وتحسب بنفس سعر الوحدة لأعمال حفريات الطرق في جداول الكميات.

ب- يتم بعد إزالة الطبقة تنظيف الأرض الطبيعية أسفل الطبقة المزالة من الجذور والأعشاب وحرثها ورشها بالماء ودخلها لدرجة رك بحد أدنى (97%) من كثافة بروكتور المعدل وبسماكة 20 سم لتهيئتها لاستقبال طبقة طمم Sub-grade.

ج- يتم تنفيذ طبقة طمم (Sub - Grade) (مكان الطبقة المزالة) ذات C.B.R $\leq 25\%$ ويشمل ذلك تقديم وتوريد ورش الماء وخلط وفرش ودخل المواد حتى المناسيب المطلوبة ودخلها لدرجة رك بحد أدنى (97%) من كثافة بروكتور المعدل لتهيئتها لاستقبال طبقة (Sub-base) . وتحسب بنفس سعر الوحدة لأعمال طمم الطرق في جداول الكميات.

5- مواصفات مواد طمم الطرق:

مواد طمم الطرق يجب أن تحقق المواصفات التالية :

- 1) تبدأ أعمال الطمم بعد تجهيز مواقع الطمم (تنظيف من المواد العضوية والجذور والحرث والرش والدخل لدرجة 95% من بروكتور المعدل بما عدا طبقة الـ (Sub-grade) تكون (97%) من بروكتور المعدل.
- 2) لا تزيد سماكة أي طبقة عن 20 سم بعد الدخل .
- 3) درجة الرك لا تقل عن 95% من كثافة بروكتور المعدل وذات C.B.R لا يقل عن 25%
- 4) الكثافة الجافة العظمى لا تقل عن 1.7 غم/سم³ .
- 5) المواد العضوية لا تزيد عن 5% حسب طريقة (AASHTO (T267) .

- (6) يسمح بخلط مواد ناتج الحفريات الصالحة مع مواد موردة من خارج الموقع لاستخدامها في أعمال طمم الطرق بحيث تحقق المواصفات أعلاه.
- (7) في حالة احتواء مواد ناتج الحفر على مواد عضوية وأعشاب وجذور فإنها تعتبر غير صالحة ويمنع استعمالها في أعمال طمم الطرق.
- (8) ان لايزيد الحجم الأعظمي لمواد الطمم عن ثلثي سماكة الطبقة.

6- طبقة (Sub-grade):

تتكون المواد التي تستخدم في طبقة (Sub-grade) من مواد مختارة تحقق المواصفات الواردة في الجدول رقم (1) بسماكة 20 سم ذات $C.B.R \leq 25\%$ والعمل المطلوب هو انجاز هذه الطبقة كما هو مبين بالمقاطع العرضية المرفقة ويشمل ذلك تقديم وتوريد ورش الماء وخلط وفرش ودخل المواد حتى المناسيب المطلوبة وبالسماكة والميول المحددة بالمقاطع العرضية بطريقة مناسبة بحيث تحقق التماسك على الميول الجانبية وحسبما يراه المهندس المشرف ودخلها لدرجة رك بحد أدنى (97%) من كثافة بروكتور المعدل لتهيأتها لإستقبال طبقات الفرشيات.

Table 1
Sub-grade طبقة

Tests	Limits	Reference Standard
Layer Thickness	20 cm after compaction	
Max Level Tolerance	+10 or -30 mm	
Max Stone Size	3"	
Pass # 200	Max 20%	AASHTO T11
C.B.R	Min 25%	AASHTO T193 ASTM D-1883
P.I	Max 10%	AASHTO T89,T90
Max Dry Density	Min 1.7 g/cm3	AASHTO T180
Compaction	Min 98%	AASHTO T191
Organic Material	Max 5%	AASHTO T267

7- طبقة تحت الأساس (Sub Base):

تتكون المواد التي تستخدم في طبقة تحت الأساس (Sub Base) من مواد مختارة تحقق المواصفات الواردة في الجدول رقم (2)، ذات $C.B.R \leq 40$ والعمل المطلوب هو انجاز هذه الطبقة كما هو مبين بالمقاطع العرضية ويشمل ذلك تقديم وتوريد ورش الماء وخلط وفرش ودخل المواد حتى المناسيب المطلوبة وبالسماكة والميول المحددة بالمقاطع العرضية بطريقة مناسبة بحيث تحقق التماسك على الميول الجانبية وحسبما يراه المهندس المشرف .

ملاحظة : يتم أخذ العينة لإجراء فحص المكافئ الرملي (S.E) في حالة المواد وهي جافة وقبل رشها بالماء. علماً أن درجة الرك لهذه الطبقة (97%) من كثافة بروكتور المعدل وحسب المعلومات الواردة بالجدول رقم (2) المرفق.

Table 2
طبقة تحت الأساس (Sub Base Course)

Tests	Limit	Reference Standard
Type of Material	Crushed lime stone, Screened wadi gravel, Crushed and screened basalt or granite	
Layer Thickness	20 cm after compaction	
Max Level Tolerance	+/- 10 mm	
Abrasion	Max 40%	AASHTO T96
Ratio of wear loss rev100/rev500	Max 0.25	AASHTO T96
C.B.R	Min 40 %	AASHTO T193
L.L	Max 30 %	AASHTO T90
P.I	2-8 %	AASHTO T89,T90
Non plastic condition might be accepted if limestone is used	Provided that angularity test (R) value shall not be less than 8.	B.S 812
Sand Equivalent S.E	Min 25 %	AASHTO T 176
Max Dry Density	Min 2.05 g/cm3	AASHTO (T180 – D)
Compaction	Min 100 %	AASHTO T191,(T180 – D)
Gradation %		
2 ½ “	100	
2 “	80-100	
1 ½ “	70-95	
1”	55-90	
½ “	45-75	
#4	30-60	
#10	22-48	
#40	10-30	
#200(Before comp.)	5-12	
#200(After comp.)	+3% Max	
Clay Lumps and Friable Particles	Max 5 %	AASHTO T112
Flakiness Index	Max 25 %	B.S 812
Elongation Index	Max 25 %	B.S 812
Soundness : Na Mg	Max 12 % Max 18 %	AASHTO T104
Gypsum Content(expressed as SO3)	Max 2 %	B.S 1369

8- طبقة الأساس (Base):

تتكون المواد التي تستخدم في طبقة الأساس (Base) من مواد مختارة تحقق المواصفات الواردة في الجدول رقم (3) ذات C.B.R ≤ 80 ، والعمل المطلوب هو انجاز هذه الطبقة كما هو مبين بالمقاطع العرضية ويشمل ذلك تقديم وتوريد ورش الماء و خلط وفرش ودحل المواد حتى المناسيب المطلوبة وبالسماكة والميول المحددة بالمقاطع العرضية بطريقة مناسبة بحيث تحقق التماسك على الميول الجانبية وحسبما يراه المهندس المشرف .

ملاحظة (1) : يتم أخذ العينة لإجراء فحص المكافئ الرملي (S.E) في حالة المواد وهي جافة وقبل رشها بالماء ودخلها حتى درجة رك (97%) من كثافة بروتكتور المعدل وحسب الجدول رقم (3) المرفق.

ملاحظة (2) : بعد الانتهاء من تنفيذ طبقة الأساس يتم البدء ببناء حجر الكنדרين إذا طلب ذلك من المقاول حسب ما هو مدرج لاحقاً مع ضرورة تغطية حجر الكنדרين بعد بنائه وقبل البدء بعملية رش الوجه التأسيسي (prime coat)

Table 3
طبقة الأساس (Base Course)

Tests	Limit	Reference Standard
Type of Material	Crushed lime stone, Crushed basalt, Crushed granite.	
Layer Thickness	20 cm after compaction	
Max Level Tolerance	+/- 10 mm	
Abrasion	Max 40%	AASHTO T96
Ratio of wear loss rev100/rev500	Max 0.25	AASHTO T96
Fractured faces (for aggregate retained on #4)	Min 80% (one face or two faces)	
C.B.R	Min 80 %	ASTM D1883 (modified)
L.L	Max 25 %	AASHTO T89
P.I	2-6 %	AASHTO T89,T90
S.E	Min 30 %	AASHTO T 176
Max Dry Density	Min 2.1 g/cm3	AASHTO T180 – D – with replacement
Compaction	Min 100 %	AASHTO (T180 – D – with replacement) AASHTO T191
Gradation %		
2 “	-----	
1 ½ “	100	
1”	75-100	
¾ “	60-90	
½ “	45-80	
3/8”	40-70	
#4	30-65	
#10	20-40	
#40	8-20	
#200(Before comp.)	5-10	
#200(After comp.)	+3% Max	
Clay Lumps and Friable Particles	Max 3 %	AASHTO T112
Flakiness Index	Max 25 %	B.S 812
Elongation Index	Max 25 %	B.S 812
Soundness : Na Mg	Max 12 % Max 18 %	AASHTO T104
Gypsum Content(expressed as SO3)	Max 2 %	B.S 1369

9- طبقة الوجه التأسيسي (Prime Coat MC-70) :

- يكون الأسفلت الذي يستخدم في طبقة الوجه التأسيسي (Prime Coat) من نوع MC-70 حسب الجدول رقم (4) .
والعمل المطلوب هو انجاز هذه الطبقة فوق جميع اسطح طبقة الأساس.
أ. ينظف السطح النهائي لطبقة الأساس بواسطة ضاغطة هوائية أو مكنسة ميكانيكية .
ب. يرش سطح طبقة الأساس بالماء وبصورة خفيفة ويدخل قبل رش الإسفلت بثلاثة ساعات .
ت. يرش إسفلت طبقة الوجه التأسيسي من نوع (MC-70) بمعدل 1.5 كغم / م².
ث. يتم رش الوجه التأسيسي بواسطة رشاش ميكانيكي ويكون الأسفلت بدرجة حرارة (45-80) درجة مئوية.
ج. يمنع رش الوجه التأسيسي في الأجواء الماطرة وذات الرياح الشديدة أو العواصف الرملية.
ح. يمنع حركة السير على الأسطح المرشوشة.

Table 4

(Prime Coat MC-70) طبقة الوجه التأسيسي

Tests	Limits	Reference Standard
Type of Material	MC - 70	D 2027
Climate temperature	Above 15 C	
Surface to be treated	Sufficiently moist, clean from dust or loose material.	
Climate condition	No fog, rain, storm winds, dusty conditions, or dust storm	
Spraying Temperature	45-80 C	
Rate of application	1.5 Kg/m ²	
Curing period	48-72 Hours	

10- طبقة الوجه الختامي (Bituminous Seal Coat) :

- تتكون المواد التي تستخدم في طبقة الوجه الختامي (Bituminous Seal Coat) من مواد تحقق المواصفات الواردة في الجدول رقم (5) ، والعمل المطلوب هو انجاز هذه الطبقة فوق طبقة الوجه التأسيسي المرشوش فوق طبقة الأساس كما هو مبين بالمقاطع العرضية للطريق ويشمل ذلك تقديم وتوريد ورش الاسفلت اللاصق (RC 800) أو (RC 250) وتقديم وتوريد وتوزيع ودخل مواد الحصة بطريقة مناسبة بحيث تحقق التماسك وحسبما يراه المهندس المشرف .
أ- يستعمل إسفلت (RC 800) أو (RC 250) ومعدل الرش 1.5 كجم/م.
ب- تستعمل حصة بالخواص المبينة في الجدول رقم (5) بمعدل 18 كجم/م².
ج- يجب استعمال موزع حصة ميكانيكي ورشاش إسفلت ميكانيكي .
د- يمنع الرش لمواد الإسفلت في الأجواء الماطرة أو ذات الرياح الشديدة أو العواصف الرملية .

طبقة الوجه الختامي (Bituminous Seal Coat)

Tests	Limit	Reference Standard
Type of Material	Crushed lime stone or basalt or granite.	
Abrasion	Max 35 %	AASHTO T96
Gradation %		AASHTO T27,T11
1/2 "	100	
3/8"	85-100	
#4	10-30	
#8	0-10	
#16	0-5	
#200	0-0.5	
Application rate of aggregates	17 Kg/m2	ASTM D-1369
Bitumen	RC 800 or RC 250	
Application rate of Bitumen	1.5 Kg/m2	

11- الخلطة الإسفلتية الساخنة (Hot Mix Asphalt) :

(1) الخلطة الإسفلتية تكون من نوع (Hot Bituminous Concrete) ويكون الإسفلت المطلوب 70/60.

(2) يجب أن لا تقل درجة الحرارة بعد الفزادة وقبل الدحل مباشرة عن 120 درجة مئوية كما يجب أن تكون درجة حرارة الخلط 158 + 3 درجة مئوية، درجة حرارة قوالب مارشال 148 + 3 درجة مئوية.

درجة الحرارة بعد الفزادة مباشرة هي الدرجة الدنيا التي يجب أن يبدأ عندها الدحل الأولي (Breakdown Rolling) ولا يسمح أن تكون درجة الحرارة أقل من ذلك كما وأنه يجب ملاحظة أن لا تزيد درجة حرارة الخلطة داخل الخلاط عن 160 درجة مئوية وأن لا تزيد درجة حرارة الحصمة عن درجة الإسفلت عند الخلط عن 10 درجة مئوية .

(3) لا تقل درجة الركن عن 97 % من كثافة مارشال المعدل.

(4) مواد التعبئة (Filler) :

يجب أن تكون مادة التعبئة من مواد مسحوقة سحقاً ناعماً كغبار الحجر الكلسي أو غبار الخامات المعدنية أو الإسمنت أو مسحوق الجير المطفأ وأن تكون خالية من الكتل الهشة أو سهولة التفككت ومن المواد العضوية وأن تكون غير لدنة وأن تكون مطابقة للتدرج التالي:

قياس المنخل	النسبة المئوية للمار من المنخل بالوزن
30 #	100 %
50#	100 – 95 %
200#	100-70 %

(5) الخصائص الطبيعية للحصمة والاختبارات (Physical Properties) جميع أنواع الحصمة المستعملة بالخليط يجب أن تطابق المتطلبات الطبيعية المذكورة في الجدول رقم (6).

Table 6
طبقة الخلطة الإسفلتية الساخنة (Hot Mix Asphalt)

Item	Limit	Reference Standard
Type of Material	Lime stone or granite.	
Type of Bitumen	60/70 penetration graded bitumen	
Stability	Min 900 kg	
Flow	2 – 4 mm	
Stiffness	Min 400 kg / mm	
Loss of Stability	Max 25	
V.M.A	Min 13 %	
Asphalt content (Total mix)	As designed	
Air void	3-5 %	
resistance to stripping AASHTO T-182 test Scandinavian test	95% min coating 60 %min coating	otherwise anti stripping agent must be added to achieve the required coating
Compaction	98 %	
Layer Thickness	7 cm after compaction	
Aggregates:		
Abrasion	Max 35 %	AASHTO T96
Ratio of wear loss rev100/rev500	Max 0.22	AASHTO T96
Sand equivalent	Min 50 (Hot bins)	
P.I	N.P (Hot bins)	
Flakiness Index BS 812	Max 25%	
Elongation Index BS 812	Max 25 %	
Clay Lumps and Friable Particles	Max 1 %	
Chert	Max 5%	
Gypsum content	Max 1 %	
Soundness : Na	Max 9 %	
Mg	Max 12 %	
Fractured faces (percent of total weight retained on #4 consists of two or more fractured faces)	Min 90 %	
Gradation %		
1"	100	
¾ "	90-100	
½ "	71-90	
3/8"	56-80	
#4	35-56	
#8	23-49	
#20	14-43	
#50	5-19	
#80	4-15	
#200	2-8	

(6) تدرج خليط الحصى :

أ - يجب أن تكون الحصى ناتج تكسير حجر جيري أو غرانيتي ولا يسمح باستعمال حصى الوديان .

ب - باقي الخواص بما فيها تدرج الحصى حسب المواصفات المرفقة .

ج - على المتعهد أن يقوم بتعديل وضبط خلطاته لتأمين التوزيع النسبي لأنواع الحصى كل على حدة ومادة التعبئة (Filler) والإسفلت من أجل إنتاج خليط نهائي إذا ما تمت مقارنته بمعادلة خليط العمل (حسب تصميم مارشال في المختبر) ضمن الحدود التالية :

التفاوتات القصوى المسموح بها	النسبة المئوية
منخل 3/8 إنش وما فوق	5+ %
منخل # 4 وحتى منخل # 200	4+ %
المر من منخل # 200	1.5+ %
نسبة الإسفلت	0.3+ %

- (7) خصائص الخلطة التصميمية (Marshall Trial Mix) :
- أ- درجة الثبات Stability AASHTO T245 الحد الأدنى 750 كجم
 - ب- (الزحف) Flow Test 1245 (8/100 – 16/100) من الإنش
 - ج- نسبة الفراغات الهوائية في الخليط الإجمالي (3-5) % .
 - د- النقص في درجة فقدان الثبات حسب فحص مارشال للعينات المنقوعة في ماء حرارته 60 م لمدة 24 ساعة بالمقارنة مع درجات الثبات التي تقاس بعد الغمر في ماء حرارته 60 م لمدة 30 دقيقة (Loss Of Stability) 25% الحد الأعلى .
 - هـ- نسبة الفراغات المعدنية VMA محسوبة بطريقة معهد الإسفلت الأمريكي (MS-2) : 13% حد أدنى الطبقة السطحية ، 12% حد أدنى الطبقة الرابطة .

- (8) تخضع الحصمة للفحوصات التالية :
- فحص التسلخ (Stripping Test) حسب (ASTM 1664) ويشترط نجاحها بتحقيق نسبة تغطية لا تقل عن 95 % .
 - فحص التسلخ الديناميكي (Dynamic Test) حسب الطريقة الإسكندنافية ويشترط نجاحها بتحقيق نسبة تغطية لا تقل عن 60% ، وفي حالة عدم تحقيق النتائج المطلوبة لأي من الفحصين أعلاه يجب إضافة مواد تساعد على التماسك (Anti Stripping Agent) حسب تعليمات الشركة الصانعة وبالنسبة التي يقررها المهندس .
 - استعمال الخلطة الإسفلتية (Batch Plant) الأتوماتيكية وعدم استخدام (Continuous Plant) أو (Dryer Drum Mix Plant) .
 - أن لا تزيد نسبة الصوان عن 5 % .

- (9) يتم عمل تصميم جديد في أي من الحالات التالية :
- إذا نقصت قيمة الثبات الأول أو زادت نسبة فقدان الثبات عن الحدود المطلوبة .
 - إذا تجاوزت معدل الوزن النوعي للحصمة + 0.1 % عن القيمة في التصميم .
 - إذا تجاوز معدل قيمة الكثافة النوعية للخليط - 0.05 عن قيمة الكثافة النوعية للتصميم الأصلي .
 - إذا تجاوزت نسبة إمتصاص الماء + 1% عن القيمة في التصميم .

- (10) سماكة الطبقة : يتم فرش الخلطة بطبقة واحدة وسماكة لا تقل عن 7 سم بعد الدحل بالعرض المحدد لكل طريق على أن تشطف الجوانب بميل (2 أفقي : 1 شاقولي)

- (11) عملية الدحل :
- أ- يجب أن يتم الدحل كما هو موضح تالياً إلا إذا كانت هناك وسائل حديثة غير ذلك وحسب موافقة المهندس :
 - ب- يجب أن يتم الدحل الأولي (Breakdown Rolling) بحيث لا تكون درجة الحرارة أقل من 120 درجة مئوية بواسطة مدحلة الحديد مع مراعاة أن تكون العجلات الجارة هي أول ما يدخل على الخلطة .
 - ج- يتم الدحل بعد ذلك بمدحلة الكاوتشوك عندما تكون درجة الحرارة لا تقل عن 90 درجة مئوية لمنع التصاق الإسفلت بالعجلات وبدونها يجب توقيف العمل مع مراعاة إضافة الماء على العجلات بشكل خفيف ولأول وجه دحل فقط ، وعند الضرورة لضمان عدم انخفاض درجة الحرارة للخليط .
 - د- يتم الدحل بعد ذلك (Finishing Rolling) مع ملاحظة أنه لا جدوى من الدحل إذا انخفضت درجة حرارة الخليط عن 70 درجة مئوية وعليه يجب أن ينتهي الدحل النهائي قبل وصول حرارة الخليط إلى هذه الدرجة .

- 12- أعمال الأطارييف الخرسانية :
- (1) بعد انتهاء تنفيذ طبقة أساس الطرق حسب المخططات وقبل البدء بتنفيذ الأسفلت يجري تنفيذ أعمال الأطارييف الخرسانية .
 - (2) يتم تحديد الاستقامات مساحياً ومن ثم تبدأ أعمال الأطارييف الخرسانية .
 - (3) تشمل أعمال الأطارييف الخرسانية الحفر وتقديم وتوريد بناء وحدات الكنדרين وتقديم وتوريد صب خرسانة القاعدة وخرسانة التدعيم خلف الكنדרين ورش الماء وإيناع الخرسانة وكافة ما يلزم وحسب المناسيب والسماكات والميول المبينة في المخططات وحسب توجيهات المهندس .

- (4) الكنדרين:
- أ- الكنדרين يكون من وحدات جاهزة الصنع طول 50 سم ارتفاع 30 سم من خرسانة صنف 25 (25 نيوتن/ ملم² على عمر 28 يوم) وحسب المواصفات الأردنية (JS NO. specified in Jordan standard specification) (479) .
 - ب- يخفض طول الوحدات على طول المنحنيات .
 - ج- يقدم المقاول للموافقة عينة مع شهادة من الشركة المصنعة بمطابقة المواصفات .

- د- لا تعتبر موافقة المهندس على العينة موافقة نهائية ، ويحق للمهندس أن يرفض أي وحدات في الموقع التي لا تستوفي المواصفات المطلوبة
- ه- يتم رش الكنדרين بالمياه قبل مباشرة البناء ، يتم بناء الوحدات بدقة في امكانها بمونة أسمنتية على القاعدة الخرسانية.
- و- مونة البناء والتكحيل تكون من الأسمنت والحصمة الناعمة بنسبة 1 : 3
- ز- الأسطح تكون مستقيمة وموحدة اللون، خالية من الشقوق والثقوب وأي عيوب.

- (5) صبة النظافة:
- أ- القاعدة الخرسانية تنفذ في طبقة الأساس حسب المبين في المخططات بعرض 40 سم وارتفاع 10 سم من خرسانة صنف 15 (15 نيوتن/ ملم² على عمر 28 يوم).
- ب- يتم ايناع الخرسانة لما لا يقل عن 7 أيام قبل بناء الكنדרين.

- (6) خرسانة التدعيم
- أ- بعد بناء الكنדרين يتم صب جسر من الخرسانة خلف الكنדרين وفوق القاعدة الخرسانية عرض 20 سم وارتفاع 15 سم من خرسانة صنف 15 (15 نيوتن/ ملم² على عمر 28 يوم).
- ب- يتم ايناع الخرسانة لما لا يقل عن 7 أيام
- (7) جميع الاعمال أسفل وضمن وعلى جانبي الأطارييف الخرسانية وكما ورد في الفقرات (1) الى (6) أعلاه تعتبر مشمولة ضمن سعر الأطارييف الخرسانية في جدول الكميات

13- منطقة الرصيف

منطقة الرصيف خلف الكنדרين تكون حسب مخطط المقطع النموذجي ، و يراعي انتظام الميل الطولي لتصريف مياه الأمطار ويتم توريد وفرش ورش ودحل طبقة بيس كورس سماكة (20 سم) خلف حجر الكنדרين حسب المخططات وتعليمات المهندس المشرف.

14- أعمال شبكة تصريف مياه الامطار:

- (1) يتم تحديد الموقع والمسار مساحياً وتحديد مناسيب المدخل والمخرج على الواقع والمقارنة مع المخططات لتصويب أي اختلاف واعداد مخطط التنفيذ وأخذ الموافقة عليه من المهندس ومن ثم تبدأ أعمال فتوح وتسوية الأرض الطبيعية لمسار المواسير للمنسوب والميل حسب المخططات.
- (2) في حالة الحفر عرض الفتوح والتسوية يساوي قطر الماسورة الخارجي + 40 سم.
- (3) في حالة الطمم عرض الفتوح والتسوية يساوي قطر الماسورة + 40 سم + مسافة العمل المناسبة من كل جانب + مسافة من كل جانب تساوي ضعف عمق الطمم اللازم.
- (4) في حالة الحفر يتم بعد الخلط المناسب بالماء دك التربة لتعطي درجة دك لا تقل عن 95% من كثافة بركتور المعدل.
- (5) في حالة الحفر يتم فرد ودك طبقة من الرمل (silica sand) بسمك 10 سم وبعرض الحفر.
- (6) في حالة الطمم يتم بعد الخلط المناسب بالماء دك التربة لتعطي درجة دك لا تقل عن 95% من كثافة بركتور المعدل ثم يتم فرد ودك طبقات الطمم بميل جانبي 1:2 للوصول الى المنسوب والميل حسب المخططات ، طبقات الطمم حسب مواصفات مواد الطمم المبينة تالياً.
- (7) في حالة الطمم وبعد انهاء طبقات الطمم يتم فرد ودك طبقة من الرمل (silica sand) بسمك 10 سم بعرض يساوي قطر الماسورة + 20 سم من كل جانب فوق طبقات الطمم.
- (8) يتم القيام بأعمال تمديد المواسير بالمنسوب والميل حسب المخططات وتجهيز وتأمين وضع المواسير عند المدخل وعند المخرج
- (9) في حالة الحفر يتم فرد ودك طبقة من الرمل (silica sand) بالتساوي على جانبي المواسير للمسافات المبينة أعلاه حتى ارتفاع 30 سم فوق المنسوب العلوي للماسورة وبعرض الحفر.
- (10) في حالة الطمم يتم فرد ودك طبقة من الرمل (silica sand) بالتساوي على جانبي المواسير للمسافات المبينة أعلاه حتى ارتفاع 30 سم فوق المنسوب العلوي للماسورة وبالتزامن مع أعمال طمم الطريق.
- (11) مواد الطمم يجب أن تحقق المواصفات التالية :
- أ- تبدأ أعمال الطمم بعد تجهيز التربة في مواقع الطمم .
- ب- لا تزيد سماكة أي طبقة عن 20 سم بعد الدحل .
- ج- درجة الرك لا تقل عن 95% من كثافة بركتور المعدل وذات C.B.R لا يقل عن 20%
- د- الكثافة الجافة العظمى لا تقل عن 1.7 غم/سم³ .
- ه- المواد العضوية لا تزيد عن 5% حسب طريقة (AASHTO (T267 .
- و- يسمح بخلط مواد ناتج الحفريات الصالحة مع مواد موروثة من خارج الموقع لاستخدامها في أعمال الطمم بحيث تحقق المواصفات أعلاه.
- ز- في حالة إحتواء مواد ناتج الحفر على مواد عضوية وأعشاب وجذور فإنها تعتبر غير صالحة ويمنع استعمالها في أعمال الطمم.

(12) في حالة صعوبة الرك حول المواسير يسمح للمقاول استعمال خرسانة بحيث لا تقل كمية الإسمنت في المتر المكعب عن 150 كغم.

(13) تكون مواسير من البولي اثيلين قطر داخلي 300 ملم حسب المواصفة (ISO 4427 1-2007 PN16) (HDPE)

(14) أعمال الطمم فوق المنسوب بارتفاع 30 سم فوق ظهر المواسير تكون ضمن بنود أعمال الطرق.

(15) جميع الاعمال أسفل وعلى جانبي وأعلى مواسير شبكة التصريف وحتى منسوب بارتفاع 30 سم فوق ظهر المواسير وكما ورد في الفقرات (1 الى 14) أعلاه تعتبر مشمولة ضمن سعر مواسير العبارات في جدول الكميات.

15- أعمال الخرسانة وحديد التسليح لمناهل تصريف مياه المطر

- (1) الإسمنت المستخدم في أعمال المشروع هو الإسمنت المقاوم للأملاح والكبريتات.
- (2) الحديد المستخدم في أعمال المشروع يكون:-
أ- شد 40 للقضبان ذوات الأقطار 8 ملم.
ب- شد 60 للقضبان ذوات الأقطار 10 ملم وما فوق.
- (3) تشمل الأعمال الحفريات وتقديم وتوريد وصب الخرسانة مع حديد التسليح ورش الماء وإيناع الخرسانة حسب المناسيب والسمكات والميول المحددة في المخططات.
- (4) يتم تحديد الموقع مساحياً ومن ثم تبدأ أعمال الحفريات والتسوية للمنسوب والميل حسب المخططات مع ضرورة أن يكون مستوى التربة الذي يستقبل أرضية مناهل التصريف ذا خصائص هندسية متجانسة مناسبة ويتم إجراء المعالجة لها في حالة تركيزها على تربة ذات خصائص هندسية ضعيفة.
- (5) يتم رك طبقة التربة الذي يستقبل أرضية مناهل التصريف بعد الخلط المناسب بالماء لتعطي درجة رك لا تقل عن 95% من كثافة بركتور المعدل.
- (6) يتم تأمين واحكام مدخل ومخرج المواسير ضمن طوبار مناهل التصريف.
- (7) يستخدم الطوبار المناسب لإعطاء سطح أملس (Fair Face) للأجزاء الظاهرة خالية من التعشيش لجميع العناصر انشاء مناهل التصريف
- (8) حديد التسليح يكون صنف (40) (Grade 40) للأقطار 8 ملم أو صنف (60) (Grade 60) للأقطار أكبر من 8 ملم وحسبما هو مذكور في المخططات على أن يكون من النوع المبروم ويجوز استخدام الحديد الأملس في الحالات التي تبيينها المخططات. يجب أن يكون حديد التسليح نظيفاً خالياً من الصدأ وأن يحفظ في أماكن تخزين مناسبة بعيداً عن الرطوبة ومرفوعاً عن سطح الأرض لحين استخدامه في أعمال الإنشاء.
- (9) الخرسانة صنف 25 (25 نيوتن/ملم² على عمر 28 يوم) ، وإيناعها لفترة زمنية حسب مواصفات إنشاء الطرق والجسور ولا يقل عن 7 أيام.
- (10) يبدأ الطمم بعد 28 يوم من انتهاء اعمال صب الخرسانة وأوصلها على القوة المحددة.
- (11) الطمم حول مناهل التصريف بمواد طمم حسب المواصفات التالية :
أ- لا تزيد سماكة أي طبقة عن 20 سم بعد الدحل .
ب- درجة الرك لا تقل عن 95% من كثافة بركتور المعدل وذات C.B.R لا يقل عن 20%
ج- الكثافة الجافة العظمى لا تقل عن 1.7 غم/سم³ .
د- المواد العضوية لا تزيد عن 5% حسب طريقة AASHTO (T267) .
هـ- يسمح بخلط مواد ناتج الحفريات الصالحة مع مواد موردة من خارج الموقع لاستخدامها في أعمال الطمم بحيث تحقق المواصفات أعلاه.
و- في حالة إحتواء مواد ناتج الحفر على مواد عضوية وأعشاب وجذور فإنها تعتبر غير صالحة ويمنع استعمالها في أعمال الطمم.
ز- يتم تهذيب الميول الترابية حسب الميول المبينة في المخططات.
- (12) لا يدفع مقابل الحفريات وأعمال الردم حول مناهل تصريف مياه الامطار وتعتبر محملة على سعر الخرسانة.
- (13) أعمال الطمم فوق المنسوب بارتفاع 30 سم فوق ظهر المواسير تكون ضمن بنود أعمال الطرق.
- (14) جميع الاعمال أسفل وضمن وعلى جوانب مناهل تصريف مياه الامطار والطمم حتى منسوب بارتفاع 30 سم فوق ظهر المواسير وكما ورد في الفقرات (1) الى (14) أعلاه تعتبر مشمولة ضمن سعر الخرسانة المسلحة في جدول الكميات.

ثامنا: مواصفات الدهان الساخن والحبيبات الزجاجية

No.	Index	Specs
1	touch dry time زمن الجفاف عند درجة حرارة 32 مئوية عند درجة حرارة 10 مئوية	AASHTO M249 اقل او تساوي 10 دقيقة اقل او تساوي 2 دقيقة
2	(binder)نسبة المواد الرابطة the proportion of the bonding material	ASTM-D4797 %18
3	عامل النصوص بعد الاستقرار الحراري luminance factor	AASHTO M249 White min. 65% Yellow min. 45%
4	مقاومة التشقق عند درجة الحرارة المنخفضة	AASHTO M250 لا تحدث أية تشققات او كسر
5	Specific gravity الوزن النوعي	ASTM –D792 اقل او تساوي 2.15 عند درجة حراره 23 مئوية
6	مقاومة الاحتكاك	BS 6088A Less than 0.5 gram
9	water resistance مقاومة المياه	BS 6088A yes
10	flow resistance مقاومة الزحف	BS 3262 Not more than 28%
11	نسبة الكريات الزجاجية الصلبة	ASTM-D4797 40-30%
12	flash point نقطة الوميض	ASTM –D92 اكثر من 230 درجة مئوية
13	softening point نقطة التلين	ASTM-D36/D36M 112-93 درجة مئوية
15	مقاومة الصدم Crash resistance	ASTM –D256 اكبر او تساوي 1.13 جول
16	التدرج للحبيبات الزجاجيه gradation	%100-95 0.850mm no (20) 75-95 % 0.600mm no (30) 15-35 % 0.300mm no 50 0-5 % 0.15mm no 10 AASHTO M247
17	الاستدارة للحبيبات الزجاجية Roundness	AASHTO M247 >75%

No.	Index	Specs
18	silica contain محتوى السيليكا t للحبيبات الزجاجية	ASTM 141 > 60%
19	Flotation معامل الطفو للحبيبات الزجاجية	AASHTO 1213 > 90 % Beads shall float In x y line.
20	Composition التركيب للحبيبات الزجاجية	BS 6088 B Sodium lime glass
21	Reflection معامل الانكسار index By soda lime glass test للحبيبات الزجاجية	ASTM-D1155 > 1.5
22	Specific الوزن النوعي gravity للحبيبات الزجاجية	BS 6088 B 2.4 - 2.6 gr/cm

SECTION 16000

ELECTRICAL - GENERAL PROVISIONS

PART 1 - GENERAL

1.01 SCOPE OF WORK

A. This Specification covers the methods, materials and standards that shall be used for the electrical, telecommunication, works for building services designated hereinafter by electrical works of First Supermarkets Co.

1.02 EXTENT OF WORK

- A. The extent of the electrical works includes the supply of materials and equipment, delivery to site, labor, installation, testing and commissioning of all electrical services as detailed or referred to in these specifications and/or shown on the drawings, including all other associated work such as supporting structure and ancillary works, attendance, etc., and the like. Unless otherwise specifically indicated, the work shall also include the supply of electrical power to all electrically operated equipment. The electrical power supply point of all stationary electrically operated equipment shall be the supply terminal box on the equipment or its nearby isolating/starting device if the equipment is supplied with a flexible cable and ready for connection. The electrical services shall be complete and in perfect working order.
- B. All equipment and/or accessories not specifically mentioned in the specifications or noted on the drawings, but which are obviously necessary for the proper and normal operations of the various systems shall be included. The Contractor shall provide and execute such works as a part of the contract and shall not be entitled to any extra payment on the account.
- C. Without restricting the generality of the foregoing, the electrical installation of the project includes the supply and installation and testing the equipment and materials detailed in the following specification sections:
 - 1. Equipment Electrical Connections
 - 2. Electrical Raceway Systems (conduits, trays, ladders, trunks)
 - 3. Wires and Cables
 - 4. Distribution Boards
 - 5. Telephone
 - 6. Outdoor Light
- D. All work shall be carried out strictly in accordance with this Specification, other applicable project particular specifications and design drawings.
- E. The Contractor shall carry out a thorough inspection of all items of electrical equipment for damage prior to locating the equipment and proceeding with the electrical installation. If any damage is evident or suspected, it shall be reported to the Engineer, who will determine the action to be taken and advise the Contractor accordingly.
- F. No variation shall be permitted without the written consent of the Engineer, who shall reserve the right to request the substitution of the correct materials and/or equipment. Should any replacement be deemed necessary by the Engineer, then the Contractor shall bear the cost of

- substitution, and all of associated builder's work and the making good of finishes attributed to the work or replacement.
- G. Any materials and/or apparatus that are supplied by others for installation and/or connection by the Contractor shall be examined on receipt to locate any possible defects in such materials and/or apparatus. Should any defects be found the Contractor shall immediately notify the Engineer to ascertain what action is necessary. The Contractor shall also allow for storing, putting into position, fixing where necessary, connecting and testing such materials and/or equipment.
 - H. The Contractor shall be responsible for the full protection of all materials supplied to him, or handed to him by others, for incorporating in the works against damage or loss until the works are handed over to the Engineer.
 - I. If the Contractor refuses or neglects to remedy, in a stipulated period, that which the Engineer considers to be in accordance with the General and Particular Specifications and/or associated schedules, and/or associated drawings, to be caused by bad workmanship the Engineer may, if he wishes, arrange for the work to be carried out by others and be entitled to deduct the amount paid from the Contract sum.
 - J. Materials shall be in accordance with the General and Particular Specification herein. Where a standard is not specified, materials shall be warranted for fitness of purpose under the conditions shown and specified.
 - K. Materials to be supplied by the Contractor shall be available on site by the date stipulated in the bar chart. Any airfreight costs to meet these dates shall be for the Contractor's account.
 - L. Where equipment or products are specified to conform to the requirements of a testing agency and labeling service of such agency is offered for such equipment or product, the proper label shall be attached to the equipment or product as proof of conformance.
 - M. Unless specifically waived in each instance, testing procedures shall be performed in the presence of the Engineer.
 - N. Materials and devices shall be inspected prior to installation by the Engineer as part of the work of this section before and after installation to ensure that they are of the quality and type specified herein, free of manufacturing defects and subsequent damage, and that they have been installed in the proper manner.
 - O. In all aspects the quality of equipment and documentation shall be governed by BS 5750: Quality Systems/ISO 9000 to ISO 9004.
 - P. The Contractor shall obtain the approval of the local authority for all electrical and telephone work to be undertaken. Any modification required by the local authority shall be deemed include in the contractor cost.

1.03 CODES AND STANDARDS

- A. All materials and equipment used in electrical installations shall comply as a minimum with the latest relevant recommendation(s) or specification(s) of the local authority. In the absence of such recommendation(s) or specification(s) all such materials shall comply with the latest recommendation(s) or specification(s) of the British Standard Specifications (BSS) and if these are not available to the latest relevant International Electro-Technical Commission (IEC). If standards mentioned above contradict with the specification then the requirements of this specification shall apply.

- B. Electrical installation shall conform to the latest editions and is to be executed in accordance with the following codes and standards.
 - 1. BS 7671 - Requirements for Electrical Installations.
 - 2 IEC 60621 - Electrical Installations for outdoor site under heavy conditions.

In case of any discrepancy or conflict between BS and IE C standards the former shall prevail unless otherwise approved by the Engineer. The entire completed electrical installations shall be to the satisfaction of the Engineer.
- C. Reference to codes and standards in the Contract Documents shall be deemed to include the latest edition or issue of such codes and standards except when specifically indicated.
- D. When codes or standard are not specifically mentioned in the Contract Documents, work, materials, equipment, performance, in-shop and at-site tests, installation and manufacturing methods shall conform as a minimum to acceptable relevant national or international codes and standards.
- E. If the Contractor wishes to adopt codes or standards other than those particularly specified, he may do so provided they are not less stringent than BSS /IEC and that he submits complete data with respect to such codes or standards and meet as a minimum, the specified codes and standards. The Contractor shall submit tabulated lists of the differences between the codes and standards proposed and those specified and shall obtain prior approval in writing from the Engineer.
- F. If more than a single degree of quality or accuracy is permitted within the scope of a particular code or standard, the highest quality shall be applicable unless otherwise noted in the Contract Document and the degree of accuracy commensurate with the intended function shall be selected but with the understanding either case, that the decision as to the degree will be made finally by the Engineer.

1.04 DRAWINGS

- A. The electrical drawings issued with the specification, indicate general arrangements of electrical equipment, cable trenches and cable routes, location of panels, cable schedules, wiring/schematic diagrams. Drawings issued, will also indicate any other relevant details relating to the particular project. The information given on the drawings is as accurate as surveys and planning can determine. Total accuracy however, cannot be guaranteed. Field conditions should be checked and electrical work shall be properly laid out, for maximum efficiency and to avoid any conflict with structures and any other work. Each item shall be verified for proper action and position before final connections are made.

1.05 SUBMITTALS

- A. The Contractor shall submit to the Engineer, in accordance with Section 01300 Submittals, shop drawings and catalogs for equipment, materials and other items furnished under Division 16.
- B. Equipment Shop drawings and engineering catalogues shall be submitted for the following equipment and systems as applicable and as specified in each section
 - 1) Distribution Boards
 - 2) LV Switchgear/Control gear
 - 3) Factory Assemblies of Switchgear /Control gear

- 4) Control Panels
 - 5) Lighting Fixtures and Lamps
 - 6) Control Equipment
- C. The Contractor shall check catalogues and shop drawings for accuracy and contract requirements prior to submittal. Shop drawings shall be stamped with the date checked and a statement indicating that the shop drawings conform to the Specifications and Drawings. This statement shall also list all exceptions to the Specifications and Drawings. Shop Drawings not so checked and noted shall be returned.
- D. The Engineer's check shall be for conformance with the design concept of the project and compliance with the Specifications and Drawings. Errors and omissions on approved shop drawings shall not relieve the Contractor from the responsibility of providing materials and workmanship required by the Specifications and Drawings.
- E. All dimensions shall be field verified at the job site and coordinated with the work of all other trades.
- F. The Shop Drawings shall show the position, dimensions, scheme, arrangement and fixing of all electrical equipment.
- G. Material shall not be ordered or shipped until the shop drawings have been approved. No material shall be ordered or shop work started if shop drawings are marked "APPROVED AS NOTED - CONFIRM", "APPROVED AS NOTED - RESUBMIT" or "NOT APPROVED".
- H. In addition to manufacturer's equipment shop drawings, submit electrical installation working drawings as follows:
1. The Contractor shall prepare based on the Contract drawings the electrical installation working drawings to a scale agreed on with the Engineer and shall issue them in accordance with the requirements of the Contract having due regard to the time required for approval procedures.
 2. Allowance shall be deemed to have been included in the Tender for the preparation of the working drawings and for executing any revisions required as directed by the Engineer and for re-submitting to the Engineer for approval.
 3. The Contractor may, in certain cases only, and with the Engineer's permission, complete and detail some of the Contract drawings and use them as working drawings, but the Contractor shall be deemed to accept full responsibility in so doing.
 4. The electrical installation working drawings shall show the position, dimensions, scheme arrangements and fixing of all electrical equipment. The drawings shall comprise, but are in no way, limited to the following:
 - Dimensioned drawings of cable routing showing accurately layouts of cables installations and their spatial relationship to associated equipment and details of installation.
 - Dimensioned drawings showing accurately scaled layouts of the location of the equipment and their spatial relationship to associated equipment.
 - Dimensioned drawings showing layout of the exact routing of all main earth/earth loops, details of connectors, earth pits and spatial relationship to associated equipment.
 - Dimensioned drawing of fire alarm, telephone systems and all other auxiliary systems showing layout plans of all equipment,

associated equipment.

- Wiring diagram schematic.
- Specific architectural or civil engineering requirements associated with the electrical installation including substations, generator rooms, electrical closets shall be detailed on the drawings.

Checking of the Contractor's working drawings and builder's work drawings by the Engineer shall not relieve the Contractor of his responsibilities for compliance with the design intent, coordination or with any other obligations and requirements under the contract

I. Operation and Maintenance Manual

1. Submit operations and maintenance data for equipment furnished under this Division, in accordance with section 01700 Contract close out. The manuals shall be prepared specifically for this installation and shall include catalog data sheets, drawings, equipment lists, descriptions, parts lists, etc., to instruct operating and maintenance personnel unfamiliar with such equipment.
2. Manuals shall include the following as a minimum:
 - a. A comprehensive index and drawing lists.
 - b. A complete "As-Built" set of approved shop and working drawings.
 - c. A complete list of equipment supplied, including serial numbers, ranges and pertinent data.
 - d. A table listing of the "as left" settings for all timing relays and alarm and trip set points.
 - e. System schematic drawings "As-Built", illustrating all components, piping and electric connections of the systems supplied under this Section.
 - f. Detailed service, maintenance and operation instructions for each item supplied.
 - g. Special maintenance requirements particular to this system shall be clearly defined, along with special calibration and test procedures
 - h. The operating instructions shall also incorporate a functional description of the entire system, with references to the systems schematic drawings and instructions.
 - i. Complete parts list with stock numbers, including spare parts.
 - j. Warranty Certificate.

1.06

AS-BUILT DRAWINGS

- A. The Contractor shall demonstrate from time to time, as required by the Engineer, during the execution of the Works that adequate and accurate records are being kept such as will ensure the ultimate completeness and accuracy of the As-Built Drawings and that the records drawings are themselves being progressively completed as the work proceeds on Site.
- B. The Contractor will be responsible for the preparation of "As Built" Drawings and will supply these bound in folios in accordance with the Engineer's instructions and to the Engineer's and Client's satisfaction. The finished As Built Drawings are to be of a high standard.
- C. All drawings prepared or amended by the Contractor to show the Works as constructed shall be known as "As Built" Drawings. All such drawings shall be prepared using S.I. Units and shall have the size of

the Contract Drawings. Reproducible copies shall be on cd, 6 copies white paper.

- D. Not more than 4 weeks after the date of the completion of the inspections or such other period of time as may be agreed with the Engineer, the Contractor will submit for the Engineer's approval two paper prints of each of the drawings.
- E. After checking the prints of "As Built" Drawings submitted by the Contractor the Engineer will return to the Contractor one copy marked to show his signed approval or comments.
- F. In the event of the Engineer's approval not being given, the Contractor shall alter the drawings in accordance with the Engineer's specific comments and shall re-submit them to the Engineer within a period of 2 weeks from receipt by the Contractor of the Engineer's comments.
- G. When the contractor has obtained from the Engineer a signed approved paper copy prints of each "As Built" Drawing, the Contractor will provide to the Engineer a reproducible copy of each approved "As Built" Drawing which the Engineer shall check and sign approved and return to the Contractor. The Engineer's approval of "As Built" Drawings shall in no way relieve the Contractor from his responsibility for ensuring the accuracy of all information shown on all such drawings.
- H.
 - 1. Following receipt of the signed approved reproducible "As Built" Drawings the Contractor shall supply to the Engineer Two (3) sets of reproducible copies of all approved and signed "As Built" Drawings bound and presented in drawing folios as described hereunder.
 - 2. A complete set of Contractor's "As Built Drawings" shall be submitted in ACAD format in duplicate on computer diskettes or laser disk.
- I. All folio prints and reproducible copies so presented shall not only accurately represent the "As Built" condition of the Works but shall also comply with the following specific requirements:
 - 1. All "As Built" prints and reproducible copies shall be completely legible with title block in bottom right hand corner.
 - 2. The drawing index page of the folios shall be sub-divided in accordance with the Engineer's instructions.
 - 3. All proprietary materials and equipment will be clearly identified on the drawings by reference to the manufacturer's name and reference number sufficient to enable identification.
 - 4. All abbreviations on drawings shall be identified on a list of symbols.
 - 5. All references on drawings to standard details, bending schedules and other layouts or details shall be checked for correctness or cross-reference. Any such items referred to on a drawing shall be made available as part of the "As Built" information.

6. Any drawings of a size larger than the size of the contract drawings shall be photographically reduced to this size and clearly marked "THIS DRAWING HAS BEEN PHOTOGRAPHICALLY REDUCED".
7. Drawings smaller than this size shall each be printed on this size sheets such that the title block appears on the bottom right hand corner of the drawing.
- J. Binding of the "As Built" Drawings shall be as follows or as otherwise instructed by the Engineer:
 1. Each set of the paper printed and reproducible copies of the signed approved "As Built" Drawings shall be unfolded and securely bound along one short edge.
 2. The maximum overall thickness of drawings held by each bind shall not exceed 25mm
- K. The "As Built" Drawings shall accurately show the installed conditions of:
 1. All equipment, conduits, trenches, lighting fixture
 2. Circuit lists for each distribution board and such lists shall agree with lists fixed within distribution board doors.
 3. Positions and nature of all earth electrodes installed and the route of the connecting copper conductors.
 4. Schematic diagrams, single line diagram, control wiring diagram and lighting fixture schedule, distribution board schedules, cable schedules,
 5. Indicate all plant room installations in drawings to scale 1:50.
 6. Legends which shall detail the symbols used and which shall conform in style and standard to those used in the working drawings.
 7. Underground raceway and duct bank routing.
 8. Plan view, sizes and locations of switchgear, transformers, motor control center, and diesel driven generator.

1.07 DOCUMENTS COORDINATIONS

- A. The general condition of the contract and any special conditions shall be equally applicable to the Electrical works in as far as they are applicable and in case of discrepancy, these particular conditions will be applied.
- B. The drawings, specifications and bills of quantities are complementary and any materials, equipment or work called for by any one document shall be considered as if called by both of them. Should any conflict occur between the drawings, specifications and bills of quantities, then the Engineer shall interpret them and determine the manner or item with which the work shall be carried out.
- C. If any deviation or departure from the drawings and specifications is deemed necessary by the Contractor for the proper and safe execution of the works, details of such departure or deviation and the reasons thereof, shall be submitted as soon as practical to the Engineer for approval. No such departures/ deviations shall be made without the prior written approval of the Engineer.

Tender Documents

1.08

PRIORITY OF THE CONTRACT DOCUMENTS

- A. If, during the performance of the work, the Contractor finds a conflict, error or discrepancy between or among one or more of the Section or between or among one or more Sections and the Contract Drawings, furnish the higher performance requirements. The higher performance requirements shall be considered the equipment, material, device or installation method, which represents the most stringent option, the highest quality or the largest quantity.
- B. In all cases, figured dimensions shall govern over scaled dimensions, but work not dimensioned shall be as directed by the Engineer and work not particularly shown, identified, sized or located shall be the same as similar work that is shown or specified.
- C. Detailed Drawings shall govern over general drawings, larger scale Drawings take precedence over smaller scale Drawings, Change Order Drawings shall govern over Contract Drawings and Contract Drawings shall govern over Shop Drawings.
- D. If the issue of priority is due to a conflict or discrepancy between the provisions of the Contract Documents and any referenced standard, or code of any technical Society, organization or association, the provisions of the Contract Documents will take precedence if they are more stringent or presumptively cause a higher level of performance. If there is any conflict or discrepancy between standard specifications, or codes of any technical society, organization or association, or between the Laws and Regulations, the high-performance requirement shall be binding on the Contractor, unless otherwise directed by the Engineer.
- E. In accordance with the intent of the Contract Documents, the Contractor accepts the fact that compliance with the priority order specified shall not justify an increase in Contract Price or an extension in Contract Time nor limit in any way, the Contractor's responsibility to comply with all Laws and Regulations at all times.

1.09

INTERPRETATION OF DRAWINGS

- A. The Drawings are not intended to show exact locations of the electrical equipment. The Contractor shall coordinate the electrical installation with other trades and the actual supplied equipment at no additional cost for the Owner.
- B. Install each 3-phase circuit in a separate conduit unless otherwise shown on the Drawings.
- C. Unless otherwise approved by the Engineer, conduit shown exposed shall be installed exposed; conduit shown concealed shall be installed concealed.
- D. Verify the exact locations and mounting heights of equipment, lighting fixtures, switches and receptacles prior to installation.
- E. Except where dimensions are shown, the locations of equipment, fixtures, outlets and similar devices shown on the Drawings are approximate only. Exact locations shall be determined by the Contractor and approved by the Engineer during construction. Obtain information relevant to the placing of electrical work and in case of any interference with other work, proceed as directed by the Engineer and furnish all labor and materials necessary to complete the work in an approved manner.

Tender Documents

- F. The electrical characteristics of the electrically operated equipment are given for guidance only. It is the Contractor's responsibility to get the exact rating of the equipment to be installed and to modify the electrical circuits accordingly at no additional expense to the Owner.
- G. Redesign of electrical or mechanical work, which is required due to the Contractor's use of an alternate item, arrangement of equipment and/or layout other than specified herein, shall be done by the Contractor at his own expense.
- H. Redesign and detailed plans shall be submitted to the Engineer for approval. No additional compensation will be provided for changes in the work, either his own or others, caused by such redesign.

1.10 INSPECTIONS AND TESTS

- A. Inspections and tests of materials, equipment or any part thereof and workmanship shall, if required by the Engineer, be carried out in the presence of the Engineer, his representatives or his appointed inspectors at any stage of manufacture or assembly and the Contractor shall serve adequate written notice to the Engineer of the proposed dates and locations of such inspections and tests. Such written notice shall be serviced to the Engineer not less than twenty-one (21) calendar days prior to the date of such inspections and tests. The Contractor shall provide competent personnel and all apparatus, instruments, etc., necessary for such inspections and tests.
- B. No inspections or test shall be carried out unless the Contractor has in hand, approved drawings and data of the equipment or materials to be inspected or tested.
- C. The Contractor shall submit for the Engineer's review, an inspection and tests schedule detailing tests intended to be conducted at the manufacturer's works. Such schedule shall show the proposed date and location of inspection and tests.
- D. The Contractor shall supply any shop or detailed drawings that may be requested by the Engineer, his representatives or his inspectors during inspection and testing carried out in his or their presence.
- E. Materials, equipment or parts thereof, that do not meet the requirements of the Contract Documents shall be rejected, removed, replaced, revised and/or retested, whichever applies, until the final product meets the requirements of the Contract Documents. All work performed to satisfy these requirements and conditions shall be the sole responsibility of the Contractor. The presence of the Engineer, his representatives or inspectors during inspections and tests shall not relieve the Contractor of his responsibilities and obligations under the Contract Documents.
- F. All inspections and tests shall be in accordance with the requirements of the Contract Documents, and the relevant approved codes and standards unless otherwise requested or approved by the Engineer.
- G. Three copies of all test certificates and data shall be supplied to the Engineer. The Contractor shall bear all costs associated with the aforesaid.
- H. In addition to the test listed in the various sections of the Specifications the Contractor shall carry out all other tests required in Part 7 of BS 7671/ IEC60364-6-61 and shall subsequently prepare and submit to the Engineer 6 copies of tests and completion certificates in the form as described in Appendix 6 of BS 7671 all duly signed, and prior to the installation being

commissioned.

- I. The Contractor shall make the following checks prior to energizing electrical equipment:
 1. Check wire and cable terminations for tightness.
 2. Check interlocking, control and instrument wiring for each system and/or part of a system to prove that the system will function properly as indicated by schematic and wiring diagrams.
 3. Verify all terminations at transformers, equipment, panels and enclosures by producing a U, V, W rotation on a phase sequenced motor when connected to "R", "Y", "B" phases.

1.11 EQUIPMENT IDENTIFICATION

- A. All items of electrical distribution equipment and cables, including local disconnectors and switches controlling fixed equipment and appliances, shall be fitted with identification labels and notices as instructed by the Engineer. These labels shall bear the equipment designation as shown on the "As-Built" Drawings plus the supply voltage, phase, frequency and distribution circuit number.
- B. Switchgear shall (in addition to the identification labels) be fitted with a stainless-steel plate fixed in a prominent position and engraved "DANGER VOLTS" together with the generally adopted "double flash" danger signal. A number indicating the nominal system shall prefix the word "VOLTS". The letters shall be 12mm minimum height in signal red code 537 to BS 381C.
- C. In addition, each distribution board shall have a typed chart detailing particular of the circuit controlled which shall be fixed to the inside of the door. A sheet of transparent rigid plastic shall be used to completely cover this chart to prevent damage.
- D. The interior of each item of 3-phase equipment shall be clearly marked to show the phases. For this purpose, either colored plastic discs screwed to fixed components or identification by means of colored plastic sleeving shall be employed.
- E. All labels and notices shall be engraved in the English language. Danger labels shall be engraved in Arabic and English.
- F. All cabinets and boxes shall bear clear external marking of their function and the areas covered.
- G. All barrier strip outlets and inputs from main equipment shall be labelled as above by means of solidly mounted engraved plastic strips held in by means of non-corroding flush head screws.
- H. All labels shall be of two- or three-layer laminated plastic, and shall be fixed by means of screws.
- I. General information labels must have block characters on a white background with characters not less than 6 mm high.
- J. Warning labels must have black characters on a yellow background with characters not less than 8 mm high and not more than 25mm.
- K. Mandatory labels must have white characters on a blue background with characters not less than 8 mm high and not more than 25mm.
- L. A main function label shall be fitted centrally on each junction box and motor stating the device number and labelled under the heading it appears on the electrical schematic/wiring diagram.
- M. All control devices such as hydraulic and pneumatic valves, pressure switches and limit switches shall be fitted with labels located adjacent to the unit detailing the device or switch number as it appears on the

schematic/wiring diagram.

- N. All fuse boards, distribution boards, switchboards and motor control centers shall be fully labelled, a main label shall be fixed to the front of the board detailing the heading or name it appears on the schematic/wiring diagram and the source of the cable feeding the distribution board.
- O. All sub-circuits in distribution boards and fuse boards shall be correctly and clearly labelled in ink or type setting.
- P. All sub-circuits label diagram attached to the inside of the distribution board cover shall also be marked up to indicate the electrical drawing number of the system being fed from the distribution board.

1.12 PROTECTION OF ELECTRICAL EQUIPMENT

- A. The electrical equipment enclosure shall be classified in accordance with BSEN 60529/IEC 60529 using the IP system and two-digit number code.
- B. All equipment for outdoor use shall be dustproof and weatherproof as classification IP 54 minimum unless otherwise indicated.
- C. All equipment for use in hazardous areas shall conform to the requirements of BS 5345 and BS 5501 and be appropriate to the classification of the hazard.

1.13 COORDINATION WITH OTHER WORKS

- A. The electrical installation work must be coordinated with the building work and work of other services. The drawings and specifications shall be carefully examined and information regarding building materials and equipment supplied by others obtained from the respective source to determine the extent, type and location of all wiring required. All holes and openings in slabs and walls which may be required for the passage of electrical conduits, trunking and cables must be determined and information regarding them passed on to building contractors so that they may be provided for at the time of pouring of concrete or construction of walls, breaking of concrete, cutting and patching of the structure shall be limited to a minimum and carried out only after securing the consent of the supervising Engineer. All holes through which cables and conduits pass must be made good by fire resistant incombustible material. Further protection of cables and conduits shall be given as instructed by the Engineer.

1.14 SAMPLES

- A. Samples of wires, cables, conduits, boxes, other items shall be submitted for approval before their acceptance for installation. Catalogue may be submitted in place of samples, but they should give complete description and specification of materials.
- B. Catalogue of major items such as switchgear, transformers, main distribution boards, motor control center, sub distribution boards, lighting fittings, etc., shall be also submitted for approval before any of these items are ordered. The Engineer reserves the right to reject any material that he may consider inferior or unsuitable for any reasons.

1.15 SERVICE CONDITIONS

- A. All electrical equipment, apparatus, accessories and fittings shall be so designed and manufactured to operate continuously in the electricity supply system having the following characteristics:

Voltage : 400 volts, 3 phase, 4 wire
Frequency : 50 Hz

- B It is the Contractor's responsibility to investigate the exact characteristics of the power supply and to adapt the design accordingly at no additional cost for the Owner.

1.16 PROTECTIVE SERVICES COORDINATION STUDY

- A. The Contractor shall provide a complete study of fault current and coordination of relays, fuses, circuit breakers and all other protective devices. The study shall include, but not be limited to the following:
1. Fault current available at each major equipment bus.
 2. A tabulation of all protective relay and circuit breaker trip settings and recommended fuse sizes and types.
 3. Motor starting profile for largest motor in each motor control center.
 4. A complete set of time- current coordination curves.
- B. The final selection of all protective devices shall be based on a preliminary draft of the coordination study which shall be submitted with the equipment shop drawings. The completed study shall be approved by the Engineer before any of the equipment is shipped. Protective devices shall be adjusted, tested and calibrated in the field, prior to energizing the equipment for the settings listed in the study.

PART 2 - PRODUCTS

2.01 MATERIALS AND EQUIPMENT

- A. Standardization:
1. Materials and products of the same kind and nature shall be the standard product of one manufacturer and of the same source and an assembly of several components, including enclosures, shall be the standard modular product of the same manufacturer of such kind of equipment supported by published catalogues (in English) giving full technical details of all components and finished product or assemblies, standards applicable and evidence that the manufacturer has been involved for at least five (5) years with the professional up-to-date production of such equipment.
- B. Quality:
1. The materials to be used as required by these specifications shall be of the best quality, brand new and of approved types, obtained from approved manufacturers.
- C. Construction:
1. All electrically operated equipment shall be of robust construction. All wound current conductors such as coils, etc., shall be insulated with Class "F" insulation unless otherwise indicated. All manufactured items shall be the product of manufacturer regularly engaged in producing works of the types specified and except for specialty items as far as possible be constructed in one plant for respective items. All items shall be constructed, finished and trimmed in the manufacturer's plant.

- D. Cleaning:
1. All materials shall be thoroughly cleaned of all dirt, grease, dust or other foreign matter and shall be free from damage or defects.
- E. Equipment:
1. All manufactured items shall be in strict accordance with the specification and free from imperfections and defects which affect their appearance or which may impair their durability and service ability.
 2. If the equipment is manufactured under license, the Contractor shall submit a written assurance of the license (the principal manufacturer) for the design and quality of the equipment produced by the licensee. This assurance should be submitted along with the submittals without which submittals will not be considered.
 3. All materials, equipment and components shall be brand new bearing stamped ratings as required, the best of their respective kind, from reputed manufacturers and shall be suitable for prolonged and trouble-free service under the climatic and other service conditions. When the Engineer will consider it needed, he may require from the Contractor to supply and install equipment identical to those already installed at no additional cost or compensation of any nature for the Contractor.
 4. Should any equipment or material be subjected to possible damage by water, it shall be dried out thoroughly and put through an approved special dielectric test as directed, or otherwise repaired.
 5. Equipment or material found defective, damaged by water or otherwise, during storage, installation, or test, or failing any test, shall be replaced or repaired by the Contractor in a manner subject to the approval of the Engineer.
- B. Prices for these additional recommended spares and tools shall be included in the Tender Prices.
- C. The Engineer shall have the option to purchase all or any of these spares and tools during the Contract Period at the prices stated.

PART 3 - EXECUTION

3.01 SLEEVES AND FORMS FOR OPENINGS

- A. The Contractor shall provide and place all sleeves for conduits penetrating floors, walls, partitions, etc., and shall locate all necessary slots for electrical work and form before concrete is poured.
- B. Exact locations are required for stubbing-up and terminating concealed conduit. Manufacturer and subcontractor shall provide shop drawings and templates for the equipment to be installed. The Contractor shall locate the concealed conduit before the floor slab is poured.
- C. Where setting drawings are not available in time to avoid delay in scheduled floor slab pours, the Engineer may allow the installations of such conduit to be exposed. Requests for this deviation must be submitted in writing. No additional compensation for such change will be allowed.
- D. All openings, sleeves, penetration and slots shall be sealed.

3.02 CUTTING AND PATCHING

- A. Cutting and patching shall be done in a thoroughly workmanlike manner and be in compliance with modifications and repair to concrete.
- B. Contractor shall install work at such time as to require the minimum amount of cutting and patching.
- C. Opening shall only be large enough to allow easy installation of the conduit.
- D. Patching to be of the same kind and quality of material as was removed.
- E. The completed patching work shall restore the surface to its original appearance or better.
- F. Patching of waterproofed surfaces shall render the area of the patching completely waterproofed.

3.03 INSTALLATION

- A. Any work not installed according to the Drawings and this Section shall be subject to change as directed by the Engineer. No extra compensation will be allowed for making these changes.
- B. Electrical equipment shall be protected at all times against mechanical injury or damage by water. Electrical equipment shall not be stored outdoors. Electrical equipment shall be stored in dry permanent shelters. Electrical equipment shall not be installed in its permanent location until structures are weather tight. If any apparatus has been subject to possible injury by water, it shall be thoroughly dried out and tested as directed by the Engineer, or shall be replaced at no additional cost at the Engineer's discretion.
- C. Equipment that has been damaged shall be replaced or repaired by the equipment manufacturer, at the Engineer's discretion.
- D. Contractor shall repaint any damage to factory applied paint finish using touch-up paint furnished by the equipment manufacturer.

3.04 COORDINATION OF ELECTRICAL WORK

- A. General: It is recognized that the contract documents are diagrammatic in showing certain physical relationships which must be established within the electrical work and in its interface with other work including utilities and mechanical work, and that such establishment is the exclusive responsibility of the Contractor. The Contractor shall refer to all relevant Architectural, Structural, Mechanical Drawings so as to maintain adequate clearance between electrical works and other works.
 - 1. Arrange electrical work in a neat, well organized manner with conduit and similar services running parallel with primary lines of the building construction.
 - 2. Locate operating and control equipment properly to provide easy access, and arrange entire electrical work with adequate access for operation and maintenance.
 - 3. All systems and electrically operated equipment shown on drawings or implied by the specification shall be supplied with the required feeder, power supply system or control circuit to the point of installation from the normal or emergency distribution network serving the respective area, including any connections, whether so indicated on the drawings or not.
The cost of such circuits shall be deemed to be included with the item unless otherwise stated.

3.05 WORKMANSHIP

- A. Particular attention is to be paid to the appearance of the electrical installation the arrangements of which is to be agreed by the Engineer before installation. The Contractor is to ensure that the installation is completed to the highest standard of neatness with respect to the visible cable runs and the arrangement and alignment of apparatus and fittings.
- B. The positions of all equipment are shown diagrammatically on the Drawings but the exact locations are to be agreed with the Engineer before installation.
- C. The Contractor is responsible for the fixing of all switches, fuse boards, switchgear, cables, fittings, cable trays, accessories and all other items comprising the electrical installation.
- D. All fixings are to be made by means of brass or stainless-steel screws with plastic raw plugs or similar approved devices.
- E. All holes for fixings are to be made neatly with a rotary drill, not of the percussion type.
- F. A single shot cartridge tool is to be used only at the discretion of the Engineer. The operator is to have an appropriate certificate to demonstrate his "Competence".
- G. No structural steel, timber work or concrete is to be drilled for the support of cables or fittings without the prior approval of the Engineer.

3.06 COMMISSIONING

The Contractor shall be responsible for satisfying himself as to the correctness of the electrical and mechanical connections to all work supplied and installed by him under the Contract before such work is put into operation.

After the connection of power supply to the installations, the Contractor shall commission all sections of the electrical installations and demonstrate to the Engineer or his Representative that the entire electrical installations is in perfect working order. Where equipment of a specialized nature is involved, the Contractor shall, if necessary or requested by the Engineer seek and obtain at his own cost the services of specialist and/or commissioning engineers from the suppliers/manufacturers.

**** END OF SECTION ****

SECTION 16110

ELECTRICAL RACEWAYS

PART 1 - GENERAL

1.01 DESCRIPTION

- A. The work to be performed includes, but is not necessarily limited to, all work involved with the construction and assembly of conduit, tubing or duct with fittings, including, but not necessarily limited to, connectors, nipples, couplings, expansion fittings, and other components and accessories as needed to form a complete system of the type indicated and shown on the drawings. The requirements of this section apply for all electrical and communication raceway systems.
- B. The types of electrical raceways required for the project include the following:
 - 1. Rigid metal conduit systems.
 - 2. Liquid-tight flexible conduit.
 - 3. Rigid non-metallic conduit systems.
 - 4. Cable trunking.
 - 5. Under – floor trunking system
 - 6. Cable trays / cable ladders

1.02 QUALITY ASSURANCE

- A. The Contractor is responsible for the quality of all purchased items and as such, must develop and submit a supplier quality inspection plan for review. The inspection plan shall cover those items intended for shop inspection and the procedures for carrying out the same.
- B. Manufacturer: Raceways shall be the standard product of a manufacturer regularly engaged in manufacture of raceway systems of types and sizes required and complying with the requirements of the listed standards and have been in satisfactory use in similar service for not less than 5 years.
- C. Codes and Standards: Comply with requirements of latest editions of the following codes and standards except as herein modified.
 - 1. BSI British Standards Institution:
 - BS 729 Specification for hot dip galvanized coatings on iron and steel articles.
 - BS 4607 Non-metallic conduits and fittings for electrical installations.
 - BS 4678 Cable trunking.
 - BS 6053 Specification for outside diameters of conduits for electrical installations and threads for conduits and fittings.
 - BS 6099 Conduits for electrical installations.
 - BS 6220 Specification for junction boxes for use in electrical installations with rated voltages not exceeding 250V.
 - 3. IEC - International Electrotechnical Commission.
 - IEC 60364 Electrical installation of buildings.
 - IEC 61084 Cable trunking and ducting systems for electrical installations.

1.03 TESTS AND ACCEPTANCE

- A. Manufacturer's Test Reports: Unless requirement is waived, submit manufacturer's type test reports certifying that equipment meets specified standards.

1.04 SUBMITTALS

- A. The Contractor shall submit to the Engineer in accordance with provision of Section 1300.
1. Manufacturer's Data: Including specifications, installation instructions and general recommendations for each type of raceway required and each system.
 2. Shop Drawings: Dimensioned drawings of raceway systems showing layout of raceways and fittings, spatial relationships to associated equipment, and adjoining raceways, if any. Show connection to electrical boards and switchboards.
 3. As-Built drawings.
 4. Type test certificates.

PART 2 - PRODUCTS

2.01 RIGID METAL CONDUITS AND FITTINGS:

- A. Conduits shall be furnished complete with all accessories and fittings.
- B. Fittings shall be installed to match the conduit being used and shall not be used to replace elbows and pull boxes, unless space or other problems make the use of fittings necessary.
- C. All steel conduits and conduit fittings shall be manufactured and tested in accordance with BS 4568 Part 2, BS 6099, IEC 60614.
- D. Conduits and fittings shall be so designed and constructed that they are not adversely affected by transport and storage and assure reliable mechanical protection to the cables.
- E. Conduit fittings shall be of the screwed types which are threaded for connection to heavy gauge conduits.
- F. Steel conduits shall be heavy gauge hot dipped galvanized, seam-welded, threaded at both ends, protected both inside and outside to Class 4.
- G. Conduits shall be marked with the following:
1. The name or identification of the manufacturer.
 2. The number of the British Standard and/or IEC.
 3. The Class of finish.
- H. Every length of conduit supplied in sections of 3 meters minimum lengths shall be fitted at one end with a coupler.
- I. The outside diameters, wall thickness and tolerance for the manufacture of conduits shall be as stated in Standard Sheet No. 2 of BS 4568.
- J. Fittings such as couplers, bends, locknuts and bushings shall comply with respective Standard Sheets of BS 4568 and shall be of the same gauges and same class of protection as the conduits.
- K. Conduits shall show no appreciable unevenness and their interior and ends shall be free from burrs, fins and the like which may cause damage to cables.
- L. Surfaces and edges over which the cables are likely to be drawn shall be smooth and well rounded.

- 2.03 LIQUID-TIGHT FLEXIBLE METAL CONDUIT:
- A. A flexible connection of short length shall be provided for the cabling to all equipment which may produce vibration or movement. A minimum length of 500 mm shall be utilized in all such locations. The flexible conduit shall be of metal spiral or bellows construction. A different size of flexible conduits shall be applied for the various services to suit the size of conductors employed.
 - B. Where a conversion from rigid conduit to flexible conduit is required, the rigid conduit shall terminate at the box and flexible conduit shall be connected into the box. A terminal box shall be installed wherever necessary to permit proper connection of P.V.C. single core wire to flexible cord properly. Connection to small motors such as small ventilating fans shall be made by means of multicore PVC cable with brass adapters or glands fitted to the conduit termination outlet.
 - C. Flexible conduits shall comprise a flexible steel core with PVC over sheath non flame propagating, self-extinguishing types.
 - D. Flexible conduits shall be to BS 731.

2.04 RIGID NON-METALLIC CONDUITS

- A. Rigid non-metallic conduits shall be UPVC high impact and heavy gauge. All conduits and conduit fittings shall be manufactured and tested generally in accordance with BS 4607 Parts 2, 3, BS 6099/IEC 60614. The wall thickness shall be as follows:

O.D. mm	20	25	32	38	50
Wall Thickness	1.8	1.9	2.5	2.5	3.2
- B. Rigid PVC conduit and conduit fittings shall be so designed and manufactured that they ensure reliable mechanical protection to cables contained therein, and shall withstand both the stresses and high temperatures liable to occur during transport, storage and installation.
- C. Rigid PVC conduits and conduit fittings shall be fully suitable for installation, storage or transport at extreme temperatures 55°C encountered and at this temperature the material shall not soften or suffer any structural degradation.
- D. Rigid PVC conduits and conduit fittings shall be suitably marked and identified by the manufacturer. Marking of conduits shall also include the nominal size. All markings shall be indelible and easily legible.
- E. Rigid P.V.C. conduit and conduit fittings shall be dark in colour unless otherwise approved by the Engineer.
- F. The inside and outside surfaces of conduits shall be smooth and free from burrs, flash and similar defects.
- G. The interior and ends of conduit fitting shall have no sharp edges and surfaces and corners over which the cables are likely to be drawn shall be smooth and well rounded.
- H. The conduit entries of fittings shall be so designed that a reliable water tight joint can be made between the conduit and fitting.
- I. Rigid P.V.C. conduits shall be so constructed that it will be possible to bend the conduit easily with the aid of a simple tool, e.g. bending spring.

- J. Rigid P.V.C. conduits and conduits accessories shall be of the unthreaded type. All conduits and fittings shall be jointed together permanently using vinyl cement and socketed accessories.
- K. Rigid P.V.C. conduits and conduit fittings shall have adequate mechanical strength and thermal stability. Conduits, when bent or compressed or exposed to impacts at extreme temperatures (85°C), either during or after installation, shall show no cracks and shall not be deformed to such an extent that the cables cannot be drawn in easily and/or are likely to be damaged whilst drawing in.
- L. Rigid P.V.C. conduits and conduit fittings shall be resistant to high temperatures and shall be non-hygroscopic. They shall also be of self-extinguishing type and non-flame propagating. The insulation resistance and electric strength of conduit accessories shall be fully adequate and they shall also be inert to all liquids, which are normally discharged from civil and industrial premises.
- M. Expansion couplers shall be fitted in straight surface rings every 12m. The free end shall be sealed with non-setting mastic to form a waterproof seal.
- N. Each length of conduit shall be not less than three (3) meters and the outside diameter shall as per listed standards.

2.05

BOXES:

- A. Conduit boxes for surface mounting shall be of small circular pattern with raised back and with internally tapped spouts threaded to a minimum length of 20 mm for use at intersections, tees, bends, draw-in and terminal positions.
- B. Loop-in boxes shall be of similar pattern but with plain rear conduit entry facilities of appropriate number.
- C. All conduit boxes for steel conduits shall be manufactured from cast iron or steel.
- D. Extension rings where required shall be manufactured in the same material and shall be of similar style and diameter to the box to which they are to be fitted.
- E. Bushes shall be brass for steel conduits.
- F. All steel conduit, cast-iron conduit boxes and accessories shall be galvanised finish unless specified otherwise. Compatibility shall be maintained between metals used in any one installation.
- G. Conduit boxes for flush-mounting installations may be of formed or welded steel construction complete with fixing lugs, conduit entry facilities and internal brass earth terminals.
- H. Boxes for external use shall be fitted with external fixing lugs and shall be weatherproof.

- I. For non-metallic rigid conduits boxes and accessories shall be made from heat resistant insulating material. The minimum wall thickness of boxes having a nominal internal depth of 16 mm or less shall be 1.5 mm. For deeper boxes the minimum wall thickness shall be 2 mm.

2.06 STEEL CABLE TRUNKING

- A. Cable trunking and fittings shall be in accordance with IEC 61084/BS 4678 Part 1 and 2.
- B. Cable trunking and fittings shall be manufactured of mild steel sheet to BS 1449 and zinc coated or of pre-galvanized mild steel sheet to BSEN 10143.
- C. Segregation of cables shall be carried out if required using continuous sheet steel barriers with the bottom edge welded to the trunking.
- D. The trunking shall have two returns for rigidity. Where necessary, additional strengthening straps shall be fitted internally.
- E. The cover shall overlap the trunking. Fixing screws for covers shall be recessed and be of the self-retaining "quick fix" type.
- F. All bends, tee piece, intersections shall be of the gusset type. All accessories shall be purpose made by the cable trunking manufacturer and shall match the design of the trunking.
- G. The thickness of the steel sheet shall not be less than 1.2 mm.
- H. The number of cables installed in the trunking shall be such as to permit easy drawing without damage to the cables but under no circumstances shall a space factor of 45% be exceeded.

2.07 NON -METALLIC CABLE TRUNKING

- A. Non -metallic cable Trunking and its fittings shall be made from high impact non- flammable, Self-extinguishing UPVC.
- B. Cable trunking and fittings shall be in accordance with IEC 61084/BS4675 Part 4 enclosing cable through and/or auxiliary wiring gutter for housing and protecting electrical cables and in which cables are to be laid in place after the trunking has been installed.
- C. Where barriers are required in the trunking they shall be of the same gauge as the main trunking material.
- D. The cable trunking shall be provided with removable covers which permit an unobstructed opening over the entire length of the run. Covers shall be of the same gauge as the trunking body and shall have turned edges to overlap the trunking body.

- E. Trunking shall be complete with all connections right angle, bends, adapters, tee pieces which shall be standard manufacturers items.

2.08 CABLE TRAYS AND LADDERS:

A. Metallic cable tray:

1. Cable trays shall be to BS 6946 of trough type made of code gauge perforated sheet steel to BS1449, hot-dip galvanized to BS 729 and protected by corrosion resistant coating, and shall be standard metric sizes 300 mm and 600 wide, 75 mm deep.
2. Cable trays shall be installed as a complete system with bends and other accessories. All accessories and fittings shall be standard manufacturers items.
3. Trays shall have formed flanges of minimum height not less than 5 mm. Upper flanges shall be rolled downward for safety of personnel and cables. The thickness shall be 1.5 mm for tray of width of 300 mm and less and 2 mm for width layer than 300 mm.
4. Cable tray shall be capable of carrying the following uniformly distributed load with 2 m spaced supports and a deflection not exceeding 9 mm.

Tray Width	mm	600	450	300	150
Load	kg/m	204	179	104	107

5. All bolts and screws shall be cadmium plated or electrolytically galvanized to BS 1706.
6. Cable tray supports shall be of ample strength to maintain rigid support to the fully laden cable tray along its entire length.

All brackets and tray work shall be suitable for withstanding a temporary weight of 125 kg.

7. Covers or sunshades shall be provided when trays are exposed to the sun.
8. Cable trays shall be supported by channels and hangers, rods, or by cantilever brackets fixed to walls or columns. Fixing shall be disposed at regular intervals not exceeding 1m. Joints shall be positioned at close as practicable to tray fixing or supports. Mid span joints shall be avoided. A minimum clear space of 25mm shall remain at wall side

B. Metallic Cable Ladder

1. Cable ladder shall be H –TYPE consist of hot dipped to BS 729 2mm mild steel to BS 1447 profiles riveted together having

horizontal spacing between two rungs not exceeding 300 mm. The flanges shall not be less than 100 mm.

2. Cable ladder shall have a minimum capacity of 200 kg/m and under normal conditions the sag is not to exceed 3 mm.
3. The cable ladders shall be part of a module system having available all required accessories and transaction pieces from one to another direction. All accessories and fittings shall be standard manufacturers items.
4. All bolts and screws shall be cadmium plated or electrolytically galvanized to BS 1706.
5. Covers or sunshades of the ventilated type shall be provided where ladders are exposed to the sun.

PART 3 - EXECUTION

3.01 RACEWAY APPLICATION

- A. Heavy Gauge PVC Conduits - unless otherwise indicated on the Drawings, are to be used throughout, embedded, concealed, in chases and underground installation for lighting, power circuits, telecommunication, signal and information systems installations.
- B. Flexible Steel Conduits with PVC Sheath - are to be used for terminating connections to motors and vibrating equipment where heavy gauge galvanised steel conduits are used.
- C. Heavy Gauge (Rigid) Galvanised Steel Conduits - are to be used for all exposed installations and as shown on the drawings in particular in the Electrical Rooms.
- D. Minimum Size of Conduits - the minimum size of conduits is to be 20 mm nominal diameter.
- E. Cable tray type shall be used where indicated on the drawings.

3.02 GENERAL INSTALLATION CONDITIONS

- A. Conduits shall be installed complete with all accessories, fittings, and boxes in an approved and workmanlike manner, so as to provide proper raceways for electrical conductors.
- B. Maintain a minimum distance of 150 mm from parallel runs of flues, steam or hot water pipes.
- C. Groups of conduits shall be uniformly spaced, where straight and at turns.

- D. Securely fasten conduits to outlets, junction and pull boxes to effect firm electrical contact. Join conduit with approved couplings.
- E. Plaster, dirt or trash shall be prevented from lodging in conduits, boxes, fittings and equipment during construction.
- F. Conduit runs between outlet and outlet, between fitting and fitting or between outlet and fitting are not to contain more than the equivalent of two quarter bends. (180 deg. total) or offsets.
- G. Conduits are to be properly capped until wiring conductors are finally drawn in. Conduits are to be installed at least 100 mm clear of and preferably above pipes of other non-electrical services. Conduits are not to cross pipe shafts or vent ducts.
- H. Where conduits pass through floors, walls, partitions or ceilings, the hole is to be made good with cement or similar fire-resisting material to full thickness of floor, wall etc. to prevent spread of fire and/or smoke.
- I. All junction boxes, draw-in boxes and inspection fittings shall be so placed that the cables can be inspected and, if necessary, withdrawn and re-run throughout the life of the installation.
- J. Empty conduit system shall be provided as indicated and shall have pull wires installed where indicated. The pull wire shall be 2.5 mm zinc-coated steel, or plastic having not less than 90 Kg tensile strength. Not less than 300 mm of slack shall be left at each end of the pull wire and will be held by wooden plugs.
- K. Conduit home runs concealed above suspended ceilings shall be supported from the slab above the ceiling in the same manner as exposed conduits and shall be easily accessible for wiring or future re-wiring without disturbing any of the lighting or power installations connected thereto.
- L. Screwdriver-operated threaded flush plugs shall be installed in conduits from which no equipment connections are made.
- M. The number and size of cables in any conduit shall not exceed that specified in the tables of applicable standards. In the absence of such table the space factor of 40% shall not be exceeded.
- N. Concealed conduits shall be securely fixed to prevent movement before laying of screed, floating of plaster, casting of columns or other building operations necessary after the conduit installation. Crumpets or similar fixings shall be used for attaching the conduit to block-work, etc. Building nails will not be accepted.
- O. At least 15mm shall be allowed for finishes over the conduit. Where this cover cannot be maintained then expanded metal shall be fitted over the conduit. Conduit cast into reinforced concrete shall be prevented from entering conduit boxes when being poured. Where possible, the conduit boxes shall be fixed to shuttering to give a flush finish.

- P. Conduit installed in voids, false ceilings, and other concealed routes shall be installed as specified for surface conduits. Draw-in wires shall not be pulled into the conduits during erection. Wiring shall be carried out after the false ceiling or permanent ducts have been completed. Conduit installed in floors shall be sealed against ingress of moisture.

3.03 RIGID STEEL CONDUIT INSTALLATION

- A. All conduits shall be threaded to suit the accessory to which it is fitted with the minimum exposed thread remaining. Such exposed thread shall be painted on completion of installation using a galvanic type paint to prevent corrosion.
- B. Inspection bends, running joints, solid bends, elbows, tees, normal bends and female bushes and all conduit fittings shall not be used without prior approval of the Engineer in writing.
- C. Surface conduits shall be saddled to the structure of the building within 150 mm of each box or fitting and at intervals not greater than 1500 mm (couplings and through type draw-in boxes shall be counted as part of a straight run of conduit). With 20 mm and 25 mm diameter conduit, saddles are to be spaced at 1000 mm but with 32 mm and larger diameter conduits at 1250 mm.
- D. Conduits shall be supported within 1000 mm of all changes in direction. Supports shall be approved pipe straps, wall brackets, hangers or ceiling trapeze. Fastenings shall be by wood screws to wood; by toggle bolts on hollow masonry units; by expansion bolts on concrete or brick; by machine screws, welded threaded studs, or spring-tension clamps on steel work. Wooden plugs inserted in masonry and the use of nail as fastening media are prohibited. Conduits or pipe straps shall not be welded to steel structures.
- E. Fasteners attached to concrete ceiling shall be vibration and shock resistant. Holes cut to a depth of more than 40 mm in reinforced concrete beams or to a depth of more than 20 mm in concrete joints shall not cut the main reinforcing bars. Holes not used shall be filled. In partitions of light steel construction, Sheet-metal screws shall be used. The load applied to fasteners shall not exceed 1/4 of the proof test load.
- F. Risers shall be supported at every floor and at a maximum spacing of 3 m.
- G. Expansion fittings shall be provided in all straight runs of 25 mm conduit size and larger, which are in excess of 30 m length.
- H. All exposed conduits used in a single run or circuit shall be of the same type and finish.
- I. Sleeves shall be provided for exposed conduits running through floor slabs or interior walls and they shall be properly sealed.
- J. Conduit installed in concrete floor slabs shall be located so as not to affect the structural strength of the slabs. Conduit shall be installed within the

middle one third of the concrete slab except where necessary so as not to disturb the reinforcement. Outside diameter of conduit shall not exceed one-third of the concrete slab except where necessary to keep from disturbing the reinforcement.

Conduit shall be spaced not closer than three diameters except at cabinet locations. Curved portions of bends shall not be visible above the slab. Where embedded conduits cross expansion joints, suitable watertight expansion fittings and bonding jumpers shall be provided. Conduit shall be parallel with or at right angles to the main reinforcement; when at right angles to the reinforcement, the conduit shall be close to one of the supports of the slab. Conduits shall not be stacked more than 2 diameters high in floor slabs; subject to above conditions.

- K. Conduits shall be run in square and symmetrical lines in relation to the building. Efficient means shall be adopted to provide for the drainage of condensation and runs shall be properly ventilated. All conduit runs shall be planned by the Contractor before installation is commenced and shall be marked on a drawing on site for approval by the Engineer. All steel conduits shall be cut square and all joints shall butt together tightly in order to ensure maximum electrical continuity. Every steel conduit to be erected shall have the ends reamed and after screwing, all internal burrs shall be removed and cleaned out. After erection, damaged or rusted conduit shall be wire brushed and painted with "Galvanite" or other equal. Throughout the duration of the Contract steel conduits shall be maintained in good condition by repainting as necessary.
- L. Where a number of conduits converge, large malleable cast iron or approved heavy gauge sheet steel adaptable boxes shall be employed in order to avoid crossing. Steel conduits shall be connected thereto by means of male brass bushes and couplers. Where conduit is greater than 25 mm in diameter, straight through draw boxes shall be of the trough type. Where conduits and/or fittings are attached to switch and/or fuse casings, steel or cast iron boxes, or other equipment, the material or case of the box shall be tapped for a depth of not less than 8 mm, or, if this is not possible, smooth bore hole bushes and flanged couplings shall be used. Heavy hexagon locknuts shall be used at all positions where running joints are required in steel conduit and great care shall be taken to ensure that they seat firmly and evenly on to mating couplings or other adjacent accessories.
- M. Conduits shall be fastened to all Sheet-metal boxes and cabinets with two locknuts, where insulated bushings are used and where bushings cannot be brought into firm contact with the box. Locknuts shall be the type with sharp edges for digging into the wall of metal enclosures. Bushings shall be installed on the ends of all conduits and shall be of the insulated or brass type.
- N. Final conduit connection to motors or other apparatus specifically mentioned shall be made utilising a maximum of 500 mm, of flexible metallic polyvinyl chloride sheathed conduit. The Contractor shall install an insulated circuit protective conductor within the flexible conduit to maintain earth continuity and bonding to the apparatus being connected.

- O. At building expansion joints, conduit installation shall be arranged so that fixings are supported at equal distances on each side of the joint and an expansion adaptor inserted midway between fixings. Due account shall be taken of the ambient conditions at the time the jointing is made to ensure maximum future movement is allowed.
- P. Bends: All bends shall be carefully made to prevent distortion of the circular cross-section.
1. Field-made bends in conduit shall have an inside radius of not less than nine diameters. Where bends of less than nine diameters are necessary standard factory elbows shall be used; however, the conduit size chosen shall be such as to permit a cable-bending radius within the factory elbow of at least eight times the cable diameter.
 2. Bends and offsets shall be made with bending machine.
 3. No conduit shall have more than two 90-degree bends off set or other deviation from the straight line.
- Q. Cutting and Threading: All conduits where cut shall be carefully reamed to remove burrs. Cutting shall be made with a hacksaw or an approved cutting machine.
- No running threads will be permitted. All threaded ends of steel conduits shall be painted with one coat of zinc-base primer prior to making of connections, and all screwed joints shall be watertight.
- R. Conduit Cleaning: All conduits shall be carefully cleaned before and after installation, all ends shall be reamed free of burrs, and inside surfaces shall be free from all imperfections likely to injure the cable.
- S. Conduits stubbed up through concrete floors for connections to free-standing equipment shall be provided with an adjustable top or coupling threaded inside for plugs, set flush with the finished floor. Wiring shall be extended in rigid threaded conduit to equipment, except that where required, flexible conduit may be used 150 mm above the floor.
- T. Where dissimilar metals are used in conjunction with each other, purpose made bi-metallic accessories shall be used otherwise suitable insulation shall be provided if applicable between adjoining surfaces so as to eliminate direct contact and any resultant electrolysis, but the electrical continuity of the system shall be maintained. The insulation shall be bituminous - impregnated felt, heavy bituminous coatings, non-metallic separators or washers or other approved materials.
- U. Care shall be taken in the installation of polyvinyl - chloride jacketed conduit to prevent damage to the jacket. The manufacturers shall be followed in the installation of conduit and for repair of damage to the polyvinyl chloride jacket during installation.

- V. Conduit Drainage: As far as practicable, conduits shall be pitched to drain to outlet boxes or otherwise so installed as to avoid trapping moisture. Trapped conduits in concealed construction shall be provided with outlet boxes for drainage.
1. Where drips are unavoidable in exposed conduits, a standard pipefitting shall be provided in the underside at the low point.
- W. Conduit Earthing: All conduit terminations, such as those at motors, transformers, motor control centres, distribution boards, control panels, and similar equipment, shall be effectively earthed by bonding, or otherwise to provide permanent and continuous low-resistance paths to earth throughout the installation.

3.04 NON-METALLIC CONDUITS INSTALLATIONS

- A. Non-metallic conduits shall generally be installed in accordance with the requirements of Clauses 3.02 and 3.03 as applicable except for the following:
- B. Coupling of conduit and termination into spouted fittings are to be made water tight and permanent by use of purpose made expansion coupler.
- C. Conduit sizes 20 mm and 25 mm must be bent with the correct size bending spring. The bend can be made without any application of heat, but if very cold, vigorous rubbing of the tubing for a few seconds will assist with bending. To achieve a right angle, bend well past 90° and allow the bend to spring back to 90° - do not attempt to bend tubing back with spring inserted - saddle as soon as possible after bending. Larger sizes 32 mm, 38 mm and 50 mm, should be heated before bending and a rubber cord inserted to prevent “kinking” when bending. The radius of bends in conduits shall not be less than four times the external diameter of the conduit. Factory made bends may only be used with the written permission of the Engineer.
- D. Expansion joints are to be installed wherever conduit run crosses an expansion joint in the structure to which it is attached and in conduit runs exceeding 6 m in length.
- E. Conduits shall have lengths coupled together by means of plastic sockets jointed by adhesive solution. Before jointing conduit lengths together with “vinyl” cement, the tube ends must be clean and free from oil or grease and the cement applied both to the tube and the fittings. On inserting the tube, it must be twisted to make sure that the cement covers the whole circumference of the tube.
- F. Conduits shall have a separate insulated protection conductor run in the conduit to assure earth continuity between exposed metal items.
- G. Conduits shall be coupled to equipment not having shaped or smooth conduit entries, by means of plastics bushes fitted inside the equipment, with external locking rings.

- H. Exposed or surface mounted conduits are to be supported by means of plastics spacer bar or distance saddle at centres not exceeding the following:

Conduit Size	Vertical & Horizontal Spacing
20 mm - 25 mm	1.2 m
32 mm - 40 mm	1.5 m
50 mm	1.8 m

They shall have saddles fixed within 150 mm each side of all bends or sets.

- I. Conduits which are to be “cast” in concrete floors shall be fixed securely to the bottom layer of reinforcing bar before the floor areas are poured. Similarly, all conduit boxes for lighting positions shall be securely fixed to the upper surfaces of the timber shuttering before concrete is placed. Extensive movement or vibration from pokers can severely damage plastic installations and a close supervision is necessary during this part of the installation programme.
- J. Standard couplings shall be used for coupling tubing together, and for terminating conduits at adaptable boxes, distribution boxes, switchgear, switch boxes, socket outlet boxes etc., male or female adapters shall be used, the female type comprises of 1/2 screwed and 1/2 plain coupling and PVC socket for the tubing and male threaded with lock ring.

3.05 CABLE TRAYS INSTALLATION

- A. Provide support at each connection point, at the end of each run and at other points required to maintain deflection to the minimum.
- B. Use expansion connectors where required.
- C. Provide fire stopping to sustain ratings when passing cable tray/through fire-rated elements.
- D. Where specified, install label signs at 1500 mm centres along cable tray/ladder and located to be visible.
- E. All cable tray changes in direction or level shall be made via sets and adequately sized angles to provide a support to the cables.
- F. Single core cables of the same circuit shall be laid and mounted in purpose made trefoil cleats.
- G. Cable trays/ladder arranged one above the other shall have spacing in relation to their width not exceeding a ratio of 1.2 with a minimum distance of 150 mm.

- H. The Contractor will be responsible for ensuring that the cable tray and ladder rack routes do not prevent access to machine components, control positions, walkways, access points and working areas.
- The Contractor will meet the costs of changing tray or ladder rack routes to comply with this condition of the contract.
- I. The Contractor will be responsible for supplying all tray and ladder rack steelwork fixings.
- J. Adequate supports shall be provided to prevent stress on cables where they enter or leave the tray. Where cable trays extend transversely through partitions and walls additional protection in the form of fire-proof non-combustible barriers shall be provided.
- K. Cables shall be fixed to the trays and ladder racks by PVC coated metal cable straps of minimum width 10 mm or PVC coated pliable metal strapping secured by adequate length galvanized roofing type bolts. Under no circumstances will strapping fixtures manufactured in PVC only, be allowed. The cable straps shall be spaced according to the manufacturer's recommendations.
- L. Cable trays and ladder racks must be sized so as to allow for a minimum of 25% spare capacity for future use.
- M. Tiered runs of more than one tray and ladder shall be suitably labelled with trifoliate type labels, with black characters should be 30 mm. The Contractor will be responsible for ensuring that the tiered run reference number is marked on the cable schedule, which shall be revised by the Contractor detailing all changes made during the installation.
- N. Trays and ladder shall be fixed to the supporting structure by approved suspension rods or steel angle brackets at intervals necessary to provide rigid fixing.
- O. All cable tray and ladder rack support, unless galvanized, shall be painted with two coats of primer before erection and installed at distances in accordance with the manufacture's recommendations.
- P. Where cable tray and ladder racks are fixed to brickwork, or similar type material, the support brackets shall be raw I bolted to the structure. Raw I bolting into joints of brickwork or blockwork will not be allowed.
- Q. Cable tray or ladder rack fixed to structural steelwork and building columns shall be made by drilling or clamping the support brackets. Where it is not practical to drill or clamp the support brackets into position, the contractor will be permitted to weld them into position. Welding of the brackets will only be allowed after consultation with and approval of the Engineer.

3.06 CABLE TRUNKING INSTALLATION

- A. Cables shall be retained in the trunking when the cover is removed by means of straps.
- B. Internal connecting sleeves shall be fitted across joints in the trunking.
- C. Non-flammable fire barriers shall be inserted where the trunking passes through walls or floors.
- D. Conduits connected to trunking shall be made by flanged couplings and male bushes.
- E. Trunking shall be supported at intervals not greater than 2 m horizontally or 2.5m vertically. Joints shall not overhang fixing joints by more than 200 mm.
- F. Crossing over extension joints shall be made in flexible conduits.
- G. Should it be necessary to cut or drill a section of trunking or a trunking fitting the bared ends shall be given a coat of zinc rich cold galvanizing paint.
- H. The trunking run shall be at least 150 mm clear of plumbing and mechanical services.
- I. The cover shall be completely accessible except through walls and floors at which points suitable fire resisting barriers shall be provided.
- J. Where trunking passes through ceilings, floors and walls, the cover shall be firmly fixed 150 mm either side of the ceilings and floors and 100 mm either side of the walls.
- K. Screws and bolts securing covers to the trunking or section of the trunking together shall be arranged so that the damage to the cable cannot occur when fixing the covers or when the cables are installed in the through.
- L. When trunking is used to connect switchgear or distribution board such connections shall be made by trunking fittings manufactured for this purpose and not by multiple conduit couplings.
- M. Where conduits enter trunking, separating washers shall be used with a coupler and male bush. Where partitioned trunking is used the partitioning shall be maintained at intersections and angles.

End OF SECTION

SECTION 16120**WIRES AND CABLES****PART 1 - GENERAL****1.01 DESCRIPTION**

- A. The work to be performed includes, but is not necessarily limited to, all work involved with the supply and installation of wires and cables and the associated connectors and terminal boards used in electrical power distribution systems.
- B. The types of wires and cables specified in this section include the following:
 - 1. Power cables (Insulated & Sheathed)
 - a. Single Core PVC insulated and sheathed 600/1000V cables.
 - b. Single core XLPE insulated PVC sheathed (600/1000V) cables.
 - c. Multicore PVC cables (600/1000V) non-armored cables.
 - d. Multicore PVC/SWA/PVC cables (600/1000V).
 - e. Multicore XLPE/PVC (600/1000V).
 - f. Multicore XLPE/SWA/PVC (600/1000V).
 - 2. Small power and lighting cables (Insulated)
 - a. Single core PVC insulated cables (450/750V).
 - 3. Signal/Instrument cables.
 - 4. Data transmission cables.

1.02 QUALITY ASSURANCE

- A. The Contractor is responsible for the quality of all purchased items and as such must develop and submit a supplier Quality Inspection Plan for review. The inspection plan shall cover those items intended for shop inspection and the procedures for carrying out same.

- B. Manufacturer: Cables and wires shall be the products of a manufacturer regularly engaged in manufacture of cables and wires of types and sizes required and complying with the requirements of the listed standards and whose products have been in satisfactory use in similar service for not less than 5 years.
- C. Codes and Standards: Comply with requirements of the latest edition of the following codes and standards except as herein specified:
1. BSI - British Standard Institution:

BS 1442	Specification for galvanized mild steel wire for armored cable.
BS 4109	Specification for copper for electrical purposes. Wire for general electrical purposes and for insulated cables and flexible cords.
BS 5308	Instrumentation Cables
BS 5467	Specification for cables with thermo-setting insulation for electricity supply for rated voltages of up to and including 600/1000V and up to and including 1700/3300V.
BS 6004	Specification for PVC insulated cables (non-armoured) for electric power and lighting.
BS 6007	Specification for rubber-insulated cables for electric power and lighting.
BS 6081	Specification for terminations for mineral insulated cables.
BS 6121	Mechanical cable glands
BS 6207	Specification for mineral insulated copper-sheathed cables with copper conductors.
BS 6234	Specification for polyethylene insulation and sheath of electric cables.
BS 6346	Specification for PVC insulated cables for electricity supply.
BS 6360	Specification for conductors in insulated cables and cords.
BS 6469	Methods of test for insulation and sheaths of electric cables.
BS 6500	Specification for insulated flexible cords and cables.
BS 6746	Specification for PVC insulation and sheath of electric cables.

1.03 TESTS AND ACCEPTANCE CRITERIA

- A. Field testing: Prior to energization, cables and wires shall be checked for the following:
 - 1. Continuity of circuitry.
 - 2. Short circuits.
 - 3. Insulation resistance test, including procedure, equipment required (such as 500V megger) and acceptable values for resistance in accordance with recognized standards.
- B. Malfunctions shall be corrected when detected.
- C. Subsequent to wire and cable hook-ups circuitry shall be energized and circuits tested for performance in accordance with all requirements.
- D. Factory test as per listed standard

1.04 SUBMITTALS

- A. The Contractor shall submit to the Engineer the required documents to establish compliance with this section. Submittal shall include at least the following:
 - 1. Manufacturer's Data: Including specifications, installation instructions dimensions and general recommendations for each type of cable.
 - 2. Shop Drawings: Dimensioned drawings of cables routing showing accurately layouts of cables installation and their special relationship to associated equipment and details of installation.
 - 3. Across sectional drawing of the cable bedding, sanding, tiles, warming, back fill.
 - 4. Test Certificates: Manufacturer shall submit against each drum, the following certificates:
 - a. High voltage DC insulation pressure test, between cores each core to earth metallic sheath or armor as applicable.
 - b. Insulation resistance test
 - c. Core continuity and identification
 - d. conductor resistance test
- B. The Contractor shall submit to the Engineer in accordance with the provisions of Section 1300.

PART 2 - PRODUCTS

2.01 GENERAL

- A. Cables shall be manufactured and tested to the latest relevant British or harmonized European Standards or IEC.
- B. The cable sheath shall be marked with the information required by the relevant BS, BS EN or IEC.
- C. Cables shall be delivered, stored and handled in accordance with the manufacturer's instructions. Where the performance of the cable is likely to be adversely affected by the ingress of moisture, it shall be adequately sealed at either end.
- D. Unless otherwise specified, the outer sheath of all cables shall be colored black for grade 600/1000 V with the exception of the following:
 - 1. Protective conductors: - Green/yellow; and
 - 2. Intrinsically safe: - Blue
- E. Cables shall have copper conductors to BS 4109/BS 6360. Cores of cross-sectional area greater than 2.5 mm² shall be stranded or flexible.
- F. The scheme of wiring shall conform to the color code requirements of BS 7671.
- G. Cables shall be delivered, stored, and handled in accordance with the manufacturer's instructions. Where the performance of the cable is likely to be adversely affected by the ingress of moisture, it shall be adequately sealed at either end.
- H. The general routing of cables shown on the Drawings is indicative of the final routes and duct locations shall be agreed with the Engineer before any work in connection with the cable installation is commenced. All cables shall be installed in strict accordance with the requirements of this Specification.
- I. All cables used shall bear the manufacturer's original guarantee and all cables shall be delivered to Site in their original wrappings.

2.02 Single Core PVC Insulated and Sheathed Cables

- A. This type of cable shall be 600/1000V grade, complying with BS 6346 and shall have stranded conductors of plain annealed copper wires.
- B. The conductor shall be PVC insulated.
- C. Over the insulated conductor an outer protecting layer of extruded PVC layer shall be applied.

2.03 SINGLE CORE XLPE INSULATED AND PVC SHEATHED CABLES

- A. This type of cable shall be 600/1000V grade, complying with BS 5467 and shall have stranded conductors of plain annealed copper wires.
- B. The conductor shall be XLPE insulated.
- C. Over the insulated conductor an outer protecting layer of extruded PVC layer shall be applied.

2.04 MULTICORE PVC/PVC 600/1000 V NON-ARMoured CABLES

- A. This type of cable shall be 600/1000V grade complying with BS 6346. The core shall have stranded conductors of plain annealed copper wires.
- B. The cores shall be PVC insulated and the cores insulation shall be colored for identification as per BS 7671.
- C. The assembled cable shall be bedded with a layer of extruded PVC in order to fill the interstices between the cores.
- D. A black outer protecting layer of extruded PVC shall be applied over the bedded cables.

2.05 MULTICORE PVC/SWA/PVC 600/1000V ARMoured CABLES

- A. This type of cable shall be 600/1000 grade complying with BS 6346, multicore. The core shall have stranded conductors of plain annealed copper wires.
- B. The cores shall be PVC insulated and the cores insulation shall be colored for identification as per BS 7671.
- C. The assembled cable shall be bedded with a layer of extruded PVC in order to fill the interstices between the cores.
- D. Over the bedding is helically applied a layer of galvanized steel wires in such a way to form a continuous metallic protecting cover.
- E. Over the armored cable, an outer black protection layer of extruded PVC shall be applied.
- F. A single core cable shall have aluminum wire armor.

2.06 MULTICORE XLPE/PVC 600/1000V NON-ARMoured CABLES

- A. This type of cable shall be 600/1000V grade complying with BS 5467, multicore. The core shall have stranded conductors of plain annealed copper wires.
- B. The cores shall be XLPE insulated and the core insulation shall be colored for identification as per BS 7671.
- C. The assembled cable shall be bedded with a layer of extruded PVC in

order to fill the interstices between the cores.

- D. A black outer protecting layer of extended PVC shall be applied over the bedded cables.

2.07 MULTICORE XLPE/SWA/PVC 600/1000V ARMoured CABLES

- A. This type of cable shall be 600/1000 grade complying with BS 5467, multi-core. The core shall have stranded conductors of plain annealed copper wires.
- B. The cores shall be XLPE insulated and the cores insulation shall be colored for identification as per BS 7671.
- C. The assembled cable shall be bedded with a layer of extruded PVC in order to fill the interstices between the cores.
- D. Over the bedding is helically applied a layer of galvanized steel wires in such a way to form a continuous metallic protecting cover.
- E. Over the armored cable, an outer black protection layer of extruded PVC shall be applied.
- F. A single core cable shall have aluminum wire armor.

2.08 SINGLE CORE PVC

- A. Cables shall comply with BS 6004, IEC 60227 and be rated at 450/750V.
- B. The insulation shall be PVC phase colored.

2.09 SIGNAL AND INSTRUMENTATION CABLES

Instrumentation cables unless otherwise indicated, shall be rated 300/500 V and comply with BS 5308 type 2.

Cables shall be PVC or polyethylene insulated twisted pair with individual or collective metallic foil screen, tape bound with extruded PVC bedding, galvanized steel wire armouring and colored overall PVC sheath. Conductors shall be multistrand copper, 24/0.2 mm (0.75 mm²) or as indicated.

- 1. Collection screened cables shall be used only with measuring transmitters and analogue controllers (4-20 m Adc) up to 30 m route length.
- 2. Individual and collective screened cables shall be used:
For circuits as in (1) but exceeding 30 m route length and for inputs to data loggers, telemetry systems, microprocessors, computer, also cable to transducers.

2.10 DATA TRANSMISSION CABLES

- A. Defined as extra low voltage, digital signaling cables between computers, programmable logic controllers (PLCS) and remote telemetry units (RTUS) and other data transmission equipment.
- B. The minimum cross-sectional area of cable conductors shall be 0.5 mm².

- C. The following types of cable may be used unless otherwise indicated:
1. Those complying with BS 5308: Parts 1 & 2;
 2. Belden or equivalent;
 3. UTP Category 6; and
 4. Those specified by the equipment manufacturer.

PART 3 - EXECUTION

1.01 INSTALLATION OF CABLES GENERAL

- A. All cables shall be installed in accordance with the applicable provisions of BS 7671/IEC 60364 and as indicated on the drawings.
- B. Detailed wiring diagrams including designations, tagging marks, labeling, etc., shall be submitted for approval before implementation.
- C. The number and sizes of wires and conduits indicated on the drawings are for guidance only. It is the contractor's responsibility to supply and install the exact number and sizes of cables required by the equipment to be installed and to provide the right size conduits for the number of cables at no extra cost to the Owner.
- D. Each cable shall be supplied in a suitable length and be continuous through its run where adequate manufacturer lengths are available through joints will not be permitted without the permission of the Engineer.
- E. Every cable whether in or out sight shall be neatly run vertically, horizontally or parallel to adjacent walls, beams or other structural members.
- F. Cables installed in groups shall run in straight lines and not cross over each other.
- G. Cables which may be subject to accidental mechanical damage shall be suitably protected by cable guards.
- H. Where cables are surface run on the external faces of structures or above ground level, suitable protection from the radiation of the sun shall be provided by means of covers or canopies.
- I. The protection covers or canopies shall be of an approved design, securely fixed to the structure or ground and be fully ventilated.
- J. All cables shall be delivered on robust cable drums with cable ends treated to form an effective seal when a cable is cut from a drum the cable end left on the drum shall be immediately sealed in an approved manner to prevent the ingress
- K. All cable hangers, cleats, saddles, brackets and similar supporting devices shall be of an approved type and of adequate strength for the cable they are supporting. They shall be treated to withstand site conditions without corroding.

- L. Spacing of clips, saddles and cleats shall be such to prevent sagging of the cable at all times during their installed life.
- M. All power shall be connected to main switchboards and other items of plant so that the correct phase sequence and phase color coding are preserved throughout the system. All such cables shall be identified with phase colors for 3 & 4 wire systems and blue and brown for single phase. On rotating plant where to achieve the required direction of rotation it is not possible to connect the phase cores to the appropriately identified terminals then special core ferrules shall be fitted to identify each core with the terminal to which it is finally connected.
- N. The general routing of cables shown on the drawings is indicative the cables shall be installed as per the approved shop drawings.
- O. Cables and their support systems shall not be fixed to protective barriers, guards or directly to hand railing.
- P. Before making of a termination, the Contractor shall ascertain whether special phasing conditions apply and shall be responsible for ensuring that all connections are correctly phased out.
- Q. The Contractor shall be responsible for obtaining drawings of all boxes or apparatus into which cables are terminated and shall ensure that the design is suitable for the use with the cables supplied under this Contract.
- R. Cables passing through floors shall be installed in the manner specified and where required shall be sealed into bushes employing fire resisting material to minimize the risk of spreading fire.
- S. In all instances where cables enter building or ducts, they shall be installed into not less than 100 mm diameter duct pipes. The ends of the pipes shall be sealed with cold plastic compound. Where cable enter below floor level the pipes will terminate in a floor recess which shall be filled with sand and covered with a thin layer of concrete, after cabling.
- T. Where cables are run within ducts, or along the surface of walls, they shall be supported by approved heavy gauge galvanized cable tray or ladder.
- U. In positions where cables rise vertically, in ducts or on the face of walls etc., they are to be fixed by means of approved cleats and spaced as recommended by the cable manufacturer.
- V. All cables shall be adequately supported and run clear of heating pipe.
- W. The wiring shall generally be carried out on the loop-in system at accessory points only. The use of junction boxes will not be permitted.
- X. Generally, all cables shall be concealed above suspended ceiling and it is intended that these shall be installed before any ceiling board is erected or plastering carried out.

Tender Documents

- Y. Cables run in floor voids and roof space, where run parallel with the joists, shall be fixed to the joint side and where run at right angles shall be supported by cable trays. Care shall be taken to prevent the cables being subjected to pressure or mechanical strain at bends and changes in direction. Easy bends and rounded supports shall be employed at all such positions. The inside radius of any bend is not to be less than 8 times the overall diameter of the cable.
- Z. All cables shall be prevented by spacing, insulation, or other means from coming into contact with water pipes, telephones and bell installed.
- AA. Cables run in roof space shall be laid on cable trays or ladders.
- BB. The cables shall be run and terminated otherwise as specified and as unobtrusive, neat and symmetrical as possible.
- CC. Industrial area
1. In the industrial areas like Main Workshop, Generator Halls, Main Transformer Chamber, Riser Shaft, the conduits shall be rigid metallic type surface mounted.
 2. The small power and lighting cables (Insulated only) shall be installed in conduits
 3. The Power cables (Insulated and sheathed) shall be clipped to the wall or installed on cable trays.
 4. Power cables in floor trench shall be installed on galvanized cable ladders.
- DD. Commercial area
1. In the commercial areas the conduits shall be of the non-metallic rigid type in the wall or above the suspended ceiling.
 2. The small power and lighting cables shall be installed in conduits.
 3. The power cables above the suspended ceiling shall be clipped to the wall or installed on cable trays.
 4. The power cables in the walls shall be installed in rigid non-metallic conduits embedded in walls.

3.02 CABLE TERMINATIONS AND JOINTS

- A. Where more than one cable is to be terminated at an item or equipment, particular care should be taken to ensure that all cables to that equipment are routed from a common direction and each is terminated in an orderly and symmetrical fashion.
- B. The Contractor shall supply and install all necessary cable glands and sealing boxes required to complete the installation. All materials used in the manufacture of the glands etc., shall have no deleterious effect on the cable core or armoring and shall not be susceptible to corrosion.
- C. The cores of each cable shall be taken direct to the terminals of the equipment to be connected. Cable ends shall be sealed in suitable chambers bolted to terminal boxes. Compression glands with armor clamps

where required are to be supplied as an integral part of switchboards, distribution boards, switches, motor starter and similar equipment unless other stated.

- D. Wherever it is necessary to remove the PVC sheath of a cable (e.g. at a joint) the minimum length necessary shall be removed and the exposed copper sheath or armoring shall be adequately covered by a PVC tape or sleeve or other suitable means.
- E. PVC or XLPE insulated cables shall be terminated with mechanical glands in accordance with BS 6121 and shall be of the type to provide adequate support to the cable by under and over locking on the cable armoring, giving a high earth continuity. Each and every mechanical cable gland shall be supplied and installed complete with brass earthing tape and a PVC gland shroud, which shall provide an effective seal on both the cable over sheath and gland.
- F. All cable conductors shall be terminated in suitable copper lugs or brass thimbles which shall be attached to the conductors by use of a pneumatic crimping machine using the correct crimping dies for each size of cable core.
- G. Where single core glands are required, these shall be non-magnetic. The gland plate shall also be of a non- magnetic material. Removable connections for bonding across the gland insulation shall be provided. The gland insulation shall withstand a test of 2 kV ac for one minute
- H. Aluminum cores of power cables shall be terminated using approved bimetallic connectors.
- I. All glands shall be provided with an earthing tag. Glands shall comply with BS 6121. They shall seal the inner and outer cable sheaths against ingress of dirt and moisture and provide mechanical support.
- J. Where cable glands are exposed to the weather, these shall be protected by heat shrink plastic tape or purpose molded sleeves covering the gland continuously from overall sheath to the gland neck.
- K. Where the apparatus enclosure classification requires sealed cable gland entries, sealing shall be achieved by using threaded cable gland holes and polytetrafluoroethylene (PTFE) tape.
- L. Multicore or control cable terminations
 - 1. A sufficient number of terminals shall be provided to terminate all cable cores. For control and auxiliary wiring and additional 20% of this number shall be provided as spares.
 - 2. Terminal blocks for terminating up to and including 35 mm² cable shall securely clamp the conductor, without damage, between two plates by means of a captive screw; pinch screw type terminal blocks shall not be used.
 - 3. For cables above 35 mm², stud or bolted terminals shall be used,

each cable core being fitted with a suitable lug.

4. Not more than one core of internal or external wiring shall be connected on any terminal. Where duplication of terminal blocks is necessary, purpose made solid links shall be incorporated in the design of the terminal blocks.
5. Terminals which remain energized when the main equipment is isolated shall be suitable screened and labelled.
6. Plant which has to be dismantled for maintenance shall have multicore cable terminations made of tough glands onto an adaptable box. The box shall have terminal blocks, and connections shall be made to the equipment by single core wires and flexible waterproof plastic conduit. A separate earth core shall link the box to the equipment.

M. Joints

Through joints shall only be allowed on long cable runs outside buildings. Where such joints are necessary in thermoplastic and elastomeric cables, the cables shall be jointed with epoxy or acrylic resin cold setting compound, which has been premeasured and prepackaged ready for use. The boxed shall be of split, moulded plastic type with filling vents for compound. Bonding straps shall be fitted with armor clamps across the joint and inspected by the Engineer prior to filling the box with compound. Conductor cores shall be jointed number to number or color to color.

3.03 CABLE AND CORE IDENTIFICATION

- A. Each and every cable shall be permanently identified at each end and at entry and exit points of building's ducts by its cable number. Cable markers shall comprise oval marker with semi-rigid black PVC carrier strip and shall be fixed axially by means of two PVC covered aluminum strips with buckles.
- B. Permanent corrosion resistant identification labels shall also be installed on cables at each and every entry and exit points of buried ducts, exits and entry to any structure and in such other positions as are necessary to identify and trace the route of any site cable. The use of punch type adhesive labels (Dymo-tape) shall not be permitted.
- C. Control cables shall have individual cores identified by means of suitable permanent ferrules bearing the same numbers at both ends. Core identification shall occur at every point of termination using an approved system of ferrule markers. Numbering shall read from the terminal outwards on all cores. At those points of interconnection between wiring where a change of number cannot be avoided double ferrules shall be provided on each wire. The change of numbering shall be shown on the wiring diagrams of the equipment at which the change is made.

- D. Where the termination of control cable cores or the supervision of termination of cores is specified as being the responsibility of another contractor (e.g. the termination of certain control and instrumentation cables) any necessary temporary means of core identification shall be agreed with that contractor. Should the Contractor propose to use junction boxes in auxiliary control cable circuits for the purpose of marshalling a number of cables feeding to a common item of equipment full details shall be given to the Engineer and the Contractor shall only proceed after receipt of the Engineer's written approval. Any such junction box shall be of the wall mounting pattern with double terminals with cores ferruled and identified in accordance with the system schematic and cable diagrams.
- E. All cables shall be identified below the gland at each end and at approved positions by means of bands engraved or stamped with the cable number, feeder name, size of cable, number of cores, phase color, etc., or such lettering as the Engineer may require. The bands shall be securely fastened in a permanent manner, and shall be made of material able to resist corrosion, damp, and mechanical damage.
- F. Single core cables are to be identified by colored tape over the cable above the gland.
- G. Tagging
1. Where two or more circuits are run to or through a control device, outlet box or ceiling junction box, each circuit shall be tagged as a guide in making connection.
 2. Conductors for which outer jacket if not color-coded shall either have an engraved identification mark or shall be tagged.
 3. Tags shall identify wire or cable number, conductor size and piece of equipment served in accordance with the schedules as shown on the drawings.
 4. Main and feeder cables shall be tagged in all pull boxes, wireway and wiring gutters of panels and at their terminals.
 5. All control cables and power cables shall be provided with cable markers attached to the outer sheath of the cables for ease of identification, and every cable shall be labelled with the number it is allocated on the relevant cable schedule.
 6. The cable markers shall be fitted to cables in an accessible position that is clearly readable, i.e.
 - a. Inside a control cubicle within 100 mm of the gland position on the cable serving.
 - b. At motors, junction boxes and remote enclosures, as near as possible to the gland position.
 7. Additional marker labels shall be fitted where cables enter and leave cable tray, ducts pipes or change direction during a run.

3.04 SEALING

- A. Cables entering or leaving ducts shall be sealed. Power and control cables shall be sealed where they enter and leave ducts at all points and in cable chambers including intermediate pulling chambers. The sealing compound shall exhibit the following properties:
 1. Adheres to all metal surfaces, un plasticized, PVC, polyethylene and glazed earthenware and to cable sheath materials.
 2. Unaffected by water.
- B. The type of sealing systems used shall be agreed with the Purchaser and shall be selected and installed with due regard to environmental and hazardous area requirements. They shall be from one of the following:
 1. Approved water, gas and fire sealing transit units with fillers and insert blocks fitted to suit all cables and conduits;
 2. Approved oil based, non-setting, reusable sealing compound inserted into the duct or opening around all cables and conduits. Or,
 3. Approved fire retardant, caulking compound or fiber blocks supplied in two halves and shaped to accommodate all cables and conduits.
- C. Each sealing arrangement shall comply with the following requirements.
 1. It shall be compatible with the material of the wiring system with which it is in contact and
 2. It shall permit thermal movement of the wiring system without reduction of the sealing quality, and
 3. It shall be removable without damage to existing cable where space permits future extension to be made, and
 4. It shall resist relevant external influences to the same degree as the wiring system with which it is used.
- D. During the erection of a wiring system temporary sealing arrangements shall be provided as appropriate.
- E. Where cables pass through walls below ground level, the point of entry shall be sealed against the ingress of water. This shall be achieved with petrolatum tape and mastic, silicon foam or proprietary cable transits.
- F. Where cables pass in or out of any duct entries into or within buildings such entries, together with any spare ducts shall be sealed against the ingress of moisture by means of duct stoppers and bituminous compounds or by any other method approved by the Engineer. The stopper shall have a fire resistance of at least 30 minutes.

3.05 CABLE SEGREGATION

- A. Only conductors carrying signals of the same instrumentation signal category shall be contained within any one multi-core cable.
- B. In each instrumentation signal category, a further segregation is required to ensure that conductors forming part of an intrinsically safe circuit are

contained within multi-core cables reserved solely for such circuits.

- C. High integrity signals such as data transmission or critical shut down signals shall be contained in separate cables.
- D. ICA/Telemetry cables sharing a cable tray, duct or route with power cables shall be avoided power cables are defined as a.c. cables above 50 volts with a 10-amp rating. Where this is not practicable, a minimum maintained separation between cables shall be provided in accordance with Table A.
- E. Where the maximum current exceeds 100 amps or the voltage exceeds 650 volts, the minimum segregation shall be 1200 mm. For higher ratings the segregation shall be progressively increased, 2000 mm from a 33 kV cable is a typical figure.
- F. Where the length of an enforced parallel run between power and ICA/Telemetry cables is greater than 500 meters, a progressive pro-rata increase in segregation distance shall apply.
- G. The segregation distances shall be maintained by positive means and shall apply to both above ground and below ground installations.
- H. Where a crossover between power and ICA/Telemetry cables is unavoidable the cable shall be arranged to cross at right angles. The number of crossovers shall be kept to a minimum.
- I. Where cable installations are of a restrictive nature such as entries into buildings, panels, etc., relation of the minimum segregation distance requirement from a power cable(s) is acceptable. The minimum segregation distance shall then be the distance, determined by the length of the parallelism at the restrictive section of the installation.

3.06 CABLE IN CONDUIT

- A. All conductors to be contained within a single conduit shall be drawn in at the same time. An approved lubricant may be used in drawing conductors through conduits.
- B. A reasonable amount of slack shall be left in each conductor at distribution boards, outlets boxes and other devices to facilitate the making of joints and connections to fixtures and equipment.
- C. Branch circuits shall be properly balanced on the buses of distribution boards.
- D. Single core cable shall be drawn into conduit or trunking with multicore cables laid on trays or run on surfaces to which they are affixed as a continuous length between points of termination. The use of junction boxes will only be permitted with the written approval of the Engineer.
- E. Single core cables run in conduit or trunking shall be limited in the number contained in each conduit or trunking in accordance with the grouping allowed in calculating their current rating and the maximum containment in accordance with BS 7671.

- F. Circuits supplied from different distribution boards shall not be installed in the same conduit.
- G. Final sub circuits shall not be installed in the same conduit as sub mains circuit.
- H. DC circuits shall be run in separate conduits.

3.07 CABLES ON LADDERS/TRAYS

- A. Cables shall be supported to avoid damage during installation, prior to dressing and fixing.
- B. Cables shall be securely fixed to ladder/trays
- C. For cables installed in accessible positions, where the entire support for the cable is derived from clips, the maximum spacing of clips shall comply with IEE Guidance Note No.1: Selection and Erection, Appendix 1.
- D. Depending on their overall diameters, single cables and groups of cables shall be secured according to the applicable standard.
- E. In outdoor locations, where installation could be subject to ultra violet light, PVC covered aluminum tape shall be used in preference to nylon cable ties.
- F. Cables installed in groups shall be installed in straight lines and not cross over each other. Cables shall not be installed in more than two layers, comprising a maximum group size of 7.
- G. Where cables leave trays shall be covered with PVC or formed to present a smooth surface to prevent damage to the cable.
- H. Single core power cables shall be secured throughout using proprietary trefoil cable cleats.

3.08 CABLES IN TRUNKING

- A. In order to prevent damage to cables during installation, cables shall not be installed into any section of trunking until that section has been completed.
- B. The trunking shall provide 10% spare rated capacity.
- C. Cables of individual circuits shall be taped together, at 1500 mm intervals, along their length to avoid damage to cables in trunking mounted other than lid up and particularly in all vertical runs and at bends, proprietary cable retainers/supports/pin racks/cable guides shall be used.
- D. Trunking shall be terminated using proprietary fittings.

3.09 CABLES TRENCH WORK

- A. Cables Routes: The Contractor shall prepare drawings to scale showing the cables routes and method of installation. He shall draw up diagrams

indicating sizes and types. These drawings shall be submitted to the Engineer.

- B. The arrangement of the cables and all methods of laying shall be approved by the Engineer and shall be planned to provide an orderly formation, free from unnecessary bends and crossing, which will permit the removal of any one cable without undue disturbance to adjacent cables. No joints shall be allowed in any cable unless approved by the Engineer.
- C. The proposed trench route shall be surveyed for the presence of underground cables and/or services before digging commences.
- D. Machine digging shall not be permitted within 1 m of suspected cable positions.
- E. Lines of trenches shall be kept as straight as possible.
- F. Trenches shall have vertical sides supported to avoid subsidence. Where a change in ground level is necessary, the bottom of the trench shall rise or fall gradually.
- G. To ensure that trench bottoms are firm, smooth and free of loose stones and debris, they shall be lined with approximately 200 mm of sand or other approved material.
- H. The trench backfill shall be compacted in layers of a maximum thickness of 200 mm and the surface reinstated to a condition not inferior to that of the surrounding ground.
- I. When excavations for trenches have been accurately executed, notice shall be given by the Contractor to the Engineer. Laying of cables or building of structures shall not be started until the Contractor has obtained the Engineer's sanction to proceed with the work.

3.10 INSTALLATION OF DIRECT BURIED CABLES

- A. The excavation and backfilling of cable trench work shall be carried out by the Contractor.
- B. The Contractor shall supply and lay the sand bedding, cables, sand blinding, cable cover tiles and marking tape. He shall also supply and lay cable route marker posts after the backfilling and top soiling, has been carried out.
- C. The sanding and laying of all cables shall satisfy the following requirements:
 - 1. Cable depths shall be assessed from the finished ground level unless otherwise directed by the Engineer.
 - 2. L.V. cables shall be laid at a depth of 0.6 meter.
 - 3. H.V. and L.V. cables may be run in the same trench but should be staggered. However where necessary to pass through ductwork, cables shall be laid vertically above each other with the H.V. cables at the lowest level with a good sand blinding forming the sand bedding for the L.V. cables.
 - 4. Before laying in cables the Contractor shall inspect the trench work to ensure that the trench bottom is of a smooth and firm contour and free from all sharp materials or obstructions.
 - 5. Cable bedding within the trenches shall be formed by a 200 mm sand layer.
 - 6. Cables shall be laid with adequate separation and shall be <<snaked>> to avoid tension during backfilling operations and subsequent settlement.
 - 7. Before sanding and backfilling, all laid cables shall be inspected by the Engineer, and a further inspection following sanding and tiling

- shall be made by the Engineer before backfilling.
8. After cables have been laid, they shall be covered by a further 200 mm of sand which shall be well tamped around the cables. Mechanical pruners shall not be used for this work.
 9. After sanding cable cover reinforced concrete tile inscribed "ELECTRIC CABLE" shall be of adequate width to ensure an overlap of 150 mm on each side of the cable or group of cables protected. Where two or more tiles are required to protect a group of cables, the longitudinal joint between adjacent tiles shall be at least 50 mm from the nearest cable.
 10. A bright yellow or orange colored plastic tape 150 mm wide by 0.1 mm thick shall be laid in a continuous manner above the center of each 300 mm width of trench, 150 mm below ground level. The tape shall be continuously indelibly marked in Arabic and English with the words.
DANGER ELECTRIC CABLE
DANGER ELECTRIC CABLE
 11. Care shall be taken to ensure complete continuity of such tape, and care taken to avoid displacement of the tape during backfilling.
 12. Cables shall be unrolled from the drums in such a manner as to avoid loops and kinks, and care shall be taken when laying to avoid damage to the outer sheath by drawing over sharp obstacles or stones.
 13. Where cables of different voltage are laid together at the same depth, vertical cable tiles shall be used to segregate the cables.
 14. Control and communication cables shall be laid not closer than 300mm to any high voltage cables.
 15. The Contractor shall carry out backfilling and shall ensure that cable cover tiles are undisturbed and that large rocks, stones and the like are eliminated from backfill spoil.
 16. After backfilling the Contractor shall reinstate to finished ground level. The Contractor shall lay in position the necessary cable route markers at a maximum of 10 meters apart and at any change in direction.
 17. The Contractor shall be solely responsible for ascertaining whether the soil is chemically active and for ensuring that the cables and accessories are suitable for the conditions prevailing on Site and for taking special precautions to protect the cables against chemical action.
 18. A sufficient number of rollers shall be provided so that the cable does not touch the ground or twist during pulling.
 19. All direct buried cables shall be provided with a sheathing material which shall not be degraded by the presence of salt or other minerals in the ground water in which they may be installed. The Contractor shall be responsible for determining the ground conditions for all externally installed cables.
 20. Cables shall be installed in ducts where trenches pass under roads, paved area and foundations.
 21. The open ends of all cable ducts (included unused ducts) and openings in building structures specifically provided for the passage of cables (including unused openings) shall be sealed after cable installation to prevent the ingress of harmful or flammable gases, liquid, smoke, fire and vermin.

**** END OF SECTION ***

SECTION 16163

DISTRIBUTION BOARDS

PART 1 - GENERAL

1.01 DESCRIPTION

- A. The work to be performed includes, but is not necessarily limited to, all work involved in the supply and installation of distribution boards as indicated on the drawings and as by the requirements of this Section.
- B. The types of distribution boards and accessories required for the project include the following:
 - 1. Final Distribution Board
 - 2. Submain Distribution Board
 - 3. Main Distribution Board

1.02 QUALITY ASSURANCE

- A. The Contractor is responsible for the quality of all its purchased items and as such, must develop and submit a Supplier Quality Inspection plan for review. The inspection plan shall cover those items intended for shop inspection and the procedures for carrying out the same.
- B.
 - 1- Manufacturer: Final, Submain and Main Distribution boards shall be the standard products of a manufacturer regularly engaged in manufacture of such equipment and complying with the requirements of the listed standards and whose products have been in satisfactory use in similar service for not less than 5 years.
 - 2- MDBs & SMDBs equipment shall be assembled and tested in the workshop of the approved local agent panel builder/ manufacturer. Where any equipment needs to be assembled at site, prior Engineers approval is required
 - 3- Before placing any order for the supply of any MDB, SMDBs, it shall be insured that the physical sizes of equipment, when installed shall not infringe any clearance required by the concerned local authorities.
- C. Codes and Standards: Comply with the requirements of latest edition of the following codes and standards except as herein modified.
 - 1. BSI - British Standard Institution:
 - BS 4293 Specification for residual current operated circuit breakers.
 - BS 5486 Low-voltage switchgear and control gear assemblies.

BSEN 60439 Specification for low voltage switchgear and control gear assemblies.

BSEN 60898 Specification for circuit breakers for over current protection for household and similar installation.

BSEN 60947 Specification for low voltage switchgear and control gear.

BSEN 61008 Residual current operated circuit breakers, without integral overcurrent protection for household and similar uses (RCCB's).

BSEN 61009 Residual current operated circuit breakers with integral overcurrent protection for household and similar uses (RCBO's).

2. IEC - International Electrotechnical Commission.

IEC 60439 Low voltage switchgear and control gear assemblies.

IEC 60755 General requirements for residual current operated protection devices.

IEC 60898 Electrical accessories circuit breaker for overcurrent protection for household and similar installations.

IEC 60947 Low voltage switchgear and control gear.

IEC 61008 Residual current operated circuit breakers without integral overcurrent protection for household and similar uses (RCCB's)

IEC 61009 Residual current operated circuit breaker with integral overcurrent protection for household and similar uses (RCBO's).

1.03 TESTS AND ACCEPTANCE CRITERIA

- A. Material Test: Unless requirement is waived in writing, submit to the Engineer two copies of manufacturer's test reports certifying that materials meet specified standards.

1.04 SUBMITTALS

- A. The Contractors shall submit to the Engineer in accordance with the provisions of Section 1300, the required documents to establish compliance with this section. Submittals shall at least include the following:
1. Manufacturer's data including specifications, installation instructions and general recommendations for each type of distribution board required. Include data substantiating that units comply with

requirements.

- B. Shop drawings single line diagram, schedule of points and dimensioned drawings of distribution boards and enclosures showing accurately scaled layouts of enclosures and required individual board devices, including but not necessarily limited to circuit breakers, residual current circuit breaker, disconnect.
- C. Test certificates.

PART 2 - PRODUCTS

2.01 DISTRIBUTION BOARDS - GENERAL

- A. Distribution boards shall be of the totally enclosed metal clad pattern manufactured to IEC 60439/BS 5486 standards unless otherwise specified.
- b. Panel boards are to be totally enclosed, dead - front safety type, IP55 for outdoor installations in accordance with IEC 144 and are to be factory designed and assembled. Panel board switching and protective devices, quantities, size, rating, types and arrangement as shown and EDCO and engineer instruction
- c. The distribution board shall be provided with fixed cover and a hinged door with lockable handle, which can be opened without any obstruction about 120 degrees and conduit knock outs from the top and bottom. The hinged door can be an integral part of the fixed cover
- d. Each distribution board shall be arranged for top and bottom cable entry and shall be provided with an ample cable termination plate and chamber to enable cables to be neatly glanced with tails grouped and terminated onto appropriate internal terminations.
- e. Distribution boards shall be wall or floor mounted and shall when specified incorporate on-load isolators which shall be front of panel operated with ON/OFF indicator and capable of being padlocked in the OFF position. Distribution boards shall incorporate combination of single pole and triple pole circuit breakers shown on the drawings.
- G. The termination of the circuit cables at distribution boards shall be neat and slack left at each circuit breaker or neutral bar to enable the complete assembly to be removed for inspection without disconnection. Neutral conductors shall be connected to the bar in the same order as the phase conductor to the circuit breaker.
- H. Each distribution board shall be complete with a permanent circuit identification chart preferably counted within the front door. This chart shall be permanently and legibly filled in as circuits are complete with the circuit description including the breaker rating.
- I. Painting of distribution boards shall be in approved colors.
- J. The boards shall be properly earthed by connecting an earthing conductor from main distribution earth bar to an earth connector welded to the cabinet.

k. Rated insulation voltage is to be in accordance with standards, and as specified here in.

- Protection: to be full rated throughout the system.
- Series (cascade) coordination protection (integrated equipment short circuit ratings) where indicated coordination between the series circuit breakers (main and branch) shall be in accordance with IEC standards and with an integrated series combination chart prepared by the manufacturer, tested and certified in the country of origin by an internationally authorized organization, where short circuit ratings are beyond available fully rated types specified, and with the approval of the Engineer .
- Short circuit rating shall be more than the calculated level at point of utilization unless indicated on the drawings.
- Panel boards shall be the product of one manufacturer unless otherwise approved by the Engineer.
- Where main bus rating is, not shown on the drawings, it shall be rated not less than the setting of the feeder over current device.
- Pre-punched neutral and earthing bars are fitted as standard to save installation.
- Panel boards shall be provided to fit in the spaces allocated even if requiring nonstandard housing and design.

1. Panel Boards Assemblies:

a) Feeder panel

- 1) F.P shall be designed, manufactured and assembled in accordance of IEC 439 BS 5486 part 1, class 3
- 2) 3 phase, 4 wire suitable for ratings of main and outgoing feeders as shown on the drawings and schedules.
- 3) Main breaker shall be of the molded case circuit breaker MCCB's.
- 4) Branch breakers shall be of the molded case circuit breakers MCCB's.
- 5) Construction: Deal front construction and separation to IEC 439 form 2A. Enclosure shall be sheet steel, minimum 1.5 mm for box and 2mm thick for trim and door. Fronts are to be single or twin covers to shield circuit breakers, terminals and live ends.

2. Enclosures

- a) Construction: General purpose type, suitable for relevant ambient conditions, flush or surface mounted as shown or indicated, comprising box, trim and door in accordance with the standards. Welded joints are to be galvanized after manufacture. Gutter spaces are to conform to standards, but are not less than 100mm on all sides. Enclosure is to have pre-designed angles or threaded end studs to support and adjust mounting of interior panel boards.
- b) Trims: are to cover and overlap front shield, covering all terminals and bus compartment to form a dead panel. Trims are to be fixed to cabinet /box by quarter turn clamps engaging flange of box. Screws where used are to be oval - head countersunk and flush. Trims for flush mounted panel boards are to overlap box and front shields by at least 20 mm.
- c) Door: are to have concealed hinges integral with trim and flush combination cylinder lock with lock and catch. Doors over 1000mm high are to have vault - type handle and multiple point latch mechanism locks are to be keyed alike.
- d) Finish: Zinc coated corrosion resistant steel enclosure shall be epoxy powder paint of standard gray color to the Engineer approval.
- e) Directories: Provide interior circuit directory frame for wire and cable color code identification for each voltage system with clear plastic covering.

- f) Provide sufficient space for terminating cables entering and leaving the panel in accordance with cable schedules.
- g) Provide instruments kit where indicated or shown on the drawings.
- 3. Panel board Interiors
 - a) Assembly of branch circuit units and electro-plated buses on a rigid back pan arranged to permit removal of any unit without disturbing adjacent units. Bus work shall be fabricated of 98 percent pure electrolytic copper, tin plated.
 - b) Provide full-size neutral bus and 50 percent sized bare un-insulated ground buses where indicated or specified. Provide suitable lugs for full circuit capacity on neutral and ground buses.
 - c) Main terminals shall be equipped with solderless pressure indent type connector with means to prevent swiveling.
 - d) Arrange buses so that any three adjacent branches, (1, 3, 5) are connected to Phases A, B and C respectively with the same phase sequence maintained throughout.
 - e) Provide appropriate bus work and hardware ready to receive future switch and fuse or circuit breaker with blank plates for circuits marked "FUTURE" or "SPACE".

A. Molded-Case Circuit-Breakers (MCCBs)

- 1. Factory-assembled, molded-case circuit-breakers of frame sizes, characteristics, and ratings including RMS symmetrical interrupting ratings indicated. Construct with trip-free, toggle-type operating mechanisms with quick-make, quick-break action and positive handle trip indication. Construct breakers for mounting and operating in any physical position, and operating in an ambient temperature of 50 degrees C. Provide breakers with mechanical screw type removable connector lugs.
- 2. Circuit-breakers shall have adjustable thermal and adjustable magnetic trip unit for size 225A and larger unless otherwise indicated. Multi-pole circuit-breakers shall be of the common trip type and not be single pole units with handle ties. Cable lugs shall be suitable for 75 degrees C wire.
MCCB s shall be in accordance with IEC 947 - 2. Types and categories to match with type of application as per IEC 947 - 2. Current limiting types shall be used where

B. Miniature Circuit Breakers

- 1. Thermal magnetic type, nonadjustable to IEC 947 - 2.
- 2. Minimum short circuit breaking capacities are to be 6 to 100 An MCB, 9KA at 415 V AC.
- 3. Rating is preferred to be 6, 10, 15, 20, 30, 40, 50, 60, 80 and 100, calibrated at 40 C°. Available as 1,2,3 and 4 pole circuit breakers.

- C. Auxiliaries: where required or shown on the drawings, are to include alarm switch, auxiliary switch, shunt trip, under voltage release, motorized mechanism or similar units which are to be modular additions to the circuit breakers.

D. Busbars

Main insulated busbar with a rating as shown on the Drawings shall be provided across the top of each structure. Each structure shall also be complete with vertical copper buses to distribute incoming power to each outgoing protective device in the structure. The distribution board bussing shall be plated and sleeved as per authorities' requirements and of sufficient cross sectional area to continuously conduct rated current with a maximum average temperature rise of 20 degree C above an ambient

temperature of 50-degree C.

Each phase and neutral busbar shall be tin plated and shall consist of hard drawn, high conductivity copper of uniform rectangular cross section throughout to BS 1433.

All bus connections shall be bolted and clamp type terminals provided for cables.

All bus bars and busbar connections shall be accessible for inspection and maintenance only, after the removal of covers secured by bolts and studs. Such covers shall be identified externally by Engraved laminated labels bearing the inscription; "Busbars - Danger 380 volts" in 30 mm high black lettering on yellow backing round.

Neutral shall be full size, unless otherwise indicated.

No Diversity shall be used in Bus Bar dropper sizing.

Earthing bus shall be sized in accordance with the BS 7430 for prospective short circuit.

Grounding (earthing) bus shall extend through the entire length of MDB & EMDB.

Main Distribution Board that is fed directly from the transformer shall have the following additional features:

- a) Neutral busbar shall be provided with a removable solid bar link for testing purposes.
- b) A separate bonding strap shall be connected from the neutral bus to the main distribution board frame. This bonding strap shall be located on the line side of the removable neutral link maintaining a service ground to the main distribution board frame when the test link is removed.
- c) Any additional feature as per the Electrical Authorities requirements.

Labels

All enclosures containing functional units shall be clearly labeled with a circuit unit reference and current rating in English and Arabic. Every functional unit shall be labeled separately from all others. External labels shall have letters not less than 5 mm in height and internal labels not less than 3 mm. The letters shall be black in color on white background.

All covers/doors not fitted with interlock switched disconnectors enclosing enshrouded live equipment, shall be fitted with warning labels inscribed "Danger-Isolate before Opening" in English and Arabic.

Warning labels shall have black letters on bright yellow background. Whenever possible, letters shall be not less than 30 mm in height. On small covers and doors 20 mm or 10 mm high letters shall be used.

All terminal blocks shall be labeled relative to respective functional unit. Every control and metering device, switch, pushbutton, indicator lamp, etc. shall be labeled to indicate its purpose.

Main identification labels shall be provided on MDB together with its rating plate.

Fixed and withdraw able portions of equipment, including fixed and plug in devices shall be labeled with both with draw able and fixed part.

Selector Switch/Push Buttons/Indicator Lamp

Selector switches shall be of the rotary type with lever or key operated actuators as specified in the schedules. Push button shall be of the flush type with colors in accordance with BSEN 60043:1993.

Pushbuttons for emergency stop purpose shall be of mushroom head type, with twist to release action or key reset facility as specified.

Contact blocks shall have double break silver plated contacts in NO or NC configuration rated at not less than 5A resistive at 230V, 50Hz.

Indicating lamps shall be of the flush type, 22 mm diameter, with removable colored lenses to permit replacement of lamps from the front. Colors shall be in accordance with BS 4094.

Indicating lamps on control circuits shall be equipped with completely sealed dual wound safety isolating transformers. Lamp test facility shall be provided.

Testing and Commissioning

The main distribution board MDB shall be tested at factory in accordance with the

requirements of BSEN 60439-1 and the associated standards.

Work tests shall include inspection of all components, wiring and a complete electrical functioning test.

Protection relays shall be tested by primary current injection method, with currents equal to overload, short circuit and earth fault conditions.

After completion of installation of the switchgear assemblies on site, they shall be subjected to the routine tests as defined in BSEN 60439-1.

All functional units shall be checked for correct mechanical operation.

Following the satisfactory conclusion of inspection and tests both at factory and on site, each MDB shall be duly commissioned and left in full working order. The commissioning process shall be deemed to include the following:

1. Energizing of functional device circuit and equipment which have been inspected, megger tested, found satisfactory and capable of being energized with complete safety.
2. Starting up of all electrically powered plant and equipment including those supplied and installed under other sections of the contract.
3. Verification of the performance of each switchgear MDB relative to all such plants and equipment by carrying out functional tests, where required and making necessary adjustments for optimum performance.
4. Testing interlock options in all possible combinations and operations of control system.

PART 3 - EXECUTION

3.01 FOUNDATION PAD

I. Provide a foundation pad for the switchboard as specified in Section 16010, Electrical General Provisions. Secure the switchboard to the pad as recommended by the manufacturer. Include openings for bottom feeds to the switchboard which are compatible with the equipment provided.

3.02 EQUIPMENT INSTALLATION

- I. Field Connections. Make field connections of buses between switchboard sections with splice bus and hardware provided by the switchboard manufacturer.
- II. Equipment Settings. Properly set adjustable current and voltage settings as noted on shop drawing submittals. Effectively accomplish grounding and bonding.
- III. Restoration. Restore all damaged surfaces to factory finish.
- IV. Inspection. Thoroughly inspect the switchboard for items such as loose connections and presence of foreign materials and remedy prior to energizing the switchboard. All bolted connections shall be torqued to the manufacturer's recommendations.
- V. Double Lugging. Double lugging on one protected device to feed two separate loads will not be permitted.

3.03 TESTING

- I. After installation and before acceptance by the Owner, the Contractor shall perform test which will include the polarity of the current sensors and give an indication of satisfactory operation of voltmeters, ammeters and their selector switches.
- II. The Contractor shall notify the Engineer of this test date 2 days in advance so the tests can be properly witness

End of secti

Section 16500: Lighting System

1. GENERAL

1.1. GENERAL REQUIREMENTS

The lighting points shall comprise the following as a minimum:

- A. Embedded, ceiling mounted lighting points shall be used.
- B. Lighting installations will be of PVC embedded conduits.
- C. PVC conduits will be of heavy gauge type and with size not less than 20mm.
- D. The maximum number of PVC wires inside the PVC conduits will be such that a free space of 40% of the PVC size will be provided.
- E. High class 2.5 mm² stranded copper, PVC insulated, 450/750 Volts wires will be used for lighting circuits (P+ N+E).
- F. Separate protective device (MCB) will be used for each circuit.
- G. Galvanized rigid steel conduits will be used in exposed installation.
- H. MCBs for lighting circuits will be of minimum of 10 Amp rating, 6kA rupturing capacity.
- I. It is strictly forbidden to feed lighting circuits from a socket outlet circuit, and vice versa.
- J. Draw boxes and covers, lighting fixtures, distribution boards etc. and anything else is needed to be fixed on the walls or the ceiling will be fixed by plastic sphenoid and zinc plated self-taping hardened steel (z s h) screws. The use of wooden sphenoid or wired is strictly forbidden.
- K. The work of this division shall comply with requirements of Section 16050 Basic Materials and Methods.

1.2. SCOPE OF WORK

- A. Supply all labor, tools, services and equipment and provide all the materials required to complete this section of the work.
- B. The lighting installation for this project shall consist of the following systems but shall not be limited to:
 1. street lightingsystem.

1.3. QUALITY ASSURANCE

- A. Acceptable Manufacturers is according to list of approved manufacturers.

1.4. SUBMITTALS

- A. Reference Applicable Divisions - Submittals
- B. Reference Applicable Divisions - shop drawings, products and data and samples.
- C. For each type of lighting fixtures, the contractor shall submit the following details:
 - i. Catalogue illustrations of luminaire proposed for each specified application.
 - ii. Installation requirements.
 - iii. Photometric curves and Isolux diagrams for each luminaire with indication of minimum light output ratio.
 - iv. Original country of origin certificates.

1.5. Manufacturer's Warranty:

The contractor shall submit manufacturer's warranty for minimum five (5) years for all lighting fixtures, exit signs, emergency lights, presence sensors and emergency conversion kits. The warranty starts from the date of the substantial completion of the system.

2. PRODUCTS

2.1. LUMINARIES - GENERAL

- A. Standards
 1. IEC standards.
 2. BS Stands.

3. CIBSE Standards - Code of Lighting.
4. Jordan local codes.
- B. Equipment
 1. Luminaires shall be completely self-contained, unless otherwise specified, and include all components, connectors, reflectors diffusers, drivers, fixing means, etc. as required.
 2. All diffusers shall be of the light stabilized and non-discoloring type.
 2. The design, construction and finish of all luminaires shall be entirely adequate for operation in the ambient conditions. All luminaires shall be designed and installed to permit easy replacement.
 7. all weather-proof luminaires shall be fully suitable for outdoor use and shall not deteriorate after extended use in the ambient site conditions state.
 8. The IP ratings for all outdoor lighting shall be applied on both front side and rear side of the luminaires.

Where shown on drawings, emergency lights shall be equipped with emergency . of lighting units intended for emergency lighting purposes.

2.2. TYPES OF LIGHTING FIXTURES:

Refer to Electrical legend.

Shall comply with all applicable requirements, as herein unless otherwise specified or shown on the Drawings, fixture shall bear manufacturer's name and the factory inspection label.

- HOUSING
 - In die-cast aluminum.
- REFLECTOR
 - In anodized, polished, pressed aluminum.
- DIFFUSER
 - Glass 4mm thermally harden
- DRIVER
 - The driver should be changeable type
- LAMPS LED 200W

3. EXECUTION

3.1. INSTALLATION OF LIGHTING FIXTURES

- A. Provide all lighting fixtures and lamps shown on the drawings luminaires schedule and data sheets attached herein.
- B. Include for assembly, and mounting of all fixtures, complete with all wiring, connections, fittings, hangers, aligners, box covers and accessories which may be required for any fixture to provide a complete, safe, fully operational assembly.
- c. Where fixtures are suspended from the structure, they shall utilize self-aligning box covers with an additional ground wire from the outlet through the hanger for continuity of ground.
- d. Carefully co-ordinate the fixture installation with the work of other trades ensuring that the necessary depths and mounting spaces are provided. Do not alter fixture locations unless approved by the Architect.
- g. All lamps shall be new and intact when the project is complete, and ready for acceptance.
- h. Earthing

1. All luminaries of metallic construction shall be suitably earthed; the earth wiring being connected by a terminal provided within each fitting specifically for this purpose.
2. Where luminaires are suspended, a cable protective conductor shall be connected between the fitting and the final sub-circuit wiring installation.

L. Luminaires Commissioning and Testing

2.03- LIGHTING POLES

- GENERAL
- The complete assembly of the lighting fixtures consisting of a pole, luminaries and bracket arms. and according specification for Highway and bridge construction –volume (IV) issued by ministry of Republic and housing
- Height, shaft octagonal shape, and dimensions shall be as shown on the Drawings. Poles shall be hot dip galvanized thickness >3mm and according BS EN ISO 1461. Each pole shall be equipped with a cable connection box protection code IP 55, for two incoming cables equipped with two fuse sockets.
 - Each pole shall have an earthing lug.
- POLES WITH FLANGE PLATE
- The base assembly of these poles shall consist of a base plate, of suitable dimensions, welded to the shaft tube. A minimum of four hot-dipped galvanized high-tensile steel anchor bolts, with square leveling nuts, hexagonal hold-down bolts, flat and lock washers shall be capable of withstanding full bending moment of the shaft at its yield strength stress. The base plate shall have wide opening for cable penetration from the concrete foundation.
- FOUNDATION
- The foundations shall be provided with conduits for cable penetration to the pole.
- BRACKET ARMS
- Brackets shall be normally formed as one part of the pole and not separately bolted to the pole.

END OF SECTION

SECTION - 16452
EARTHING / GROUNDING

PART 1 - GENERAL

1.01 SUMMARY

A. This Section includes solid earthing of electrical systems (unless otherwise indicated) and equipment. It includes basic requirements for earthing for protection of life, equipment, circuits, and systems.

1.02 SUBMITTALS

A. General: Submit each item in this Article according to the Conditions of the Contract and Sections 16010.

B. Product Data for earthing rods, connectors and connection materials, and earthing fittings.

C. Workshop Drawings:

Submit drawings for approval including but not limited to the following:

- a) Exact location of earth pits, rods and details of installation and connection.
- b) Exact routing of buried earthing conductors with indication of cross section, depth of laying and covering.
- c) Cross sectional area of all earthing, protective and bonding conductors.
- d) Layout and details of earthing provisions at substations, generator rooms, switchgear, distribution panel boards etc. indicating fittings used, insulation, plates and marking, passage and routing of earthing conductors, conduits, etc. giving sizes and dimensions of component parts.

1.03 QUALITY ASSURANCE

A. Provide products as specified in this section and in compliance with the following applicable standards, codes and regulations' 364.

1. IEE wiring regulation for electrical installations.
2. British standard code of practice

2. PRODUCTS

2.01 EARTHING AND BONDING PRODUCTS

A. Products: of types indicated and sizes and ratings to comply with IEE. Where types, sizes, ratings and quantities indicated are in excess of IEE requirements, the more stringent requirements and the greater size, rating, and quantity indicated govern.

B. Equipment Earthing Conductors: Insulated stranded copper with green color insulation.

C. Earthing -Electrode Conductors: Stranded green / yellow cable.

D. Underground earth Conductors: Bare stranded copper conductor of 120 sq. mm. cross section minimum

E. Tinned Copper Conductors: Conform to IEC / BS standards or equal

2.03 MISCELLANEOUS CONDUCTORS

A. Earthing Bus: Tinned, annealed-copper bars of rectangular cross section.

B. Braided Bonding Jumpers: Copper tape, braided 0.6 sq. mm Tinned copper wire, terminated with copper ferrules.

C. Bonding Straps: Soft copper, 1mm thick and 50mm wide, except as indicated.

2.04 CONNECTOR PRODUCTS

- A. Pressure Connectors: High-conductivity-plated units, tinned copper type.
- B. Bolted Clamps: Heavy-duty type, tinned copper.

2.05 GROUNDING ELECTRODES AND TEST WELLS

- A. Earthing Rods: Copper-clad steel with high strength steel core and electrolytic - grade copper outer sheath, molten welded to core.
 - 1. Size $\phi 5/8$ -inch mm by 3 meters extensible as necessary to obtain required earth resistance, and complete with couplings, head and bolted connector of sufficient size.
 - 2. Copper thickness should be 250 micron and should be of 99.9% pure electrolytic copper molecularly bonded to the steel core.

Copper clad steel rods should be of low carbon steel with a tensile strength of approximately 600 N/sq.mm. grade 43 A of BS 4360 or equal.

- 3. Couplings should be made from silicon bronze alloy grade CS 101 of B. S 2874 or bronze alloy grade CA 102 of BS 2871 or equal.
- B. Plate Electrodes: Where indicated shall be copper, square or rectangular shape. Minimum 3mm thick, size as indicated.
- C. Earth Pit (Test well): Precast, square or circular section concrete handhole with concrete cover and as detailed on drawings. Earth rod corer is to have insert brass plate with inscription earth pit - Do Not Remove.

PART 3 - EXECUTION

3.01 APPLICATION

- A. Equipment Earthing Conductors (Protective conductor) for exposed conductive parts: Comply with IEC 364 -3 and 364 - 4 - 41 and IEE for types, sizes and quantities of equipment earthing conductors.
 - 1. Install separate insulated equipment earthing conductor with circuit conductors for the following in addition to locations where required by the Code:
 - a. Feeders and branch circuits.
 - b. Lighting circuits.
 - 2. Bus way Supply Circuits: Install separate equipment earthing conductor from the earthing bus in the switchgear, switchboard, or distribution board to equipment earthing-bar terminal on bus way unless otherwise proposed and approved by the Engineer.
 - 3. Isolated Equipment Enclosure Circuits: For designated equipment supplied by a branch circuit or feeder, isolate equipment enclosure from supply raceway with a nonmetallic raceway fitting listed for the purpose. Install fitting where raceway enters enclosure, and install a separate equipment grounding conductor. Isolate equipment grounding conductor from raceway and from panel board grounding terminals. Terminate at the equipment grounding-conductor terminal of the applicable derived system or service, except as otherwise indicated.
 - 4. Terminal Cabinets: Terminate grounding conductor on cabinet grounding terminal.

3.02 INSTALLATION

- A. General: Ground electrical systems and equipment according to IEC / IEE requirements, except where Drawings or Specifications exceed standard

- requirements. Other applicable international codes are accepted if they exceed IEC regulation.
- b. Earthing Rods: Locate a minimum of two-rod length from each other and at least the same distance from any other earthing electrode.
- 1. Drive rods until tops are 150 mm below finished floor or final grade, except as otherwise indicated.
- 2. Interconnect earthing rods with bare conductors buried at least 600mm below grade. Use exothermic welds, except at test pits wells and as otherwise indicated. Make these connections without damaging copper coating or exposing steel.
- c. Earthing Conductors: Route along the shortest and straightest paths possible, except as otherwise indicated. Avoid obstructing access or placing conductors where they may be subjected to strain, impact, or damage.
- d. Underground Earthing Conductors: Use bare copper wire. Bury at least 600 mm below grade.
- I. Earth Pits: One for each driven earthing electrode, except as otherwise indicated. Set top of pit flush with finished grade or floor. Fill with 25-mm maximum-size crushed stone or gravel. Locate as indicated and fabricate in accordance with details indicated.

3.03 CONNECTIONS

- A. General: Make connections so possibility of galvanic action or electrolysis is minimized. Select connectors, connection hardware, conductors, and connection methods so metals in direct contact will be galvanically compatible.
- 1. Use electroplated or hot-tin-coated materials to assure high conductivity and to make contact points closer in order of galvanic series.
- 2. Make connections with clean, bare metal at points of contact.
- 3. Where earth connection between dissimilar metals must be made, use bimetallic fittings and protect by coating with moisture resisting bituminous paint or compound to prevent future penetration of moisture to contact surfaces.
- b. Tighten screws and bolts for earthing and bonding connectors and terminals according to manufacturer's published torque-tightening values.
- c. Moisture Protection: Where insulated earthing conductors are connected to earthing rods or earthing buses, insulate entire area of connection and seal against moisture penetration of insulation and cable.

1. 3.04 FIELD QUALITY CONTROL

- A. Tests: Subject the completed grounding system to a megger test at each location where a maximum ground-resistance level is specified, at service disconnect enclosure grounding terminal, and at ground test wells. Measure ground resistance not less than 2 full days after the last trace of precipitation, and without the soil being moistened by any means other than natural drainage or seepage and without chemical treatment or other artificial means of reducing natural ground resistance. Perform the tests according to IEEE specifications.
- B. Maximum earthing resistance are as follows:
- C. The overall resistance between the earthing system and the general mass of earth shall be less than 2.0 ohms. Install additional earth electrodes or earth plates if these figures are not

met

- D. Excessive Ground Resistance: Where resistance to ground exceeds specified values, notify the Engineer promptly and include recommendations to reduce ground resistance and to accomplish recommended work.
- E. Report: Prepare test reports, certified by the testing organization, of ground resistance at each test location. Include observations of weather and other phenomena that may affect test results. Describe measures taken to improve test results.
- F. Electrical continuity of all earthing and protective conductors including main and supplementary equipotential bonding conductors is to be checked in accordance with IEE specifications.
- G. Check operation of residual current protective devices.
- H. Check earth loop impedance against calculated figures.

3.05 ADJUSTING AND CLEANING

- A. Restore surface features, including vegetation, at areas disturbed by work of this Section. Reestablish original grades, except as otherwise indicated. Where soil has been removed, replace it as soon as possible after back filling is completed. Restore areas disturbed by trenching, storing of dirt, cable laying, and other activities to their original condition.

- UNDERGROUND DUCTS AND MANHOLES

PART 1 – GENERAL

1.01 SUMMARY

- A. Provide labor, materials, equipment and services, and perform operations required for installation of underground ducts and manholes and related work as indicated on the drawings and specified herein.
- B. Work Included: The work shall include, but not be limited to, the following:
1. Excavation for underground utilities and services,
 2. Conduit ducts, reinforcing steel, and concrete encasement.
 3. Manholes, frames, covers,

1.02 DEFINITIONS

- A. The following definitions apply to excavation operations:
1. Additional Excavation: Where excavation has reached required subgrade elevations, if unsuitable bearing materials are encountered, continue excavation until suitable bearing materials are reached.
 2. Subbase: As used in this section refer to the compacted soil layer used in pavement systems between the subgrade and the pavement base course material.
 3. Subgrade: As used in this section refers to the compacted soil immediately below the slab or pavement system.
 4. Unauthorized excavation consists of removal of materials beyond indicated subgrade elevations or dimensions without specific direction from the Engineer.

1.03 QUALITY ASSURANCE

- A. Materials and equipment shall conform to the latest edition of reference specifications specified herein and to applicable codes and requirements of local authorities having jurisdiction.

1.04 SUBMITTALS

- *. Coordination drawings for work of other trades.
- *. Schedules indicating proposed methods and sequence of operations. Coordinate sequencing with construction phasing and Owner occupancy.

PART 2 – PRODUCTS

2.01 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, by Local authorities, or equal approved
- B. Manhole Frames and Covers
1. Heavy duty, cast iron, conforming to ASTM specifications. Unless otherwise indicated
Covers shall have an approved anti-slip surface with the word "Electric", "Signal", or "Telephone" cast in the top face as appropriate for the contents.
 2. Covers shall fit the frame without undue play. Steel and iron shall be formed to shape and size with sharp lines and angles. Castings shall be free from warp and blow holes that may impair their strength or appearance. Frames

shall be set with covers level with finished grade over a minimum of 3 courses of brick (200 mm overall height) on top of manhole or as shown on the drawings.

- J. Pulling Irons: formed steel bars and cast in the walls and floors. In the floor, locate irons centered under the manhole cover, and in walls not less than 150 mm above or below, and opposite the conduits entering the manhole. Pulling irons in the wall shall project into the manhole approximately 110 mm and in the floors shall be recessed. Irons shall be heavily zinc-coated after fabrication.

PART 3 – EXECUTION

3.01 EXAMINATION

- A. Examine conditions at the job site where work of this section is to be performed to ensure proper arrangement and fit of the work. Start of work implies acceptance of job site conditions.

3.02 PREPARATION

- A. Examine the Contract Drawings and specifications in order to ensure the completeness of the work required under this section.
- B. Verify measurements and dimensions at the job site and cooperate in the coordination and scheduling of the work of this section with the work of related trades, so as not to delay job progress.
- C. Provide templates as required to related trade for location of support and anchorage items.

3.03 EXCAVATION

- A. Slope sides of excavation to comply with local codes and ordinances. Shore and brace as required for stability of excavation.
- B. Install sediment and erosion control measures in accordance with local codes and ordinances.
- c. Locate and retain soil materials away from edge of excavations. Do not store within drip-line of trees indicated to remain.
- d. Remove and legally dispose of excess excavated materials and materials not acceptable for use as backfill or fill.
- E. Trenching: Excavate trenches for electrical installations as follows:
1. Excavate trenches to the uniform width, sufficiently wide to provide ample working room and a minimum of 150 - 250 mm clearance on both sides of raceways and equipment.
 2. Excavate trenches to depth indicated or required.
 3. Limit the length of open trench to that in which installations can be made and the trench backfilled within the same day.
 4. Where rock is encountered, carry excavation below required elevation and backfill with a layer of crushed stone or gravel prior to installation of raceways and equipment. Provide a minimum of 150mm of stone or gravel cushion between rock bearing surface and electrical installations.

- F. Backfilling and Filling: Place soil materials in layers to required sub-grade elevations for each area classification listed below, using materials specified in Part 2 of this Section.

1. Under walks and pavements, use a combination of sub-base materials and excavated or borrowed materials.
3. For raceways less than 750 mm below surface of roadways, provide 100 mm thick concrete base slab support. After installation of raceways, provide a 100

mm thick concrete encasement (sides and top) prior to backfilling and placement of roadway sub-base.

4. Other areas, use excavated or borrowed materials.

G. Backfill excavations as promptly as work permits, but not until completion of the following:

1. Inspection, testing, approval and location of underground utilities have been recorded.
2. Removal of concrete formwork.
3. Removal of shoring and bracing, and backfilling of voids.
4. Removal of trash and debris.

H. Place backfill and fill materials evenly adjacent to structures, piping and equipment to required elevations. Prevent displacement of raceways and equipment by carrying material uniformly around them to approximately same elevation in each lift.

I. Compaction: Control soil compaction during construction, providing minimum percentage of density specified for each area classification indicated below.

END OF SECTION

SECTION - 16752
PASSIVE SYSTEM COMMUNICATION

PART 1- GENERAL

APPLICABLE DOCUMENTS

The cabling system (by communication company) described in this specification is derived in part from the recommendations made in industry standard documents. The list of documents below is incorporated by reference:

ANSI/TIA-568.0-D "Generic Telecommunications Cabling for Customer Premises published

September,2015

ANSI/TIA-568-D.1, "Commercial Building Telecommunications Cabling Standard", published

September,2015

ANSI/TIA-568-D.2, "Balanced Twisted-Pair Telecommunication Cabling and Components

Standard", published September,2018

ANSI/TIA-568-D.3, "Optical Fiber Cabling Components Standard", published October,2016

ISO/IEC 11801-2 Edition 1.0 "Generic Cabling for Customer Premises - Part 2: Office

Premises" Published November,2017

ISO/IEC 11801-1 Edition 1.0 "Generic Cabling for Customer Premises - Part 1: General

Requirements" Published November,2017

ANSI/TIA-569-D "Telecommunications Pathways and Spaces" Published April,2015

ANSI/TIA-606-C "Administration Standard for Telecommunications Infrastructure" Published

June,2017

ANSI/TIA-607-C Generic "Telecommunications Bonding and Grounding (Earthing) for

Customer Premises" published November,2015

ANSI/TIA-942A (Telecommunications infrastructure standard for datacenters).

The cabling system shall also be compatible with a series of standards, products and protocols, i.e., at least:

IEEE 802.3-2008 (Ethernet, Fast Ethernet, Gigabit Ethernet).

IEEE 802.3-2008 (10 Gigabit Ethernet for fiber)

ISO/IEC 8802.3 published 2014 (all equivalents to IEEE 802.3)

IEEE 802.5 (Token Ring)

ANSI/TIA-942 Rev. B Published 2017, Telecommunication infrastructure standards for Data center.

ITU-T Rec.

1.02. COMPLIANCE WITH SAFETY STANDARDS

All cables used on project shall comply with the safety specifications established by IEC-322-1 standard, for buildings with a high-density population and fire protection within buildings.

In contact with flames, cables can become a vehicle for propagating fire and substances produced by combustion can, in turn, have a harmful effect on both Persons and equipment.

Fire propagation shall be deemed the main risk factor and, therefore, the main item to be considered when setting up protective measures.

The results obtained from research on the most advanced production-related technologies and materials have enabled the development of cables that are specially suited for use in installations where it is essential to eliminate, or at least limit, the risks for both persons and equipment.

Among the types of cable having characteristics likely to reduce fire-related risks, groups with flame retardant cable jacket and reduced emissions of smoke and toxic gases stand out called as Low Smoke Zero Halogen (LSZH). The composite materials used to make them must limit the production of smoke (which reduces visibility) and the release of halogen gases (which lead to asphyxia).

1.03 .DESIGN ASSUMPTIONS

The cable Infrastructure solution is based on international standards to provide bandwidth needed to accommodate estimated numbers of occupants and any future expansion in order to avoid any congestion. Furthermore, Infrastructure is designed to maximize the Return on Investment (ROI) to owners in terms of reducing administrations, integrations, and future expansion cost.

The Cable infrastructure design is assuming compliance to the following:

Redundancy

Security

High Availability

Scalability and Expandability

Quality Assurance

PATHWAY AND ROUTES

The cable run from the connection point of (ORANGE ,ZAIN .UMINIAH)companies to each point shall be through a direct connection using under floor UPVC as route as shown in drawing the

END OF SECTION

SPECIFICATIONS OF MATERIALS VALVES, PIPES AND FITTINGS

1. General :

1. Supply and Quality of Materials :

All materials shall comply with those Standards and Specifications laid down by internationally recognized institutions, for the water industrial. Preference will be given to manufacturers that are quality certified to ISO. 9001.

All materials supplied to the site in Jordan shall be subject to acceptance tests carried out by the Royal Scientific Society, or a similar approved Authority.

All materials supplied shall be subject to the Engineer's approval.

Any or all materials and manufactured articles supplied by the Contractor for use in the works, shall (if so required by the Engineer) be tested in advance at the Contractor's expense, in accordance with the required specifications.

Inspection or approval by the Engineer of any equipment or materials supplied by the Contractor shall not release the Contractor from any of his obligations under this Contract .

All information and specifications relating to Products and materials proposed for this Contract, must accompany each Tender Submission.

2. Storage of Materials :

The Contractor shall be responsible for the storage and well being of all materials purchased under this Contract, and any discrepancies found therein.

The Contractor shall manage and maintain stock - yards that can accommodate all materials purchased and approved by the Engineer under this Contract, stored either in the open area or under cover as required by the Manufacture's / supplier's instructions, and shall be regularly inspected by the Engineer's staff and maintained to the Engineer's satisfaction.

3. Scope :

The Contractor shall furnish and deliver to the site, all kind of pipes, valves, fittings, closure pieces, flanges, bolts, nuts gaskets, jointing materials ...etc. and appurtenances as specified and required.

All valves shall be flanged. Pipe fittings and valves shall be Suitable for buried installation.

All tapers (reducers) required at tees and other locations to meet the specified diameters may be furnished in the manufacturer's standard lengths and diameters.

4. References :

Reference to any national standard or publication (as ISO, BS, DIN. etc.) in these specifications is intended to indicate general configuration, type and quality. Goods may be furnished which meet other internationally accepted standard, provided that overall quality will be at least equal to that required by the standard specified. Supporting documents / certificates shall be submitted hereto.

5. Potable Water Certification :

All pipe and coating materials shall be certified for potable water use and shall contain no ingredients that may migrate into water in amounts that are considered to be toxic or otherwise dangerous for health. All pipes shall be certified as safe for transporting potable water by an independent testing laboratory.

6. Materials and Standards :

All materials shall be complying with ISO, BS, API & DIN. standard and shall be supplied from approved manufactures.

The Contractor is requested to submit a list of suppliers that he intends to use together with his Tender bid.

The Contractor shall also submit for the approval of the Engineer, before ordering:

- a) Type of materials to be used, dimensions, thickness, lengths, shape, weight, class, tolerance limits and quality.
- b) Standard to which the item is manufactured.
- c) Details of specials, adapters, fittings and joint design.
- d) Coating and lining methods.

7. Fittings :

Fittings unless otherwise specified shall be furnished with a type of joint compatible with the pipe system at the supplier's option. Any adaptors necessary to joint fittings to the adjacent pipes, even of different materials, shall be provided by the Contractor at no extra cost.

8. Toxic Materials :

The Contractor is prohibited to import or to use any of the "Acrylamide and N-Methylolacrylamide Grouts" or any other toxic or poisonous materials or submaterials used in piping, it's accessories, lining, coating, sealing ...etc, or in various kinds of concrete or in soil in any kind of usage. Any import or usage of the above mentioned materials by the Contractor, requires to be licensed in writing by the Employer, otherwise, the Contractor shall be subject to legal pursuance.

9. Submittals :

The Contractor shall submit :

- i – Detailed manufacturer's proposals for pipes and fittings manufacture, coating and lining ... etc.
- ii – Certified copies of manufacturers quality control test results and reports .
- iii – Certified copies of compliance certificates for pipes, fittings and other components .

“ This is to certify that the pipes and specials delivered in this consignment comply with the required specification .

No payment shall be made in respect of any consignment of pipes and specials in case it is not accompanied by above mentioned certificates .

10. Payment of Taxes and Duties :

The contractor shall take in his consideration that all materials in this Contract shall not exempted from customs duties, import duties, sale taxes and all other kinds of duties and taxes.

11. Tests After Delivery :

The Employer & the Engineer have the right to take samples of the supplied materials, and the following tests shall be carried out in accordance with the relevant ISO, BS, DIN or regulations by an approved laboratory.

1. Hydrostatic pressure test .
2. Hardness test .
3. Tensile strength test .
4. Elongation test .
5. Measurement and weight .
6. Test of cement mortar lining .

All tests as mentioned or directed by the Engineer shall be borne by the Contractor and the costs shall be included in the Contract unit rates.

12. Third Party Control :

The Contractor shall at his own expense provide a recognized independent third party control to monitor quality and witness testing during manufacturing process and to ensure that the products used in the works (such as pipes , fittings , valves . various electrical and mechanical apertures, lap equipment ... etc.) are all manufactured in accordance with the specific standards in this Contract (or any other specifications approved by the Employer) .

The third party control should also issue test certificates stating that they had witnessed all the tests performed on the products, and all materials are conforming to Specifications and they had checked and inspected all materials regarding the proper packing and shipment, and certifying the bill of lading .

Before signing the Contract , the Contractor shall inform the Employer of the name of the control party he intends to engage , and obtain the Employer's approval.

The third party control should be selected from the following list which issued by the Central Tenders Directorate :

- 1 – SGS – Societe General De Servwillance .
- 2 – Tuboscope Verco International .
- 3 – OMIC – Overseas Merchandise Inspection Company LTD .
- 4 – Baltic Control LYTD .
- 5 – Inspecturate (suisse) S . A .
- 6 – Control Union International .
- 7 – Socotec International Inspection .
- 8 – Bureau Veritas - Messers. Red Sea Shipping Agency W .L .L
Box. 1284 – Amman –Jordan

2. Valves

1. GENERAL :

Materials used in valves shall be suitable for potable water.

All valves, on any type of pipeline must be jointed to the pipe by flanges (unless otherwise specified) and shall have a testing pressure of 1.5 times the nominal pressure.

All valves shall be of the non-rising stem type, and shall be capable with standing the specified test pressure without leaking.

The hand wheels of all valves (including those which incorporate gear) shall be arranged for clockwise closing. All hand wheels shall have, in their periphery, the words OPEN and SHUT and appropriately positioned arrows.

When valves have inaccessible positions, extension spindles shall be fitted to suit the situation.

The contractor shall submit a certificate from the manufacturer certifying that all valves have been mill tested and that they have successfully passed the tests prescribed by the relative standard specifications.

2. Gate Valves :

Valves of maximum working pressure up to (25) bars, the valve shall be designed for water works duty and shall comply with (BS.5163) or equivalent standard.

The materials to be used in the construction of the gate valves shall be as follows:

Body, bonnet	Cast Iron, Ductile GGG 50 or Ductile GGG 40
Spindle (stem)	Copper Alloy or Stainless Steel.
Stem nut	Gun Metal or Aluminium Bronze Alloy
Hand Wheel, Stem cap	Cast Iron
Body Seat and Facing	Gun Metal facing disk and body seat to(BS.1400) or Ductile coated with (EPDM). The valve shall be of stuffing box and gland type.

Valves of maximum working pressure greater than (25) bars, the valves should be flange ended, steel globe type for water works duty and shall comply with (BS. 5160) or equivalent standard.

Valves to be installed in concrete chambers, shall where necessary be of the short type to gain space. The valves shall be of the double flange type, utilizing the Same differential pressure across the gate, with screwless bonnet connection, pressure loaded

and pressure sealed with easy assembly and dismantling of functional parts or otherwise with stainless steel connected bonnet.

All connecting material and rubber ring gaskets or adapters shall be provided by the Contractor as necessary to connect the valve with the adjoining pipe material) without any additional cost.

Surface protection of valve internal and external by plastic enamel coat (epoxy resin) applied by electro-static spray process.

Buried valves shall be supplied with stem nuts coupling, sleeves and extension spindles of 0.5 m and 1.00 m length according to the requirements on site.

If necessary spindles have to be shortened. The top of the extension spindle (key rod) shall be fitted with cast iron surface box according to DIN 4056 with pre-cast concrete supports. The spindle itself shall be protected by a suitable PE. or PVC. guard tube including tube covers. Valves to be installed above ground shall be provided with hand wheels. All valves shall be supported by concrete blocks,

Valves with diameter > 200 mm. shall be installed in concrete valve chambers according to the Standard Drawings. These valves shall be operated by supplied handwheels inside the valve chamber.

Additionally these valves shall be equipped with extension spindles and surface boxes, as described above, and as shown as a general detail on the Standard Drawings.

Extension spindles to be connected to the hand wheels by stem unit couplings.

All accessories necessary (as described before) for the above mentioned valve types shall be included in the relevant unit rates for those particular valves.

Min. diameter of hand wheels for valves shall be as follows:

DN. 250 : 500 mm.

DN. 200 : 400 mm.

DN. 150 : 315 mm.

DN. 125 : 315 mm.

DN. 100 : 315 mm

Valves with diameter < 200 mm. shall be installed in the ground according to the Standard Drawings.

One operating key shall be provided for every 10 (or fraction of 10) valves delivered. One extra hand wheel shall be provided for every 100 valves of 100, 150, 200 and 250 mm diameter delivered. The keys and hand wheels shall be included in the unit rates for the valves.

3. Air Valves :

- Where shown on the Drawings, automatic air vacuum and air release valves shall be supplied and shall be of the "Double" or "Single" type , and obtained from approved manufacturer.

- Air valves shall be of the combined type with a larger venting cross section, which permits passage of large volumes of air for vacuum breaking and venting on starting up and closing down, and with a small venting cross section for release of small volumes of air under full internal pressure.

- The air valves shall be fitted with floats made of soft rubber coated carbon steel or stainless steel complying with (DIN. 17440) , suitable for operation in tropical climates. A minimum of one float for each size of valve shall be included in the delivery and in the unit rates for the air valves.

- The Valve casings and covers shall be made of ductile cast iron GGG. 50 conforming with DIN. 1693 . Valve spindles shall be made of stainless steel 20 C13 , according to DIN 17440.

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

- Air valves shall be designed to limit water hammer effects, and all shall conform to the working pressures of the pipe.

- Each air valve of any type shall be supplied or fitted with an isolating valve. Where possible these shall be of the integral screwdown type and shall have gunmetal seats and stoppers and forged bronze spindles fitted with cast iron caps for key operation. The isolating valves shall be suitable for manual operation against the maximum working pressure stated. In cases where separate isolating sluice valves are supplied, these shall be so arranged, with the provision of bevel gearing if necessary, so that they may be operated by (tee) T - key from above.

- Each air valve shall be suitable for the maximum working pressure as stated in the Drawings .

- Single air valves shall be fitted with one large or small orifice as may be specified in the Drawings, suitable for the automatic release of small quantities of air during normal working conditions in the main .

- Double air valves shall be fitted with large and small orifices suitable for the admission and discharge of bulk volumes of air during drainage and filling of the main, and for the release of small quantities of air during normal working.

The isolating valves and all fittings required to install the air release valve .of any type, shall be included in the unit rates of the air valve

- Air valves shall be installed as follows:

A - For Polyethelene pipelines,the contractor shall install a suitable flanged tee (T) and install a pipe of suitable length and diameter in order to install the flanged air valve

B - For ductile iron main pipelines, the contractor shall install a suitable flange tee (T) and install a pipe of suitable length and diameter in order to install the A.V provided with a neck to suit the flanged air valve.

C - The Welding and the air valve pipes welded joints together with flanged joints, shall be properly protected in accordance with the specifications.

D - Air valves with diameter 1 ½ “ and larger shall be installed in concrete valve chambers according to the Standard Drawings.

E - Air valves with diameter 1 ¼ “ and less shall be installed in the ground according to the Standard Drawings (unless otherwise specified).

4 - Wash-Outs :

The types of wash - out specified for this contract, whether in concrete chambers or buried type are as shown on the Standard Drawings. All wash - outs will be constructed as indicated on these Standard Drawings or as instructed by the Engineer.

At places shown on the drawings or directed by the engineer, wash - outs shall be installed as follows:

A - For Polyethelene pipelines, the contractor shall install a suitable flanged tee (T) using electro fusion connection , double flanged piece and flanged bend to install the flanged washout valve.

B - For ductile iron main pipelines, the contractor shall install a suitable flanged tee (T) to install the flanged washout valve.

C - The welding and the W.O pipes welded joints together with flanged joints of the valves shall be properly protected in accordance with the specifications.

D - The wash - out pipes shall be extended to such a length and reach discharge area as is required for every particular site condition as not to flood the trenches or cause any damage to the surrounding area.

The unit price of wash - out pipelines shall also include all concrete and other works at the end of W.O pipelines (outlet structure with riprap) as shown on the drawings, unless otherwise noted .

5 . WATER METERS :

1 . DIGITAL PROPELLER TYPE – MECHANICAL :

The water meter shall be flange ended of the helical type and shall have a registration dial with six digit integrator calibrated to read in cubic meters and shall be of the straight reading type and shall have cover plate and a bank lid to be fitted in place of the lid fixed to the metering mechanism, in case the later is removed for repair.

The water meter shall be suitable for a working pressure as indicated on the Drawings and the Contractor shall supply the tapers and the necessary flanges required for the proper completion of the work.

The length of the pipes connected to and from the water meter shall be at least ten (10) times the diameter of each pipe away from fittings or valves.

The Contractor shall supply install and operate these type of flow meters to measure the flow in water mains, it shall be installed as located on the Drawings. The nominal working pressure of these flow meters type shall be as indicated on the Drawings.

2 . ELECTRICAL TYPE :

A - Scope of Work :

The Contractor shall supply, install, calibrate, test and operate flow meters (ultra sonic or magnetic, as indicated in the Drawing or BOQ. cleaning less flow meter type with

recorder, folded chart type) to measure the flow in water mains. It shall be installed on the delivery pipeline as located on the Drawings.

The locations and nominal working pressure of the flow meters shall be as shown on the Drawings.

The contractor shall install the ultra sonic meter at the water mains by using drilling and he shall supply, install, and operate the flow meter in the pump station control panel and supply and install all the equipment and materials. .etc needed for this work.

B – Specifications :

The transducers must be fitted to the water mains inside socket and isolated from process stream, and also to be easily replaced without shutdown. The transducers can be mounted on horizontal or vertical water mains.

Transmitter / signal converter : the supply voltage shall be 230.V, 50.HZ. The operating signal of the flow water shall be 4 - 20 m A .

The flowmeter shall operate using a pulse D.C. field generated by a signal converter. The signal converter shall be separately housed in an enclosure to IP.68. Where necessary a separate power Driver unit shall be employed housed in an enclosure to IP68.

Connections between the flowmeter and the signal converter, which shall be mounted locally, shall be made using special screened transmission cable.

The signal converter shall provide a suitable output to drive a digital indicator displaying actual flow rate and an electronic counter indicating the flow volume. A rechargeable battery pack shall be incorporated to prevent loss of volume count in the event of mains failure to the instrument Memory Save) .

The digital indicator, chart recorder, totalizer and the electronic counter shall be in one box and located in the control room in wells or the pumps houses or elsewhere as approved by the Engineer.

The transmitter shall be packaged in rugged enclosure, water proof and weather proof enclosure of IP 68 .

The flow meter must be equipped with the sensor, signal converter, transducer, transmitter, chart recorder (12 cm. chart width, folded type), non resttable totalizer, all the remote mounting and every thing to make the flow meter system to be complete. The chart shall cover a period of minimum 3 months, it shall be graded in hour intervals along the chart. The recorder gear shall be of adjustable variable speed type.

Where any of the flowmeter parts are installed in the sun, then this parts shall be sheltered by a wide shed (approved by the Employer) , made of galvanized steel, and the contractor shall submit the detailed drawings , all costs shall be deemed to be included in the unit price of the flow meter .

If the FM. Installed of the cleaning type (if approved by the Employer) , then the Contractor shall provide a cleaning device for the FM. The cost of the cleaning device shall be deemed to be included in the unit price of the FM.

6 . Butterfly Valves :

Shut-off valves (Butterfly Valves type) shall be in accordance with DIN. 3354 and be installed in concrete valve chambers according to the Standard Drawings (unless otherwise noted). The valves shall be of PN.40, PN.25, PN.16, or PN.10 according to the Drawings, offset disc type, double flanged and shall close in a clockwise direction.

The valves shall be provided with an endless rubber sealing ring on the disc, made of ethylene - propylene – Ter. rubber.

The body of the valve and the disc shall be made of ductile cast iron GGG 50. The body seat face shall be of absolutely corrosion proof and wear resistant nickel weld overlay, micro finished.

The valve shaft shall be of stainless steel, shaft sealed with O-rings of EPDM / Perbunan rubber.

The valve shaft shall be supported on bearings of impregnated, self-lubricating materials.

Valve discs shall be designed as double offset on shaft, with optimum hydraulic flow pattern and low flow coefficient.

The valve shall be furnished with a hand wheel for operation inside the concrete valve chamber.

Min. Diameter of hand wheel for: DN. 300 : 250 mm.
DN. 350 : 350 mm.
DN. 400 : 400 mm.
DN. 600 : 400 mm.

Additionally these valves shall be equipped with extension spindles and surface boxes, as shown as a general detail on the Standard Drawings. Extension spindles to be connected to the hand wheels by stem unit couplings.

All accessories necessary for the above mentioned valve types shall be included in the relevant unit rates for those particular valves.

The rubber seal on the disc shall be easily replaceable and made of synthetic EPDM. rubber.

The shaft of the valve disc shall be located in a horizontal position when installed.

The gear case of the valve shall have protection class IP. 67 and mechanical position indicator.

Internal and external surface protection shall be by epoxy resin coat applied by electrostatic process.

7 . ALTITUDE VALVE:

Altitude valve shall Control the level of water in reservoir via a slave ball cock in the top of the reservoir. Small-bore piping in an approved non- corrodable material shall connect the ball cock to the underside of a diaphragm in the relay valve, then through a needle cock to strainer block on the inlet side of the valve.

With a fall of water level in the reservoir and opening of the ball cock, the relay valve shall open, allowing a pressure reduction above the main valve diaphragm. This shall cause the main valve to open and allow filling of the reservoir. When the water level in the reservoir reaches top water level, closure of the ball cock shall cause the relay valve to shut. This shall in turn lead to a build up of pressure above the diaphragm and hence closure of the main valve.

The rate of response of opening and closing of the main valve shall be controlled by an adjustable needle valve which shall enable the operation to be executed slowly, preventing sudden closure likely to cause problems on the pipeline. The main valve shall open fully in response to a fall of 200 mm. or less in the water level of the reservoir.

Details and materials of altitude valve shall otherwise be as specified below . It shall be double-flanged gray or ductile cast iron. Flanges shall be to BS. 4504, PN.16. The nominal diameter shall be as shown on the Drawings.

All materials used in the manufacture of the valve shall conform with the following minimum standards :

Body, Cover and Disc:	Spheroidal graphite iron to BS.2789
Valve guide, rings etc.:	Gunmetal to BS. 1400, Grade, LG2 .
Liner:	Bronze, to BS. 2870 .
Seating Face:	Gunmetal, Synthetic or other approved material as appropriate
Indicator Rod:	Stainless steel to BS.970 part 4 Grade: 316529.
Actuating Valve Body:	Bronze to BS.2870 .
Spindle:	Stainless steel to BS.970 Part 4 Grade : 316529.
Valve Face:	Nylon
Diaphragm and Bellows:	Reinforced synthetic rubber or approved equivalent.
Orifice body and plate:	Bronze to BS.2870 .
Strainer:	Cooper wire cloth.
Spring:	Spring steel.

All detail parts not listed shall be in homogenous corrosion resistant material.

8 . Pressure Control Valves (PCV.) :

Pressure control valves for pipe bores of 80 mm. diameter and above , used for pressure reduction , pressure sustaining or pressure relief shall be of the double flanged type , of gray or ductile cast iron. Operation shall be by the use of an integral auxiliary actuating mechanism suitable for the application. For bores of less than 80 mm. diameter a direct spring controlled valve may be used.

Valves shall be adequately sized to control the flow and pressure differential required for the application , with an accuracy of plus or minus 2½ % of the set valve. They shall be capable of operating at sustained pressure of 20 % in excess of the nominal declared working pressure.

Valves shall be sized -to ensure that their full capacity will be more than adequate to accept the desired maximum flow at the minimum required differential pressure.

Flanges shall comply with BS. 4504 and be suitable for the sustained pressure detailed above but in any case not less than PN. 40.

The main valve disc, ported guide and pressure differential piston shall be of high grade cast iron or gunmetal as appropriate. For cast iron discs the seating face shall be of gunmetal, synthetic or other approved material to suit the application. The piston cylinder shall be fitted with a bronze liner.

The piston shall be fitted with rings suitable for maintaining a pressure seal with the cylinder. These shall be suitable for the maximum designed pressure differential of the valve.

Where specified, an externally projecting indicator rod shall be fitted to the top of the piston to indicate the position of the main valve disc.

The main pressure control valve operation shall be actuated by a hydraulic differential pressure system in balance with a spring loaded bellows type diaphragm, the reference being bled from the inlet and outlet of the main valve.

The diaphragm spring shall be adjusted by a screw to cover the range of pressure adjustment specified for the valve application.

The Contractor shall provide minimum of two suitable pressure gauges for each PCV. to indicate the pressure before and after the valve and he shall calibrate and check the inlet and outlet pressures during commissioning and the maintenance period.

Monitoring orifices shall be protected by suitably fine mesh strainer on the pipe line side, the elements, strainer, pipe work and fittings being in suitable corrosion resistant materials.

Before the application of paint or other similar treatment, valve shall be works tested hydrostatically, the test pressure for the body and disc being 1.5 times the maximum rated pressure.

All materials used in the manufacture of valve shall conform with the following minimum standards:

Body, Cover and disc :	Spheroidal graphite iron to BS. 2789
Valve Guide, Ring ..etc:	Gunmetal to BS. 1400, Grade LG. 2
Liner :	Bronze to BS. 2870
Seating Face :	Gunmetal, Synthetic or other approved material as approved as appropriate
Indicator Rod :	Stainless steel to BS. 970 part (4) Grade 316529 .
Actuating valve Body :	Bronze to BS. 2870
Spindle :	Stainless Steel to BS. 970 part (4) Grade 316529
Valve Face :	Nylon.
Diaphragm and Bellows :	Reinforced Synthetic Rubber , or Approved equivalent.
Orifice body and plate :	Bronze to BS. 2870
Strainer :	Copper wire cloth .
Spring :	Spring Steel .

All detail parts not listed , shall be in homogenous corrosion – resistant material .

9 . Pressure Reducing Valves (PRV) :

The main valve shall be with throttling cone, counter piston, spring loaded. The valve shall maintain a constant downstream pressure regardless of varying inlet pressure .

The valve body shall be in cast iron GG. 25 for the minimum pressure rating as indicated on the drawings and the body shall have an epoxy coating both internally and externally.

The spring shall be of stainless steel 50 CrV4. The pilot control shall be a direct – acting, adjustable spring loaded, normally open, diaphragm. The pilot valve shall be in bronze or stainless steel and Pilot System tube in copper. The pilot valve system shall have a stopcock to isolate the valve if necessary.

The PRV. Shall have a device indicating the position of the moving part and shall have two manometers to measure the upstream and downstream pressures.

The flanges of the RRV. Shall comply with DIN. 2501. The PRV. Shall be hydrostatically tested at the factory at 1.5 times the nominal pressure. The downstream pressure shall be set as indicated on Drawings. It shall maintain the downstream pressure within a range of $\pm 10\%$ with respect to the pressure.

All necessary repairs shall be possible for without removing the valve from the line.

10 . CHECK VALVES:

The check valves shall be suitable for potable water and shall conform to (BS.5153) for valves of working pressure up to 25 bars. They shall have cast iron bodies, hung single disc doors, the valves seating shall be gunmetal faced and the doors shall have facing of gunmetal.

For valves of maximum working pressures greater than 25 bars, the valves should be flange ended of lift type, designed for water works duty and comply with (BS 5160) or equivalent specification.

The Spindles shall be of solid forged manganese bronze or equivalent The bearings shall be designed to minimise hinge friction and be accessible for inspection and replacement from the outside of the valve. A soft packed gland shall be provided.

A plugged pressure taping point shall be provided for the insertion of pressure monitoring devices during commissioning.

The valves shall be suitable for operating either in the vertical or horizontal position as required, and shall be non-slam type.

11 . Pressure Gauges:

The pressure gauges shall be from an approved manufactures.

All gauges shall have concentric dials of 150 mm. diameter ,or as approved by the Employer .

The graduation of the pressure shall be in 0.5 bar:

a- For suction pipes from 0.00 – 5 bar.

b- For discharge pipes from 0.00 – 25 bar or from 0.00 – 40 bar.

The cover of the facia shall not be less than 4 mm. glass.

The gauge mechanism shall be of the Bourdon tube type, having stainless steel movments and shall comply with BS.1780 . It shall be sealed from the liquid being measured by means of a diaphragm or capsule and be filled with silicon oil.

The gauge shall be fitted with a pressure snubber, I.e. orifice, to dampen pressure pulsation . In addition to a small stopcock for venting.

Each gauge must have a test certificate stating that it is tested according to BS. 1780 and confirming that it is the required accuracy.

12 . FLOAT VALVES :

Unless otherwise specified, float valves shall be flanged, of angle pattern, lever operated, direct acting, with the body made of Meehanite cast iron fitted with gunmetal seat rings and cylinder liner .

The seat rings shall be leather packed, the lever of galvanized steel and the float of copper . The valve shall be suitable for the specified nominal pressure .

Float valve shall be installed in accordance with the Drawings and the instructions of the Engineer

13. FLOW CONTROL VALVES:

The rate of flow control valve shall maintain a predetermined constant rate flow regardless of fluctuations in the upstream pressure. The valve shall be a hydraulically operated, adjustable pilot controlled, diaphragm or piston type globe or angle valves as indicated. The pilot controlled, direct acting diaphragm or piston shall close the valve when the actuating differential pressure increases. The actuating differential pressure shall be produced by an orifice plate installed in an orifice flange located upstream or downstream of the valve. All necessary repairs shall be possible without removing the valve from the pipeline.

Solenoid control shall be provided to intercept the operation of the differential control and close the main valve.

VALVE CONSTRUCTION:

Valve Body: The valve body shall be of cast iron to ASTM. A 48-Specification for Gray Iron castings, or ASTM. A 126-Specification for Gray Iron casting for Valves, Flanges, and Pipe fittings, with 250 lb. flanged ends to ANSI / ASME B 16.1 - Cast Iron Pipe Flanges and Flanged fittings, Class 250, or the body shall be of ductile iron to ASTM. A 536 - Specification for Ductile Iron Casting, with 300 lb. flanged ends to ANSI / ASME b 16.42- Ductile Iron Pipe Flanges and Flanged Fittings. The valve cover shall be flanged and of the same material as the body.

Valve Trim: The valve stems with position indication, springs, body rings, and bolts, nuts and washers shall be of Type 302, or 316 stainless steel. The valve stems shall have top and bottom guides. All rubber parts shall be of Buna-N. The diaphragm shall be Nylon-reinforced Buna-N. supported firmly between body and valve cover. The valve pistons and piston liners shall be bronze to ASTM. B62- Specifications for composition Brons of Ounce Metal Castings.

Orifice Plate: The orifice plate shall be of Type 303 stainless steel, internally mounted at inlet port of main valve, or minimum of five pipe diameters downstream of the valve, and it shall be sized and furnished by the valve. Manufacturer for the flow indicated in accordance with ANSI / ASME. B 16.36- Orifice Flanges.

Valve Control: The valve shall be furnished with a complete externally mounted control system, including differential control, adjustable, double-acting pilot valve, solenoid, speed control needle valves, strainer, and all necessary copper or stainless steel connecting tubing and fittings. The

controls shall be capable of achieving all the flow and speed adjustment workmanship.

Factory Tests & Warranty:

All valves shall be factory tested with a hydrostatic test and a functional test. A test certificate shall be submitted to the Engineer prior to delivery of the valve. The valve shall be warranted for a period of 3 years from the date of shipment to be free of defects in materials and workmanship.

14. PRESSURE RELIEF VALVE :

Flanged pressure relief valves and appurtenances shall be complete and operable, in accordance with the specifications.

A . Valve Characteristics :

The pressure relief valve shall open when the inlet pressure exceed a set maximum level It shall maintain that level and gradually close as the inlet pressure drops below the maximum pressure. The valve shall be a hydraulically operated, adjustable, pilot controlled, diaphragm or piston type globe or angle valve as indicated. All necessary repairs shall be possible without removing the valve from the pipeline .

B. Valve Body :

The valve body shall be of cast Iron, ASTM A 48 – Gray Iron Castings, or ASTM A 126 – Gray Iron Castings for Valves , Flanges and Pipe Fittings, with 250 lb flanged ends to ANSI / ASME B 16.1 – Cast Iron Pipe Flanges and Flanged Fittings, Class 250, and 800 , or the body shall be of Ductile Iron to ASTM A 536 – Ductile Iron Castings, with 300 lb flanged ends to ANSI / ASME B 16.42 – Ductile Iron Pipe Flanges and Flanged Fittings . The valve cover shall be flanged and be of the same material as the body .

C . Valve Trim :

The valve stems, springs, body seat rings, and all bolts , nuts , and washers shall be of type 302, 303, or 316 stainless steel. The valve stems shall have top and bottom guides. All rubber parts shall be of Buna – N. The diaphragms shall be of Nylon – reinforced Buna – N , supported firmly between body and valve cover .The valve pistons and piston liners shall be bronze to ASTM B 62 – Composition Bronze or Ounce Metal Casting .

D . Valve Controls :

The Valve shall be furnished with complete, externally mounted control system, including adjustable speed control needle valve, strainer, and all necessary copper or stainless steel connecting tubing and fittings. The controls shall be capable of achieving all the flow and speed adjustment indicated .

E . Factory Tests And Warranty :

Valves shall be factory tested with hydrostatic test and a functional test, A test certificate shall be submitted to the Engineer prior to delivery of the valves. Each valve shall be warranted for a period of (3) years from the date of shipment to be free of defects in materials and workmanship .

F . Operating Conditions :

The valve shall be designed to operate under the following conditions :

- 1 . Total flow (L p s) : =
- 2 . Maximum inlet pressure (bar) : =
- 3 . Valve size (mm) : =
- 4 . Size of pipeline : =

15. Flexible Couplings and Flange Adaptors:

- For connection of the existing to the new pipeline system, flexible couplings shall be installed as indicated on the drawings or as directed by the Engineer.
- Couplings must be capable of adapting to different pipe materials.

- Flexible couplings and flange adaptors shall be of mild steel and of an approved type suitable for making a watertight flexible connection between plain-ended pipes, or between a plain-ended pipe and a flanged fitting (e.g. Viking-Johnson couplings as manufactured by the Victualic Co. Ltd. Or Dresser Couplings as manufactured by the Dresser Manufacturing Division in the U.S.A.' or equivalent approved by the Engineer.

- Unless otherwise specified, the external and internal surfaces of couplings and adaptors shall be cleaned down to a metallic finish, then primed and painted with epoxy resin paint, applied by an electro static process.

- All mechanical couplings shall be of appropriate internal diameter and shall be capable of withstanding the maximum working test pressure specified for the pipes they are to connect, including a joint deflection of up to 3 degrees in any direction.

- All mechanical couplings and flange adaptors shall be supplied complete with all necessary coupling rings, nuts, bolts, washers and rubber rings. Wedge joint rings shall comply with BS. 2494, and shall be made of nitrile rubber, ethylene propylene rubber (EPDM) or styrene butadiene rubber (SBR) or other approved materials.

- Bolts and nuts of galvanized steel shall be hexagonal with dimensions in accordance with BS. 4190 or DIN. 601/555.

- Where a Harnessed Steel Flange Adaptor is shown on the drawings, the bolts connecting the flange of the Flexible Flange Adaptor to the Flange of the adjacent fitting shall be replaced by tie-bars threaded at both ends.

- One threaded end of each tie bar shall pass through holes in the abutting flanges and be anchored by two nuts to make the flanged joints in the normal way. The other threaded end shall be anchored by two further nuts in a corresponding bolt-hole on the flange, soundly welded integrally on to the fitting which it is intended to harness to the adaptor.

- The integrally-cast flange on the flange-spigot shall be located such that, after the joint has been made and all nuts fully tightened, the integrally-cast flange is about 400 mm axially from the abutting flanges.

- The bolt circles on all the flanges shall comply with BS 4504 PN 16, as specified.

- The threaded tie bars shall be machined from steel at least equal to that specified for flange bolts of corresponding duty and threaded in the same way. The threaded length shall allow the nuts to be run forward sufficiently to permit complete withdrawal of the tie

bars from the flange of the abutting fitting without requiring any other joint to be dismantled.

- The strength of the threaded tie-bars in both tension and compression shall be appropriate to the pressure rating of the flanged joints.

16. Dismantling Joints:

Dismantling joints shall be provided and installed with each valve as indicated on the Drawings for convenient installation or re-installation of valves or similar items.

For prevention of any move of the pipe joints adjacent to closed valves, dismantling joints shall be provided in general by restrained dismantling pieces (short version) according to DIN. 2541 or DIN 2547 or flanged adapters as indicated on drawings or as directed by the Engineer.

Body and glands of steel welded dismantling pieces shall be of pressure similar to the valve or pipeline connected to it, with bolts and nuts of stainless steel. Surface protection by epoxy resin coating or equivalent quality. Rubber sealing rings made of Perbunan material, nitrile rubber or equivalent quality, shall be used.

17. Surface Boxes

Cast Iron surface boxes with round lid according to DIN. 4056 shall be supplied for operation of valves as described. Surface boxes shall be suitable for a 100 kN load.

The surface box made of cast iron or ductile iron shall be situated at ground level on the road or pavement.

The hinge of the lid shall be of non-corrosive material. Circular lids shall be used for valves (gate and butterfly).

Surface boxes shall have a cold applied bituminous black paint coating.

Surface boxes shall be supported by - reinforced concrete slabs of 65 mm. thickness to suit the surface box.

18. Reinforced Concrete Encasement (RCE):

The Contractor shall supply all materials and construct reinforced concrete encasement (RCE), as shown on the Drawings or directed by the Engineer.

RCE. shall be constructed of cast - in – place reinforced concrete in accordance with the detailed typical Drawings.

All (RCE) shall be allowed to cure for at least (7) days before backfilling of the trenches.

The costs of (RCE.) includes reinforced concrete, reinforcement steel, formwork, additional excavations, backfilling ... etc. and shall be paid separately as an extra item over pipelines installations, as indicated in BOQ.

19. Reinforced Concrete Valve Chambers:

Where shown on Drawing, a complete valve chambers of reinforced concrete shall be constructed for all kinds of valves and air relies valves.

Valve chambers and similar structures shall be built into the pipe lines as demanded and in accordance with the Standard Drawings. Given dimensions on the drawings are to be verified by the Contractor so as to suit the pipe installation and the prevailing conditions on site.

Reinforced concrete valve chambers shall be constructed of cast in-place concrete in accordance with the detailed typical Drawings.

Valve chambers shall be allowed to cure for at least (7) days before backfilling .

Concrete supports for pipes, valves and any other fittings shall be placed at appropriate locations inside the chamber under the direction of the Engineer (even if not shown on the Standard Drawings).

Cast iron manhole covers with frames shall be installed for all valve chambers as specified or shown on the drawings. The wording on each cover shall be agreed with and approved by the Engineer prior to ordering.

Covers to be used in surfaces which are subject to vehicular traffic shall be tested for a load of 400 kN.

Manhole covers with bearing capacities of 40 kN and 250 kN according to DIN. 1229 shall be installed as instructed by the Engineer.

Two pairs of keys for use with each type of cover shall be handed over by the Contractor after completion of the Contract at no extra cost.

As shown on the Drawings, all valve chambers shall be equipped with step irons, which shall be of malleable cast iron, according to DIN 1211 or galvanized iron or as directed by the Engineer.

Types of Drainage for the valve chambers shall be according to the Standard Drawings or decided on site.

Penetration holes with G.S. sleeve pipes shall be inserted in the ceiling slabs, details of which are shown on the Standard Drawings, so as to incorporate the extension spindles of the valves inside the concrete chambers.

Ventilation pipes as instructed shall be installed at the highest possible point in all air release valve chambers (considering traffic load) and led to the nearest convenient outlet above ground. End of pipe to be flanged with a stand pipe equipped with protection cap including non-corrosive insect screen. Ventilation pipes shall be covered by the price of the valve chamber.

Structural calculations including reinforcement drawings for all valve chambers shall be made by the Contractor and submitted for approval by the Engineer. These calculations are to take into consideration the prevailing load and soil conditions.

The cost of reinforcement for concrete chambers shall be included in valve chambers. All items as described above as well as additional excavation and back filling works shall be included in the valve chambers.

Ductile Iron (DI) Pipes And Fittings

1. Materials :

Ductile iron pipes shall conform to the requirements of “Ductile iron pipes, fittings and accessories for pressure pipelines” (ISO 2531 or BS 4772) or other internationally accepted standards which ensure an equal or higher quality than the standard mentioned. All pipework shall be class K9 unless otherwise stated in the Contract Documents.

DN mm	Wall Thickness mm
80	6.0
100	6.1
150	6.3
200	6.4
250	6.8
300	7.2
400	8.1

DN mm	Wall Thickness mm
500	9.0
600	9.9
700	10.8
800	11.7
1000	13.5
1200	15.3

2 . Design Conditions Requirements :

Each length of pipe shall be designed to withstand the relevant test requirements of ISO. 2531. Hydrostatic pressure tests shall be performed prior to coating or lining of pipes.

3 . Joints :

Ductile iron pipes and fittings shall be manufactured with spigot and socket ends in which the seal is achieved by means of a suitable retained rubber gasket (push-on joint). The gasket shall be of such size and shape that, when joined in accordance with the manufacturer's instructions, it shall provide a positive seal within the manufacturer's range of maximum joint deflection and withdrawal under all combinations of joint and gasket dimensional tolerances and in the range of pressure specified.

The joint shall be capable of accommodating the longitudinal movement resulting from a change in temperature of the pipe of 50 degrees Celsius without loss of water tightness.

The manufacturer's allowable joint deflection shall not be more than :

5 degrees up to	DN 300
4 degrees for	DN 400
3 degrees for	DN 500 to DN 600

Where flanged connections are covered by backfill material, then all flanged joints shall be wrapped in Denso Tape or similar approved.

Where connections are in valve chambers then bolts, nuts and washers shall be of stainless steel.

All connecting materials and rubber ring gaskets (steel reinforced) or adaptors shall be provided by the supplier as necessary to connect the valves and any other fittings to the adjoining pipe material, without any additional cost.

“Push-On” joints of any type could be used, that satisfy the pressure as specified in the Tender Documents (test pressure = 1.5 x Nominal pressure) and shall be according to ISO 2531 or equivalent.

4 . Rubber Ring Gaskets :

Unless otherwise indicated rubber ring gaskets for pipe installation shall be vulcanized rubber or vulcanized synthetic rubber in accordance with the International Standard ISO 4633. Reclaimed rubber may not be used. Sufficient Lubricant as recommended by the pipe manufacturer shall be provided for pipe installation plus five (5) percent as surplus material costs to be included in the unit rates. Lubricant containers shall be adequate for extended storage and the pipe manufacturer shall supply instructions for storage limitations and environment.

5 . Fittings :

Fittings shall be made of ductile iron (ISO 2531) with push-on flexible joints . The pressure class of fittings and special castings shall be class K12 for fittings without branches and K14 for fittings with branches (unless otherwise stated in the contract documents)

6. Pipe Lengths :

Pipe lengths shall be 6m in accordance with ISO 2531.

7. Lining :

Ductile iron pipes and fittings shall have a blast furnace cement mortar lining . It shall be applied so that it adheres strongly to the pipe. For pipes the lining shall be as specified in ISO 4179 and shall be applied by a centrifugal process. The lining on fittings shall also conform with ISO 4179 and shall be applied by a projection method or by hand application with respect to thickness for straight pipes of the same diameter.

The cement mortar lining thickness for pipes and fittings will be in accordance with ISO. 4179. A thickness tolerance of plus 3 mm based on the normal value shall be permitted on pipes and plus 6 mm on fittings.

As an alternative the fittings can be internally protected with a bituminous paint in accordance with (ISO 2531) or with a 150 microns minimum thickness special fusion bonded powder epoxy coating.

8. External Coating :

Ductile iron Pipes (DIP.) shall be provided with standard external coatings for normal soil, ie. metallic zinc layer, with bituminous paint according to ISO. 8179. Fittings shall be protected with bituminous coating.

When corrosive soil are encountered, Pipes and fittings shall be supplied with polyethylene sleeving of 200 microns minimum thickness according to BS. 6076, DIN. 30674 or ISO. 8180 or approved equivalent standard.

9 . Marking :

Each pipe and fitting shall bear the mark of the year of manufacture, nominal diameter, and the word “DUCTILE” on the body of the pipe or fitting. The marks may be cast on, painted or cold stamped.

10 . Testing and Inspection at Place of Manufacture:

Inspection for external appearance, shape, dimensions, and weight shall be carried out on each pipe and fitting. Pipes and fittings shall be coated with care to avoid warping. All pipes and fittings shall be sound and free from surface defects.

Each pipe centrifugally cast shall be subjected to the hydrostatic pressure test as specified in ISO 2531. Each fittings and accessory not centrifugally cast shall be subjected to a leak tightness that carried out with water or air as specified in ISO 2531. Any pipe or fitting that leaks or does not withstand the test pressure shall be rejected.

Mechanical tests for hardness, tensile strength, and elongation shall be performed on test pipes selected at random out of castings grouped in lots. Each lot shall be made up of pipes cast successively and shall comprise 200 pipes.

HIGH DENSITY POLYETHYLENE PIPES (HDPE)

1. General:

High Density Poly Ethylene pipes shall comply with ISO 4427 – 1996 (E) and ISO. 161-1: 1996

The pipes shall be designed for a nominal working pressure Class of PN 16.

Designation of material of PE.100. Pipes designated as PE.100 shall be jointed with push-fit coupling or compression fittings or electro fusion, or mechanical fittings.

The pipes designated as PE 100 shall have maximum allowable hydrostatic design stress of 8 Mpa. and minimum Required Strength (MRS) of 10 Mpa. at 50 years and 20 °C.

The nominal outside diameter and wall thickness of the pipes are as shown in the following table :

Nominal Outside Diameter (mm)	Wall Thickness (mm)
25	2.8
32	3.6
63	7.1
125	11.4
180	16.4
250	22.7

The length of the coiled pipes shall be 50-100 m or straight lengths if the pipe are to be coiled this must be done at temperature not less than 30°C. For sizes > 63 mm all coils shall be securely, banded with tough tape which cannot be removed except by butting.

The minimum diameter of the rollers for coiled pipe should be such that kinking of the pipe is prevented.

The minimum internal diameter of the rollers shall not be less than 24 times the nominal outside diameter of the pipe. with a minimum of 600 mm

The ends of the pipe shall be plugged or covered.

1. Materials of pipes:

The pipes shall be manufacture from polyethylene containing only those antioxidants, UV stabilizers and pigments necessary for the manufacture of potable water pipes and shall be either black or black with blue stripes and comply with (ISO 4427).

The Contractor shall provide an approved third party certificate to verify the above.

Materials in contact with or likely to come into contact with potable water shall not constitute a toxic hazard, shall not support microbial growth and shall not give rise to unpleasant taste or odor and cloudiness or discoloration of the water. Concentration of substances, chemicals and biological agents leached from materials in contact with potable water, and measurements of the relevant organoleptic /physical parameters shall not exceed the maximum values recommended by the World Health Organization (WHO, 1984) or as required by the EEC, Council Directive of 15 July 1980, official Journal of the European Communities, L 229 ,pp.11 to 29) on the quality of water intended for human consumption, whichever is the more stringent in each case.

Material of unknown composition shall not be used. Only Polyethylene granules that are approved and listed by International approval bodies (i.e. DVGW Germany / DWI UK or equivalent) shall be used in the manufacturing of PE pipes supplied.

Recycled material generated from a manufacturer's own production of pipes **should not be used**.

Non-metallic products in contact with, or likely to come into contact with, potable water shall comply with the requirements of BS 6920, 1996.

Carbon black content according to ISO 6964.

The pipe manufacturer shall provide evidence of the nominal values of the density, melt flow rate (index) of the raw material.

The density of the raw material (compound) shall not be less than 0.950 gm/cm³. The pipe manufacture shall provide evidence of the nominal value of the density once, at the beginning of the contract upon delivery of material on site, and as instructed by the Engineer.

Density test for raw material and pipes shall be performed according to ISO 1183 or equivalent.

Melt flow rate (MFR) this shall be determined to the method given in ISO 1133 or equivalent.

MFR shall be less than 1.0 gm/10 min. tested at 190/5 kg, change of (MFR) by processing shall be less than 20%.

2 . Quality of Pipes:

The manufacturer's shall operate a quality system conforming to ISO 9001/9002 as applicable.

This shall include a quality plan whereby details and results for each test, shall be made available to the purchaser or his representative on request. The manufacturer's shall have a written declaration that the polyethylene pipes, which they produce for use in public water supplies are manufactured from the granules approved and listed by International approval bodies (i.e. DVGW Germany / DWI UK or equivalent) and that no chemicals or recycled materials are added.

2.1: Testing Status

General

Type and batch release tests are carried out by the pipe manufacturer to demonstrate compliance with relevant standard.

Type Tests:

1. Short term hydrostatic strength at 20°C 100 hour according to ISO 1167/1996.
2. Long term hydrostatic strength at 80°C at 1000 hour according to ISO 1167/1996.
3. Long term 80°C stress crack resistance on notched pipe. When tested in accordance with ISO 13479. Notched pipe test the pipe shall not fail within 1000 hours when pressurized at 9.2 bar (PE 100)). This test shall be carried out on SDR 11 pipe.
4. Suitability of non-metallic products for use in contact with drinking water intended for Human consumption with regard to the Quality of Water according to BS 6920: 1996.

Hydrostatic Strength:

When tested in accordance with ISO 1167, the pipes shall conform to the requirements given in table below.

Table – Hydrostatic Strength of Pipes (MPa)

Pipe Material	Test Stress 100 Hour at 20°C	Test Stress 165 Hour at 80°C	Test Stress 1000 Hour at 80°C
PE100	12.4	5.5	5.0

For locally manufacture pipes; (regarding test 4 mentioned above) random samples will be taken from production under a quality assurance system once every 15 months or the requirements shall be met whenever a change or an introduction of a new or modified raw material (compound) has occurred.

For imported pipes; following the delivery of imported pipes to final destination, for each batch delivered, samples will be taken at random to be tested according to BD 6920 dated 1996.

For tests 1, 2, 3 once per size group.

2.2 Batch Release Test / Factory:

Before releasing any batch of pipe, the supplier is required to carry out basic tests specified below:

1. Dimensions and appearance ISO 4427 1996.
2. Thermal stability ISO 4427.
3. Tensile properties, elongation – according to ISO 6259 – 1997. 3.
4. Melt flow rate ISO 1133 – 1997.
5. Short term 80°C stress crack resistance on notched pipe ISO 13479-1997.

All type and batch release tests shall be conducted by pipe manufacturer and shall be witnessed and verified by third party.

An approved list of accredited third party agencies is issued by Governmental Tenders Directorate (GTD). Only recognized third party by (GTD) may be used by manufacturer or contractor.

Third party shall verify that pipes are produced in compliance with ISO 4427.

No pipe shall be accepted unless all type and batch release tests have been passed.

2.3. Test after Delivery / Acceptance Tests

Samples of PE pipes shall be taken from site as instructed by the Engineer at random from both locally manufactured and imported pipes for every lot of 10 km of pipes with diameter 63, 110, 125 and every 5 ton consignment of pipes with a diameter 32 mm and 25 mm delivered to site.

Raw material samples shall be supplied by the imported pipes manufacturer, especially for carrying out test 2 mentioned below (MFR). The Engineer may instruct in addition to type and batch release tests to conduct any or all of the following tests on the samples taken from site.

1. Dimensions ISO 4427 – 1996 / ISO 161-1.
2. Melting flow ISO 1133 – 1997.
3. Tensile properties, elongation ISO 6259 – 1997.
4. Thermal stability ISO/TR 10837.
5. Longitudinal reversion test ISO 2505-1994.

2.4 Marking of Pipe:

All HDPE pipes shall be indelibly marked at maximum intervals of one meter.

The marking shall show at least the following information:

- Manufacture's name and/or trade mark.
- Dimensions (nominal diameter, wall thickness).
- Material, material class (e.g. PE 100) and pressure class e.g. (PN 16).
- Production period (date).
- "Water" to indicate that pipes are intended for potable water.
- "Water" to indicate that pipes or fittings intended for potable water.
- Serial number.
- Batch number.

The pipes and fittings (especially the plastic type) shall be rejected, if the above information for marking is not shown clearly on each piece.

2.5 Storage and Handling

Polyethylene pipes, tubing and fittings should be stored according to the manufacturer's recommendations.

The following general points should be taken into consideration:

- Contact with sharp metal edges on racks, etc. should be avoided.
- The ends of pipes should be protected from damage to avoid the risk of unsatisfactory jointing.
- The pipes should be stored under cover and protected from direct sunlight including when stacked at the places of delivery. The Contractor shall take all measures such as providing covers of suitable size and durability to protect the pipes from direct sunlight especially for blue pipes.
- Coils may be stored wither on edge or stacked flat on top of the other, but in either case they should not be allowed to come into contact with hot water to steam pipes and should be kept away from hot surfaces. Coils should not be dragged over rough ground to avoid damaging the pipes.
- Storage of pipes in heated areas acceding 23°C should be avoided. If , due to unsatisfactory storage or handling, a pipe is damaged or kinked, the damaged portion should be cut out completely.
- If, due to unsatisfactory storage or handling , a pipe is damaged or kinked, the damaged portion should be cut completely at the contractors expense.

3. Fittings and Joints

3.1. Mechanical Fittings

Mechanical coupling, push fit or compression fitting or electro fusion, may be used. They shall be produced in acetal, gunmetal or polypropylene. The joints should provide the system with strength in tension and water tightness. All fittings shall be designed for a nominal working pressure of PN16 and they shall be compatible to PE pipes.

The mechanical jointing shall consist of lightening the pipe by means of screwed connections with compression push in such away that water tightness is fully secured by means of elastomer "O" ring and PVC grip ring.

Push fit jointing shall consist of a PVC grip and nitrile elastomer "O" ring.

All fittings of any type shall be designed for working pressure of 16 bar.

3.2. Testing of Pipes and Fittings

HDPE: Pipes and fittings shall be inspected, tested and certified by the Plastic and Rubber Laboratory in the Design and Mechanical technology Centre in the Royal Scientific Society (RSS) or any other specified firm approved by the Engineer.

- Pipes

Tests for determining the resistance of Pipes to constant internal pressure and the bursting time of these pipes are required and should comply with ISO-1167.

Two types of test are required:

1. Acceptance test, carried out at a temperature of 20°C (1 hr test). These allow a fast verification of the conformity of a batch of pipes to a specified type. At least one sample test shall be carried out for each bath of pipes.
2. Quality test (170 hr test) carried out at an elevated temperature as a nature of the pipes tested.

These allow evaluation of the standard of the production and the pipe material used.

The pipelines of transmission and water distribution system and all the joints shall be tested after laying for water tightness in accordance with cp. 312 part 3.

The procedure of test shall be as follows:

Allowable leakage < 3 liter/km/25mm dia. of pipe/3 bar/24 hours

Hydrostatic testing should be carried out at ambient temperature (20°C) otherwise factor should be applied as a correction to the nominal pressure.

Test should be applied on sections of length less than (500-800)m with uncovered joints.

Partially backfill to maintain adequate support and anchoring and to avoid floating of pipes during testing, with joints exposed and valves in the open Position.

Slow fill with water (and not with compressed air to avoid danger of injury or damage).

The filling should be at a rate given a maximum water velocity of (0.5 m/s) in the pipe to ensure no surge and to give air time to be released by the installed permanent air valves or installing corporation cocks.

Leave to reach equilibrium, i.e. the same temperature as the pipe and the surrounding soil and to remove all existing air and for the saturation of pipe material, if any.

Apply test pressure slowly to avoid surge ($1.5 \times$ max. nominal working pressure at lowest point) or 16 bars whichever is greater and hold for (one hour). The system should be isolated from the test pump, i.e. no pumping during the one hour test period allowed.

Apply the equation to decide on the success of test.

Finally after completing testing the line should be emptied slowly to prevent shocks or sudden contraction of pipes.

- Assembled Joints

If the pipes and fittings are produced by the same manufacture, the Contractor shall provide documents demonstrating that the assembled joints comply with the following tests:

- ISO 3458, ISO 3459:
Assembled joints between fittings and polyethylene pipes under internal pressure..
- ISO 3501
Polyethylene pressure pipes joints assembled with mechanical fittings test of leak proofness under internal pressure.
- ISO 3501
Assembled joints between fittings and polyethylene pressure pipes test of resistance to pull out.
- ISO 3503
Assembled joints between fittings and polyethylene pressure pipes test of leak proofness under internal pressure when subjected to bending.

The tests of (ISO 3458, ISO 3459, ISO 3501 & ISO 3503) for the assembled joints shall include testing of tees, bends, reducers and caps, self tapping ferrules and any other fittings to be assembled on the P.E. pipes.

Fittings which made of polypropylene shall comply with (WHO – 1984) and the requirement of ECC. Council Directive – 1980.

If the pipes and fittings are not produces by the same manufacturer, the Contractor shall perform the above test at his own expenses by an approved laboratory.

4 . Pipe Tapping Saddles:

Saddles are required to be used as indicated on the Drawings for service line connections. One pipe tapping saddle shall be included for each house connection or as indicated on the Drawings. They shall be suitable for a working pressure of 16 bar.

Saddle shall be fixed around the existing and/or proposed main distribution lines of diameters equal or greater than (3"). The saddle shall be of single strap design and in two parts, flat top and bottom-bolted at both sides, pressure through the disc of max. 1.5" in diameter for mains of 100mm diameter or less, and 2" for mains of diameters greater than 100mm (4"). The inside corners of the saddle strap should be rounded to prevent digging into the pipes. The saddles shall be manufactured from gunmetal to DIN 1705 or BS 1400 to suit DI pipes. The saddle shall be supplied complete with the following:

a -Bolts and nuts of stainless steel to ISO 3506 or equivalent. Bolt heads shall be clearlymarked with the manufacturer's name or his identification mark.

b -Nitrile rubber sealing "O" rings, suitable for service connections to be fixed between the disc and the pipe in groove in accordance with DIN 16963 and DIN EN 681. They shall be suitable for working pressure of 16 bar.

c -The saddles shall be suitable for use with screwdown ferrules. Saddles shall be tapped for internal pipe threads in accordance with ISO 7/1 or BS21.

5 . Self-Tapping Ferrule Strap

House connections (DN 20mm and DN 25mm) shall be connected directly to the HDPE service lines by one of the following (2) two procedures:

- a. Completely self contained integral cutter self tapping ferrule and saddle as indicated on the Drawings, or as directed by the Engineer shall be used. The service saddle should be bolted around the service line and the house connection connected via the ferrule pushfit outlet. The tapping may be dry or under pressure.
- b. Suitable (Tee) made of HDPE.
"Using of suitable (tee) is preferred when it is possible" .

The self tapping ferrule and saddle shall be manufacture from:

1. Gunmetal to BS 1400, and shall be supplied complete with the following:
 - a. Bolts and nuts of stainless steel to ISO 3506 or equivalent. Bolts should be clearly marked with the manufacturer's name or his identification mark.
 - b. Nitrile rubber sealing "O" rings, suitable for service connections shall be fixed between the pipe and the saddle in groove in accordance with Din 16963 and DIN EN 681. Self drilling cutters shall be of aluminum bronze in accordance with Din 1725 and DIN EN 601 or approved international standards, Or
2. Polyethylene, Acetal or Polypropylene, and shall be supplied complete with bolts, nuts, "O" rings .. etc. as mentioned above (in a and b).

6. Ferrule

Ferrule cock shall be designed with single outlet of 25, 32 or 63mm suitable for pipes of working pressure 16 bars. They shall be screwdown type that can take the place of a stopcock and designed as a main stem with a swivel outlet control of water flow via a threaded inner plug. The cock shall have inlets with male threads to ISO 7/1 or BS 21 for underground use. The ferrule should be easily "shut off" by means of a spindle attached to the inner plug. The single ferrule should be of push fit outlet.

The design of the ferrule shall permit service line installation via dry/under pressure machines which mount on to the ferrule/saddle assembly.

The machine manufacturer's recommendations shall be followed in respect of the tapping machine.

The screw down ferrule cock shall be manufactured of gunmetal complying to BS 1400 with minimum percentage of zinc. Complete with nitrile rubber washer in accordance with DIN 16963 and DIN EN 681.

Cast iron surface boxes with hexagonal lid as specified shall be supplied and installed for single ferrule house connections on mains of min. dia. 3". Surface boxes shall be suitable for a 100 KN load.

Extension rod with coupling sleeve and PE-protection tube shall be installed as required, as to operate the ferrule cock from the surface box.

7 . Electro fusion Connections

a. General :

Connection design limitations and manufacturer's joining procedures must be observed. Tools and components required to construct and install joints shall be in accordance with the best installation practices and manufacturers recommendations, all in accordance with ASTM – F 1055-98 Standard Specifications for Electro fusions Type Polyethylene Fittings For Outside Diameter Controlled Polyethylene Pipe and Tubing". However / filed connections shall be controlled by and are the responsibility of the field installer, and shall be performed by, or under the supervision of experienced personnel provided by the pipe manufacturer or distributor (proof of personnel qualifications shall be provided by the Contractor by means of an official certificate from a certified trainer, upon request by the Engineer) with proper equipment in addition the procedures recommended by Plastic Pipe Institute (PPI) shall be taken into consideration.

- Electrofusion Jointing :

Electrofusion fitting, Saddles, Tapping Tees, Tapping Valves, Connectors, Tees and Elbows shall be produced from Polyethylene material (designation PE 80 or PE 100) PN 16 color black and comply with ISO 4427/1996 or equivalent and shall be installed in accordance with the requirements of the manufacturers instructions using appropriate jointing welding equipment.

- Fusion Compatibility

Compound designated PE 80 or PE 100 having MFR (190°/5 kg) within the range 0.2g/10 min. to 1.3g/10 min. shall be considered compatible for fusion to each other.

Polyethylene fittings designed as PE 80 or PE 100 PN 16 can be used to join pipes with different designations:

1. All fittings shall be injection molded from recognized top quality resin PE 100 or PE 80 complying with ISO 4427/1996.
2. All fittings must be packed in such a way to allow instant use on site without additional cleaning.
3. No heating coil may be exposed and is to be fully imbedded into the body of the fitting for protection purposes during assembly.
4. All fittings must have molded-in identification and product information.
5. A limited path style fusion indicator as visual recognition of completed fusion cycle should be incorporated into the body of the fitting.
6. Quality control test results regarding "Wire temperature coefficient" and "Heating element and wire resistance" should be provided by manufacturer.
7. All fitting should have barcode.
8. The pipe and fittings shall be of the same material.
9. Contractor should provide certificates from manufacturers on the pressure rating for the electro fusion connection to be at least PN 16.

b. General Procedures :

The component ends to be connected must be clean, dry and free of detrimental surface defects before the connection is made.

c. Cleaning :

Before joining, and before any special surface preparation, surfaces must be clean and dry.

General dust and light soil shall be removed by wiping the surfaces with clean, dry, lint free cloths. Heavier soil shall be washed or scrubbed off with soap and water solutions, followed by through rinsing with clean water, and drying with dry, clean, lint free cloths.

d. Safety :

Before using chemical cleaning solvents, the potential risks and hazards to persons shall be known by the user, and appropriate safety precautions must be taken. Special handling and personal protective equipment shall be used as necessary.

The manufacturer's instructions for use, and the material safety data sheet (MSDS) for the chemical should be consulted for information on risks to persons and for safe handling and use procedures.

e. Cutting Pipe :

Joining methods shall produce square-cut ends. Pipe cutting shall be accomplished with guillotine shears, run-around cutters, and saws.

Care shall be taken to avoid cutting a spiral groove around the pipe. Guillotine and run-around cutters shall provide a clean cut without chips.

Chain saws shall be operated without chain lubrication. Bucking spikes shall be removed.

Chips shall be removed from the pipe bore and cleared from the job site. Pipes ends shall be deturred. It is essential that operators take care to ensure that jointing procedures are rigorously respected and in particular that :

- The pipe ends are properly scraped.
- All parts of the joint should be kept clean and dry prior to assembly.
- Clamps are used correctly to ensure that no movement of the joint can take place during the heating and cooling cycle.
- Welding shelters are used to ensure that rain does not contaminate the joint.

Only trained and qualified welders should weld fitting on pipes.

f. Dimensions and Tolerances :

HDPE fittings shall be manufacture to the requirements of applicable to ISO 8085/PrEN 12201-3.

- 1) The minimum wall thickness of any part of a fitting exposed to the full hydrostatic pressure shall not be less than that of a pipe of the same material with the same nominal pressure rating.
- 2) The minimum bore diameter in any cross-section, (excluding pipe penetration stops) shall be not less than the maximum outside diameter of the pipe or fittings, for which the socket is intended.

g. Tests :

The Contractor shall provide certificates from a third party demonstrating that all tests in accordance with the applicable ISO are performed on electrofusion assemblies. The tests shall include, but not limited to the following test:

- ISO 13954: 1997 Plastics pipes and fittings – Peel decohesion test for (PE) electrofusion assemblies of nominal outside diameter greater than or equal to 900 mm.
- ISO 13955:1995 Plastics pipes and fittings – Crushing decohesion test for (PE) electrofusion assemblies.

- ISO 13956: 1995 Plastics pipes and fittings – Pull out decohesion test for (PE) electrofusion assemblies.
- EN 1716 Plastics piping systems – (PE) tapping tees – Test method for impact resistance of an assembled tapping tee.

Samples of welded fittings shall be taken as instructed by the Engineer from site for the above-mentioned tests, at least once for every 600 joined connections.

The manufacturer shall subject samples of each production lot of molded fittings to x-ray inspection for voids. Voids shall not be permitted, should voids be found in the samples, the entire production shall be x-ray inspected. If additional voids are found, the production lot shall be rejected. The x-ray testing shall be conducted by an independent laboratory and certified test report made available to the Engineer upon request. Initial sampling shall be limited to not less than 5% of the production lot.

- **Cutting Branch Outlet Holes :**

Exceeding self tapping saddle tees, hole cutting will be required for field installed side outlet Fittings. Commercial hole saws for metal shall not be used. Polyethylene pipe hole saws only shall be used.

When cutting, hole saws shall be withdrawn as frequently as necessary to clear the chips. Powered hole saws shall be operated at properly low speeds to avoid overheating and melting Material.

- **Submittals :**

Contractor should provide certificate from manufacturers on the pressure rating for the Electro fusion connections to be at least 16 bar.

- **Payment :**

All electro fusion connections works and fittings shall be included in the unit prices of the relevant pipelines.

3. Installation of pipes and fittings.

3.1 General

1. The contractor should take into consideration that water pipe must be installed within 2 m of the road right of way or planned road irrespective of any obstacles and difficulties in construction unless otherwise mentioned.

Based upon that, the contractor should make full coordination with Ministry of Public Works and Housing, Municipality, Land and Survey Department to locate the route of pipes and to be sure that installation of pipes will be in the planned roads which be submitted to the contractor by the concerned Authorities, all in coordination with the Engineer for his approval before commencement of work.

2. The contractor should explore and locate existing water pipes before start of the work. Work will include excavation in any type of soil, backfilling and reinstatement of surfaces according to specifications. Cost of such works is considered to be included in the unit rates of related items.
3. No water quantity is permitted to be taken from existing water pipe by the contractor without approval of engineer and client.

In case of approval, quantity of water consumed shall be measured and the contractor shall pay the cost as per Engineer's Instruction.

4. Any Engineer's approval for any work will not release the contractor from his responsibility as stated in conditions of contract.
5. Cutting of the existing water pipe to be connected to the new pipes should be done by special equipment approved by the engineer since no electric or gaseous welding is permitted and the cut surface shall be normal to the axis of pipe.
6. During connection of the proposed water lines to the existing pipelines, the contractor shall take into considerations not to permit access of debris and foreign material into the opened pipes and the contractor shall supply all necessary equipments, including water pump to transfer water from the site of connection before start of pipe cutting to reduce polluted water entry into the existing pipes and to prevent delay in re-operation of existing pipes.
7. Contractor shall take into consideration all protection measures to prevent any damage in the existing water pipes, sewers, cables and all infrastructure utilities (surface or underground utilities).

In case that any damage is made to such utilities, the contractor shall repair or replace these utilities before commencement of work, costs of such repair or replacement shall be included in the related item at no extra cost.

8. All material to be used in the contract should be approved by the Engineer and tested, according to specified specifications or equivalents, at the contractor expense.
9. Any imported material, rejected by the engineer due to low quality or unsuitable of such materials to be used in the contract work, should be removed out side of the project area at the contractor expense.
10. Contractor should implement the contract according to Jordan National Building Codes for engineering project in all construction stages, that could include design work or construction work or based on contract requirements, operation and maintenance works, safety regulations and all related works due to application of Jordan National Building Codes No. 7 (1993), (Item 5) and its appendices, all in coordination with the Engineer. (Refer to letter of Secretary General – Water Authority of Jordan no.625/2/7/WA, dated 12/1/2005)

3.2 Earth Works

2.2.1Excavation

All surface excavations shall be made to the lines, grades and dimensions shown on the longitudinal sections and /or the standard drawings or as directed by the Engineer. Cost of over excavation shall be included in the respective unit rates of the B.O.Q. During the progress of the work, it may be found necessary or desirable to vary the slopes or the dimensions of the

excavations or the alignment of the pipeline from those shown on the drawings or as directed by the Engineer. The Contractor shall not be entitled to any additional allowance above the rates tendered due to such changes.

Before commencing any trench excavations, the route of the trench shall be set out accurately, the natural ground levels recorded and the longitudinal sections prepared.

The Contractor shall provide all necessary support for the excavated areas to ensure the safety of the public and the staff working in these areas so as to prevent collapse or fall of rock or other materials into the excavated area. The Contractor shall also ensure that all sites are kept clean and tidy at all times.

If for any reason whatsoever and despite adequate measures being taken re-excavation or remedial work has to be performed on already excavated trenches, this shall be carried out by the Contractor at his own expense.

The Contractor shall also provide all site safety equipment for use by his staff and the Engineer's site staff, such as hard hats, safety shoes, reflective jackets and when required, water-proof jackets and trousers.

As the excavation approaches underground facilities, digging by machinery shall be discontinued and the excavation shall be continued by means of hand tools. Where necessary, the Contractor shall provide temporary support for the existing utilities to prevent damage during his operations.

- Trenches shall be excavated to a depth of 150mm below the bottom of the pipelines, the 150mm shall be filled by sand bedding, and in case where the excavation carried out in loose or moist soil this depth could be increased and on the contractor expenses.
- The contractor shall not allowed to excavate long distance of trenches so far before pipe laying, embedment sand shall be placed as soon as the pipe laying process is completed. The trenches width shall be as shown in Standard Drawings. The contractor shall not allow using hard materials like stones and concrete blocks under the pipelines as permanent or temporary supports during pipe laying.
- The Contractor shall use Asphalt cutter to cut the Asphalt layer of the roads at a width extend 150mm from each side of the pipe trench.
- The Contractor shall remove all surplus materials to the areas approved by the concerned authorities.

2.2.2 Backfilling

All ductile iron pipes and polyethylene pipes of diameters 63mm and above shall be laid on a 150 mm compacted sand and shall be embedded by sand as shown on drawings to a depth of 300 mm above the top of the pipe and 150mm for polyethylene pipes of diameters 32 mm or less.

Sand backfilling materials from different sources of supply shall not be mixed or stored in the same pile nor used alternately in the same class of construction without permission from the Engineer.

- a) The sand backfilling material shall be uniformly graded and meet the following grading requirements:

Sieve Designation	Pass square-mesh Sieves Percentage by Weight AASHTO T27
3/8"	100
No.4	95-100
No.16	54-80
No.50	10-30
No.100	2-10
No. 200	0-3

The sand backfill material shall not contain deleterious substances in excess of the following percentages:

	DIN/AASHTO Method	Test	1. Per centage by Weight
Clay Lumps	18123-T 112		1
Coal and Lignite	18128-T 113		1
Material Passing No.200 Sieve	18123- T11		3
Cl	4030-T1 & T2-BS 812		0.1
SO ₃	4030-T1 & T2-BS 812		0.4
Hollow Shells			3.0

- b) Selected fine materials from crushed stone shall have the following graduation:-

Sieve Designation	Percent of Passage
3/4" (19mm)	100
1/2" (12.7mm)	9-100
3/8" (9.5mm)	40-70
No.4 (4.75mm)	0-15
No.8 (2.36mm)	0-5

Note:

The most suitable crushed stone has size from 5-10mm and contain no fine, chalky and clay materials to prevent settlement of pipes.

2.2.3 Backfilling to Surface:

The type of backfilling material shall be according to ground surface structure:

a) Trenches in Dirt or Natural Surface:

From 300 mm above the top of the pipe to the finished ground level, the trench shall be backfilled with approved selected materials, consolidated by approved mechanical methods in layers of thickness not more than 150 mm compacted thickness.

The degree of compacting shall not be less than 90% of maximum dry density based on the modified proctor (AASHTO-T-180) for backfilling in natural ground areas and as shown on the Drawings.

The approved selected materials to be free from any impurities and will be graded to achieve the required degree of compaction, contain no stones or concrete fragments greater than 50mm, the plasticity index for such materials will be less than 10 according to BS 1377 and the maximum dry density greater than 1.6 gm/cm³ according to standard proctor test. In the event that excavated material is insufficient or unsuitable for the backfilling operations on site, the contractor, and at his own expenses, shall obtain the suitable selected materials required from approved borrow pits.

b) Trenches in Paved Roads, Streets, Side Walks etc.:

When excavation is made through roads, highways, pavements, curbs, sidewalks or any paved or pedestrian areas, the contractor shall restore all pavements, side walks, curbing, or other property and surface structures removed or disturbed as a part of the work to a condition suitable and satisfactory to the Engineer.

From 300 mm above the top of the pipe the surface in roads, paved areas or side walks shall be backfilled on layers not exceeding 150mm each after compaction and compacted 95% according to the requirements of the Modified Dry Density Proctor. Backfilling shall be according to the pipe route as follows:

- * Along Streets (Asphalted, M.C, and Seal Coated), side walks and paved areas, all backfilling materials shall be base course. The surface condition shall be restored as the original one.
- * Across or Skewing Streets (Asphalted, M.C, and Seal Coated Areas).

All the backfilling shall be base course except for the top 300 mm which shall be plain concrete (200kg/cm² after 28 days) as shown on the Standard Drawings, with thickness of 300 mm for ductile iron pipes and 200mm for polyethylene pipes 63mm diameter.

Base course material shall be tested in accordance with the Jordanian Standard Specification for the Construction of Roads and Bridges issued by the Ministry of Public Works (1991). The material shall be designation "B" and graded as follows:

2.2.4

Sieve size (mm)	Sieve size (inch) & No.	Percentage by weight passing
51.00	2 in	100
37.50	1½"	70 - 100
25.00	1"	55 - 85
19.00	¾"	50 - 80
9.5	⅜"	40 - 70
4.75	No. 4	30 - 60
2.00	No. 10	20 - 50
0.425	No. 40	10 - 30
0.075	No. 200	5 - 15

Surface Reinstatement

In roads, streets, highways, stairs, footpaths, agricultural areas, fields, etc. where excavation works are to be carried out, the Contractor shall use the appropriate equipment to ensure that damage to adjacent surfaces is minimized. Pavement cutting shall be in straight lines with vertical cuts.

Where the surface of the road (other than that which lies immediately above the trench) is damaged either by the concentration of traffic caused by an open trench, by subsidence of other causes arising from the operations of the Contractor, the Contractor shall permanently reinstate all of the surface so damaged to its original condition.

Asphalt Surfaces damaged during construction works shall be replaced with an asphalt surface in accordance with the details shown on the Typical Drawings. All pavements shall be sawn 150 mm wider than the trench. From each side the materials used in the asphalt replacement shall be those normally used by the Ministry of Public Works of Jordan (Highway Specifications for Asphalt surfaces 1991). At every 500 m of reinstatement and other locations as directed by the engineer, at least one material test shall be carried out as required by the Ministry of Public Works of Jordan (Highway Specification for Asphalt surfaces 1991).

Reinstatement of the surfaces is included in the unit rate of the meter run of pipelines

1. Reinstatement of Roads, Asphalted areas

After completion of backfilling of the trenches the surface reinstatement will be carried as follows:

- a- Supply and install sub-base course layer of 150mm thick and compacted to 95% according to modified proctor test AASHTO – T180.
- b- Supply and install base course layer of 150mm thick and compacted to 95% according to modified proctor test AASHTO – T180.

- c- The material of the two above mentioned layers will be according to General Specification for Roads and Bridges, clause 1-3, table 2-3, class B.
- d- Prime coat of MC-70 used in a rate of 1.5 kg/m² and mechanically performed.
- e- Hot bituminous concrete of 10cm thick after rolling.

2. Reinstatement of sidewalks will be in accordance with the requirements of the Typical Drawings, and including 10cm of concrete under tiles. Curbstones shall be reinstated so as to match the adjacent materials as far as is practicable and in accordance with the following requirements:

Curbs to be pre-cast concrete, Class "C20" hydraulically pressed. Curbs shall be laid true to line and level, bedded on a layer of 3:1 sand cement mortar 13mm thick, laid on a concrete foundation and shall be back filled and shaped to the required cross section.

Especially cast circular curbs shall be used on curves of 12 m radius or less.

Curbs shall be jointed with cement mortar 1:3 except at expansion joints that shall be made with approved joint filler 13mm thick.

Work shall include the concrete base for the curbs, concrete behind the curbs all with strength of 200kg/cm².

All roads and street "improvements" including stairs, excavated or damaged and any damage to adjoining property caused by construction operations, shall be restored or repaired by the Contractor at his own expense to a technically sound condition at least equal to that pertaining before the Contractor started work. Materials used and work done in such restoration and repair shall be of the same kind, shall conform to the same dimensions and be of approved quality and shall conform to the requirements of the agency having jurisdiction.

At the discretion of the Engineer (where deemed necessary), temporary pavement reinstatement, 50 mm thick, shall be supplied laid and maintained, to the satisfaction of the Engineer, for all trenches where traffic is allowed to drive over or along the excavated and backfilled areas before carrying out the permanent reinstatement.

3.3 Reinforced Concrete Encasement (RCE):

The Contractor shall supply all materials and construct reinforced concrete encasement (RCE), as shown on the Drawings or directed by the Engineer specially but not limited to RCE for water or sewer pipelines crossing each others or both as shown in standard drawings and for water pipes crossing wadies or passing through culverts or water pipes with cover less than one meter.

RCE shall be of cast in place reinforced concrete with cubic strength of 250 kg/cm² after 28 days. All work shall be according to Specification, and Engineer's Instruction.

All (RCE) shall be allowed to cure for at least (7) days before backfilling of the trenches.

The costs of (RCE.) includes reinforced concrete, blinding concrete (150 kg/cm²), reinforcement steel ($f_y = 2800$ kg/cm²), formwork, additional excavations, backfilling ... etc, all according to Specifications, Drawings and Engineer

Instructions (the cost shall be included in the unit rate of the meter run of the pipeline).

3.4 House connections:

- 1- The Contractor shall supply all pipes, fittings and Appurtenance to install house connection up to 1.0m inside the costumer property lines and as indicated by the Engineer on site.
- 2- The house connection shall be executed as per attached Instructions.
- 3- The Contractor shall submit house connection sheet for each one as per the attached form.
- 4- House connections shall executed of polyethylene pipe of diameter 32 or 25m and up to 1.0m inside the boundary of the land lots.
- 5- The polyethylene house connections shall end by end plug.
- 6- House connection shall be connected to polyethylene service lines, using electro Fusion tapping saddles and ferrules or using self tapping saddles and ferrules.
- 7- Polyethylene pipes of diameters 63, 32 and 25mm shall be connected to ductile iron mains using under pressure tapping gunmetal ferrule and saddle, the work shall include supplying and installation of ferrule and saddle, surface boxes, extension spindles, and all required fittings and accessories.
- 8- Instruction for House connection execution.
 - House connections diameters shall be as follows:-

House diameter	Connection	No. of water meter per house connection
3/4"		10 or Less
1"		11 - 21
2"		22 - 130

- For large communities such as hospitals, schools, residential buildings more than three stories, commercial complex, mosques, health centers ...etc. use 32mm diameter house connection OR diameter of such house connections are to be determined by the Contractor according to water requirement for the community and subjected to the Engineer's Approval.

Typical House Connection Sheet

No.: Date:	Ministry of Water and Irrigation Water Authority			
No. of Customer	No. of Flats	Land Lot No.	Basin No.	Area
The Contractor shall submit this form in Tracing Paper				
Contractor	Date of connection	Surveyor	Draft	Engineer

3.5 Pipe laying of Pipes:

1. In general all pipes shall be laid in accordance with the Standard Drawings. Pipes and fittings shall be laid true to lines and grades shown on the Drawings and specified herein unless otherwise approved by the Engineer's Representative. Pipes and fittings shall be lowered carefully into the trench in such a manner to prevent damage to the exterior surface and interior lining. Under no circumstances shall pipes or fittings be dropped into the trench. All trenches shall be dewatered prior to installation of pipes.

The spigot and socket ends of pipes and fittings shall be inspected prior to installation and all lumps, blisters and excess coatings shall be removed. The spigot and socket ends of pipes and fittings shall be wiped clean and dry of all dirt, sand and foreign material. The rubber gasket shall be placed in the correct direction, and be correctly seated. Lubricant, furnished by manufacturer of the pipe, shall be applied to the previously cleaned spigot end of the pipe. The contractor shall ensure that the spigot end of the pipe is beveled, as square or sharp edges may damage or dislodge the gasket and cause a leak. All pipes cut in the field shall have the spigot beveled with a heavy file or grinder to remove all sharp edges. The spigot end shall be pushed into the socket end of the pipe or fitting making sure the joint is straight and the spigot centered in the socket.

The Contractor shall familiarize himself fully with all literature furnished by the manufacturer with respect to installation of pipes and fittings prior to installation of pipes and fittings.

The pipes shall be secured in place with backfill material.

At the close of a day's work or whenever pipe laying is not in progress, the open ends of the pipe shall be plugged, capped or otherwise made watertight to prevent the entry of foreign material of any nature. Care must be taken to prevent pipe flotation should the trench fill with water. The Contractor shall be responsible for all damage to the installed pipes, fittings and valves resulting from flotation or any other cause.

Flanged joints shall incorporate full-faced, one piece gaskets. Flange faces should bear uniformly on the gasket, and bolts should be tightened uniformly until the joint is perfectly tight. The Contractor shall use torque wrenches, for tightening all bolts.

When it is necessary to deflect pipes from a straight line in a horizontal or vertical plane, said deflection shall be accomplished after the spigot has been properly installed in the socket ends of the pipe. Deflections shall not exceed the values recommended by the pipe manufacturer.

Cutting of pipes may be authorized. Care shall be taken however, to ensure that such cuts are only made when strictly necessary.

Cutting will be carried out according to the manufacturer's requirements, without damage to the pipe or the protective coating and so as to leave a smooth face normal to the axis of the pipe. All cutting shall be done with proper cutting tools and apparatus. The Contractor shall remove all unused cut-off pieces from site on completion of the works and return them to the stores.

In all cases the Contractor shall be responsible for the accuracy of the measurement of the cut pipe required.

To suit the requirements of Pipes passing through concrete walls of valve chambers, as indicated on the Standard Drawings, pipes shall be cut to suitable lengths and be furnished with welding neck flanges.

Backfill, bedding, and compaction shall be in accordance with the provisions of item (2.2). All pipe trenches shall be backfilled to original or finished ground surfaces as specified. All backfill material shall be placed and compacted in such a manner as to not disturb the pipe.

Pipes shall be protected by concrete encasements where indicated on the drawings or directed by the Engineer. Execution of works shall be according to the Standard Drawings and in accordance with the provisions of item (2 .3).

All welded and flanged joints shall be coated and protected (before the water tightness test and hydrostatic pressure test) in accordance with the relative clauses of the specifications and the approval of the Engineer .

2. Thrust Blocks and Collars:

- The Contractor shall construct all thrust blocks and collars (End Caps) as shown on the Drawings and specified herein. Thrust blocks shall be constructed at all bends, tees, tapers, valves, dead-ends etc. unless otherwise shown on the Drawings. Thrust collars shall be constructed at plugged dead-end pipes with push-on joints (EU-piece and X-piece, or F-piece and X-piece if required).
- Thrust blocks and collars shall be constructed of cast-in-place concrete in accordance with the requirements of Specs. The bearing faces of the thrust blocks shall be placed against undisturbed natural earth except as specified hereinafter.
- Thrust forces and sitting of anchor blocks shall conform with the field test pressure and be calculated by the Contractor considering the prevailing soil bearing capacity. Dimensions given on the standard drawings are approximate only.
- In concrete chambers, thrust forces from closed valves shall be absorbed by the concrete walls by means of puddle flanges welded on the pipes. Additional structural reinforcements to be provided by the contractor.
- All concrete thrust blocks and collars shall be allowed to cure for at least 7 days before backfilling the thrust blocks and prior to any loads being applied to the blocks and collars.
- The cost of thrust blocks and collars shall be included in the unit price of pipelines.

3. Field Adjustments:

The pipe and methods of jointing shall be such that the locations of fittings and lengths of pipe can be adjusted in the field to suit field conditions and variations in stationing. A reasonable tolerance in the locations of lines will be allowed upon approval of the Engineer's Representative.

4. Measurement:

The quantity of all pipes in place and all fittings shall be the number of linear meters of each size installed within the limits shown on the Drawings or as ordered by the Engineer. The length will be the distance between the ends of the pipes measured or computed along the centerline of the pipe without deduction for fittings. Every type of fittings (bends, tees, tapers, adapters, end

plugs, dismantling joints, flexible couplings, etc.) shall be included in the unit rate of pipes. All kinds of valves such as gate valves, air valves, water meter....etc. shall be quoted as Extra Over item, which shall include their concrete chamber.

5. Payment:

The unit prices for each of the items installing pipes, shall be full compensation for furnishing all labour, materials, tools, equipment, etc., necessary to furnish, install, test and disinfect the water mains as shown on the drawings or as directed, all as specified. The unit prices shall include all auxil work necessary for water main construction but not specifically included for payment under other items of the contract.

6. Hydrostatic Pressure Testing of Pipes :

After completing the installation of a water main, or a section of the line, and before the joints are covered, a hydrostatic test of the line shall be made by the Contractor. The test pressure shall be 25 bars for all lines. A sufficient time for the curing of concrete thrust blocks must be allowed before the test is made. All backfilling and compaction over and around the pipes and thrust blocks must be completed, before the test is made.

The Contractor shall submit to the Engineer's Representative for approval, detailed procedures for performing hydrostatic pressure tests of installed pipes, fittings and valves. Procedures for performing the hydrostatic pressure test should indicate the location and capacity of the test pump for each test section, test pressure at the pump, procedure for venting the air from the pipeline, procedure of filling the pipe with water and length of the pipe section.

6.1 Duration of Pressure Test:

The initial test pressure shall be applied for a period of 24 hours before all tests are assumed to begin, to allow for a soaking period. . The test pressure for the main test shall then be applied for at least three hours for pipe diameters up to DN 200 and six hours for pipe diameters DN 250 to DN 400.

The test pressure shall not be allowed to fall below 75% of the test pressure for all lines. If and when it does during the test period, the pressure shall be increased to the stated value and a record kept of the additional water added.

6.2 Procedure:

The pressure for the initial test will start with the nominal pressure, and shall reach the test pressure within the last 6 hours of the initial test.

Test pressure to be taken at the lowest point of the pipe line to be tested and corrected to the elevation of the test gauge.

The test pressure of the main test is 25 bar

The tests have to be carried out in the presence of the Engineer's Representative in accordance with the relevant standards for the pipe material applied.

When filling the pipe system, the contractor shall not exceed the amount of water charged into the system as follows :

- up to 200 mm diameter 1.5 liters / second
- up to 300 mm diameter 3.0 liters / second
- up to 400 mm diameter 6.0 liters / second
- up to 500 mm diameter 9.0 liters / second
- up to 600 mm diameter 14,0 liters / second

The test pressure shall be applied by a suitable pump equipped with connection valves and gauges, etc., to the satisfaction of the Engineer's Representative. The gauges and meters shall be new and accompanied by a certificate for test and calibration.

The results of the tests, specifying the layout of sections of system, pipes and fittings tested including all relevant data of testing as weather, time, duration, filling time, pressure, etc., shall be produced in the form of a report by the contractor and signed by the contractor and the Engineer's Representative.

This report shall not relieve the contractor of his responsibility for care and maintenance of the system until the date of final acceptance of the completed work.

6.3 Stop Ends :

A simple stop end consists of a section of steel pipe about 0.5-1.0 m long on to which a closing plate has been welded, containing the necessary openings for accommodating ingoing water and out coming air. The stop end may also include an opening through which the test water may be pumped from the line, if necessary. The stop end may be jointed to the pipe to be tested by means of a standard coupling or other method approved by the Engineer's Representative. Thrust blocks or a temporary anchorage must be provided to hold the stop end in place against the test pressure.

6.4 Air Removal before Test :

Before applying the test pressure, all air shall be expelled from the pipe. After all the air has been expelled, all cocks shall be closed and the test pressure applied as specified above. The line shall be filled slowly to prevent possible water hammer.

6.5 Examination during Test :

All exposed pipes, fittings, valves, hydrants and joints shall be carefully examined during the pressure test. All joints showing leaks shall be rejoined until tight, or the pipe material replaced.

Any defective pipes or joints, fittings or valves discovered as a result of this pressure test shall be repaired or removed and replaced by the Contractor at his own expense with sound material and the test shall be repeated until proved satisfactory to the Engineer's Representative.

6.6 Permissible Addition of Water :

Additional water is defined as the quantity of water which must be supplied to the laid pipe, or any section thereof, to maintain the specified test pressure after the pipe has been filled with water and the air expelled. The quantity of additional water pumped into the pipe shall be measured accurately.

No section of the water main will be accepted until the additional water calculated in litres per km per 24 hours for the test pressure is less than $0.3 D$, where D is the nominal diameter of the pipe in mm.

The Engineer's Representative shall prepare a written report of the results of the leakage test that identifies the specific test, length of pipe tested, the pressure, the duration of the test, and the amount of additional water required. The report shall be signed by the Contractor and the Engineer's Representative.

6.7 Cost of Testing

The Contractor shall provide a sufficient quantity of gauges, pumps, stop ends, pipes and connections and all things necessary and suitable for the testing of all pipes as described herein. The Contractor shall also provide all necessary temporary works in connection with the test, and shall remove the same on successful completion of the test. All tests shall be done in the presence of the Engineer's Representative and the results of such tests shall be signed by the Contractor and handed to the Engineer's Representative who shall prepare the required test reports.

All equipment, labour, materials, and water necessary for the carrying out of these tests to the complete satisfaction of the Engineer's Representative shall be provided by the Contractor at his own expense. Should any test fail, the Contractor shall, after repairing and making good any leaks, carry out further tests all as described above until such tests meet with the requirements contained herein. All such tests and retests shall be at the expense of the Contractor, and shall be included in the unite rates for the relative pipeline.

3.6 Polyethylene Pipe Installation Procedures:

- 1- In general all HDPE pipes shall be laid in accordance with the standard Drawings .

Cuts in pipes should always be square and clean . Sand paper should be used to remove any excess materials, flashing or burrs if any to smooth the end of the pipe.

The width of the trench for service connection shall be restricted to the absolute minimum of (55cm) consistant with the required compaction of the backfilling. All stones and hard materials which in the opinion of the Engineer could damage the service connection pipe shall be removed from the trench bottom and sand spread so that the polyethylene pipe may be embedded in soft materials for its full length and 150 mm. Above the crown of the pipe . The trench shall then be backfilled and compacted and reinstatement carried out . The specifications for the sand bedding, should be the same as stated in section (2-2) Bedding & backfilling .

Service pipe fittings such as connectors, redusing connectors, 90° bends or equal Tee made of ultra violet resistant body with PVC Grip Ring and nitrile elastomer "o" ring should be used . Extractor tools for removing fittings from pipes if required shall be used. Some pushfit fitting do not required the extractor tolls and are provided with end caps that are screwed .

House connection of 1" or ¾" (HDPE) diameter from service lines (HDPE) should be constructed as indicated on the Drawings. The house connection should be extended to the floor level of the premises exactly below the water-meter assembly location unless otherwise specified by the Engineer .

Tapping shall be made into saddles affixed to the main on lines not in service as shown in on the detailed drawing and care shall be taken to avoid breaking away concrete lining .

Tapping shall be positioned on the main so that the ferrule inserted into the main at the crown. The jointing of the threaded ferrule to the main line shall be made using lead free jointing compound or p.t.f.e . tape .

The outlet of the ferrule shall be set to point in the direction in which the service pipe is to be laid . The service pipe (Polyethylene) shall be laid with a cover of not less than that shown on the drawings .

The jointing on the polyethylene pipe to the push-fit shall be in accordance to the manufacturer's of the pushfit fittings instructions . The pushfit joint which is a quick and simple to assemble has a sealing and gripping components and are encapsulated within the body of the fitting . There is no thrust nut . The "o" ring is compressed by the water pressure and not by hand . The greater the pull on the pipe the better the gripping effect

The machine manufacturer's recommendations shall be followed in respect of the tapping machine.

Sterilization of the service connection will be carried out at the same time as the main to which it is connected .

House connections from proposed HDPE service lines should be connected as indicated on Drawings .

The contractor shall install all fittings , valves, bends , tees, pushfit , tapers, unions, ferrules, saddles, etc. which may be needed to complete the job at no separate payments. All buried fittings should be suitable for under ground use .

2- Service Pipelines Connection Installation

A service pipeline of 63mm. diameter made of high density Polyethylene pipes shall be used to connect the main pipeline to the House Connection pipes (25mm and 32mm P.E pipes).

Service Connections on existing pipelines shall be made by under pressure tapping or as shown in the detailed drawing.

A gunmetal saddle is to be provided with stainless steel nuts and bolts and Nitile rubber sealing ring / washer Suitable for working pressure of 16 bar. The tapping will be made for 2".

The gunmetal ferrules shall have single outlet with pushfit outlet suitable for 2" inch outlets. The Engineer will issue instructions regarding the size location and fittings of each service connection.

Tapping shall be positioned on the main so that the ferrule is inserted into the main at the crown. The jointing of the threaded ferrule to the main line shall be made using lead free jointing compound.

The outlet of the ferrule shall be set to point in the direction in which the service pipe is to be laid. The service pipe (polyethylene) shall be laid with a cover as shown on Drawings .

3- Pressure Test of HDPE Pipes :

Test pressure shall be 24 bars. The service lines including joints, fittings and appurtenances shall be tested for water tightness in accordance with ISO 1167 as follows:

- 1) Allowable quantity of water required to restore pressure at the end of the test Period : <3 Litres / km / 25 mm dia. of pipe / 3bar /24 hours.
- 2) Hydrostatic testing should be carried out at ambient temperature (20 C) otherwise a correction factor should be applied to the nominal pressure.
- 3) Test should be applied on sections of length less than 800 m with uncovered joints.
- 4) Partial backfilling to maintain adequate support and anchoring and to avoid floating of pipes during testing. Test procedure with joints exposed and valves in the open position .
- 5) The filling of pipes should be at a rate giving a maximum water velocity of 0.5 m /s in the pipe to insure no surge and to give the air the necessary time to be released by the installed temporary air valves or cocks .
- 6) Water to be left for sufficient time to reach equilibrium i.e, the same temperature as the pipe and the surrounding soil and to remove all existing air for the saturation of pipe material, if any.
- 7) Apply test pressure slowly to avoid surge and hold for one hour .The system should be isolated from the test pump i.e ., no pumping during the one hour test period allowed Test pressure shall be 24 bars for service lines including all couplings and fittings in the open position , with consideration to temperature variation .
- 8) Apply the equation to determine if the section under test satisfies the requirements of (1) above
- 9) Finally after completing testing , the line should be emptied slowly to prevent shocks or sudden counteraction of pipes .

4- Short Pressure Test

The so- called “short test” may be used for pipelines up approx. 30 m and nominal diameter not than DN 50 .

The test pressure for the short test is 24 bars .

The test pressure is applied to the pipe and the first reading taken after 30 minutes. Note that this pressure is usually slightly less than initial pressure due to the normal expansion of the pipeline under pressure, but no additional “top up” pressure should be applied

For the short test the results are deemed to be satisfactory when pressure loss from the HDPE pressure pipeline is ≤ 0.1 bar per 5 mins

Short pressure test for the house connections can be applied when approved by the Engineer.

3.7 Water Pipeline Detection

The contractor shall supply all materials and workmanship required for water pipelines detection, to be installed above the embedment sand as per the following:-

- a) Ferrous Tracking tape (Metallic Warning tape) for high density polyethylene pipes of diameters 32 and 25 mm. as per typical drawings.
- b) Electronic Identifiers and warning tape for ductile iron pipes of all diameters and high-density polyethylene pipes of diameters 125 and 63 mm. as per typical drawings.

The cost of the Ferrous Tracking tape and Electronic Identifiers and warning taps will be included in the unit rate of the pipelines.

1. Ferrous Tracking Tape:

An aluminum foil laminate with purity not less than 99.5% and having aluminum thickness of 9 microns & Width OF 50mm shall be laminated in between 2 layers of inert plastic material. The bond for this lamination is to be made with 2-parts, self curing adhesive which withstands a hot melt bonding temperature of 180 C without dolamination. The lamination bond must also be water resistant.

The above described laminats is then laid onto an embossed extruded sheet of low density polyethylene of not less than 400 microns Thick . The width of this base layer of polyethylene shall not be less than 200 mm.

Over the top of the aluminum foil, a final layer of inert plastic film of 100 microns thickness. This bond shall be made of heat sealing and with no adhesive employed. The bond shall be complete over the base layer and also over the conductive aluminum foil The width of this film is the same as the width of the base layer of embossed polyethylene

The top surface of the film shall be printed in both Arabic and English with suitable font by:

CAUTION
JORDAN WATER AUTHORITY
Water Pipe line

تحذير
سلطة وادي الأردن
خط مياه

The overall thickness of the complete tape shall be (500) microns + 5 %
The breaking strain per 150 mm. of width shall not be less than 75 kg.

2. Electronic Identifiers (E.I.) :

Scope :

Electronic Identifiers shall be installed over proposed underground net works being Water and Waste Water Utilities, Electric Power Utilities, and Telecommunication Utilities according to the following specs. :

2.1 Specifications :

- The design and construction of the Electronic Identifier shall be rugged, reliable, and durable

- The cross sectional area, shall be small in order to fit in tight place
- the following is the required specification

Utility	Water	Waste Water	Electric Power	Telecommunication	Gas	CATV
Color	Blue	Green	Red	Orange	Yellow	Black Orange
Frequency	145.7 kHz	121.6 kHz	169.8 kHz	101.4 kHz	83.0 kHz.	77.0 kHz.
Accuracy	± 1%					
Depth Range	60 – 150 cm					
Operating Temp. C°	- 40 to +70c°					
Storage Temp. C°	- 40 to + 85 c°.					
RLC Circuit	Core of the indicator should be a ferrite core					
Housing	Rugged, with a water proof insulating materials to protect the RLC. circuit in case the casing is broken					
Life Expectancy	45 years min.					
Field Trials	Required, and cannot be conducted during the execution of the project. Any product to be suggested for use should pass a field trial test where sample of the product is placed in position for 3 months, and tested for operation on monthly bases.					

Samples of (E.I.) shall be submitted by the Contractor to be approved by the Engineer without any additional costs .

Installation : 2.2

Electronic Identifiers shall be installed in the following both manners:

- a. Vertically: Within the top of the soft backfill layer (Bedding), over the utility at a depth not exceeding 90 cm. from the surface of the ground .

- b. Horizontally: One identifier every (12) meters max. for straight utilities and (4) meters in long curves and where there are more than one pipeline in the area, to the satisfaction of the Engineer.

When all identifiers are installed (before backfilling to surface and after surface reinstatement) a locator shall be used to verify that all identifiers have been installed properly. The locator shall be supplied by the Contractor at his own expense and shall be the property of the Contractor after completion.

Identifiers shall be positioned 10 cm . min - away from any metallic or magnetic Materials.

All Networks Record Drawings, shall have a note on each, stating that the Networks in that DRG. has Electronic Identifiers .

For special fixtures (such as valves, meters, bends, tees, manholes covers under pavement, joints ...etc), two identifiers shall be installed (one on each side of the fixture) 50 – 100 cm . apart symmetrically across the main.

2.3 Electronic Identifier Locator :

Electronic Identifiers respond to start frequencies. The locating device should be compatible with said frequencies at :

Utility	Water	Waste Water	Electric Power	Telecommunication	Gas
Frequency	145.7 KHz	121.6 kHz	169.8 kHz	101.4 kHz	83.0k Hz

- Locating device should be:

1. Rugged and durable and suitable for field use.
2. Battery operated, average battery life above 20 hrs.
3. Compatible with standard EMS. Frequencies as mentioned above.
4. Able to locate two frequencies at the same time.

- Payment :

The cost of supply and installation of the Electronic Identifiers shall be deemed to be included in the Contract unit prices .

3. Plastic Warning Tape :

The Contractor shall lay above the Electronic Identifier as shown in typical drawings an plastic (Warning Tape) of 200mm. Microns thickness 50mm. Wide, with a red color for primary and blue for secondary . The top surface of the tape shall be printed in both Arabic and English with suitable font by :

6- UPVC Pipe and Fittings

6.1 General

UPVC pipes are used for gravity sewers having diameter 250 mm or less. Product manufacture, testing and installation shall comply with the following references, unless otherwise stated in the specification or unless

otherwise approved by the Engineer.

- a. ISO 161/1 Thermoplastics pipes for the transport of fluids Nominal outside diameters and nominal pressures –Part 1 : Metric Series.
- b. ISO 1167 Plastic pipes for the transport of fluid –Determination of resistant to internal pressure.
- c. ISO 2045 Single sockets for unplasticized polyvinyl chloride (uPVC) pressure pipes with elastic sealing ring type joints –Minimum depths of engagement.
- d. ISO 2048 Double sockets for unplasticized polyvinyl chloride (uPVC) pressure pipes with elastic sealing ring type joints – Minimum depths of engagement.
- e. BS EN ISO 2505:2005 Unplasticized polyvinyl chloride (uPVC) pipes –Longitudinal reversion – Test methods and Specification. Method B – Oven test.
- f. ISO 2507 Unplasticized polyvinyl chloride (uPVC) pipes and fittings – Vicat softening temperature – Test methods and Specification.
- g. BS EN ISO 3126:2005 Plastic Pipes – Measurement of dimensions.

- h. ISO 3127 Unplasticized polyvinyl chloride (uPVC) pipes for the transport of fluids – Determination and specification of resistance to external blows.
 - i. ISO 3472 Unplasticized polyvinyl chloride (uPVC) pipes – Specification and determination of resistance of acetone.
 - j. ISO 3473 Unplasticized polyvinyl chloride (uPVC) pipes –Effect of sulphuric acid – Requirement and test method.
 - k. ISO 3606 Unplasticized polyvinyl chloride (uPVC) pipes –tolerances on outside diameters and wall thicknesses.
 - l. BS EN 1401-1: 1998 u-PVC gravity sewer pipes
- 6.2 Pipe sizes shall be as shown on the drawings, unless otherwise approved by the Engineer. The designated sizes on the drawings refer to nominal internal diameters. Pipe class shall be as follows, unless otherwise noted or unless otherwise approved by the Engineer.
- a. Pressure pipes: Class 16
 - b. Non-pressure pipes:

The pipe shall have the nominal dimensions shown on the Drawings. Non Pressure Pipes shall have a ring stiffness of 4,000 N/m² between manholes where the depth of cover over the crown of the pipe is less than 3.5 m in any part of that section between manholes. Non-Pressure Pipes shall have the ring stiffness of 8,000 N/m² between manholes where the depth of the cover over the crown of the pipe is equal to or greater than 3.5m in any part of that section between manholes.

Where pressure pipe is designated for non-pressure applications, manufacturing shall conform to the designated pressure class, unless otherwise approved by the Engineer. Pipes shall be suitable for sustained operating temperatures of up to 45°C.

- 6.3 Pipe lengths shall be as follows, unless otherwise approved by the Engineer.
- a. For 225mm outside Dia. and above, standard pipe length shall be 6 meters.
 - b. For 200mm outside Dia. and below, standard pipe length shall be 3 meters.

Maximum buried depth for uPVC pipes shall be 6 meters, unless approved otherwise by the Engineer.

- 6.4 All joints shall be spigot and socket type with flexible elastomeric sealing rings, unless approved otherwise by the Engineer.
- a. Double sockets or slip on sockets may be used adjacent structures or special fittings.
 - b. Solvent welded joints may be used for buried fittings if assembled in the manufacturer's workshop under the Engineer's supervision. Solvent shall be as per the pipe manufacturer's recommendations.
 - c. Solvent welded fittings may be used for exposed piping, if approved by the Engineer.
- 6.5 All elastomeric joint seals (rubber gaskets) shall be obtained from the pipe manufacturer. All joints shall be capable of withstanding an external pressure of 100 Kpa without infiltration in both the straight and misaligned positions.
- 6.6 All bends and special fittings, even if manufactured elsewhere, shall be obtained from the pipe manufacturer, unless approved otherwise by the Engineer. All bends shall be "long-radius" unless otherwise approved by the Engineer. Additional testing for bends and special fittings may be directed by the Engineer at the Contractor's expense.
- 6.7 Each pipe, special or fitting shall be clearly marked at the place of manufacture with the following information.
- a. The name or distinctive mark of the manufacturer.
 - b. The date of manufacture.
 - c. The pressure rating (if applicable)
 - d. The nominal diameter
 - e. The manufacturing standard to which the product has been produced
 - f. The angle of bends or branches
 - g. Where appropriate, the name of the Client and contract number

- h. Where appropriate, individual reference number
- i. Number and mark of independent testing agency (if applicable)

6.8 Pipe and standard joints shall be submitted for all proposed sizes and pressure classes for the Engineer's approval. The submittal shall clearly indicate or include the following:

- a. Pipe manufacturer's name.
- b. Proposed pipe diameters
- c. Proposed pipe pressure class or rating for pressure pipes and ring stiffness for non pressure pipes
- d. Proposed manufactured lengths
- e. Proposed joint type
- f. Proposed sealing ring material and manufacturer's name
- g. Maximum depth of cover
- h. Minimum depth of cover
- i. Maximum internal operating pressure
- j. Maximum internal test pressure
- k. Maximum allowable external pressure

l. Recent type test results according to the relevant standard of manufacture to prove the adequacy of the products

6.9 Fittings, bends and specials for all proposed sizes and pressure classes shall also be submitted for the Engineer's approval. Samples shall be supplied according to the Engineer's request.

6.10 The uPVC material supplier shall demonstrate to the Engineer, that he has the capability of manufacturing the required uPVC pipelines of the sizes in accordance with the contract. The company shall have an internationally recognized quality management system in place and shall be accredited to ISO 9002 or equivalent.

6.11 Pipes, fittings and spools shall be delivered, handled and stored according to the manufacturer's recommendations along with the following provisions. Transportation, handling and storage shall at all times be performed in a manner to avoid product damage. Only nylon slings shall be allowed for lifting pipes and fittings. Steel chains, clamps or cables shall not be allowed for lifting purposes. Steel chains or cables may be allowed for securing pipes during transport or storage provided protective padding or timber blocking is utilized. Any pipes damaged during delivery, storage or installation shall be marked and set aside. Proposals for repair of any damaged pipes shall be submitted in writing to the Engineer for approval. No repairs to damaged pipes shall be attempted without the Engineer's approval. Any damaged pipes deemed unsuitable for repair by the Engineer shall be removed from site and replaced at the Contractor's expense.

Elastomeric sealing rings (rubber gaskets) shall be stored in closed containers out of direct sunlight until needed.

6.12 uPVC pipes shall be manufactured in metric sizes according to ISO standards, unless otherwise approved by the Engineer. uPVC pipes shall be manufactured from new materials. Recycled PVC shall not be used.

6.13 Elastomeric sealing rings shall be manufactured with the following material in compliance with the following standards, unless otherwise approved by the Engineer:

EPDM material conforming to BS 2494 Type "D" requirements for irrigation service.
EPDM material conforming to BS 7874:1998, BS EN 681-1:1996, BS EN 681-2:2000 requirements.

6.14 Pipe spools shall be manufactured according to the manufacturer's recommendations or as approved by the Engineer.

6.15 Pipe surround shall conform to the requirements in Section 3 of CESWI 6th Edition and the same section of this document. Solvent cement shall be as recommended by the pipe manufacturer.

6.16 Pipe Layers

- a. No piece of pipe shall be laid unless it is straight. The centerline of the pipe shall not deviate from a straight line drawn between the centers of the openings at the ends of the pipe by more than 5mm/meter of length. If a piece of pipe fails to meet this requirement check for straightness, it shall be rejected and removed from the site. Laying instructions of the manufacturer shall be explicitly followed.
- b. If any defective pipe is discovered after it has been installed, it shall be removed and replaced with a sound pipe in a satisfactory manner at no additional cost to the Employer. All pipe and fittings shall be thoroughly cleaned before installation, shall be kept clean until they are used in the work and when laid, shall conform to the lines and grades required. PVC pipe and fittings shall be installed in accordance with requirements of the manufacturer, or as otherwise provided herein.
- c. As soon as the excavation is complete to normal grade of the bottom of the trench, bedding shall be placed, compacted and graded to provide firm, uniform and continuous support for the pipe. Bell holes shall be excavated so that only the barrel of the pipe bears upon the bedding. The pipe shall be laid accurately to the lines and grades indicated on the Drawings. Blocking under the pipe will not be permitted. Bedding shall be placed evenly on each side of the pipe to mid-diameter and hand tools shall be used to force the bedding under the haunches of the pipe and into the bell holes to give firm continuous support for the pipe. Bedding shall then be placed to 30 cm above the top of the pipe. The initial 90 cm of backfill above the bedding shall be placed in 30 cm layers and carefully compacted. Generally the compaction shall be done evenly on each side of the pipe and compaction equipment shall not be operated directly over the pipe until sufficient backfill has been placed to ensure that such compaction equipment will not have a damaging effect on the pipe. Equipment used in compacting the initial 90 cm of backfill shall be approved by the pipe manufacturer's representative prior to use.
- d. All pipes shall be sound and clean before installation. When installation is not in progress, including lunchtime, the open ends of the pipe shall be closed by watertight plug or other approved means. Good alignment shall be preserved during installation. The deflection at joints shall not exceed that recommended by manufacturer. Fittings, in addition to those shown on the Drawings, shall be provided, if required, in crossing utilities which may be encountered upon opening the trench.
- e. When cutting pipe is required, the cutting shall be done by machine, leaving a smooth cut at right angles to the axis of the pipe. Cut ends of pipe to be used with a bell shall be beveled to conform to the manufactured spigot end.

- f. The Engineer may examine each bell and spigot end to determine whether any preformed joint has been damaged prior to installation. Any pipe having defective joint surfaces shall be rejected, marked as such and immediately removed from the job site.
- g. Each length of the pipe shall have the assembly mark aligned with the pipe previously laid and held securely until enough backfill has been placed to hold the pipe in place. Joints shall not be “pulled” or “cramped”.
- h. Before any joint is made, the pipe shall be checked to assure that a close joint with the next adjoining pipe has been maintained and that the inverts are matched and conform to the required grade. The pipe shall not be driven down to grade by striking it.
- i. Precautions shall be taken to prevent flotation of the pipe in the trench.
- j. When moveable trench bracing such as trench boxes, moveable sheeting, shoring or plates are used to support the sides of the trench, care shall be taken in placing and moving the boxes or supporting bracing to prevent movement of the pipe, or disturbance of the pipe bedding and the backfill. Trench boxes, moveable sheeting, shoring or plates shall not be allowed to extend below top of the pipe. As trench boxes, moveable sheeting, shoring or plates are moved, pipe bedding shall be placed to fill any voids created and the backfill shall be recomputed to provide uniform side support for the pipe.
- k. Concrete thrust blocks shall be installed at all fittings and other locations as directed by the Engineer. Minimum bearing area shall be as shown on the Drawings. Concrete shall be placed against undisturbed material and shall not cover joints, bolts or nuts, or interfere with the removal of any joint. Wooden side forms shall be provided for thrust blocks.

6.17 Jointing

- a. Joints shall be made in strict accordance with the manufacturer's instructions. Pipe shall be laid with bell ends looking ahead. A rubber gasket shall be inserted in the groove of the bell end of the pipe and the joint surfaces cleaned and lubricated. The plain end of the pipe to be entered shall then be inserted in alignment with the bell of the pipe to which it is to be joined and pushed home with a come-along or by other means. Check that the reference mark on the spigot end is flush with the end of the bell. Pipe and fittings shall be jointed in accordance with the recommendations of the detailed instructions of the manufacturer. The pipe manufacturer shall furnish information and supervise the installation of at least the first five joints. The pipe manufacturer shall be available on site for 3 days to supervise and inspect installation.
- b. All manhole connections shall be as shown on the Drawings except that concrete and mortared connections shall be equipped with an integral O-ring or other sealant such that a positive watertight seal is established.

7. Concrete Encasement

Where concrete bedding or surround is required, the backfill shall not be placed before the compressive strength of the site concrete has reached the specified strength. Where concreting to pipeline is specified, a blinding layer of Grade as specified in the Contract shall be placed over the full width of the trench. Pipes to be bedded on or cradled with concrete shall be supported on precast concrete setting blocks, the top face of each block being covered with a separation layer. Concreting to the pipeline shall be either bed or bed and surround as shown on the Drawings and shall be of Grade as specified in the Contract drawings along such lengths as are shown on the Drawings or ordered by the Engineer.

The pipe shall be prevented from moving or floating during concreting. Where concrete bed and surround is used with GRP and PVC-U pipes the maximum spacing between pipe joints shall be 3 m. For other pipe materials the maximum spacing shall be as directed by the Engineer.

In the case of concrete surround for pipes with flexible joints, the joints shall be interrupted in a vertical plane at the edge of the socket by a strip of fiberboard or

any other approved joint filler in accordance with the following thicknesses:

Up to 300 mm nominal bore - 13 mm

Over 300 mm and up to 600 mm nominal bore - 25 mm Over 600 mm and up to 1200 mm nominal bore - 38 mm Over 1200 mm and up to 2000 mm nominal bore - 50 mm

Where concrete slab protection to GRP and PVC-U pipelines is required such protection shall extend a minimum of 200 mm either side of the pipe trench. The slab shall be of reinforced concrete as shown on the Contract Drawings.

8. Wadi Crossings

Work at any crossing of a wadi or other waterway shall be carried out as expeditiously as possible to the satisfaction of the Engineer and any responsible Government agency or other authority, with minimum interference to the free flow of water. Details of any temporary works which may affect the flow of the wadi shall be submitted to the Engineer at least 14 days before starting work.

Where pipelines passes underneath a wadi, ditch, open surface water channel, or other waterway, the pipelines shall be encased in concrete. The minimum thickness of encasement shall be 150 mm. Unless otherwise designated, the depth of cover shall not be less than 600 mm from the bed of the water course to the top of the concrete.

The Contractor shall fill the trench in both banks with rock fill or concrete up to the designated levels. The extent of this work may be varied to suit each individual crossing.

Unless otherwise ordered, the concrete encasement of the pipe shall extend at least to a section vertically below the tops of the banks. Protection against erosion to the banks shall be provided by means of stone pitching or riprap.

9. Pipe Supports

All weight of piping and contained fluids shall be transferred to a structures or foundation system through stools, brackets, pipe saddle supports, or overhead hanger systems

Supports shall be provided for each pipe at or near the point where it is connected to machinery or valves. Supports shall be provided for each valve and special fitting. flexible joints shall be required at either ends of the support system, where necessary expansion joints shall also be provided Pipe hangers and supports shall